The Institution of Engineers of Kenya
Founded 1972

Engineering in KENYA

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Food Engineering

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In this Issue

Engineering in KENYA

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Call for Papers

Engineering in Kenya Magazine - Issue 024

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 October, 2025** for our next issue, whose theme is **Petroleum 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**

Eng. Prof. Lawrence Gumbe

Message from the Editor

Food Engineering is a branch of engineering dedicated to the production, processing, transport of food. The traditional focus of food engineering was preservation, which involved stabilizing and sterilizing foods, preventing spoilage, and preserving nutrients in food for prolonged periods of time.

The unit operations of food engineering include food dehydration and concentration, protective packaging, canning and freeze-drying. The development of food technologies were greatly influenced and urged by wars and long voyages, including space missions, where long-lasting and nutritious foods were essential for survival. Other ancient activities include milling, storage, and fermentation processes. Although several traditional activities remain of concern and form the basis of today's technologies and innovations, the focus of food engineering has recently shifted to food quality, safety, taste, health and sustainability.

Food engineering is vital to the world for ensuring global food security by transforming raw materials into safe, nutritious food, optimizing supply chains to reduce waste, and developing sustainable practices to minimize environmental impact. It drives innovation in food processing, packaging, and storage, while also enhancing nutritional value and meeting evolving consumer demands and regulatory standards.

Food engineering addresses the challenge of feeding a growing global population by developing processes to convert raw materials into edible products and ensuring their safe and efficient distribution. Food engineers design and implement efficient storage systems, cold chains, and transport infrastructure to reduce food spoilage and loss from farm to consumer. Food engineering establishes processes to maintain consistent quality, ensure food safety, and meet regulatory standards, protecting consumers from unsafe products. Processes like fortification and enrichment are used to enhance the nutritional content of food, helping to combat malnutrition.

Food engineers work to minimize the environmental footprint of food production by optimizing resource use, recycling water, and recovering energy from waste streams. Food engineers develop new food products and processes, often utilizing advanced technologies like AI, to meet changing consumer demands and create new food solutions. By optimizing production, storage, and transportation, food engineering ensures that food products reach consumers in a timely and efficient manner.

Engineers help in developing products that are appealing in taste, texture, and convenience, while also incorporating aspects like branding and sustainability to build consumer trust.

The global Processed Food Market size will be USD 164215.2 million in 2024. It will expand at a compound annual growth rate of 6.00% from 2024 to 2030 according to Cognitive Market Research.

Kenya Processed Food Market is growing, driven by the increasing demand for convenient and shelf-stable food products. Processed foods, including canned, frozen, and packaged foods, offer convenience and variety to consumers. The market growth is supported by the expanding urban population, changing lifestyles, and the demand for ready-to-eat meals. Innovations in food processing technology and the availability of a wide range of processed food products further contribute to market expansion.

The Kenya Processed Food Market is expanding due to changing consumer lifestyles and dietary habits, leading to increased consumption of convenience foods. Processed food products offer convenience, longer shelf life, and nutritional fortification, driving market growth.

The Kenya processed food market encounters challenges related to food safety regulations and consumer perception of processed foods. Market players face difficulties in addressing health concerns and maintaining product quality. Additionally, competition from homemade and fresh food alternatives poses hurdles for market expansion.

Challenges in the Kenya processed food market include addressing consumer demands for healthier and more natural food options amidst growing awareness of the impact of processed foods on health. Additionally, meeting stringent regulatory requirements and quality standards while ensuring cost-effectiveness and product innovation poses significant hurdles for market players. Moreover, maintaining supply chain efficiency and sustainability remains a key challenge in the processed food industry.

Some of the universities offering options in food engineering in the world include Technical University of Munich, Germany, University of Nottingham, UK, Wageningen University, Netherlands, University of Nairobi, Kenya, Jomo Kenyatta University of Agriculture and Technology, Kenya, and Herriott-Watt University, UK, Ohio State University, USA, Purdue, USA, University of California Davis, USA, and Rutgers, USA, among others many others internationally. These programmes often integrate biological, chemical, physical, and engineering sciences to cover food production, processing, and preservation.

This issue of Engineering in Kenya is dedicated to Food Engineering. We hope that you will find the issue informative, educative and entertaining.

Eng Prof Lawrence Gumbe

Editor

Eng. Shammah Kiteme, CE, FIEK, PMP
President, Institution of Engineers of Kenya

Message from the President

This issue of Engineering in Kenya Magazine focuses on food engineering. This is a testimony that the magazine that informs, entertains and educates you is alive to all the entire scope of areas where services of engineers are required.

Issue 23 of the Engineering in Kenya magazine is also a testimony to the resilience of this production. Indeed, it has remained going even in the toughest challenges and it will continue to serve the central purpose it serves to our members and stakeholders.

The subject of food is central to our very existence. Not only is food essential for our normal functioning but it is also cultural and spiritual. It is for this reason therefore that Engineering has to be relevant in this vital reality of our society.

Food Engineering concerns itself with all the stages involved in food preparation to deliver safe, nutritious food. This process involves various stages and systems.

It involves designing and developing various systems and processes for food production, storage, distribution and delivery. It is very important that food safety is taken into consideration and therefore the choice of materials as well as handling in all stages becomes very critical to ensure food safety.

Engineers are involved in the design of food handling equipment. This includes preparation, packaging, transportation, processing and finally equipment used for food consumption. The design and development of this equipment must factor in the basic math and applied science to ensure that the purpose for which they are required for is met.

Engineers will apply their understanding of chemical and mechanical processes as well as their understanding of heat transfer to ensure that key processes like harvesting, drying, freezing, transportation, storage, heating and all other actions and processes involved in food handling from harvesting to consumption.

A very key component of engineering in this space is quality control. Quality control is an essential component of this branch of engineering because food made for human consumption must be handled in a manner to ensure that there are no chances of contamination which would lead to food poisoning. As such, there is a lot of testing to ascertain that at every stage the quality of food being handled meets minimum safety standards and if this is not achievable then the food must be declared unsafe for human consumption.

Food security remains a key global conversation in this age of sustainable development goals. We have many populations in various countries that face food insecurity. As such, the processes of handling food should extend the shelf life so that we conserve as much as we can. It may be difficult to retain the original freshness but food engineering should deliver effective storage to ensure that as much as possible the food quality is preserved during storage. Whether it is through canning or drying the food should retain its nutritional value when it is required for consumption.

In this sector, many engineering disciplines converge as is the norm in engineering practice generally.

Ordinarily, any project or undertaking always involves various engineering disciplines to be successfully delivered. This requires collaboration and, in many instances, other professionals outside engineering like food science and dietetics play an equally important role. Chemical Engineers, Industrial Engineers, Mechanical Engineers, Civil Engineers, Mechatronics Engineers, Electrical Engineers will in many ways be involved in the various stages, processes and systems in food Engineering. They are expected to apply the engineering science to drive known principals of biological and chemical processes engineering them towards designing safe food management and handling methods, tools and equipment. Equally important is the innate understanding and appreciation of physics, microbiology and heat transfer.

Various standards are applied both locally and globally. These include Food Safety Management Systems that guarantee that various stages of food preparation and handling are monitored, recorded and checked for compliance as well as continuous improvement. Several audits of the processes involved in food handling are required to be done in order to comply with both internal and external requirements.

With globalization, food is often imported from one part of the world to another. This means the internationalization and standardization of the global food handling standards has become very key. This is particularly important because some parts of the world produce food in surplus while other parts have a shortfall in food production. Global trade in food ensures that the needy parts receive the food from surplus areas.

All this means that Engineers involved in food business must remain adept and updated with the latest global standards. They must therefore engage in lifelong learning and maintenance of globally recognized certifications in order to be able to practice anywhere in the globe.

The Institution of Engineers of Kenya continues to develop and roll out capacity building programs aimed at building the capacity of our members to acquire the necessary skills to remain current and relevant in their practice. Towards this end, a number of programs targeting members who are at different levels of their careers continue to be rolled out and they are available for equipping members with latest ideas in practice.

I now invite you our readers to yet another important read in this issue 23. You will find quality content just like the magazine has continued to produce every two months. IEK values your loyalty and we commit to continue producing quality content for you in our subsequent issues.

Message from the Honorary Secretary

Eng. Jacton Mwembe, PE

> ... the engineering profession has a vital role to play in advancing food security and industrial transformation. Whether working in infrastructure, manufacturing, academia, or consultancy, every engineer can contribute to building a stronger, safer, and more resilient food system.

I welcome you to EiK Issue 23 publication dedicated to a theme of utmost relevance and national importance: **Food Engineering.** As the demand for safe, nutritious, and sustainably produced food grows across the region, engineering professionals are being called upon to offer bold, practical, and forward-thinking solutions to address the challenges facing our agri-food systems.

The current era we are living in has witnessed increased climate variability, population growth, and changing consumer preferences, thus the transformation of food systems is both a necessity and an opportunity.

This edition explores how engineering can—and is—playing a vital role in enabling more resilient, efficient, and innovative food value chains. Production, manufacturing, processing, packaging, storage, and distribution of food products underpins engineering in every stage of the modern food ecosystem.

The future of agriculture and food production sustainability in Kenya relies in the increased application of Engineering knowledge and skills, which includes design and implementation of climate-smart irrigation systems, energy-efficient post-harvest storage solutions, and robust transportation infrastructure—all being the crucial components in ensuring year-round food availability and accessibility.

Through advancements in water management, precision agriculture, and improved farm mechanization, the agric- sector can optimize input use, reduce waste, and increase productivity. These innovations are especially critical in regions affected by erratic rainfall and poor soil quality, where efficient resource use is no longer optional but essential.

We take this opportune time to call upon the professionals in the Food processing sector, the engineers, to support the development of cleaner, faster, and safer manufacturing systems. This sector has embraced automation, digital monitoring, and data-driven quality control. These technologies, amongst many emerging technologies helps food producers maintain consistency, reduce contamination risks, and meet local and international safety standards.

The Kenyan Government puts an emphasis on value addition, calling for continuous innovation. The value addition chain ensures that the produce from the farm is taken trough the processing lines that turn raw agricultural produce into higher-value products such as packaged snacks, beverages, and convenience foods. This not only boosts incomes along the value chain but also enhances food preservation and shelf-life—critical to addressing post-harvest losses.

In other developing countries, the use of digital transformation is already taking root, with smart factory concepts being adopted to streamline operations. These systems enable real-time tracking of energy use, water consumption, equipment efficiency, and product flow—ultimately resulting in higher productivity and lower environmental impact.

The IEK Council calls for extensive training and engineering research. IEK held its first AJERI Scientific conference on **24th, July, 2025 at Kenyatta University.** The main aim of this was to strengthen partnerships with learning institutions, disseminate knowledge sharing and embrace the power of engineering innovations across the Africa continent. Its through such trainings and workshops that we empower the next generation of food engineers, ensuring for food sustaining progress in this field. This collaborative spirit between the IEK alongside academic reforms, ensures that education providers and the food industry, foster practical skills development, internship programs, and joint research initiatives aimed at solving real-world problems in food engineering.

This involvement of engineers in food research, pilot projects, and equipment prototyping would enable for continuous innovation, especially among small and medium-sized enterprises.

Some of the notable projects being undertaken by the Engineers in the food engineering sector includes, Smart irrigation and water-efficient farming technologies, which are enables for sustainable agriculture in water-scarce regions, Solar-powered cold storage and refrigeration systems, helping to reduce post-harvest losses and improve access to fresh produce in rural areas ,Advanced packaging innovations, including biodegradable materials and intelligent packaging systems that extend shelf life and track freshness. Use of automation and robotics in food sorting, grading, and processing, improves efficiency and hygiene in food handling facilities. These developments, while still evolving, reflect the expanding scope of food engineering and the growing reliance on technological solutions to feed growing populations sustainably.

As we reflect on the insights shared in this publication, one message is clear: *the engineering profession has a vital role to play in advancing food security and industrial transformation. Whether working in infrastructure, manufacturing, academia, or consultancy, every engineer can contribute to building a stronger, safer, and more resilient food system.*

I therefore take this moment to encourage professionals in all disciplines to take an active role in food systems development—through innovation, knowledge sharing, or direct involvement in agri-food projects.

We also urge our members to contribute articles, case studies, and field experiences to future editions of EiK, as we continue to grow our collective knowledge and amplify the voice of engineering in national development.

In conclusion, I commend the Editorial Board, contributors, and stakeholders who have made this edition possible. May this publication inspire deeper engagement, thoughtful dialogue, and fresh ideas on how engineers can power the future of food in Kenya and beyond.

Let us remain united in our mission to innovate, improve, and impact. Let us engineer solutions that nourish our people, protect our planet, and drive sustainable prosperity.

ENGINEERS BOARD OF KENYA
Enhancing Professionalism

Advancing Food Engineering in Kenya:
Integrating Manufacturing and Food Security Under Vision 2030

By Eng. Margaret Ogai, CE, FIEK
Registrar/CEO
Engineers Board of Kenya

> EBK has also intensified efforts to raise the number of Professional Engineers to 10,000 by 2028 from the current 4000 Professional Engineers, strengthening the sector's capacity to deliver on food security and industrial development.

Kenya Kenya Vision 2030 identifies manufacturing and food security as two central drivers of the nation's long-term transformation. These sectors are inseparably linked: manufacturing depends on a steady supply of agricultural raw materials, while food security relies on efficient systems of storage, processing, and distribution. Engineering sits at the centre of this relationship, providing the infrastructure, technologies, and innovations required to modernize agriculture, strengthen industry, and build resilient supply chains.

The United Nations SDGs Report 2025 acknowledges that while millions of lives worldwide have improved, the pace of progress remains insufficient to meet the 2030 deadline. The report highlights six areas requiring urgent action: food systems, energy access, digital transformation, education, jobs and social protection, and climate and biodiversity. In each of these, engineering is not only supportive but indispensable.

In Kenya, the gaps in food production and distribution remain stark. Water storage facilities are inadequate, irrigation coverage is low, and many farmers still rely on unmechanised methods that limit yields and resilience. The country also depends heavily on food imports, including basic items such as baby food, which undermines food sovereignty. Raw produce is often exported with little value addition, eroding opportunities for job creation and industrial growth.

Despite these challenges, engineering offers immense opportunities. Expansion of irrigation and construction of modern water storage facilities would enable year-round farming. Establishing agro-processing plants for cereals, dairy, horticulture, and livestock would enhance value addition and market competitiveness. Kenya's accession to the Washington Accord in June 2025 has further strengthened recognition of engineering qualifications and opened new opportunities for global mobility. AfCFTA provides a platform to expand exports, provided production systems are modernised and standards upheld. Smart farming and digital distribution can bring greater transparency and efficiency, while agri-industrial parks that cluster storage, processing, and transport hubs would cut losses and reduce costs.

The first call, therefore, is for government to lean more deliberately on engineers, technologists, and other professionals to increase production. This means expanding investments in irrigation, water storage, access roads, food distribution systems, and digital technologies, alongside policies that favour local production and strengthen food sovereignty.

The second call relates to human capital. Kenya has already invested heavily in engineering, and EBK's register today lists more than 28,000 engineers across diverse disciplines. EBK has also intensified efforts to raise the number of Professional Engineers to 10,000 by 2028 from the current 4000 Professional Engineers, strengthening the sector's capacity to deliver on food security and industrial development. In February 2025, the Public Service Commission approved Career Progression Guidelines for engineers in the public service, which EBK is now disseminating. These guidelines will address career stagnation, ensure structured growth, and create opportunities for deployment of critical skills. In the public space

Engineering is therefore not only about building roads, bridges, and power plants; it is also about ensuring that Kenya can feed itself, create jobs, and develop industries that add value to what it produces. By closing structural gaps in production, distribution, and processing, and by scaling up investment in infrastructure, human capital, and innovation, Kenya can accelerate progress towards food sovereignty and the goals of Vision 2030. The Engineers Board of Kenya reaffirms its commitment to supporting government, industry, and academia, and mobilising engineers to deliver solutions that feed the nation, grow the economy, and secure a dignified, high-quality life for all citizens.

ENGINEERS BOARD OF KENYA
Enhancing Professionalism

Report 2019 – 2025

6 Years Performance Report

REPUBLIC OF KENYA

Ministry of Roads and Transport

Kenya VISION 2030

ENGINEERS BOARD OF KENYA
Enhancing Professionalism

Introduction

The Board Independent members were appointed for an initial three-year term on *23rd August 2019 until 23rd August 2022* and subsequently reappointed for a further three years until 23rd August 2025.

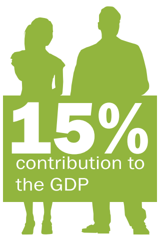
The 2019–2025 tenure marked a period of significant strengthening of services across the entire value chain of engineering education, training, regulation, and practice in Kenya. The Board assumed office at a time of rapid national infrastructure expansion, fast-paced technological change, and increasing globalization of professional standards.

With a strong sense of responsibility, the outgoing Board worked to build a competent, ethical, and globally competitive engineering profession. This Exit Report highlights the key achievements, challenges in regulating engineering services, recommended areas for improvement, and the legacy of the Board over the past six years.

Key Entity Information and Management

(a) Background information

The Engineers Board of Kenya (EBK) is a regulatory body established under Section 3(1) of the Engineers Act 2011 to succeed the Engineers Registration Board (ERB) established by the Engineers Registration Act, Cap 530 (1969). It is charged with the mandate of registration of engineers and engineering consulting firms, regulation of engineering professional services, setting of engineering standards and development and general practice of engineering.



Under the country's Vision 2030 development blueprint, manufacturing sector is identified as priority sector for job and wealth creation and is targeted to increase its contribution to the GDP to 15%. Further, quality infrastructure is recognised as an enabler; Vision 2030 targets to increase access to clean and affordable water and sanitation services, energy, transportation, housing and increasing agricultural production. In all these sectors, the development and regulation of engineering practice is considered a key component to the achievement of Vision 2030 goals.

Engineers Board of Kenya Vision Statement

The Board's Vision is *"Safe and sustainable engineering infrastructure."*

Engineers Board of Kenya Mission Statement

The Board's Mission is *"To ensure production of globally competitive 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."*

Engineers Board of Kenya Core Values

The Board's core values are:

- Integrity
- Customer Centric
- Accountability
- Respect
- Excellence

(b) Principal Activities

The principal mandate (functions and powers) of the Board is to: -

(a) Receive, consider, make decisions on applications for registration and register approved Applications.

(b) Keep and maintain the Register.

(c) Publish the names of registered and licensed persons under the Engineers Act 2011.

(d) Issue licences to qualified persons under the provisions of the Engineers Act 2011.

(e) Publish and disseminate materials relating to its work and activities.

(f) Carry out inquiries on matters pertaining to registration of engineers and practice of engineering.

(g) Enter and inspect sites where construction, installation, erection, alteration, renovation, maintenance, processing or manufacturing works are in progress for the purpose of verifying that—

i) Professional engineering services and works are undertaken by registered persons under this Act.

ii) Standards and professional ethics and relevant health and safety aspects are observed.

(h) Assess, approve or reject engineering qualifications of foreign persons intending to offer professional engineering services or works.

(i) Evaluate other engineering programmes both local and foreign for recognition by the Board.

(j) Enter and inspect business premises for verification purposes or for monitoring professional engineering works services and goods rendered by professional engineers.

(k) Instruct, direct or order the suspension of any professional engineering services works, projects, installation process or any other engineering works, which are done without meeting the set-out standards.

(l) Approve and accredit engineering programs in public and private universities and other tertiary level educational institutions offering education in engineering.

(m) Set standards for engineers in management, marketing, professional ethics, environmental issues, safety, legal matters or any other relevant field.

(n) Prepare detailed curriculum for registration of engineers and conduct professional examinations for the purposes of registration.

(o) Establish a school of engineering and provide facilities and opportunities for learning, professional exposure and skills acquisition, and cause continuing professional development programmes for engineers to be held.

(p) Establish the Kenya Academy of Engineering and Technology whose purpose shall be to advise the National and the County Governments on policy matters relating to engineering and technology.

(q) Plan, arrange, co-ordinate and oversee continuing professional training and development and facilitate internship of graduate engineers.

(r) Collaborate with engineering training institutions, professional associations, engineering organizations and other relevant bodies in matters relating to training and professional development of engineers.

(s) Determine the fees to be charged by professional engineers and firms for professional engineering services rendered from time to time.

(t) Hear and determine disputes relating to professional conduct or ethics of engineers.

(u) Develop, maintain and enforce the code of ethics for the engineers and regulate the conduct and ethics of engineering profession in general.

(v) Determine and define disciplines of engineering recognised under the Engineers Act 2011.

(w) Conduct recruitment of staff of the Board through a competitive process; and

(x) Carry out such other functions related to the implementation of the Engineers Act 2011.

EBK Board Members

Eng. Erastus K. Mwongera, FIEK CBS
Chairperson of the Board
(2019 – 2025)

Eng. Erastus Mwongera is a registered consulting engineer with the Board and a Fellow of the Institution of Engineers of Kenya.

He holds a Bachelor's degree (Civil Engineering) from the University of Swansea, United Kingdom.

Eng. Mwongera has a vast experience in the Public Service and the Private Sector and has recently served as the Chairman on Kenya Airports Authority, Kenya National Highways Authority, Sameer Group of Companies among many other organizations.

Eng. Mwongera is a representative of the private sector in the Board.

Eng. Julia W. Ondeyo
Vice-Chairperson of the Board
(2019 – 2025)

Eng. Julia Ondeyo is a professional engineer with the Board and a Corporate member of the Institution of Engineers of Kenya.

She holds Bachelor's degree (Civil Engineering) from the University of Nairobi and a Master degree in Business Administration from the Strathmore University.

Eng. Ondeyo boasts of over twenty years' experience in the roads sector and is currently Deputy Director at the Kenya National Highways Authority (KeNHA).

Eng. Ondeyo represents state corporations in the Board.

Mr. Evans Atambo
PS Rep, Ministry of Education
(2022 – 2025)

Mr. Evans Atambo holds a Bachelor of Education (B.ED) from Moi University and a Master of Philosophy in Curriculum Development from Moi University and currently pursuing a Doctor of Philosophy degree in Curriculum Development at Catholic University of East Africa.

Mr. Atambo has vast experience in the Education Sector and has worked as a teacher and in the management of the education sector sitting in councils of public universities in Kenya.

Mr. Atambo represents the Principal Secretary State Department for Higher Education and Research in the Board.

FA Daniel M. Mutua
Alternate Director, The National Treasury
(2020 – 2023)

Mr Daniel Mutua is a Financial Analyst and holds B.E.D Economics / Business Studies from Kenyatta University and Masters in Business Administration from Maastricht Netherlands.

Mr Mutua has served in various capacities as financial analyst with vast experience in management of state corporations.

Mr Mutua represents the Principal Secretary, National Treasury in the Board.

Eng. Shammah Kiteme
President, Institution of Engineers of Kenya
(2024 to date)

Profile - Eng. Shammah Kiteme, CE, FIEK, PMP®

Eng. Shammah Kiteme is the President of The Institution of Engineers of Kenya (IEK). He is the Principal Engineer and Director of Projects at CengProm Services Ltd, an Engineering firm he founded. He is an accomplished practicing Civil Structural Engineer. He has practiced in the areas of Structural Engineering and Waste Water treatment for over 15 years. He has consulted both in Kenya and in other countries in Africa. He has delivered key projects with multidisciplinary teams of Engineers drawn from other countries.

Eng. Shammah isa registered Consulting Engineer with Engineers Board of Kenya (EBK) and a certified Project Management Professional (PMP®) with Project Management International- USA

Eng. Prof. Silvester O. Abuodha
Representative, Universities
(2019 – 2025)

Eng. (Prof) Silvester Abuodha is a consulting engineer with the Board and a Fellow of the Institution of Engineers of Kenya.

Eng. Prof Abuodha holds Bachelors degree (Civil Engineering) from the University of Nairobi and Msc (Civil Engineering) as well as PhD (Civil Engineering) both from the University of Manchester, United Kingdom.

Eng Prof Abuodha has a wealth of experience in engineering cutting across the academia, private practice and in the from the public sector where he having begun his career at the Kenya Railways Corporation.

Eng. Prof. Abuodha represents Universities in the Board.

Eng. Jane A. Simiyu
Nominee, Institution of Engineers of Kenya
(2019 – 2025)

Key Qualifications

Eng. Jane Simiyu is a consulting engineer with the Board and a corporate member of the Institution of Engineers of Kenya.

Eng. Simiyu holds a Bachelor's degree in Agricultural Engineering and an MBA (Project Planning & Management) from the University of Nairobi

Eng. Simiyu has vast experience in agricultural engineering having worked in the public service and consulting industry.

Eng. Simiyu is a Director/ Shareholder at the Tertiary Consulting Engineers.

Eng. Simiyu was nominated to the Board by the Institution of Engineers of Kenya.

Eng. Johnson M. Matu
Representative, Private Sector
(2019 – 2025)

Key Qualifications

Eng. Johnson Matu is a consulting engineer with the Board and a Fellow of the Institution of Engineers of Kenya.

Eng. Matu holds a Bachelors degree in Civil Engineering and an MBA from the University of Nairobi.

Eng. Matu has vast experience in engineering industry and has previously served as the Chairman of the Association of Consulting Engineers of Kenya (ACEK). He has also served as the Chairperson of the Kenya Private Sector Alliance (KEPSA) Energy and Infrastructure Board. Eng Matu is the proprietor of APEC Consulting.

Eng. Matu represents the Private sector in the Board.

James Gatere
Representing PS Roads
Board Member representing the Principal Secretary
(2024 to date)

Currently Director, Human Resource Management and Development, State Department for Roads.

Career Civil Servant with over 25 years experience in the service.

Academic Qualifications

Bachelor's degree in education - Kenyatta University

Master's degree in educational administration - Moi University.

Higher National Diploma in Human Resource Management - College of Human Resource Management, Nairobi.

Eng. Benjamin K. Maingi
Representative, Private Sector
(2019 – 2025)

Eng. Benjamin Maingi is a consulting engineer with the Board and a corporate member of the Institution of Engineers of Kenya.

Eng. Maingi holds a Bachelor's degree in Civil Engineering from the University of Nairobi and an Msc (Highway Engineering) from the University of Birmingham UK.

Eng. Maingi has vast experience in the engineering sector having served in various senior capacities in the public service before leaving the service as the General Manager (Planning) at the Kenya Roads Board.

Eng. Maingi was nominated to the Board by the Institution of Engineers of Kenya.

Eng. Roselane Ambasi Jilo
Nominee, Institution of Engineers of Kenya
(2019 – 2025)

Eng Roselane Jilo is a professional engineer with the Board and a Fellow of the Institution of Engineer of Kenya.

Eng Jilo holds a Bachelor's degree in Electrical Engineering from the University of Nairobi, and an MBA (Strategic Management) from Kenya Methodist University.

Eng Jillo has vast experience in engineering management in the public sector and currently works at the Kenya Pipeline Company.

Eng. Jilo was nominated to the Board by the Institution of Engineers of Kenya.

Eng. Margaret Ogai
Registrar/CEO
(2021 to date)

Masters degree in Business Administration (Procurement) and Bachelor Science in Civil Engineering from the University of Nairobi.

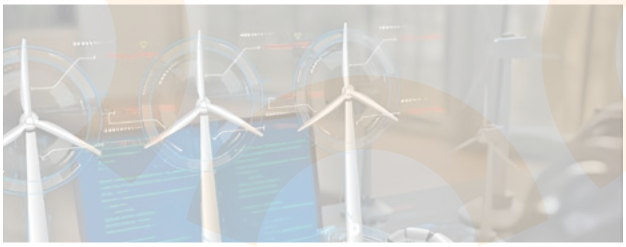
Eng Margaret Ogai is a registered Consulting Engineer with the Board (EBK) and a Fellow Member of the Institution of Engineers of Kenya(IEK).

She has over 30 years wealth of experience in Infrastructure Development and Management that cuts across both public and private sector.

She is responsible to for the implementation of the Boards strategic goals and the management of its resources including giving direction and leadership for the achievement of its mission.

Eng. Nicholas Musuni
Former Registrar/CEO
(2013 - 2021)

Eng. Nicholas Musuni is a seasoned civil engineer with a distinguished career spanning over two decades. This is marked by notable achievements and extensive experience across various sectors. He is a holder of a Bachelor of Science in Civil Engineering degree from the University of Nairobi and is a Consulting Engineer registered with the Engineers Board of Kenya.



Former Board Members

Eng. Nathaniel O. Matalanga, CE
(2022 – 2024)

Eng. Nathaniel Matalanga is a consulting engineer with the Board and a Fellow of the Institution of Engineers of Kenya.

He holds Bachelor's degree (Civil Engineering) from the University of Nairobi.

Eng. Matalanga has over 30 years in engineering practice and is an expert in structural engineering having started his career in the public service before joining the consulting industry. He is the proprietor of Ngasi Consulting Engineers.

Eng. Matalanga sat in the Board as the President of the Institution of Engineers of Kenya up to 31st March 2022.

Eng. Erick O. Ohaga, CE
(2022 – 2024)

Eng. Erick Ohaga is a consulting engineer with the Board and a Fellow of the Institution of Engineers of Kenya.

He holds an MSc. Nuclear Engineering (KINGS), Master of Business Administration (MBA), BSc. in Electrical/Electronic Engineering and Post-Graduate Diploma in Project Planning and Management.

He has vast experience spanning over 17 years in Energy Policy Development, Nuclear Policy and Strategy Formulation, Design, Construction, Contract Management, Operations, Maintenance and Planning of Power Systems. He is currently the Director, Nuclear Energy and Infrastructure Development at Nuclear Power and Energy Agency (NuPEA).

Eng. Ohaga sits in the Board as the President of the Institution of Engineers of Kenya effective 1st April 2022.

Mr. Charles Obiero- PS
Rep Ministry of Education
(2019 - 2022)

Mr Charles Obiero holds a Bachelor of Education (B.Ed) from Kenyatta University and Masters in Education from the MVNU University, India.

Mr Obiero has vast experience in the education sector and has worked as a teacher and in the management of the education sector sitting in Governing Councils of public universities in Kenya.

Mr Obiero represents the Principal Secretary, State Department of Higher education in the Board.

Mr. Bernard J. Leparmarai, EBS
(2021 – 2024)

Mr Bernard Leparmarai holds a Diploma in Public Administration and Master Degree in Governance & Development Management from the University of Birmingham, United Kingdom.

Mr Bernard has over 30 years-experience in the public service as an administrator (formerly Regional Commissioner) for the Nairobi and Coast regions.

Mr. Bernard represents the Principal Secretary, State Department of Infrastructure, in the Board.

Summary of Board Achievements 2019 - 2025 at Glance

Area	2019	2025	Remarks
ENGINEERING EDUCATION			
Recognition of Programs – Local Standards	**37 (47%)**	**75 (96%)**	Only 3 programs pending, to be evaluated by Dec 2025, putting EBK on track for 100% recognition of engineering programs.
Recognition of Programs – Internation Standards (Washington Accord)	Nil	EBK admitted to provisional signatory status in June 2025 3 programs approved by International Engineering Alliance (IEA) International Standards, full compliance projected by 2029	• There is almost 100% transition of Graduate Engineers to cover 2,500 students graduating per year to register as GEs at Board, therefore unlocking employment opportunities. • Intent 100% Engineering education to Outcome Based Education (OBE). • Support mobility of Engineers and now negotiating with Japan for a mobility program for our Engineers and also setting up Elite Engineers School with Tongji University - China. • Seeking full Washington Accord signatory intent by 2029.
ENGINEERING TRAINING			
Graduate Engineers Internship Programme (GEIP)	Nil	Over 3,000 Graduate Engineers trained (378 under Exchequer support)	• GEIP has transitioned from concept to reality. Upscale to 10,000 per year to meet economy demand. • Engage Head of Public Service and Public Service Commission to ringfence slots for GEs.
Registration of Professional Engineers	**2,165**	**4,132**	**Doubled in six years;** growth trajectory demonstrates maturing professional ecosystem. On course to register 10,000 by 2028 to support Vision 2030 and government transformation agenda.
Career Progression Guidelines (CPGs)	Nil	Approved by Public Service Commission in Feb 2025 & disseminated	• Established a structured pathway for engineers in MDAs, boosting technical capacity and retention of engineering talent in public service. • EBK to enforce with Career Progression Guidelines across MDAs. • Ensure Engineering function is headed by Professional Engineers and supports career progression and growth for professional Engineers.
ENGINEERING PRACTICE			
International Collaborations	EAC MRA	**Joined:** • Washington Accord (June 2025) • WFEO (Oct 2022) • FAEO (Jan 2025) **MOUs with:** • Korean Professional Engineering Association (KPEA) (Oct 2023) • Chinese Society of Engineers (Feb 2025)	Kenya has moved from regional to global visibility. Strategic partnerships position the country as an African hub for engineering innovation and mobility.

Area	2019	2025	Remarks
International Collaborations	EAC MRA	**Ongoing Negotiations with:** • Japan for mobility for engineers is construction sector • Establish Tongji University on Elite Engineering School in Kenya intent to roll out in Jan 2026 Jan 2026. (First cohort of 50 GEs)	Kenya has moved from regional to global visibility. Strategic partnerships position the country as an African hub for engineering innovation and mobility.
COMPLIANCE & STANDARDS			
Standards	Engineers Rules 2019	• Engineers Rules 2022 (Scale of Fees) • Establishment of Multi-Sectoral Consultative Committee • Engineers Project Registration Portal (EPRP) in June 2023	• Platform for harmonizing standards and enhancing enforcement across the built environment sector. • Developed Draft Monitoring of Engineering Services. • Regulation to make registration of projects on EPRP mandatory submitted to Ministry.
Compliance Levels	**<25%**	**43%**	Marked progress; nearly doubled compliance. Indicates rising trust in regulation as our Strategic Plan aiming for 100% achievement by 2028.
Licensure	**<1,000 (<50%)**	**2,700 (65%)**	Significant progress in licensing professionals and firms, strengthening accountability in practice.
Disciplinary	-	Resolved 21/ 33 cases resolved (3 suspensions, 3 warning)	Integrate EBK portal with county governments, NCA BORAQs to weed out quacks.
CAPACITY BUILDING			
CPD	Engineers rule 2019	• CPD Policy 2014, • Accredited Service Providers, • KSE & KAET instruments, • 4No approved GAP programme to transition BTech to BEng	• Lifelong learning institutionalized. Engineers now have structured professional development and academic transition pathways. • Launch GAP program by October 2025.
INSTITUTIONAL STRENGTHENING			
Revenue:	**110M**	Ksh. 230M (**90%** internally generated)	Revenue doubled. EBK is now firmly on journey to self-sustainability – a major financial turnaround.
Governance	Clean Audit	Clean Audit Legal & Governance Audit conducted – Compliance is good (**84%**)	Board committed to strong go governance, transparency, and accountability.
Performance Contracting	Consistently "Good"	"Very Good" ratings sustained for last four years	Reflects a performance-driven culture and delivery on strategic goals.
Board Self Evaluation	-	**94.%** (Excellent)	Demonstrating the Board's high standards of governance, strategic oversight, and accountability. This reflects a cohesive leadership team committed to continuous improvement and setting a benchmark for regulatory bodies in Kenya.
ISO Certification	ISO Certified (initial)	ISO Recertified (Feb 2025)	Quality management systems entrenched, ensuring global best practice in regulation.
Digitalisation	-	Ecitizen ERP	Board on journey towards one Government approach and increasing efficiency and effectiveness through digitalisation.

Acknowledgements

The outgoing Board expresses deep gratitude to:

- H.E. the President of the Republic of Kenya for infrastructure leadership and policy support.
- The Cabinet Secretary, Ministry of Roads and Transport.
- Principal Secretaries, government ministries, academia, industry players, and international partners.
- Washington Accord mentors including Board Engineers Malaysia (BEM) and Pakistan Engineering Council (PEC)
- Development partners including the World Bank, Lloyd's Register Foundation, GIZ, and AfDB.
- The Registrar/CEO and EBK Secretariat for their dedication.

Conclusion

The Board concludes its term with pride in its achievements. EBK has emerged stronger, digitally enabled, and globally engaged. With a solid foundation in place, the Board hands over to the incoming leadership with full confidence in their ability to advance Kenya's engineering profession.

A retreat of members of EBK Board

The State Department for Irrigation's Vision for a Food-Secure Future

By CPA Ephantus Kimotho Kimani, CBS

1. What are some of the key priorities of the State Department for Irrigation at the moment, and how do they align with the national development agenda?

The State Department for Irrigation is prioritizing the expansion of irrigated agriculture as a strategic move to transform Kenya's agricultural sector. The department aims to increase land under irrigation from 664,000 acres in 2023 to 1.75 million acres by 2035. This target is designed to enhance food security, improve resilience to climate change, and create employment, particularly in rural areas where agriculture remains the main source of livelihood.

To achieve this, the department is investing heavily in infrastructure, including large dams, small dams, water pans, and conveyance systems. A flagship example is the Thiba Dam in Kirinyaga County, which has enabled double cropping in the Mwea Irrigation Scheme and boosted rice production. Similarly, the Galana Kulalu Food Security Project and various community schemes have increased agricultural output and economic empowerment at the grassroots level.

Reducing Kenya's rice deficit is another critical focus. Paddy rice production rose from 192,299 metric tonnes in 2022 to 293,950 metric tonnes in 2024, a 65 percent increase valued at KSh 20.5 billion. Despite having over 314,000 acres of gazetted land for rice cultivation, only about 71,000 acres are in production. The department aims to increase rice output to 440,000 metric tonnes by 2027 by expanding cultivated acreage, improving productivity, and strengthening value chains.

The department is also promoting smart irrigation technologies such as precision irrigation systems and automated sluice gates to maximize yield per unit of water. Efficient water use is vital to ensuring long-term sustainability in water-scarce areas under changing climate conditions.

Public-private partnerships (PPPs) are central to scaling up these efforts. Through a KSh 598 billion irrigation plan, 61 percent of which is expected to come from the private sector, projects like Galana Kulalu and Bura are unlocking the potential of large-scale irrigated agriculture. Galana alone could yield 14 million bags of maize annually when fully developed and double-cropped. These projects have already created over 500,000 jobs, highlighting irrigation's role in national development.

2. How is the department ensuring smallholder farmers, especially in arid and semi-arid regions, benefit directly from these irrigation investments?

The National Irrigation Sector Investment Plan (NISIP) seeks to increase land under irrigation for smallholder farmers by over 500,000 acres. The Department is committed to ensuring that smallholder farmers in arid and semi-arid regions directly benefit from irrigation investments through a comprehensive and integrated approach. By focusing on the development of small and medium water storage infrastructure such as farm ponds, small dams, and cascading sand dams, farmers gain reliable access to stored surface water (BLUE water) for irrigation of food and fodder crops. Additionally, the promotion of farm- and landscape-scale rainwater harvesting practices enhances soil moisture (GREEN water), boosting crop and rangeland productivity. These interventions, combined with new micro and small-scale irrigation developments, improve water and land security, increase food and fodder availability, and support sustainable groundwater recharge. Nature-based solutions further enhance resilience by mitigating drought and flood risks, reducing erosion, and maintaining biodiversity, thereby strengthening the livelihoods and climate resilience of smallholder farmers in these vulnerable regions.

3. The National Irrigation Sector Investment Plan (NISIP) was launched recently. What outcomes are you aiming to achieve by the end of the 10-year plan?

As a response to the agricultural transformation and inclusive growth espoused in the Bottom-Up Economic Transformation Agenda Plan, the State Department for Irrigation has formulated the National Irrigation Sector Investment Plan (NISIP). NISIP will provide a strategic blueprint that aligns and optimizes Government and private investments in the irrigation sector to achieve a set of national economic and agricultural development goals. The plan targets to add 1 million acres under irrigation that will translate to exploiting over 50% of the total irrigation potential estimated at 3.5 million acres.

The 10-year plan is estimated to cost KSh 598 billion (equiv. USD 4.60 Billion) with government contribution at 39% and private sector at 61%. The government contribution is through GoK exchequer and development partner financing while private sector contribution targets PPP investors, local banks and microfinance institutions, farmers (beneficiary equity), agri aggregators and irrigation tech suppliers.

To deliver NISIP, the Ministry has identified five pathways that have the following outcomes:

i. **Expanded farmer-led irrigation development (FLID)** whose aim is to facilitate rapid micro-irrigation expansion at a large scale. The target for FLID is set at 250,000 acres under Tier 1 and 100,000 acres under Tier 2. This will require KSh 163 billion out of which KSh 101 billion will be investment from the private sector.

ii. **High-performing public schemes** that entail optimizing service delivery in existing public irrigation schemes namely Mwea, Bura, Hola, Perkerra, Ahero, West Kano and Bunyala (now Lower Nzoia). The target is 69,000 acres to be optimized and 10,000 acres to be added at an estimated cost of KSh 14 billion, out of which KSh 4 billion is from the private sector.

iii. **Enabled corporate agribusiness** to scale up corporate and commercial investments in irrigated agriculture, mainly focusing on PPP projects particularly in government-owned land. The target is 350,000 acres of new area at an estimated cost of KSh 260 billion, with KSh 195 billion expected from the private sector.

iv. **Revitalized irrigation in Arid and Semiarid Lands**, focusing on ensuring food and fodder production in vulnerable pastoralist communities through water harvesting from ephemeral streams for use in producing fodder and watering livestock. The target is 140,000 acres of new area at an estimated cost of KSh 54 billion, with KSh 13 billion from the private sector.

v. **Maximized community scheme benefits** that will enhance community-based irrigation for maximum benefits, focusing on governance and sustainability of existing irrigation schemes and development of new community projects. The target is 250,000 acres to be optimized and 150,000 acres to be added at an estimated cost of KSh 107 billion, with KSh 53 billion from the private sector.

vi. Lastly, the ultimate impact is increasing revenue for farmers, lowering the cost of living, reducing imports, increasing exports, enhancing food security, creating jobs, mitigating against climate shocks and increasing

foreign direct investments. The irrigation revolution will indeed transform lives and livelihoods for Kenyan farmers and the rural populace that sit at the bottom of the pyramid.

4. What role do public-private partnerships play in your irrigation agenda, and how are you attracting investors into this space?

Public-private partnerships (PPPs) are central to the implementation of our irrigation agenda under the 10-year National Irrigation Sector Plan (NISP), which is estimated to cost KSh 598 billion (USD 4.60 billion). With 61 percent of the investment expected to come from the private sector, PPPs are vital in mobilizing financial, technological, and operational resources to transform Kenya's irrigation potential into a driver of food security, value addition, and export growth.

PPPs bring in capital to develop large-scale irrigation infrastructure, supply modern irrigation technologies, and enhance production systems. Our goal is to shift from fragmented small-scale farming to commercial irrigation on large tracts of public land such as Galana, Bura, and Taita Taveta, thereby achieving economies of scale, increasing productivity, and supporting the national goal of reducing maize, rice, and sugar imports while boosting exports of processed goods.

To attract and facilitate investment, the government has established a coordination unit to streamline approvals, remove bureaucratic hurdles, and support investor onboarding. Experience has shown that delays of up to two years can occur due to regulatory complexity. By simplifying land leasing, speeding up infrastructure development, and offering one-stop support, we are making the investment process more predictable.

The government is also investing alongside development partners in water security and core infrastructure, including roads and solar energy, to reduce investor risk. With a target of mobilizing KSh 68.65 billion for enabling infrastructure, this public investment is unlocking private capital for irrigation and agro-processing expansion.

We support investors in identifying priority value chains, linking with aggregators, and accessing both domestic and export markets. By aligning investor interests with national goals such as job creation, improved trade balance, and enhanced foreign reserves, we are building a long-term partnership framework that delivers impact and sustainable returns.

5. What are some of your proudest achievements since assuming office as the Permanent Secretary?

> Under my stewardship, the department's budget doubled from KSh 10.34 billion to KSh 21.128 billion, and land under irrigation grew from 664,000 to 747,000 acres, with a target of 1.75 million acres under NISIP.

I operationalized Phase 1 of the Galana Kulalu Food Security Project, bringing 20,000 acres under maize and setting the stage for 200,000 acres with Galana Dam. I also converted the Bura Irrigation Scheme to gravity-based irrigation, saving farmers KSh 120 million annually, and resolved longstanding issues in the Lower Nzoia Scheme, supporting over 12,600 farmers.

I spearheaded over 10 PPP projects covering 320,000 acres and oversaw a 28.5 percent increase in water storage capacity. I also accelerated the Mwache Dam from 4 percent to 44 percent completion, unlocking water access for Mombasa and Kwale.

To date, more than 40 projects have connected 32,000 farmers to water, many through cooperatives. These farmers now earn average gross margins of KSh 240,000, a testament to the economic impact of irrigation

(Photo Courtesy)

CPA Ephantus Kimotho Kimani, CBS, currently serves as the Principal Secretary for the State Department for Irrigation. He is a financial expert and a long-serving public officer with a strong background in development strategy. PS Kimotho was appointed in 2023 to lead the young department. Since then, he has steered key institutional changes and helped push forward major reforms in Kenya's irrigation sector. His focus? Long-term solutions that tie water management directly to food security, livelihoods, and national development. Here's what he shared with Engineering in Kenya magazine:

How Kenya Tea Development Agency (KTDA) is Redefining Kenya's Tea Industry

By Dr. Nickson Kipng'etich Lang'at

Dr. Lang'at, a key voice in the agricultural research space, offered an in-depth look at how KTDA is weaving research and innovation on matters technology, quality enhancement, and sustainable practices. His perspective highlights the sector's potential for growth and transformation. We share his thoughts below:

Research and Innovation are key drivers of progress and development in any society. They enable the creation of new products, services, and technologies that can improve people's lives and enhance the overall economic growth of a region. In food engineering perspective, it focuses on applying scientific and engineering principles to improve food production, processing, and distribution, ultimately enhancing food quality, safety, and sustainability. Food engineering research and innovation is crucial for addressing global challenges related to food security, nutrition, and sustainability. Tea production and processing areas fall under this space.

KTDA is a major player in the global tea industry. As the organization implements farmer- first mantra, research and innovation has been positioned as a pillar in various business models. Research and Innovation (R&I) department sets research driven models supported by statistical evidence to guide in decision making in product development, change of process, cost management, process efficiencies and marketing. KTDA focus areas in the last financial year as far as food engineering research innovation is concerned included green energy, product diversification, collaboration and partnership, health benefits of tea, technology for food security.

Green energy

Kenya is a major tea producer globally, with a significant portion of its tea grown in the highlands on either side of the Great Rift Valley, producing over 400,000 metric tons of tea annually. Currently, about 62% of tea in the country is produced by the smallholder growers who process and market their crop through their own management agency. To process such huge volume into made tea involves series of sub processes including withering, fermentation, drying and grading. Of all the processes, drying is the most energy intensive in the tea factory and is a major contributor in cost of production. It consumes 3.5–6 kWh of thermal energy per kg of made tea. KTDA managed factories consume 1.4million cubic meters of firewood to make 320 million kg of made tea in a year. The impact of harvesting firewood to meet factory demand is huge as far as forest cover and climate change is concerned. As a way of mitigating the impact, R&I department is collaborating with local and international partners to integrate green energy technology in processing tea. This will reduce pressure on Kenya's forest resources and enhance sustainability credentials for discerning international markets.

Product diversification

As a way of enhancing food security in the country, KTDA has embarked on a new product development programme through the Research and Innovation department. In the last financial year, the department implemented a number of innovative projects. First, the newly developed composite tea product which carries rich chemical and physical attributes. They include flavor and color among others. Secondly, the purple tea products.

> Since the introduction of purple tea variety (TRFK 306/1) in Kenya in 2011, its market growth has been low. In order to enhance its market penetration, the department has developed a unique and innovative purple tea blends that offer not only health advantages but also novel taste experiences.

[Photo Courtesy]

Thirdly, the department in partnership with KTDA-managed factories and its engineering subsidiary company (Tea Machinery and Engineering Company) has invented an improved technology for manufacturing green and purple tea.

Collaborations and partnership

Collaboration is vital in the tea industry for fostering sustainability, addressing challenges, and driving progress, benefiting farmers, manufacturers, and the wider ecosystem. By working together, the industry can improve market outcomes, empower stakeholders, and ensure sustainable growth. Collaboration is crucial for achieving better outcomes, fostering innovation, and strengthening relationships, as it leverages diverse skills and perspectives to solve problems and achieve goals more effectively. In the spirit of partnership, KTDA has signed a Memorandum of Understanding with a number of universities and research institutions. Discussions are ongoing with other relevant organizations so as to on- board additional expertise, improve knowledge sharing and enhance access to modern facilities and equipment. There are a number of international partners working with our organization in new product developments, process efficiency and climate change and mitigation. Our focus going into the future is to deepen this cooperation in order respond quickly to new challenges, improve returns to the farmer and enhance food security.

Health benefits of tea

KTDA together with Kenya Medical Research Institute (KEMRI) are exploring medicinal value of Kenyan teas. The project includes profiling of medicinal properties of tea and development of specialized products for new markets. Previous studies have shown that health benefits include but not limited to:

i. Diabetes risk reduction- Tea consumption may help modulate blood sugar levels and potentially reduce the risk of developing type 2 diabetes

ii. Weight management- Tea is naturally calorie-free and can be a healthy alternative to sugary drinks, potentially aiding in weight control.

iii. Stress and anxiety reduction- Tea can help lower cortisol levels, a stress hormone, and promote a sense of calm and relaxation.

iv. Heart health- Tea, particularly black and green tea, is linked to lower blood pressure, a reduced risk of cardiovascular events like heart attacks and strokes, and a lower risk of heart disease.

v. Cancer prevention- Tea, especially green tea, contains polyphenols that may help reduce cancer cell growth and spread, and potentially decrease the risk of developing certain cancers.

The KTDA research department is keen to scientifically bring out all these benefits and upscale finding through research partnerships and collaborations.

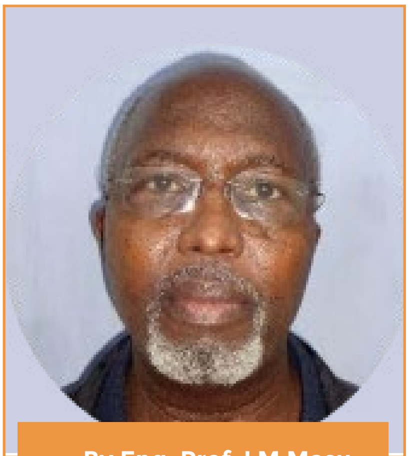
Technology and food security

Although the tea industry in Kenya has had an unmatched record of growth, returns from the enterprise have declined due to stagnating unit prices of made tea and increasing production costs. Expansions of production capacities and favorable weather conditions have led to an increase in tea supply. Increased supply and reduced demand lead to a glut in the market and consequently low prices. Due to reduced earnings, the livelihoods of small-scale farmers have been negatively affected. Artificial Intelligence (AI) is reshaping the tea industry in distinctive ways, from optimizing cultivation and production processes to enhancing customer engagement and driving innovation. Integration of AI not only improves efficiency but also supports sustainability efforts and product innovation. KTDA Research and ICT departments are currently implementing AI and IoT projects to control and optimize energy and product quality. All these are being undertaken to support the existing and upcoming factories be energy efficient and with guaranteed product quality.

Additionally, automation is crucial for the tea industry's survival and growth. It offers numerous benefits that address challenges like labor costs, efficiency and quality management. By implementing automation, tea industry can reduce field labor costs, improve the timeliness of operations, and enhance market access, ultimately boosting production, quality and market. R&I department is also supporting factories to implement automation. There are notable milestones in the automation programme which have resulted in improved product quality and reduced operational cost.

(Photo Courtesy)

Championing Engineering Design, Research, and Publication The Story of Eng. Prof. LM Masu



By Eng. Prof. LM Masu

Eng. Prof Masu is currently a Full Professor in the department Mechanical and Manufacturing Engineering, Faculty of Engineering & Built Environment at The Technical University of Kenya. He holds a PhD in Mechanical engineering from Leeds University (UK) and has over 40 years of teaching and research as well as 4 years' industrial experience. He is a registered engineer with Engineering Council of South Africa (ECSA). He is a Fellow of the South African Institution of Mechanical Engineering, a registered engineer with Engineering Registration Board of Kenya and a Member of the Institution of Engineers Kenya.

Could you briefly share your journey in engineering — from your studies at the University of Nairobi to earning your PhD at Leeds University and eventually becoming a full professor?

After graduating from the University of Nairobi in 1979, I worked for 2 years at Bamburi Portland Cement company. I spent another 2 years at Union Carbide Kenya. I then got a DAAD scholarship to join a taught Master's degree programme at the University of Nairobi in 1982.

At UoN, I served as a tutorial fellow from 18th July 1984 till 18th April 1985. After acquiring my MSc degree on the 11th February 1985, from The University of Nairobi, I was promoted to a lecturer's position on 18th April 1985.

On 25th September, 1986, I proceeded to the university of Leeds for my doctoral studies which culminated in the award of a PhD (Mechanical Engineering) on the 22nd September, 1989. On the 14th December 1990, I moved to JKUCAT (currently JKUAT) as a senior lecturer in mechanical Engineering Department and on the 1st September 1991, I was appointed Chairman of the department. A position I held until 11th April 1994. I then took up an appointment at the Associate professorial level at the University of Durban-Westville, South Africa.

I served as a dean elect, at University of Durban-Westville, for 3.5 years (July 1996 - 31st Dec 1999).

On the 01st November 2002, I was appointed Full Professor & Director, School of Mechanical Engineering & Applied Mathematics, Central University of Technology, Free State. A position I held till 31st Dec 2007.

On the 01st January 2008, I was appointed Executive Dean: Faculty of Engineering & Technology, Vaal University of Technology. A position I held till 2010.

From October 2010 till June 2021, I became the Faculty Research professor for the Faculty of Engineering & Technology, Vaal university of Technology (~12 years).

In July 2021, I took up a Professorship appointment at The Technical University of Kenya.

With over 40 years in teaching and research, what would you consider your most significant contributions to Mechanical and Manufacturing Engineering education?

Mentoring and supervision of students at both undergraduate as well as post graduate levels.

How has your experience in the industry early in your career shaped your teaching, research, and engagement with students?

The industrial experience gained during this period gave me a lot of confidence and exposed me to many industrial problems which I would later use as examples in the classroom. Thus, seamlessly linking theory to practice. For instance, both my masters as well as my doctoral studies addressed problems in the industry.

As a registered engineer in both Kenya and South Africa, how have your international affiliations influenced your professional outlook and practice?

This duo registration has allowed me to benchmark the quality of education in the institutions I taught, both in Kenya and South Africa. I realized that, there is a lot of commonalities in Engineering registration bodies as well as affiliations worldwide. It feels good to be accepted by other engineering bodies worldwide. I am therefore happy that I do not have to worry about registration within the Washington Accord countries in order to practice engineering.

What major changes have you observed in engineering education and practice over the decades, and how have you adapted to or led those changes?

The major changes which have taken place over the decades, inter alia are: teaching methodology driven by changing technology, i.e. from blackboard and chalk, white boards all the way to the online teaching through the use of virtual platforms. Online examinations through these platforms.

In mathematics, manual/ memory calculations to the use of mathematical tables, slide rules to programmable calculators as well as computers.

Stress and Strain Analysis, from first principal derivations and experimentations (destructive testing), to the use of strain gauges, photo-elasticity, source programs/ algorithms, packages (FEA, Boundary element analysis, etc.,), Non-Destructive testing techniques and to many others.

Manufacturing: From subtractive manufacturing to Additive manufacturing (driven by research in material science from Nano to Macro levels).

I wanted to remain current; therefore, I did not find it difficult to adapt. A lot of my research work is done using the FEA packages. I also supervised research projects in additive manufacturing.

You are actively involved in the IEK Editorial Board. What role have you played in developing content for the Engineering in Kenya Magazine and the AJERI journal?

I am the Secretary to the Editorial committee of AJERI. I have supported both the Engineering in Kenya Magazine and the AJERI journal through submission of articles for publication. Engineering in Kenya Magazine (2) and the AJERI journal (6 articles plus 1 conference paper). However, my main role is editorial and ensuring that good quality articles are published in them.

Why do you believe engineering publications are critical for the growth and visibility of local engineering talent and research?

Publications act as a source of currently generated new knowledge, current innovations as well as patents. It also serves as a source of knowledge which can be protected and commercialized for the benefit of the country as well as the owners of the patents.

What have been some key challenges and successes in your efforts to promote research and innovation within the Faculty of Engineering & Built Environment at the Technical University of Kenya?

Promotion of Research and innovation has never been my portfolio at the Technical University of Kenya; however, Funding is a challenge. Despite this, I have managed to publish 16 journal articles within my 4-year stint at TUK. I have been chairing the research and the postgraduate committee in the school of Mechanical Engineering and Manufacturing (currently known as the Department of Mechanical and Aeronautical Engineering). Currently, I have two Masters postgraduate candidates under my supervision.

As a mentor, what qualities do you believe are essential in shaping the next generation of engineers in Kenya and across Africa?

The 11 graduate attributes as per the Washington Accord as well as their corresponding competencies are essential in shaping next generation of engineers in Kenya and beyond. These attributes are as listed below:

a. Problem Solving
b. Application Of Scientific and Engineering Knowledge
c. Engineering Design
d. Investigations, Experiments and Data Analysis
e. Engineering Methods, Skills and Tools, Including Information Technology
f. Professional And Technical Communication
g. Sustainability And Impact of Engineering Activity
h. Individual, Team and Multidisciplinary Working
i. Independent Learning Ability
j. Engineering Professionalism
k. Engineering Management.

Looking ahead, what is your vision for engineering education and research in Kenya, and what legacy would you like to leave behind?

Our students are hardworking because they are doing very well in the other countries they go for studies. I therefore believe that if financially well supported and the standards are adhered to, the future is bright for engineering education and research in Kenya.

Optimization and Performance Evaluation of a Locally Fabricated Amaranth Popping Machine Using the Taguchi Technique

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Abstract

Amaranth grains are a highly nutritious food source, yet their commercial popping efficiency remains a challenge due to energy inefficiency, seed wastage, and inconsistent product quality. This study investigates the effect of key process parameters on the performance of a locally fabricated amaranth popping machine, focusing on popping yield (PY), motor vibration and their controls.

The Taguchi Design of Experiments (DOE) was applied to systematically analyze the impact of heating temperature, heating plate material, and motor vibration frequency. This method streamlined the experimental process by employing orthogonal arrays, which reduced the number of trials while ensuring robust evaluation of parameter interactions. Additionally, nutritional analysis was performed on both popped and un-popped amaranth, evaluating moisture, protein, fat and fiber content to assess the impact of the popping process on nutritional quality.

The findings indicated that a set temperature of and spindle speed of 800 rpm were the optimum parameters, contributing to 15% seed wastage for the overall performance of the machine. Nutritional analysis revealed that popping retained protein, fiber and fat content while reducing the moisture content. These results validate the potential of locally fabricated machines as scalable solutions for commercial use.

Keywords – Amaranth, Popping, Optimization, Taguchi, Energy Efficiency, Nutritional Analysis.

Introduction

Amaranth locally known as *Terere*, is a cereal renowned for its high nutritional value, that has gained global attention as a sustainable food source rich in protein, fiber, and essential micronutrients (Ajmera, 2018). Despite its benefits, commercial processing of amaranth particularly popping faces significant challenges, including energy inefficiency, inconsistent product quality, and high seed wastage. Traditional popping methods, such as manual pan-roasting, are labor-intensive and poorly scalable, while imported automated machines are often cost-prohibitive and difficult to maintain in resource-limited settings. This gap underscores the need for locally fabricated, energy-efficient solutions tailored to small-scale processors in developing regions.

Recent advancements in agricultural machinery design emphasize the integration of systematic optimization techniques to enhance performance. However, limited research exists on applying these methods to amaranth popping machines, particularly those utilizing locally available materials. This study addresses this gap by developing and optimizing a cost-effective, locally fabricated amaranth popping machine. The primary objectives include evaluating the effects of key parameters such as temperature, vibration frequency of the motor, and seed quality, while ensuring nutritional retention.

The Taguchi method was employed to systematically identify optimal operating conditions, minimizing experimental iterations and resource expenditure. By focusing on energy efficiency and scalability, this research aligns with Sustainable Development Goals (SDGs) targeting food security and sustainable industrialization. Furthermore, the study validates the machine's performance through nutritional analysis of popped seeds, ensuring that the process retains critical nutrients while reducing moisture content (Dias et al., 2018).

This work contributes to the growing body of knowledge on agro-processing technologies by demonstrating the viability of locally engineered solutions. In Kenya, where agriculture is central to national development strategies such as Vision 2030 particularly its agricultural pillar aiming to transform the sector into a driver of economic growth, food security, and wealth creation this research offers actionable insights. It provides a framework for adapting advanced optimization techniques to low-resource contexts, empowering small-scale farmers and processors to enhance productivity and reduce post-harvest losses.

Literature Review

Amaranth processing has been extensively studied, with prior research highlighting its nutritional value, highlighting the technical challenges of popping. Early studies identified moisture content and heating uniformity as critical factors affecting popping yield (Joshi et al., 2018), while others emphasized the role of thermal conductivity in heating plate materials (Gupta & Sharma, 2020). However, these investigations predominantly focused on laboratory-scale setups, neglecting practical constraints such as affordability and maintenance in rural settings.

The application of statistical optimization in agro-processing has gained traction, with the Taguchi method emerging as a robust tool for parameter optimization. For instance, (Kumar and Singh 2021) utilized Taguchi's orthogonal arrays to optimize a millet dehulling machine, achieving a 25% improvement in efficiency.

Existing commercial popping machines, though effective, often rely on imported components and complex control systems, rendering them unsuitable for localized fabrication. A review by (Mwangi et al. 2019) noted that stainless steel and mild steel due to their thermal resilience and availability are preferred materials for small-scale agro-processing equipment in sub-Saharan Africa. Despite this, few studies have explored their integration into amaranth-specific designs or evaluated nutritional outcomes post-processing (Adebowale et al., 2021).

This study bridges these gaps by leveraging locally sourced materials and statistical optimization to develop a scalable popping machine. It builds on earlier work by incorporating vibration mechanisms for uniform heat distribution and rigorous nutritional validation a dimension often overlooked in prior engineering-focused research (Ndiritu et al., 2022). By aligning technical innovation with socio-economic realities, this research offers a replicable model for enhancing food processing in resource-constrained environments.

Materials and methods

This study adopted a systematic engineering approach for the design, fabrication, and optimization of a locally made amaranth popping machine. The machine was fabricated at the Mechanical Engineering Laboratories, while the nutritional analysis of the popped amaranth was conducted at the Chemical Engineering Laboratories of Dedan Kimathi University of Technology. The methodology consisted of major phases such as, computer-aided design, material selection, fabrication, experimental setup, testing, and optimization of both the amaranth popping machine and the amaranth seeds.

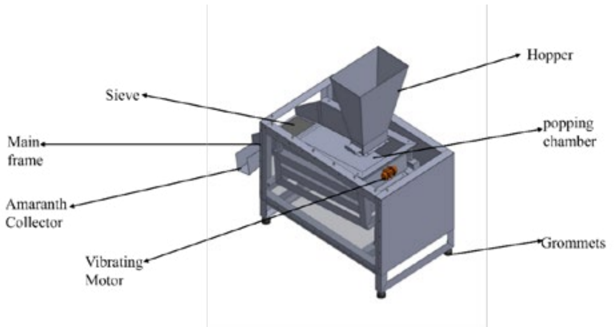

Figure 1.Amaranth popping Machine

The material selection was guided by performance requirements, cost, and local availability. Stainless steel (Grade 304) was used for the hopper and popping chamber due to its excellent corrosion resistance, food safety compliance, and ability to withstand high temperatures. Mild steel was chosen for the frame structure for its strength, affordability, and ease of fabrication.

Heating elements were mounted on brackets welded to the surface of the popping chamber rather than directly onto it. This design allows for easy replacement and reduces the risk of thermal damage. The entire assembly process was supervised to ensure adherence to safety and quality standards.

The feeding system included a hopper, seed control valve, sieve, and popping chamber, all fabricated from stainless steel to ensure durability, high corrosion resistance, and safe food handling. These components were designed to facilitate smooth seed flow.

The heating system comprised of the heating coils mounted on the base of the popping chamber using brackets, allowing close contact for efficient heat transfer. A thermocouple was integrated to monitor heat distribution, and a temperature sensor was installed for accurate measurement of internal chamber temperature.

The vibration mechanism featured a 1400 rpm vibrating motor, securely mounted on the popping table. This motor ensured uniform distribution of seeds within the chamber, promoting even heat exposure, enhancing popping efficiency, and minimizing seed burning.

Initial trials were carried out to evaluate the effects of temperature and time on popping efficiency and quality. Key performance indicators included:

- Popping efficiency (% of seeds successfully popped),
- Seed wastage rate (burnt or un-popped seeds), and
- Energy consumption.

A digital thermocouple was used to monitor chamber temperature during testing as the ambient temperature was measured by the use of an infra-red thermal camera.

Optimization of operating parameters was conducted using the Taguchi Design of Experiments (DOE) method. An L16 orthogonal array was employed to study the effects of two control factors, each at three levels. Table 1 presents the selected factors and levels, while Table 2 outlines the L16 experimental design

Table 1. Experimental Factors and Levels

Factors	Level 1	Level 2	Level 3	Level 4
Popping Temperature (°C)	100	140	200	300
Spindle speed (rpm)	800	1400	2600	3000

Table 2. Taguchi L16 Optimization Parameters

Experiment Number	Spindle Speed (rpm)	Temperature (°C)
1	800	100
2	800	140
3	800	200
4	800	300
5	1400	100
6	1400	140
7	1400	200
8	1400	300
9	2600	100
10	2600	140
11	2600	200
12	2600	300
13	3000	100
14	3000	140
15	3000	200
16	3000	300

The amaranth seeds were then subjected to various test to determine their nutritional value retention such as protein testing, fat content retention and fiber content analysis as described.

1. Protein Testing

Protein retention in popped versus non-popped amaranth seeds was determined using the Kjeldahl method. Crushed samples (0.2 g) were digested with concentrated H_2SO_4 and a copper-selenium catalyst for ~3 hours until a green-yellow ammonium sulfate solution formed. The digested sample was neutralized with NaOH, and evolved ammonia gas was distilled into boric acid containing bromocresol green indicator. The ammonia-boric acid complex was titrated with 0.02N HCl to quantify nitrogen content. Protein percentage was calculated as

$$\%Protein = [(V \times N \times 1.4007) / W] \times 6.25$$

where V = HCl volume, N = HCl normality, and W = sample weight.

2. Fat Content Testing

Fat retention in popped amaranth was analyzed via Soxhlet extraction. Crushed seeds (5 g) were placed in a thimble and extracted with an organic solvent for 4–6 hours using a Soxhlet apparatus. Post-extraction, the solvent was evaporated, and the residual oil was weighed.

Fat content (%) was calculated as

(Weight of extracted oil / original sample weight) × 100.

3. Fiber Content Analysis

Fiber retention was analyzed through sequential acid-alkaline digestion. A 0.2 g sample was digested in 30 ml 1.25% H_2SO_4 (acid digestion), reduced to half volume, filtered, and the residue further digested in 30 ml 1.25% NaOH (alkaline digestion). The final residue was filtered, oven-dried, and ashed in a muffle furnace.

Fiber content (%) was calculated as

[(residue weight – ash weight) / sample weight] × 100.

Results and Discussion

Taguchi-designed experiments assessed the impact of spindle speed and temperature on popping efficiency using 500 g samples processed for 2 minutes, with wastage calculated as the percentage of un-popped and burnt seeds. Optimal results were observed at 800 rpm and 140°C (Experiment 2), yielding the lowest wastage (15%) and 425 g of fully popped seeds, indicating a balance between efficiency and quality.

Temperatures below 140°C led to high un-popped rates (up to 70%), while higher temperatures caused excessive burning (40–50% wastage). Additionally, spindle speeds ≥2600 rpm resulted in 60–100% wastage due to uneven heat distribution.

The Taguchi method's use of an orthogonal array proved effective for identifying optimal agro-processing parameters with minimal experimentation.

Equation 1 was used to calculate the percentage waste. Table 6 contains the results obtained after the calculations.

$$\text{Wastage } (\%) = \frac{\text{Weight of un-popped seeds + Weight of burnt seeds}}{\text{Initial weight of seeds}} \times 100$$

Table 3.Results of the seeds wastage after popping amaranth seeds

Exp. No.	Spindle Speed (rpm)	Tem-pera-ture (°C)	Fully Popped (g)	Un-popped (U), (g)	Burnt Seed (B), (g)	Wast-age (%)	Quality of Amaranth Seeds
1	800	100	150	350	0	70%	Seeds were of good texture few popped
2	800	140	425	65	10	15%	Seeds were of good quality
3	800	200	300	0	200	40%	Popped seeds got burnt
4	800	300	0	500	0	100%	No change of the seeds
5	1400	100	200	300	0	60%	Few popped
6	1400	140	350	100	50	30%	Seeds were of good texture
7	1400	200	250	50	200	50%	Popped seeds got burnt
8	1400	300	0	500	0	100%	Popped seeds got burnt
9	2600	100	100	400	0	80%	Few Popped
11	2600	200	200	150	150	60%	Few Popped
12	2600	300	50	450	0	90%	Few Popped
13	3000	100	0	500	0	100%	Few Popped
14	3000	140	50	400	50	90%	Few Popped
15	3000	200	150	250	100	70%	Few Popped
16	3000	300	0	500	0	100%	Few Popped

To evaluate the nutritional impact of the popping process, a detailed analysis was carried out focusing on protein content, fiber content, and fat content. Both raw and popped amaranth seed samples were analyzed at the Chemical Engineering Laboratories of Dedan Kimathi University of Technology using standard analytical procedures. Figure 2 and figure 3 shows popped and non-popped amaranth seeds respectively. The goal was to determine whether the popping process preserved or altered the seeds' nutritional quality.

Figure 2 and figure 3

Protein Content analysis

The protein content of popped was obtained as 2.37% and non-popped amaranth seeds was 2.36%. Table 4, suggest that the popping process retains protein integrity without significant degradation.

Table 4. *Results for Protein Analysis*

Sample Identification	% Protein of the Popped (w/w)	% Protein of non-popped (w/w)
A	2.3618	2.3989
B	2.3563	2.3323
C	2.3857	2.3534
Average	= (2.3618+2.3563+2.3857) ÷3 **= 2.3679**	= (2.3989+2.3323+2.3544) ÷3 **= 2.3619**

Fat Content retention

Fat content in popped amaranth (5.79% w/w) slightly increased compared to non-popped (5.70% w/w), likely due to moisture loss concentrating lipids, confirming minimal fat degradation during popping. The results were highlighted in Table 5 and 6.

Table 5.Results for Fat content of Non-Popped Amaranth Seeds

Non-Popped Sample ID	Wt. of the empty round Bottomed Flask (g)	Wt. of the flask + oil (g)	Wt. of the oil	% Oil
A	118.5114	118.7933	0.2819	5.6380
B	111.3428	111.6331	0.2903	5.8060
C	116.1984	116.4814	0.2830	5.6600
Average fat content for the popped				**= 5.7010% w/w**

Table 6.Results for Fat content of Non-Popped Amaranth Seeds

Popped Sample ID	Wt. of the empty round Bottomed Flask (g)	Wt. of the flask + oil (g)	Wt. of the oil
A	118.5114	118.7983	0.2869
B	111.3428	111.6381	0.2953
C	116.1984	116.4854	0.2870
Average fat content for the non-popped			

Fiber Content Analysis

The results confirmed that popped amaranth had a fiber content (15.28% w/w) and non-popped with (15.03% w/w), confirming minimal degradation during processing and the calculated data was presented in Table 7 and 8.

Table 7.Fat content for non-popped Amaranth Seeds

Sample ID for the non-popped	Beaker wt. (g)	Beaker + sample wt. (g)	Sample wt. (g)	Beaker + Residue (g)	Beaker + Ash (g)	Fiber content (g)	% Fiber Content
A	49.3400	49.5579	0.2179	49.4079	49.3772	0.0307	14.089
B	48. 7741	48.9780	0.2039	48.8129	48.7929	0.0311	15.2526
C	49.4005	49.6029	0.2024	49.4188	49.4939	0.0319	15.7609
Average Fibre content for the non-popped	**= 15.0342% w/w**						

Table 8.Fat content for non-popped Amaranth Seeds

Sample ID for the popped	Beaker wt. (g)	Beaker + sample wt. (g)	Sample wt. (g)	Beaker + Residue (g)	Beaker + Ash (g)	Fibre content (g)	%fiber Content
A	49.3400	49.5581	0.2181	49.4079	49.3761	0.0318	14. 5804
B	48. 7741	48.9801	0.2060	48.8129	48.7814	0.0315	15.2913
C	49.4005	49.6015	0.2010	49.4188	49.3867	0.0321	15.9701
Average Fiber content for the popped	**= 15.2806% w/w**						

Conclusion

The optimization of a locally fabricated amaranth popping machine using the Taguchi method successfully addressed key challenges in seed wastage and nutritional retention. By systematically evaluating spindle speed and temperature, the study identified **140°C and 800 rpm** as optimal parameters in achieving high-quality seed popping while reducing seed wastage to **15%**.

Nutritional analysis confirmed that popping retained critical nutrients, with protein (2.37%), fat (5.79%), and fibre (15.28%) levels comparable to non-popped seeds. The machine's design, utilizing locally sourced stainless steel and mild steel, ensured affordability, durability, and ease of maintenance, aligning with Kenya's Vision 2030 goals for agricultural transformation and food security. These findings underscore the viability of Taguchi-optimized, locally engineered solutions in enhancing agro-processing efficiency, reducing post-harvest losses, and supporting sustainable industrialization in resource-constrained regions.

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The Role of Food Engineering in Shaping Kenya's Agricultural Future

By EiK Correspondent

The global food industry is a vast network connecting farmers, manufacturers, retailers, and consumers. With the world's population steadily increasing, the need for efficient and sustainable food production has never been more urgent. At the center of this challenge lies food engineering a discipline that blends science and technology to create food systems that are productive, safe, and environmentally responsible.

Food engineering covers a wide spectrum of processes, from designing and optimizing production systems to developing new products, preservation techniques, packaging solutions, and quality control measures. Its relevance is especially strong in regions where food security remains a pressing issue. In Kenya, where agriculture is a cornerstone of the economy, food engineering is proving essential in improving both the efficiency and resilience of food production and distribution.

Kenya's food industry reflects a unique mix of agricultural richness and logistical challenges. From smallholder farmers to large agribusinesses, the nation is working to boost food production while reducing waste and safeguarding food safety. Innovations in food engineering are central to these efforts. Engineers are developing advanced processing methods that extend the shelf life of perishables, improving logistics to streamline distribution, and applying smart technologies to monitor food quality throughout the supply chain.

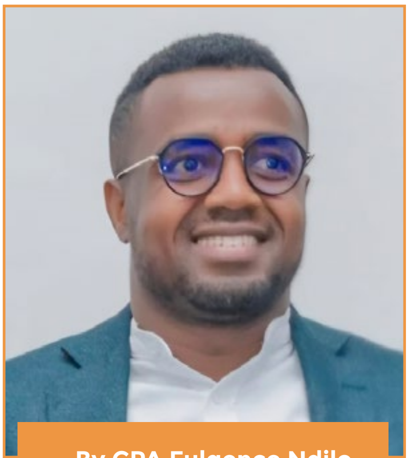
Recent years have also seen the Kenyan government emphasize food security and nutrition, making the integration of engineering solutions into policy a national priority. By advancing food engineering, Kenya can unlock its agricultural potential and equip farmers - especially smallholders - with the tools and knowledge needed to raise yields, increase incomes, and reduce losses.

ACTOM is a key player in this transformation. With more than a century of engineering expertise, ACTOM supports the food industry in Kenya by providing advanced electro-mechanical equipment that drives critical processes such as production, cold storage, and packaging. By embedding energy-efficient and sustainable technologies into these systems, ACTOM helps food processors cut costs, reduce waste, and ensure consistent operations. In doing so, the company not only strengthens food security but also contributes to the long-term growth of Kenya's agricultural economy.

Through close collaboration with government bodies, private enterprises, and food industry stakeholders, ACTOM's integrated solutions tackle challenges ranging from energy efficiency to waste management in food processing. These initiatives support local economies while ensuring that safe, affordable food reaches communities across the country.

The challenges facing the global food industry are reflected in Kenya's agricultural landscape. Food engineering provides the innovative foundation needed to address them. By investing in technology and fostering collaboration between engineers, policymakers, and the private sector, Kenya can build a food system that is equitable, efficient, and resilient. The opportunity is clear: with the right partnerships and investments, Kenya can secure its food future for generations to come - demonstrating the transformative power of food engineering.

Life, Leadership & Legacy in Engineering Administration



By CPA Fulgence Ndilo, Finance and Admin Manager, IEK

> Integrity – Numbers don't lie, and neither should leaders. Though numbers can give you a headache if you misplace one zero.
> Inclusion – Diverse voices make better solutions.
> Impact – Every decision must change lives beyond the boardroom.

If you had told young me, the small boy running up Eldoro's hills chasing goats and dreams, that one day I'd be crunching numbers for the engineers' Professional body, I'd probably have laughed… *then asked if there was a football pitch nearby.*

I grew up in the peaceful village of Eldoro, Taita Taveta, the last-born in a spirited family of six. Now, I know what you're thinking, last-born equals spoilt, lazy, and always running to Mum and Dad for help, right? ***Well… spoiler alert: I was the hardworking plot twist nobody saw coming.*** From herding goats uphill to solving math puzzles under a palm tree, I was wired for curiosity and motion.

In 1994, I joined Eldoro Primary School, where I powered through eight years with grit, grace, and more than a few scraped knees. My KCPE results got me an offer from Kenyatta High School, Mwatate, but ***plot twist number two,*** my parents, both strict teachers, sent me to St. Mary's Seminary Secondary School in Kwale instead. I was actually on the priesthood path (altar boy all through high school, from a staunch Catholic family), but somewhere along the way… *let's just say my collar stayed figurative.*

Still, the discipline and prayerfulness stuck. My parents still wake up at 3:00 a.m. to pray the rosary *and trust me, if you've ever heard the sound of a Catholic parent's footsteps at 3:00 a.m., you know it's not a suggestion; it's a summons.*

Later, I joined Kenyatta University for a Bachelor's in Commerce-Accounting option and United States International University-Africa for Masters in Business Administration specializing in Strategic Management. Numbers were my jam ***yes, I'm that person who gets excited about balancing accounts***. If there was a calculator, a budget, or a tricky puzzle to solve, I was in my happy place. Outside class? Football. I play full-back 3 and, yes, I'm a staunch Arsenal supporter, *proof that I can survive long-term hope and the occasional heartbreak.*

From Village Hills to the IEK Boardroom

My upbringing drilled two things into me: discipline and service. Our house was basically a mini-school you showed up, you did the work, and you aimed higher than yesterday. My family wasn't just supportive, they were my first Board of Directors. My siblings pushed me, my parents corrected me (often in red pen), and excellence wasn't optional; it was expected.

By 2010, I had dipped my toes into the world of finance, starting with an internship at the Kenya Bureau of Standards (KEBS). The people I met there were more than just colleagues, they became my mentors. Under their guidance, I quickly realized that accounting wasn't just about numbers; it was about creating a foundation for something much bigger. KEBS opened the door to what would become a long journey in the financial world, one that eventually led me to the United States International University-Africa (USIU-Africa).

It was at USIU that I truly began to rise through the ranks. From an accountant in the trenches to Principal Accountant, I became deeply involved in the financial systems that powered the institution. It wasn't just about crunching numbers; it was about ensuring every financial decision supported the mission of the institution, giving students the resources and environment, they needed to succeed. By 2023, I had reached the pinnacle of my accounting career at USIU, but a new challenge awaited.

When the opportunity arose to join the Institution of Engineers of Kenya

(IEK), it felt like stepping into a world of superheroes. Sure, they didn't have capes, they had helmets and blueprints but the mission was just as bold. My role? Be the bridge between the dreamers and the doers, between the big ideas and the budgets that make them possible. *In short: part accountant, part translator, part dream-police.*

I started with a very operations-focused role, but over time, my responsibilities evolved. I found myself deeply immersed in strategic budgeting for innovation projects, aligning policies to support sustainable engineering practices, and ensuring that the financials reflected the institution's ambitions. It was about more than just balancing books—it was about fueling the very engine that drives the future of engineering in Kenya.

And as I look back now, from the hills of my village to the boardrooms of IEK, I can see how far I've come. But what excites me the most is knowing that the story is far from over. The future is filled with challenges, yes—but also endless opportunities. And I'm ready to face them head-on, with the same discipline, service, and ambition that have defined my journey so far.

It's not just about numbers; it's about building a legacy, one budget at a time.

The Referee Between Creativity and Compliance

Managing finance in a technical field is like refereeing a high-stakes match between creativity and compliance. Engineers dream in structures and systems; finance dreams in numbers and regulations. My job is to make sure the dreamers can dream without overdrawing the account.

It's a mix of collaboration, translation, and storytelling. You can't just hand an engineer a budget sheet; you have to walk them through the "why" and "how" like you're narrating the play-by-play of their own vision. *And yes, snacks at meetings improve approval rates by at least 20% scientifically proven by my own experience.*

Mentors, Mentees, and the Crossroads of Finance & Tech

I've had mentors who didn't just give advice they gave perspective. One told me, *"Never be the smartest in the room. Be the one who learns the fastest."* That has guided my leadership ever since.

Now, I mentor young professionals, especially those standing at that tricky crossroads between finance and technology. My advice? Don't pick a lane learn both. Speak both languages. I run guidance sessions, offer training, and host coffee chats where we swap stories about spreadsheets and career dreams *and where at least one person will say, "I hated math in school" and I'll still try to convert them.*

Fueling Innovation with Vision and Funding

From my seat at IEK, I see innovation as a marriage of vision and funding. We align our financial strategies with Kenya's development goals like Kenya Kwanza Agenda, Vision 2030 and green tech initiatives. That means creating room in the budget for R&D, pilot projects, and sustainable engineering systems. *Because a brilliant idea without funding is just a very expensive daydream.*

Balancing Budgets and Bedtime Stories

Work-life balance? Let's call it a work-in-progress. I start my mornings with quiet reflection (and a strong cup of tea) and guard my evenings as family time no budgets allowed. Weekends are for unplugging, football, and fresh air. The trick is to be fully present wherever I am 100% at work, 100% at home. *Okay, maybe 99%... because sometimes even at home, I find myself mentally balancing a spreadsheet.*

Integrity, Inclusion, Impact

My leadership rests on three values:

- **Integrity** – Numbers don't lie, and neither should leaders. *Though numbers can give you a headache if you misplace one zero.*
- **Inclusion** – Diverse voices make better solutions.
- **Impact** – Every decision must change lives beyond the boardroom.

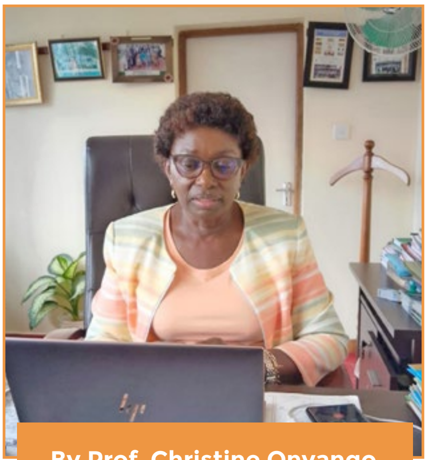
These guide me whether I'm budgeting for food processing innovations, industrial energy solutions, or agricultural tech.

The Legacy I Hope to Leave

I want to be remembered as a bridge-builder, the guy who connected finance with innovation, policy with practice, leadership with legacy. I want future generations to dream in both digits and designs, to lead with purpose and passion, and to remember that a little humor goes a long way... even in a budget meeting.

And if somewhere in that legacy there's also a football trophy for Arsenal, well, *that would just be the cherry on top of the balance sheet.*

Empowering Food Security through Innovation: Insights from Taita Taveta University on Advancing Food Engineering in Kenya



By Prof. Christine Onyango

Have you ever watched people line up for pizza at a popular outlet and wondered if there ever will come a time when people in other countries will line up for one or more of Kenya's indigenous foods like mukimo or obambla with a side of millet ugali, with just as much enthusiasm?

This, Prof. Christine Onyango says, this is very possible, but first, Kenya needs to implement policies to refine and improve the food industry in Kenya, and it is also about time, she insists, Food Scientists are recognized as a professionals like engineers, doctors, agronomists among others, in Kenya.

"We are rapidly losing a lot of indigenous food knowledge due to our adaptation to modern lifestyles, but countries like China have simply innovated, industrialized and monetized the same indigenous foods, food knowledge and processes, creating impressive industries, jobs and other modern conveniences around their indigenous foods, "says the good professor.

Over the course of our interview, she breaks down the steps on how Kenya can improve her food industry and why Food Science has an important role to play in this.

Who is Professor Christine Akoth?

Prof. Christine Akoth Onyango is a food scientist, a professor of Food Science and Technology specializing in food chemistry and the chemistry of muscle foods who also dabbles in nutrition and nutraceuticals and food safety. She is currently the Deputy Vice Chancellor in charge of Academic, Research and Outreach at Taita Taveta University.

Growing up, she had wanted to be a pediatrician or a surgeon, or a pediatric surgeon, but quite unfortunately, her subject combination of Chemistry, Biology, Geography and Subsidiary Maths (instead of Principle Maths) saw her miss out on studying medicine.

Fortunately, this subject combination earned her a place in the Food Science program which catered to people in areas of food processing, quality assurance, food science research, academia and for the brave at heart, entrepreneurship.

Food Science Core Competencies

According to Prof Christine Akoth, Food Science is strongly founded in the basic sciences like Chemistry, Biology, biochemistry, Physics and Math, just like any engineering programme, apart from the biology subjects. Therefore, students must possess deep scientific knowledge of food composition; structure and function of the physical and biological components, their behaviour in different environments and how to maximize this knowledge to enhance preservation and create new food products that have never existed before. Therefore, a food engineer has a deep understanding of food commodities, how to convert them into the desired final products and persevere them for a given time without losing the nutritional and sensory qualities that result in high value products. Such products can be minimally processed, such as fresh fruits and vegetables or completely processed and developed into what has never existed before like ice-cream and spaghetti.

The Food Scientist must top up all this with soft skills needed to engage engineers in designing processing equipment, packaging and other technical areas and also be able to liaise with grassroots producers and consumers to develop and sustain the products that the people want! This fires the excellence required in any food science program. On top of these skills, a student must be passionate about what they are doing.

Why do we call it food engineering yet we are looking at foods which are biological components?

Engineering is very deeply imbued in food processing.

"As the food grows, it mines nutrients from the ground. Some of these nutrients are the very nutrients an engineer would mine from the ground, like iron. They then utilize these minerals in their biological ecosystem to come up with their commodities, fresh leafy vegetables, fruits, cereals (dry) and animal products such as milk. Everything after harvest becomes the subject for a food scientist; including: fresh harvesting, fresh sales, cold storage chains, transport to market or industry. This is because, food quality begins to change immediately after harvest, so the Food Engineer must develop systems to stop or minimize the changes. The postharvest processes are mainly mechanical and chemical engineering with a biological twist, intensive. Processes like turning milk into butter, baking pies and making pasta on an industrial level, requires machinery that can knead that quantity of dough and take on processes that may otherwise not be able to be done by hand at that level of production. Mechanical engineers are therefore a very integral part of the processing floor but require biological knowledge of food to make processing happen. Thus, Food engineers must be part of all the processes, pre- and post-harvest. Engineers design the process flows and these consist of various unit operations that are basic in any engineering programme. A food plant requires energy to run, water not just for washing raw materials but also forming an integral part of different products, and see to it that products moved all the way to the point of packaging, packing and dispatch to marketing outlets. The unit operations would not be complete without the mechanical engineers," she says.

How does your work intersect with local farmers and small-scale food processors?

Most people have a milk brand or a bread brand that they prefer over the other brands. Some people simply believe that some brands in the market are of a higher quality than the others. This trust in one brand, Prof Christine Akoth says, does not begin at the shelf, it starts from the ground. The quality of the produce determines the quality of the final products on the shelves. Therefore, her work does not just intersect with local farmers and small-scale food processors, they are deeply connected and dependent on one another. For this reason, they work closely with agronomists and researchers, conduct farmer trainings to enhance commodity quality, correct harvesting and on-farm storage and other matters that ensure the final products meet their quality thresholds.

"When processing dairy for cheese, for example, the farmers have to be trained on milk hygiene, safety and storage so they meet the minimum requirement for product development. They are also trained on how to handle the products right from when they get it from the animals to when it is delivered to the processing plants. The temperature of raw milk should not exceed 4∘ C, and upon receipt at the plant, the density is measured to determine that no adulteration has taken place in such as addition of water, or anything to prolong milk shelf-life,' she says.

How has research on indigenous flora contributed to sustainable food systems in rural Kenya?

A particular community in Kitui suffered low yields and were frustrated with growing maize, up until Prof Christine and her team swooped in and encouraged them to try less thirsty crops like sorghum. The team took an interesting approach to encouraging this shift by not just asking them to kindly grow sorghum, but getting the buy-in and guiding them through the planting, harvesting and safe storage, before turning it into flour, and using the wastes as animal feed and/or turning them into charcoal briquettes. They introduced the farmers to 300 sorghum-based products, and with the knowledge of how to utilize the crop, it easily became a cash crop.

"We started by identifying specific community needs. The success of farming in areas like Europe lies in the close liaison of farmers with researchers and the government to create policies and an ecosystem which recognizes everyone's effort at different levels," she explains.

"Some of the biggest banks in the Netherlands like Rabobank was built on the gains of the value chains that were created in the farm-to-fork food ecosystem. Yet another good example is the Credit Agricole bank in France which merged local agricultural credit cooperatives. They built resilient value chains for both the farm fresh and processed foods and invested in the safe post-harvest ecosystem of the food commodities," she further states. This made farmers grow rich and build successful livelihoods that enabled innovation and productivity enhancement for food security and consistent value to the value chain players.

The farmer can grow good food but if there are no good post-harvest management systems the produce can easily go to waste. For this reason, she has led teams in train farmers in good post-harvest practices, play their part as value chain actors, influence commodity pricing with high produce that meet international standards to expand their markets.

Instant Sorghum Cereal

Yet another key achievement of hers is the creation of instant cereal using sorghum. "Instant cereal does not have to be wheat-based, we have to import wheat to meet demands, but we have indigenous crops like sorghum, that can equally be exploited" she says.

Food Science as a Professional Program

After graduation, Prof.Christine's cohort had a pretty rough introduction to the employment field. First, they faced some bit of competition from the polytechnic graduates, who she says employers preferred as they assumed they would require less salary. There are some industries, like the tea industry, which shied from employing women. Moreover, there was regional bias where some people felt some positions were to be reserved for people who came from the regions that these industries were allied to, and finally there was the matter of connection where who you knew determined whether you were placed. Then came the biggest blow, the Ministry of Agriculture made the decision to downgrade the food scientists in the ministry and declared that Food Science was not a professional discipline. To this date food scientists are still fighting for recognition through their professional body, the Kenya Institute of Food Science and Technology (KIFST)

"Food scientists are trained in food processing, food quality and food quality assurance, food safety and toxicology, so we can work in very many sectors of the government. I ended up in academia, and I draw my pride from having trained many food scientists who have performed impressively, and using my knowledge and skills in improving the livelihoods of different communities," she says.

The Role Food Science Plays in Achieving Kenya's Food Security and Nutrition Goals

40%-50% of Kenya's commodity post-harvest goes to waste, which points to a lapse in our food security systems. These foods could be converted into other forms, or fertilizer, or animal feed or even bio energy, but this hardly happens. Food science through research and innovation is trying to change this by looking into improving the crop value chains and circular systems for sustainability in this era of climate change.

"In Kenya we measure food security in terms of bags of maize, but it goes well beyond that. The food industry is a multi-billion-dollar industry and if well harnessed we will not only have enough food, but we will also create more than enough jobs," she says.

The fact that food science is still not recognized as a professional programme remains a thorn in Prof Akoth's side, and indeed the entire Food Science field as it demonstrates an unwillingness in harnessing the potential of the agricultural value chain.

"Do you know a lot of beer in Kenya used to be made from barley, which is import-reliant, up until a food scientist found out they could make just as good beer using sorghum. As we speak, most of the beer in Kenya is now sorghum-based. The reason why we were even able to convince farmers in Kitui to switch to sorghum is because in so doing, they had a cash crop with ready market. With the money sorghum makes them they can now buy maize. The waste from sorghum goes into animal feed, charcoal briquettes among others. This makes for one robust circular economy," she explains. Sorghum, among other cereal and root crops, is also useful for flour fortification. This would bring down the cost of ugali and dependence on maize as the chief staple in Kenya she avers from research she did in the early 1990's.

International Training and Collaborations

After her PhD, Prof Christine was nominated for her post-graduate Diploma at the Hebrew University of Jerusalem in Israel on Food Quality Systems where she undertook modeling statistics, consumer behavior and leadership training.

She undertook further training at the East Africa Women in Agriculture for Research and Development (AWARD), a program for women in agriculture and leadership under the Consultative Group of International Agricultural Research (CGIAR).

"There is an active broken rank system when it comes to women in management where most women tend to only rise to a certain level and not any further. In order to even get to that level, there is an almost pre-determined code of conduct women have to adhere to in order to be considered. You cannot be too assertive for instance," she says.

Among the core topics this training touched was navigating hurdles in management, how to position themselves, how to seek and get grants, how to write and publish papers and it also gave them a global perspective on food and entrepreneurship.

Yet another training was the Integrated Agricultural Research for Development in the Netherlands which again brought out the need for soft skills for positive engagement of different value chain actors in the market, which most engineers and the nature of their work sometimes do not allow.

"If you are confined to a lab or a factory where you watch bottles of beer being filled, capped and packaged, there is no room for soft skills. But engineers also interact with other people be it in training, conferences, sales and networking events, that will call for soft skills," she says.

How can more students, especially women, be encouraged to join this program?

"This is not a glamourous program!" she chuckles. Prof Christine has an easy manner about her. There is something regal and deported in the way she carries herself. The processing floor however, she says, is no place for jewellery, perfume, manicure and fancy hair, much to the chagrin of most female students. Should any of these products mingle with food, they will ruin its quality so they have to be in boots, overalls and cover their hair at all times.

But it is not just the processing floor that women may find restrictive, even those in management experience unique challenges and; Prof. Christine would know because many are the times she has found herself the only woman in board meetings.

"The harsh truth is that women work from dawn to dusk which means that after working in the office there is usually more work to do at home. My kids were grown when I was coming into professorship so it was easy to work without feeling the guilt that accompanies most women in management positions. It makes it harder to focus on work, outside work," she says.

Thankfully, the many training sessions she attended prepared her for these kinds of challenges and she is taking each in stride.

"During training, we were taught how to carry ourselves professionally in our conduct, speech, manner and deportment - things that are an integral part of leadership. Some things can never be taught in class, you learn them as you rise through the ranks," she reveals. While there is a considerable number of women in research and academia, the truth remains that there are way more men in that space.

"Many at times I have found myself being the only woman in a meeting, therefore I take it upon myself to pass on the things I have learned to young professionals. It is almost ingrained in men open doors for one other be it through alumni associations, investment – women need to hold the hands of the women who are coming behind them, mentor and accelerate them to bigger spaces and reach the horizons they themselves could only dream of."

"Women have to be self-motivated and help our spirit arise above all the negativity. We need focus and vision and to encourage ourselves. There are things you have to do by yourself, there are those than can be achieved together, and then there are those that will need some level of training to bring out the best in yourself," she advises.

A call for innovation

In her many professional travels, Prof Christine happened upon a meat processing plant in Sweden where she learned of one of their popular inventions, Grandma's Fingers.

"There is this well-loved pie that grandmas made, and every attempt to mass produce it had failed up until an engineer was brought in. He studied the kneading patterns of these grandmas, then developed a machine called Grandma's Fingers which replicated the process. Today, the plant makes thousands of these pies to perfection," she narrates.

Her call, then, to young engineers is that they think beyond buildings, roads and huge complex machinery for making cars and computers, but to think also about making equipment for processing foods at different scales and availing in them market at affordable rates to encourage development of the food processing industry.

"We have whole lines of people developing computers and phones, why can't we have a whole line of engineers turning some of these traditional culinary crafts into engineered products, like an ugali-making machine?" she poses- "the Japanese have rice cookers, because that is their staple food and to-date their brand of rice cookers is widely acclaimed. China today is graduating 660,000 engineers a year while Kenya is barely hitting 1,000. The biggest difference is that the engineers in China, many as they are, are innovating every single day and we end up buying their products here in Kenya. That is enough to tell us how we are thinking about our engineers," says Prof. Christine.

Parting Shot

"We cannot solve our country's problems in individual silos, Prof. Christine advises, "Every profession matters as we need to work together, not in professional silos, to address matters such as food security and job creation. It does not matter whether you are an engineer, a doctor, a fine artist, a songstress, at the end of the day we all need food. We need a system that enables everyone to get the type of food they want even if they are not direct producers of the same. We need robust policies that will ensure agriculture becomes a key driver of many industries in this country."

Prof. Christine Onyango is the Deputy Vice Chancellor (ARO) -Taita Taveta University

Engineering Kenya's Irrigation-Led Agricultural Progress

By Eng. Charles Muasya, MBS

How does National Irrigation Authority's core mandate complement the broader goals of the Ministry of Water, Sanitation, and Irrigation?

The Authority's focus on irrigation development is a practical vehicle through which the Ministry's broader mission of ensuring water security, sanitation and sustainable irrigation is realized, making NIA a key cog in driving Kenya's food security and economic growth agenda.

The mission of the National Irrigation Authority (NIA) is to develop, coordinate and manage sustainable irrigation services for socio-economic development in Kenya. Its focus is to increase the area under irrigation, enhance agricultural productivity and promote food and nutrition security, thereby steering the country towards food security and prosperity. This mandate directly complements the broader goals of the Ministry of Water, Sanitation, and Irrigation (MoWSI) in several ways:

i. Food and Nutrition Security - By expanding irrigated agriculture, NIA steers the country towards reliable food production, reducing dependence on rain-fed agriculture and supporting the Ministry's goal of forming partnerships and collaborations in support of land reclamation, Climate Resilience for water and food security activities in accordance with CoK, 2010.

ii. Water Resource Management - NIA's projects are designed to harness, store and efficiently use water for agricultural purposes, aligning with the Ministry's broader objective of sustainable water resource utilization.

iii. Climate Change Adaptation - Through irrigation, NIA helps communities cope with erratic rainfall and drought, supporting the Ministry's agenda on climate resilience and sustainable livelihoods.

iv. Economic Growth and Rural Development - Irrigation projects boost farmer incomes, create employment and stimulate rural economies, complementing the Ministry's vision of water as an enabler of socio-economic transformation.

v. Integration with Sanitation and Hygiene Goals - By ensuring communities have access to water infrastructure, NIA indirectly contributes to improved sanitation and hygiene outcomes, reinforcing the Ministry's integrated approach to water services.

As an Authority, how do you prioritize and select irrigation projects across different regions, especially considering Kenya's diverse water and agricultural needs?

The National Irrigation Authority (NIA) prioritizes and selects irrigation projects through a structured approach that considers Kenya's diverse water availability, agricultural potential and community needs. The process involves:

i. National Priorities and Policy Alignment - Projects are aligned with government priorities such as the Kenya Vision 2030 and the Food and Nutrition Security pillar Bottom-Up Economic Transformation Agenda (BETA) among others.

ii. Water Resource Availability - Feasibility studies assess rivers, dams, groundwater and rainfall patterns to ensure water availability and sustainability before a project is initiated.

iii. Agricultural Potential - Regions with high potential for food production, cash crops and livestock feed are prioritized to maximize impact on national and household food security.

iv. Community Needs and Demand - NIA engages local communities, County Governments, and stakeholders to identify areas where irrigation can directly improve livelihoods and reduce vulnerability to drought.

v. Equity and Regional Balance - Given Kenya's diverse geography,

(Photo Courtesy)

projects are distributed across counties to ensure equitable access to irrigation benefits, especially in arid and semi-arid lands (ASALs) where rainfall is unreliable.

vi. Economic Viability and Sustainability - Projects are evaluated based on cost-effectiveness, potential returns on investment, and ability to be maintained by communities or Irrigation Water Users Associations in the long term.

vii. Climate Change and Resilience Considerations - Priority is given to areas prone to climate shocks, where irrigation can stabilize production and build resilience against drought and floods.

What mechanisms does NIA use to monitor implementation progress and ensure accountability in the delivery of irrigation infrastructure?

The National Irrigation Authority (NIA) has put in place several mechanisms to monitor project implementation and ensure accountability in delivering irrigation infrastructure:

i. Project Planning and Pre-Feasibility Studies - Each project begins with feasibility studies, environmental and social impact assessments, and clear baseline data to guide monitoring and evaluation.

ii. Performance Contracts and Work Plans - Project teams operate under performance contracts and annual work plans aligned with national targets, ensuring accountability from inception to completion.

iii. Regular Site Inspections and Supervision - Engineers, technical staff, Regional Managers, Top Management and the Board conduct periodic field visits to monitor construction progress, quality of works and adherence to specifications. Even the ministry's top leadership led by the CS and PS conducts periodic field visits to inspect irrigation projects across the country.

iv. Monitoring and Evaluation (M&E) Framework - NIA uses structured M&E tools to track timelines, budgets, and outputs, with progress reports submitted to management, the Board, and the parent Ministry.

v. Stakeholder Engagement and customer satisfaction surveys - Continuous consultations with County Governments, local communities and farmer organizations provide feedback and promote transparency during implementation.

vi. Independent Audits and Oversight - Internal and external audits (technical, financial, systems and processes) are conducted regularly to ensure compliance with regulations and safeguard public resources.

vii. Digital Monitoring Tools - Use of GIS, remote sensing and digital reporting systems enhance real-time tracking of progress, especially in large-scale and dispersed projects.

viii. Impact Assessment and Post-Project Reviews - Upon completion, projects are evaluated for effectiveness, sustainability and alignment with food security objectives. Lessons learned inform future interventions.

How does national irrigation authority strengthen institutional capacity both internally and among irrigation scheme managers to handle increasing demand and complexity of projects?

National Irrigation Authority (NIA) is dedicated to strengthening its institutional capacity, both internally and among irrigation scheme managers, to effectively handle the increasing demand and complexity of irrigation projects. The NIA's multifaceted approach focuses on training, partnerships and governance.

To effectively oversee and manage large-scale irrigation projects, the NIA invests in the continuous education and training of its staff. This includes developing skills in project management, financial management and technical areas, ensuring personnel are up-to-date with the latest technologies and best practices. The Authority also promotes the use of smart technologies and innovation, such as using data for decision-making and implementing efficient systems for resource management and project monitoring. By embracing technology, the NIA improves its operational efficiency and its ability to respond to challenges.

NIA is also developing a robust knowledge management system to capture and share critical information and lessons from various projects. This creates an institutional memory that informs future initiatives and aids in training new staff. Additionally, the authority is improving its governance and management systems to ensure transparency, accountability and efficiency by developing and adopting appropriate policies, legal frameworks and quality assurance systems.

NIA's role extends beyond its internal functions to empower managers and farmers at the scheme level, which is crucial for the sustainable management of irrigation schemes. The Authority forms and trains Irrigation Water User Associations (IWUAs), providing modules on financial management, basic leadership, irrigation system maintenance and community mobilization.

NIA also offers technical advisory services to scheme managers and farmers on a wide range of issues, from design and construction to operation and maintenance. This hands-on support helps them effectively manage their schemes and improve agricultural productivity.

The Authority works with various stakeholders, including County Governments, private sector organizations, and other state agencies, to provide support services to irrigation schemes. These partnerships help in resource mobilization, collaborating on research to identify and address priority technical issues like water conservation and crop management. Linking farmers to markets and promoting the processing of their produce to increase their income.

In what ways is National Irrigation Authority incorporating innovation such as digitization or modern irrigation models to improve efficiency in project delivery?

National Irrigation Authority is incorporating innovation to enhance the efficiency of its project delivery, with a strategic focus on digitization, modern irrigation models and research, as outlined in its Strategic Plan 2023–2027. This approach is crucial for boosting productivity and ensuring sustainability.

Given that over 80% of the land is classified as arid or semi-arid, the NIA is promoting modern irrigation methods to optimize water use and increase crop yields. This includes the wider adoption of drip and sprinkler irrigation, which minimize water waste through evaporation and runoff. The Authority also advocates for climate-smart irrigation, which uses sensors to monitor real-time soil moisture, weather conditions and plant health, ensuring water is delivered precisely when and where it's needed. Additionally, the NIA is constructing household and community water pans to increase water storage capacity in arid and semi-arid regions.

To further improve efficiency and reduce reliance on fossil fuels, the NIA is promoting the use of solar-powered pumps, which are both cost-effective and environmentally friendly.

A key part of the NIA's innovation strategy is embracing digitization to improve operational efficiency and decision-making. The Authority is automating various internal processes to enhance transparency and accountability in its service delivery. By using data from sensors and monitoring systems, the NIA is able to make informed decisions on water allocation, project management and resource optimization, leading to a more responsive and effective approach. This is part of a broader Government trend toward digitization, which also includes the use of E-Citizen in the payment of O and M charges.

Looking ahead how do you envision the Authority evolving to play a stronger role in national food security and climate adaptation?

National Irrigation Authority is set to transform into a more proactive institution by directly linking its core mandate to the pressing issues of national food security and climate adaptation. This evolution will be guided by strategic goals focused on improving agricultural productivity, enhancing resilience, and leveraging technology and partnerships.

Shifting from a purely technical focus on irrigation to a holistic, market-oriented approach will play a central role in achieving national food security. This involves diversifying agricultural production beyond traditional staple crops to include high-value, climate-resilient crops and horticulture, which can boost farmers' incomes.

Supporting the development of storage, processing and value-addition facilities within irrigation schemes to reduce post-harvest losses and create new income opportunities. Furthermore, NIA will integrate with the broader food system by strengthening coordination with other government agencies, the private sector and research institutions to link farmers to markets and ensure produce reaches consumers efficiently.

Given Kenya's vulnerability to climate change, the NIA's role in adaptation is critical especially through accelerating the construction of both large and small-scale infrastructure like dams and household water pans. This is essential for buffering against increasingly frequent and severe drought and flood cycles. NIA will also continue to champion Climate-Smart Agriculture practices, which increase productivity and resilience while reducing greenhouse gas emissions. This includes promoting technologies like drip irrigation, drought-resistant crops and soil conservation techniques.

NIA will also leverage technology to develop and disseminate early warning systems for farmers, providing timely information on impending droughts or floods. A forward-looking NIA will increasingly incorporate Ecosystem-Based Adaptation, using nature-based solutions like rehabilitating water catchments and promoting agroforestry to build resilience in the agricultural sector.

Eng. Charles Muasya, MBS is the Chief Executive Officer, National Irrigation Authority

Advancements in Farm Mechanization

By EiK Correspondent

Agriculture is the backbone of Kenya's economy. Not only is it a primary driver of exports in Kenya, it ensures food security in the country. Moreover, the agricultural sector of the economy provides employment to scores of people and offers a platform for technological innovation, thereby advancing food engineering. In developing countries especially, advancements in farm mechanization have consistently acted as an impetus for economic growth and industrialization.

Some of the earliest advancements in farm mechanization date back to the Industrial Revolution, in the 18th century, which was marked by the introduction of farming equipment such as plows and tractors. This introduction marked a pivotal shift from human and animal labor to machine labor, a change that enhanced efficiency in farming and ultimately improved yields. Over the centuries, farm mechanization has steadily evolved, each advancement more efficient than the last one.

Modern advancements are a decent mix of both technological and mechanical innovations.

> Precision equipment and agricultural management software are at the forefront of revolutionizing modern farm management. A prime illustration of precision farm equipment is the smart tractors that have been designed to self-navigate in such a way that they can automatically adjust their depth or speed on a need basis.

Farmers in Kenya are now also able to use automated multi-seed planters that plant a variety of crops while maintaining precise spacing between seeds in each row. Such precision equipment provides savings to farmers in terms of labor, cost, and farm hours.

Kenya is currently piloting a smart tractor, Smart Tractor 2.0, in collaboration with the Hello Tractor organization under a pay-as-you-go financing model, as reported in the article "Unlocking Capital, Profit Pools, and Jobs for African Agriculture" by Hello Tractor.

This model is intended to reduce the ownership cost of farm equipment as it allows farmers to use tractors on a hire basis as opposed to full purchase. In addition to its affordability, the Smart Tractor 2.0 is IoT-enabled, in that it is integrated with sensors that enable farmers to monitor its performance and fuel usage as well as its location at all times.

Modern farm equipment doesn't just stop at planting – they come in handy at the harvest phase too. Farmers don't have to spend several man-hours and money to process their harvest anymore. Mechanical threshers and peelers can now process farm produce in an efficient and timely manner. Some even use AI vision technologies to automatically sort crop yields by different categories such as grade and ripeness, and put aside the ones with defects.

Kenya News Agency, in its article "Mechanization Enhances Rice Farming in Mwea" reports that the introduction of mini combine harvesters in Mwea has made rice harvesting so much easier, as they operate much faster than a human being would within the same duration of time.

According to a rice farmer in the region, the harvester takes about one and a half hours to harvest a portion that would take a laborer about ten hours. The only downside to the harvester, he says, is its hefty price, which could be a barrier to obtaining it.

According to an article published in 2023 by the Food and Agriculture Organization of the United Nations titled 'Climate Resistant Livelihoods in Kenya,' Kenya has a lot of potential in the agricultural sector, most of which unfortunately goes unharnessed. There are several reasons for this, the main one being underdevelopment in the arid and semi-arid lands (ASALS), which accounts for about 82% of the land area in Kenya.

These lands remain underdeveloped because most available modern farming solutions are so niche that they have yet to be adopted by the mainstream, and therefore are largely underutilized within the country.

Additionally, such solutions may be unaffordable to the average farmer with the mini harvester being a case in point; or worse, unknown to them due to their niche nature.

For Kenya to realize the full potential of her agricultural sector, relevant stakeholders need to make concerted efforts to avail these solutions to farmers all over the country. Not only will this put Kenya ahead of its regional peers in terms of agricultural production, but it will also increase the contribution of the sector to the country's GDP, both which are a win for Kenya.

By Dr.-Ing. Calvin Onyango

FT-RC's role in advancing Kenya's Agro-Food Industry

1. How is the Food Technology Research Centre (FT-RC) driving value addition through the use of indigenous and underutilized plant, animal, and blue economy resources, particularly in promoting food security and nutrition?

The FT-RC works in collaboration with strategic partners, institutions of higher learning, state agencies and other organizations to undertake various value addition initiatives through the documentation of indigenous technical knowledge (ITK) and the development of appropriate food processing technologies. Traditional methods of extending the shelf-life of food such as dehydration technologies and fermentation technologies take centre stage in the utilization of underutilized locally available resources.

Our research also focuses on identifying and overcoming barriers to the adoption and utilization of underutilized resources, including socio-economic and cultural challenges. We lay emphasis on addressing the nutritional benefits of orphan and neglected crops. Research has found that these crops are nutrient dense and their consumption goes a long way to address malnutrition and hidden hunger. The institute is at the forefront of implementing communication campaigns to shed light on the health benefits of indigenous vegetables.

2. What specific strategies is FT-RC implementing to support green manufacturing and circular economy practices within Kenya's food processing sector?

The Centre is committed to support green manufacturing and circular economy by empowering our industrial partners through a combination of policy initiatives, technological advancements, and collaborative efforts focused on resource efficiency, waste minimization, and sustainable production. We encourage our clients to source their raw materials locally, embrace the use of eco-friendly packaging materials and reduce the reliance of the use of plastics. The practice of reusing, reduce and recycling is strongly emphasized.

In addition, the Centre is exploring the use of renewable energy sources for food production such as the use of solar driers for food dehydration.

3. FT-RC hosts several pilot plants and advanced laboratories for cereals, fruits, vegetables, oils, and baking technologies. How is this infrastructure being used to accelerate food innovation, support SMEs, and build technical capacity across Kenya's food sector?

There has been an increase in the number of Kenyans who are interested in establishing food manufacturing businesses. The infrastructure at our Centre enables individuals to establish these food processing businesses through our incubation programme. Basically, it allows SMEs to develop innovative products and tests them in the market without having to have their own individual manufacturing plants. If the business idea proofs successful, the SMEs transition to the Common Manufacturing facilities or they establish their own processing plants.

Testing is an important aspect of food safety and as such, the products that we develop are tested all the time at our laboratories to ensure that the meet the food safety standards as required by the law before the products are certified by the Kenya Bureau of Standards.

4. With increasing concerns around food contamination, allergens, and antimicrobial resistance, what steps is FT-RC taking to strengthen food safety systems and traceability in the country?

The FT-RC pilot plants are utilized by SMEs to manufacture food products that are sold throughout the country. As such, we must carry out a robust cleaning system throughout our facilities in order to prevent food products from being contaminated. The first step that we undertake when on-boarding SMEs is to emphasize on good manufacturing practices and good hygiene practices when we take our clients through our programmes. In addition, we use farm-to-fork risk assessment models to help identify and manage food safety risks. We have also implemented an allergen management policy at our pilot plants and we continuously educate our clients on the same.

5. How is FT-RC positioning itself to lead in research and development of plant-based, fortified, or preservative-free food alternatives for Kenyan consumers?

The Centre has seen a rise in the demand for Plant-based products, gluten free products and dairy free products over the last few years as Kenyans move to diversify the diets and embrace healthier food choices. There has been an increase in demand for clean label products that have natural ingredients and free from additives. As a result, our research focus has also shifted to develop such kind of products in order to meet the rising demand by SMEs interested in investing in such niche product lines.

Dr.-Ing. Calvin Onyango is the Director General, Kenya Industrial Research and Development Institute (KIRDI)

The Role of Digital Transformation on Industrialization for Economic Transformation and Employment Creation in Kenya

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Abstract

Digital transformation is reshaping industries, driving economic growth, and creating employment opportunities on an unprecedented scale. In tandem with the Kenyan government's Bottom-up Economic Transformation Agenda (BETA) priorities, particularly in employment creation, investment attraction, and foreign exchange earnings, this paper examines the role of digital transformation in the context of industrialization, focusing on its potential to spur economic transformation and generate employment. Integrating digital technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and cloud computing, we highlight the transformative impact of digital transformation on manufacturing processes, supply chain management, and product innovation in Kenya. The study employs mediation regression analysis using Hayes' Model 4 to assess the mediating role of economic transformation in the relationship between digital transformation and employment creation. Our findings emphasize the importance of workforce upskilling and policy support to leverage digital transformation, maximize its economic benefits and enhance the country's competitiveness in the global market.

Target Event: 31st IEK International Convention

Convention/Summit Sub-theme: Digital Transformation, ICT, Innovations, R&D, Advanced Manufacturing Technologies

Key Words: Digital Transformation, Industrialization, Employment Creation, Economic Transformation

Introduction

The manufacturing industry in Kenya has long been recognized as a crucial driver of economic growth and employment, accounting for 15.9% of wage employment in the private sector in 2023 (Kenya National Bureau of Statistics (KNBS, 2024). However, despite its potential, the sector's contribution to the country's Gross Domestic Product (GDP) has in the last 10 years, shown a declining trend, plummeting from 10.0% in 2014 to 7.8% in 2023, a decrease from the previous decade's consistent levels around 10% (KNBS, 2018; KNBS, 2024). In 2014, the sector accounted for 10.0% of GDP, but this figure steadily decreased to 9.4% in 2015, 9.3% in 2016, and 7.2% in 2017 (KNBS, 2018). This improved in 2018, at 8.4%, then steadily dropped again to 7.9% in 2019, 7.6% in 2020, and 7.4% in 2021. With the 2020 and 2021 decline largely attributed to the global economic downturn caused by the COVID-19 pandemic, the sector showed slight recovery in 2022, contributing 7.8%. It however slightly decreased again to 7.6% in 2023 (KNBS, 2024).

A comparatively better trend, albeit dismal, has been observed in the sector's wage employment, exhibiting gradual growth with some fluctuations. In 2014, the sector accounted for about 20.0% of wage employment (KNBS, 2019). This share slightly increased over the years, reaching 20.3% in 2015 and 20.4% in 2016. The trend continued with 20.2% in 2017, 2018, 2019 and 2020 (KNBS, 2021). The share slightly increased to 20.7% in 2020. However, it notably plummeted to 15.8% in 2021 and 15.9% in 2022. It stagnated at 15.9% in 2023 (KNBS, 2023).

The observed decline reflects the sector's struggle with persistent challenges, including high production costs, inadequate infrastructure, and competition from cheaper imports, which have limited its growth potential (Kenya Association of Manufacturers (KAM), 2024). Despite government initiatives such as the Big Four Agenda, which prioritizes manufacturing as a key pillar for economic development, the sector has yet to achieve the targeted 15% contribution to GDP as outlined in the Vision 2030 development plan (Government of Kenya, 2018), highlighting the need for renewed focus and strategic interventions. In recent years, digital transformation has emerged as a potential solution to these challenges, offering opportunities to enhance efficiency, innovation, and competitiveness (Martínez-Peláez et al., 2023). Integrating advanced technologies such as automation, artificial intelligence (AI), data analystics and the Internet of Things (IoT), manufacturers can significantly enhance operational efficiency, reduce production costs, and improve product quality (Aldoseri et al., 2024).

Globally, manufacturing firms have increasingly adopted digital transformation technologies to enhance efficiency, productivity, and competitiveness (Baldwin et al., 2019). For example, General Electric (GE) employs AI and IoT in its "Brilliant Manufacturing" initiative, optimizing production processes and reducing downtime. Siemens uses AI and IoT in its "Digital Factory" to enhance efficiency and flexibility, while Tesla's Gigafactories leverage automation and robotics for mass production of electric vehicles. In Japan, Toyota integrates data analytics and cloud computing in its "Smart Factory" initiatives to optimize supply chains (SYSPRO, 2023). In Sub-Saharan Africa, firms like Nigeria's Dangote Cement have adopted automation and data analytics to improve production efficiency, although the region faces challenges such as limited digital infrastructure (World Bank, 2020; SYSPRO, 2023).

In Kenya, the manufacturing sector has historically been characterized by labor-intensive processes, outdated technology, and limited integration into global value chains. In the current administration's Bottom-up Economic Transformation Agenda (BETA) however, manufacturing and digital transformation hold central roles as enablers of socio-economic transformation through driving employment creation, attracting investment, and boosting foreign exchange earnings (Parliamentary Service Commission, 2023). Implemented by the Fourth Medium Term

Plan (MTP IV) 2023-2027, BETA is geared towards economic turnaround and inclusive growth through a value chain approach. To this end, BETA targets sectors with high impact to drive economic recovery, key among which, manufacturing. The Digital Superhighway pillar of BETA is particularly foundational to manufacturing, as it aims to enhance digital infrastructure across Kenya, providing the backbone for widespread digital transformation in key sectors, including manufacturing (Republic of Kenya, 2023). In the private sector, several large manufacturers (100 employees and above) have already adopted digital systems into their operations in a bid to boost competitiveness and enhance efficiencies while cutting costs and wastage (Igadwah, 2022). This adoption has especially accelerated on the realization of the depth and scope of business disruptions caused by Covid-19 pandemic. For instance, Bidco Africa are beginning to utilize automation and data analytics to streamline operations and improve decision-making (SYSPRO, 2021).

The extent to which digital transformation can drive industrialization for economic transformation and employment creation in Kenya's manufacturing sector however remains underexplored. While several studies have explored the general impact of digitalization on economic growth (OECD, 2019; UNCTAD, 2020), there is a gap in the literature regarding its specific influence on economic transformation and employment creation with reference to the manufacturing sector in Kenya. This research is thus motivated by the need to understand the role of digital transformation in advancing Kenya's industrialization agenda and its impact on economic transformation and employment creation. Understanding this relationship is critical for policymakers, industry stakeholders, and development partners aiming to leverage digital technologies for economic transformation and job creation.

This study differentiates itself by focusing specifically on the manufacturing industry in Kenya, providing an in-depth analysis of how digital transformation can drive economic transformation and employment creation within this sector. Unlike previous studies that often take a broad approach, this research zeroes in on the manufacturing context, addressing the unique challenges and opportunities present in Kenya. More specifically, it set out to determine the effect of digital transformation on economic transformation, focusing on the manufacturing share of GDP; evaluate the effect of digital transformation on employment creation in the manufacturing sector; and assess the mediating role of economic transformation on the relationship between digital transformation and employment creation within the country's manufacturing sector.

Materials and Methods

This study employed the cross-sectional research design. This design was particularly suitable for capturing data from manufacturing firms across various metrics: Digital technologies and leadership as indicators of digital transformation; Firm performance as an indicator of economic transformation; and employment growth rate as indicator of employment creation. Utilizing this approach enabled the study examine existing relationships between digital transformation and key performance indicators, making it effective for identifying trends and correlations without requiring longitudinal data (Kumar,2018). According to KAM (2024), manufacturers are are grouped into 14 sectors, which are further broken down into Sub-sectors. The main sectors include: Agriculture/Agro-processing, Automotive, Building, Mining and Construction, Chemical & Allied, Energy, Electrical and Electronics, Food and Beverages, Leather and Footwear, Metal and Allied, Paper, Pharmaceutical and Medical Equipment, Plastics and Rubber, Textile and Apparels Sector, Timber and Services and Consultants. The accessible population comprised KAM membership, who total 1128 (KAM, 2023). KAM is the representative organization for manufacturing value-add industries in Kenya, drawing countrywide membership across the 14 manufacturing sectors. The study focused on Nairobi County, as a majority approximately 60% of KAM members (682) are based in Nairobi, therefore providing a larger representative pool of the different sub-sectors in manufacturing. To arrive at the desired sample size, the Yamane (1967) formula was employed:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = Required sample

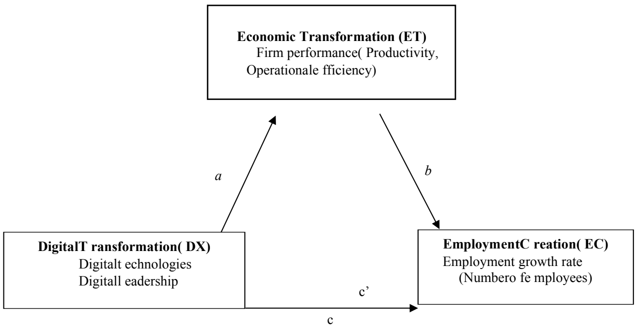
N = Total population = 682

e = Margin of error, set at 0.1 (90% confidence level)

A sample of 87 was thus reached, sampled based on the systematic random sampling technique. As per Saunders et al. (2019), systematic random sampling is a probability sampling technique where sample elements are selected from a larger population at a regular interval after choosing a random starting point. In this regard, every 5th firm was selected. The sampling frame was obtained from KAM.

The study relied on quantitative data, collected from both primary and secondary sources. Primary data was gathered from sampled manufacturing firms through structured questionnaires, while secondary data was sourced from reputable publications such as the KNBS Economic Surveys, industry reports from KAM, and other relevant economic and industrial reports. The independent variable, digital transformation, was measured by the level of investment in digital infrastructure by manufacturing firms; while the mediating variable, Economic Transformation, was measured by the manufacturing sector's share of GDP over the 10-year period. The dependent variable, Employment Creation, was measured by the employment growth rate within the manufacturing sector.

The study employed quantitative data analysis techniques, specifically using mediation regression analysis with Hayes' Model 4. This model (Figure a) is well-suited for examining indirect effects and is commonly used to test mediation hypotheses, making it ideal for exploring the complex relationships among digital transformation, economic transformation, and employment creation (Hayes, 2017).



Fi 1: Hayes Model 4

Source: Hayes (2017)

Where:

DX is Digital Transformation

ET is Economic Transformation (Mediating Variable (M))

EC is Employment Creation

a is the direct effect of DX on ET

b is the direct effect of ET on EC

c is the direct effect of DX on EC

c' is the indirect effect of DX on EC through ET

The following regression models were employed:

$EC = \alpha 1 + cDX + \varepsilon 1$... Model I (Direct Effect)

$ET = \alpha 2 + aDX + \varepsilon 2$... Model II (Direct effect)

$EC = \alpha 3 + c'DX + bET + \varepsilon 3$.............................Model III (Indirect effect)

Results

The reliability of the research instruments was assessed using Cronbach's Alpha, a widely accepted measure for evaluating internal consistency. According to Nunnally (1978), a Cronbach Alpha threshold of 0.7 or higher indicates acceptable reliability. As shown in Table 1, all scales exceeded the 0.7 threshold—Digital Transformation (0.7), Economic Transformation (0.787), and Employment Creation (0.764)—demonstrating that the instruments used in the study were reliable for measuring the constructs. These values suggest strong internal consistency, affirming the reliability of the data collection tools.

Table 1: Instrument Reliability

Scale	Cronbach Alpha	No. of Items	Verdict
Digital Transformation	0.7	13	Reliable
Economic Transformation	0.787	10	Reliable
Employment Creation	0.764	8	Reliable

Digital Transformation and Employment Creation

The study first set out to evaluate the effect of digital transformation on employment creation in the manufacturing sector. A linear regression model was thus adopted, producing three outputs: Model summary, Analysis of Variance (ANOVA), and Coefficients. The Model Summary (Table 1) shows that the regression model explains 7% of the variance in employment creation, as indicated by the R-Square value of 0.070. Although this indicates that digital transformation has a relatively low explanatory power in predicting employment creation, it is still statistically significant.

Table 1: Model Summary (Model 1)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.265[a]	.070	.056	3.46570
a. Predictors: (Constant), Digital Transformation				

The ANOVA (Table 2) confirms the significance of the model, with an F-value of 4.822 and a p-value of 0.032, which is below the 0.05 threshold. This suggests that digital transformation has a statistically significant impact on employment creation, although the effect is modest.

Table 2: ANOVA (Model 1)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	57.912	1	57.912	4.822	.032[b]
	Residual	768.709	64	12.011		
	Total	826.621	65			

a. Dependent Variable: Employment Creation

b. Predictors: (Constant), Digital Transformation

Finally, the Coefficients table (Table 3) reveals that digital transformation has a negative effect on employment creation, with an unstandardized coefficient of -.265 and a p-value of 0.032. This means that for every unit increase in digital transformation, employment creation decreases by .265 units. The effect was also statistically significant, implying that digital transformation has a negative and significant effect on employment creation ($\beta = -.265$, SE = 4.112, t = -2.196, $p < .05$). The result reflects automation replacing certain jobs, especially in labour-intensive manufacturing sectors.

Table 3: Coefficients (Model 1)

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	43.238	4.112		10.515	.000
	Digital Transformation	-.167	.076	-.265	-2.196	.032

a. Dependent Variable: Employment Creation

The model can be fitted as follows: Employment creation = 43.238 + cDigital Transformation (-.265)

Digital Transformation and Economic Transformation

The study also sought to determine the effect of digital transformation on economic transformation, focusing on firm performance as an indicator for economic transformation. A linear regression model was similarly adopted, producing three outputs: Model summary, ANOVA, and Coefficients. In the Model Summary (Table 4), the R-Square value of 0.079 indicates that digital transformation explains 7.9% of the variance in economic transformation, specifically in terms of the manufacturing share of GDP. While the model has a low explanatory power, the Adjusted R-Square of 0.064 suggests that the relationship between digital transformation and economic transformation is still meaningful, though not robust.

Table 4: Model Summary (Model 2)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.280[a]	.079	.064	4.08289
a. Predictors: (Constant), Digital Transformation				

In the ANOVA (Table 5), the F-value of 5.463 and a p-value of 0.023 indicate that the regression model is statistically significant. This suggests that digital transformation has a significant impact on economic transformation, reinforcing the idea that digital technologies play a role in shaping the manufacturing sector's contribution to GDP.

Table 5: ANOVA (Model 2)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	91.062	1	91.062	5.463	.023[b]
	Residual	1066.877	64	16.670		
	Total	1157.939	65			

a. Dependent Variable: Economic Transformation
b. Predictors: (Constant), Digital Transformation

The Coefficients table (Table 6) shows that digital transformation has a negative effect on economic transformation, with an unstandardized coefficient of -0.280 and a p-value of 0.023. This implies that as digital transformation increases, the manufacturing share of GDP slightly decreases by 0.209 units. The effect was also statistically significant, implying that digital transformation has a negative and significant effect on economic transformation (β = -.280, SE = 4.844, t = -2.337, p < .05). This could be due to factors like automation reducing the labor-intensive processes that traditionally contribute to GDP, or challenges in fully realizing the benefits of digital tools in the sector.

Table 6: Coefficients (Model 2)

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	54.230	4.844		11.195	.000
	Digital Transformation	-.209	.089	-.280	-2.337	.023

a. Dependent Variable: Economic Transformation
The model can be fitted as follows: Economic Transformation = 54.230 + a_3 Digital Transformation (-.280)

Digital Transformation, Economic Transformation and Employment Creation

The study finally sought to assess the mediating role of economic transformation on the relationship between digital transformation and employment creation within the country's manufacturing sector. Adopting Hayes' Model 4, four regression outputs were produced overall: Economic Transformation as the Outcome Variable, Employment Creation as the Outcome Variable, the Direct effect of X on Y; and the indirect effect of X on Y. In Table 7, the R-squared value is 0.0786, indicating that digital transformation (DT) explains 7.86% of the variance in economic transformation. The F-statistic (5.4626, p=0.0226) shows that the model is statistically significant, meaning digital transformation significantly impacts economic transformation. The coefficient for digital transformation is negative (-0.2092, p=0.0226), implying that increased digital transformation slightly reduces economic transformation, potentially due to challenges in adapting technologies or structural shifts within the sector.

Table 7: Model Summary (Model 3 - Outcome Variable: Economic Transformation)

R	R-sq	MSE	F	df1	df2	P
.2804	.0786	16.6700	5.4626	1.0000	64.0000	.0226

Model

	coeff	se	t	P	LLCI	ULCI
constant	54.2304	4.8441	11.1951	.0000	44.5531	63.9077
DT	-.2092	.0895	-2.3372	.0226	-.3880	-.0304

For Table 8, the R-squared value of 0.9440 suggests that 94.4% of the variance in employment creation is explained by digital transformation (DT) and economic transformation (ET). The F-statistic of 530.6471 (p=0.0000) confirms the model's overall significance. While digital transformation has an insignificant effect on employment creation (p=0.7871), economic transformation significantly drives employment creation, with a coefficient of 0.8229 (p=0.0000). This emphasizes that economic transformation is a strong predictor of job creation in the manufacturing sector.

Table 8: Model Summary (Model 3 - Outcome Variable: Employment Creation)

R	R-sq	MSE	F	df1	df2	P
.9716	.9440	.7352	530.6471	2.0000	63.0000	.0000

Model

	coeff	se	t	P	LLCI	ULCI
constant	-1.3866	1.7498	-.7924	.4311	-4.8832	2.1101
DX	.0053	.0196	.2712	.7871	-.0338	.0444
ET	.8229	.0263	31.3453	.0000	.7704	.8753

Table 9 evaluates the direct effect of digital transformation on employment creation. The coefficient (0.0053) is positive but very small, and the p-value (0.7871) indicates that the effect is statistically insignificant. This implies that digital transformation does not have a meaningful direct influence on employment creation in the manufacturing sector. The confidence interval (-0.0338, 0.0444) also crosses zero, reinforcing the lack of significance in the direct effect.

Table 9: Direct effect of X on Y

Effect	se	t	P	LLCI	ULCI
.0053	.0196	.2712	.7871	-.0338	.0444

Table 10 examines the indirect effect of digital transformation on employment creation, mediated by economic transformation. The indirect effect (-0.1721) is significant, as shown by the confidence interval (-0.3159, -0.0072) not crossing zero. This suggests that economic transformation (β = -.1721, BootSE = .0785, BootLLCI = -.3159, BootULCI = -.0072) mediates the relationship, meaning digital transformation indirectly impacts employment creation through changes in the economic structure. The negative value indicates that digital transformation may reduce employment through its influence on economic transformation.

Table 10: Indirect effect(s) of X on Y

	Effect	BootSE	BootLLCI	BootULCI
ET	-.1721	.0785	-.3159	-.0072

The model can be fitted as follows: Employment creation = -1.3866 + c'Digital Transformation (.0053) + b_2Economic Transformation (.8229)

Discussion

The findings reveal that digital transformation has a statistically significant negative effect on employment creation in the manufacturing sector (β= -.265, SE = 4.112, t = -2.196, p < .05). This suggests that as digital technologies like automation and artificial intelligence are increasingly integrated, certain manual jobs are being replaced, hence negatively impacting employment creation. These results are in line with literature showing that automation, especially in labor-intensive industries, often leads to a reduction in low-skilled jobs, as machines and smart systems take over tasks that were traditionally performed by humans. However, empirical studies highlight that while digital transformation can reduce employment in certain sectors, it also creates opportunities for new jobs in other areas, particularly in high-skilled positions related to technology management, innovation, and data analytics. Studies like Brynjolfsson and McAfee (2014), Frey and Osborne (2017), Bessen (2019) and Acemoglu and Restrepo (2020) argue that digital technologies shift the nature of work, fostering growth in sectors that leverage tech skills while displacing more routine, manual tasks. The findings thus reflect both the disruptive and transformative impacts of technology on labor markets.

The finding that digital transformation has a negative and significant effect on economic transformation (β = -.280, SE = 4.844, t = -2.337, p < .05) suggests that, in some contexts, digital tools may not yield immediate positive results in terms of economic growth. While digital transformation may have short-term negative effects on economic growth due to job displacement, adjustment costs, and skill mismatches, its long-term impact may be generally positive. Over time, it drives productivity, innovation, and the emergence of new industries, all of which contribute to sustained economic growth. This aligns with Bessen (2019) who posits that while digital transformation offers long-term productivity gains, its short-term impact on GDP may be negative due to disruption and the inability of sectors to adapt quickly. This may explain the findings, as Sub-Saharan African economies, including Kenya, might struggle with challenges such as inadequate infrastructure and skills gaps, delaying the realization of digital transformation benefits in contributing to economic transformation. The findings emphasize the complexity of transitioning to a digital economy in such contexts. Similarly, studies have highlighted how automation, while boosting efficiency, often reduces the contribution of labor-intensive processes to GDP, particularly in developing economies. For instance, Frey and Osborne (2017) argue that automation can disproportionately affect industries where human labor traditionally drives GDP growth.

The study found that economic transformation (β = -.1721, BootSE = .0785, BootLLCI = -.3159, BootULCI = -.0072) mediates the relationship between digital transformation and employment creation, and it does so in a negative way. This suggests that, as digital transformation progresses, the economic shifts that follow (like investments in automation, AI and other digital technologies) tend to reduce job opportunities in the labor-intensive manufacturing industry. The net effect in the long-term however, would depend on how well the workforce and industries adapt. If digital transformation leads to upskilling, innovation, and job creation in new industries, it may reduce or offset the negative impacts of on employment creation. This is consistent with Brynjolfsson and McAfee (2014), who argue that automation and AI can displace jobs by reducing reliance on manual labor while reshaping entire industries. Furthermore, empirical studies have demonstrated that while digital transformation boosts efficiency, it can contribute to structural unemployment. Acemoglu and Restrepo (2020) points out that as automation advances, the demand for low-skilled labor decreases, leading to job polarization. This mediation effect reflects how the manufacturing sector, especially in developing economies, struggles to balance technological innovation with employment growth, underscoring the need for policies that facilitate workforce adaptation to the digital economy.

Conclusions

The findings indicate a complex relationship between digital transformation and employment creation in Kenya's manufacturing sector. The statistically significant negative effect suggests that the integration of digital technologies, particularly automation and artificial intelligence, is leading to the replacement of manual jobs. This aligns with existing literature that highlights how labor-intensive industries are particularly vulnerable to job losses as machines take over tasks traditionally performed by humans. While some positions are displaced, it is essential to recognize that digital transformation also generates new opportunities in high-skilled areas such as technology management and data analytics. Thus, the findings reflect the dual nature of technological advancement, emphasizing both its disruptive and transformative potential on labor markets.

The finding that digital transformation has a negative and significant effect on economic transformation highlights the short-term challenges it presents, such as job displacement, adjustment costs, and skill mismatches, particularly in developing economies like Kenya. However, while its immediate impact on economic growth may be negative, over the long term, digital transformation tends to drive productivity gains, foster innovation, and stimulate the emergence of new industries. These factors collectively contribute to sustained economic growth, suggesting that the short-term disruptions can be mitigated with the right policies and investments, ultimately leading to positive outcomes as economies adapt to technological advancements.

The study's finding that economic transformation negatively mediates the relationship between digital transformation and employment creation suggests that as digital technologies like automation and AI are adopted, job opportunities in labor-intensive industries, such as manufacturing, decline while employment shifts toward emerging sectors like technology, finance, and services. The long-term impact on employment, however, hinges on how effectively the workforce and industries adapt to these changes. If the transition is supported by upskilling, innovation, and job creation in new industries, the negative effects on employment could be mitigated or even reversed, highlighting the importance of proactive policies to ensure an inclusive digital economy.

Recommendations

To address the negative impact of digital transformation on employment in Kenya's manufacturing sector, policymakers should prioritize initiatives aimed at workforce reskilling and upskilling. This involves developing targeted training programs that equip workers with the necessary skills to adapt to new technologies and roles created by digital transformation. Collaborations between government, industry, and educational institutions can facilitate the design of curricula that reflect the evolving demands of the job market, ensuring that workers are prepared for high-skilled positions in technology management and data analytics. Such proactive measures will help mitigate job displacement and enhance the employability of the workforce.

In addition, policymakers must focus on creating a supportive environment for small and medium-sized enterprises (SMEs) that can foster innovation and job creation in a digitally transformed economy. Providing financial incentives, such as grants or tax breaks, can encourage SMEs to adopt digital tools while simultaneously investing in their workforce. Furthermore, facilitating access to technology and infrastructure in underserved areas can empower local businesses to leverage digital transformation for growth. In nurturing a vibrant SME sector, the government can stimulate economic diversification, ultimately leading to increased employment opportunities across various industries.

Finally, it is crucial for policymakers to adopt a holistic approach that balances technological advancement with social welfare considerations. Implementing social safety nets and unemployment insurance programs can help cushion the effects of job displacement due to automation. These measures should be accompanied by policies that promote inclusive growth, ensuring that the benefits of digital transformation reach all segments of society. By addressing the disparities exacerbated by technological change, the government can create a more resilient economy that not only embraces innovation but also prioritizes the well-being of its workforce.

To revitalize Kenya's manufacturing sector, the recommendations from this study align well with those from the IEK (2024), in their statement on the Kenya's underperforming manufacturing sector. Both emphasize the adoption of advanced technologies such as big data analytics to monitor industry performance, and blockchain technology to ensure transparency in project management. Additionally, this study supports policy reforms to streamline regulatory frameworks, reduce bureaucracy, and encourage private sector investment. Incentives for innovation, such as tax breaks and energy subsidies, would further bolster manufacturing, lowering operational costs and fostering technology adoption in the sector.

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(Photo Courtesy)

The Evolution of Unga (Flour) Processing in Kenya

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Few staples connect Kenyans as deeply as unga. Whether it's maize flour for the ever-present ugali or wheat flour for chapati, mandazi, samosas, or pastries, flour remains an integral part of the Kenyan diet and culture. However, the story of how flour is produced from traditional techniques to advanced milling systems reveals a deeper tale of innovation, resilience, and the nation's evolving priorities around food security, nutrition, and efficiency.

Long before the rise of modern industries, flour processing in Kenya was a communal task, rooted in indigenous practices and manual labor. Women played a central role in food preparation, spending hours grinding dried grains primarily maize, millet, sorghum, or cassava using stone tools, wooden mortars and pestles, or hand-powered grinders. In some highland communities, water-powered mills made from wooden paddles and stone bases were used to turn river energy into mechanical motion, slightly easing the workload.

This flour, though coarse and unrefined, was nutrient-dense, retaining the bran, germ, and endosperm of the grain. It was high in fiber and essential minerals but had low shelf stability, requiring immediate use to avoid spoilage. Such processing was time-consuming and limited to household or village-level production.

As urbanization picked up in the mid-20th century, posho mills became an important innovation in Kenyan flour processing. These small, diesel or electric-powered mills provide communities with a faster and more efficient way to grind maize or millet into flour. People could carry their grain to the local mill, pay a small fee, and return home with fresh ground flour.

Posho mills were particularly popular in informal settlements and rural areas, where access to industrially processed flour was either limited or too expensive. Despite their simplicity, these mills democratized flour access and enabled more flexible consumption people could process as much or as little as they needed, retaining the nutritional benefits of whole grain flour.

The post-independence era saw a turning point in the mechanization and commercialization of flour processing. With national development goals emphasizing food security and industrial growth, Kenya witnessed the emergence of large-scale milling companies. Pioneers such as Unga Group Ltd, Mombasa Maize Millers, and Pembe Flour Mills ushered in an era of industrial roller mills and semi-automated production lines.

This new wave of production introduced sifted maize flour and refined wheat flour, both of which offered smoother textures, longer shelf life, and more uniform quality. Flour could now be branded, packaged, and distributed nationwide, transforming unga from a local product to a mass-market commodity.

Brands like Jogoo, Dola, Hostess, Ajab, and ExE became household names, available in supermarkets, kiosks, and corner shops from Nairobi to Marsabit. With modern packaging and regulated pricing, industrial unga reached a wider audience and became part of everyday life, especially in urban settings.

Today, Kenya's flour processing sector is a highly modernized industry driven by innovation, automation, and nutrition science. State-of-the-art mills now employ computerized monitoring systems, automated grain cleaning, and precision sifting, all designed to increase yield, maintain consistency, and minimize waste.

In response to rising public health concerns, the government through agencies like the Ministry of Health and the Kenya Bureau of Standards (KEBS) has mandated the fortification of maize and wheat flours with key micronutrients such as iron, folic acid, zinc, and vitamin A. This initiative aims to address hidden hunger, a silent form of malnutrition that affects millions of Kenyans, particularly children and pregnant women.

For instance, fortified maize flour has been shown to reduce cases of iron-deficiency anemia in low-income populations. Similarly, fortified wheat flour plays a role in improving maternal health outcomes and reducing birth defects.

The evolution of unga isn't just about milling, packaging and safety standards have advanced significantly. Modern flour is sealed in airtight, tamper-proof, moisture-resistant packaging that enhances shelf life and prevents contamination.

Inside the mills, quality control laboratories test flour at every stage of production, from raw grain inspection to final packaging. KEBS, together with county health departments, regularly audits millers for compliance with national food safety standards, ensuring that consumers receive safe, nutritious products.

The contemporary unga market is no longer dominated by just maize and wheat. Growing health consciousness and dietary shifts have led to the development of alternative flours such as: Sorghum flour used for porridge and millet flour that's rich in calcium and preferred by diabetic patients, cassava flour which is popular in coastal and Western Kenya regions, blended flours that's combining maize with soy, amaranth or pumpkin seed flour for added protein, gluten-free flours catering to those with celiac disease or gluten intolerance and Atta flour favored in Kenyan-Asian households for making traditional Indian flatbreads like roti and paratha.

This diversification reflects the shifting preferences of Kenyan consumers, especially in urban areas, who are increasingly seeking variety, functionality, and health benefits in their diets.

Despite its progress, the unga industry in Kenya faces persistent hurdles. These include high operational costs, especially from electricity and fuel, volatile grain prices, driven by climate change, regional instability, and global supply chain issues, competition between large-scale millers and local posho mills, which sometimes leads to pricing conflicts or market imbalances, post-harvest losses and poor storage, which affect raw material quality and availability.

However, the sector is adapting. Some companies are investing in solar-powered milling equipment, digital supply chain tracking, and recycling grain husks into animal feed or biomass fuel. Others are engaging with farmers directly through contract farming and extension services to ensure quality grain supply and fair pricing.

From pounding maize with stones to operating AI-enhanced milling plants, the evolution of unga processing in Kenya is more than just a tale of food production it's a reflection of how tradition and technology can work hand in hand. It underscores the resilience of Kenyan communities and the adaptability of local industries to meet the changing demands of nutrition, health, and economy.

As unga continues to grace family tables across the nation whether as a steaming mound of ugali, a golden-brown chapati, or a flaky mandazi its journey reminds us that food is not just sustenance. It's culture. It's science. And it's the future.

Electine Ometa is a Communications and Marketing Intern at the Institution of Engineers of Kenya. She pursued Journalism and is passionate about media, storytelling, and strategic communication, with a vision to inspire and inform society.

[Photo Courtesy]

Beyond the Reactor: Nuclear Technology for Food, Nutrition, and Sustainability

By Lois Kinya Thuranira

When most people think of nuclear technology, power plants and radiation therapy likely come to mind. However, the peaceful use of nuclear science goes far beyond electricity generation and medicine. In today's rapidly changing world marked by food insecurity, climate change, and environmental degradation, nuclear technology is quietly playing a transformative role in agriculture, nutrition, and sustainable development.

Nuclear Science in Agriculture: Engineering Better Crops

One of the most successful applications of nuclear technology in agriculture is plant mutation breeding. Exposing seeds to ionizing radiation such as gamma rays, scientists can induce genetic variations that help produce crops with desirable traits. These may include higher yields, improved nutritional content, pest and disease resistance, or the ability to thrive in arid or saline soils.

The International Atomic Energy Agency (IAEA), jointly with Food and Agriculture (FAO), assist its member states in the development of plant mutation breeding. The technique has a number of important advantages: it is proven, cost-effective, non-hazardous, and environmentally friendly. According to World Nuclear Association, several countries have used plant mutation breeding, yielding greater socio-economic benefit as a result. They include; Mali, Bangladesh, USA, New Zealand, Australia, and Namibia, just to name a few. For instance: in Mali, irradiation of sorghum and rice seeds has produced more productive and marketable varieties, in Bangladesh, new varieties of rice produced through mutation breeding have increased crops three-fold in the last few decades. During a period of rapid population growth, the use of nuclear techniques has enabled Bangladesh, and large parts of Asia in general, to achieve comparative food security and improved nutrition, and in Namibia, mutation breeding has produced seeds of the country's most important crops – cowpea, sorghum, and pearl millet – that have yields increased by 10-20%. The new varieties are more resistant to drought, temperature stress, and pests – essential attributes in Namibia's difficult growing environment. This exemplifies the transformation power of nuclear science and Technology in addressing food security and malnutrition.

Additionally, Food safety remains a global concern, with contamination from bacteria such as Salmonella and E. coli causing widespread illness. Food irradiation, a nuclear technique involving controlled doses of ionizing radiation, helps eliminate these pathogens without compromising nutritional quality or taste. The method is also used to extend the shelf life of fruits and vegetables, reduce spoilage, and eliminate insect pests in stored grains. This is particularly beneficial for countries seeking to export produce under strict Food Safety Standards.

Tackling Malnutrition with Isotopic Techniques

Nuclear technology is not just for farms and markets, it's also helping scientists understand how nutrients are absorbed in the body. Using stable isotopes, which are safe and non-radioactive, researchers can track how much iron, zinc, or vitamin A is absorbed from food. This enables nutrition assessments which are essential for shaping effective public health interventions, particularly essential in regions facing the double burden of undernutrition and obesity, making it possible for researchers to measure nutrient absorption, breastfeeding practices, and body composition. For example, deuterium dilution methods are used to monitor lean body mass in children, while carbon-13-labeled tests track how the body digests and metabolizes food. These techniques provide policymakers and health workers with accurate, evidence-based data to guide national nutrition programs.

Helping Farmers Conserve Soil and Water for Sustainable Farming

With water scarcity becoming a growing challenge, nuclear techniques are also improving how we manage natural resources. Isotope hydrology, for example, helps scientists trace water movement in soil and determine the most efficient use of irrigation and fertilizers.

In **Turkana and Makueni**, where farmers often rely on scarce rain or boreholes, this technique can enable farmers and agricultural engineers to adopt precision farming practices, minimize environmental damage, and enhance long-term productivity in developing more sustainable water and land use policies. Similar techniques are used in Tunisia and Morocco. This shows how Africa can lead in climate-smart agriculture.

Animal Health and Disease Control

Livestock is a critical component of food systems and rural economies. Nuclear technology supports livestock productivity by aiding in the diagnosis and control of animal diseases, which has direct implications for food availability and safety. For instance, **Radioimmunoassay (RIA)** helps detect hormone levels and nutritional deficiencies, and **Enzyme-Linked Immunosorbent Assay (ELISA)** help detect animal diseases early and accurately. These tools are crucial in managing zoonotic diseases and improving animal productivity and food safety.

Capacity Building and Collaboration

Nuclear Science and Technology in Agriculture present a prime opportunity for Kenya to leverage in adapting and mitigating climate change, and address food security and nutrition. Ultimately, this will enhance public health, increase agricultural production and accelerate economic growth.

In conclusion, at Crossroad of Engineering and Sustainability; it's needless to say that nuclear technology offers far more than energy. It's a powerful tool Kenya can harness in contributing to food systems, nutrition, and environmental management. Further highlighting its relevance in achieving Sustainable Development Goals, particularly SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 13 (Climate Action).

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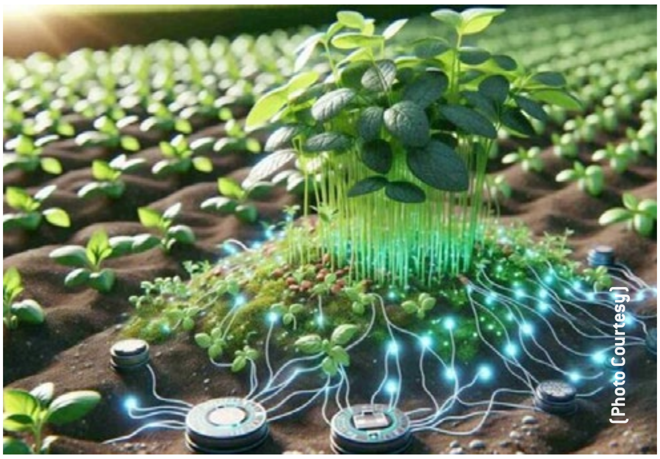
[Photo Courtesy]


[Photo Courtesy]

Acceleration of Structural Transformation of Economies of EAC Region: Case of EAC Industrialization Action Plan

By Eng. Jennifer Atieno Gache
Regional Expert, GFA Consulting Group support to EAC commissioned by GIZ| Email: jennygache@gmail.com

Abstract

The manufacturing sector in East Africa is a major pillar for economic development contributing to at least 8 % of GDP. The Manufactured Value Added (MVA) growth however remains a key policy concern in the region as it has slowed down in recent years, from 5.3 % in 2000s to 4.6 % in 2020s. This falls short of the envisaged 10% annual growth leading to the share of manufacturing in GDP contracting, from previously > 10% a decade ago to less than 8%, raising doubts about structural transformation through industrialization. The implication of this is that the economies are not creating significant employment opportunities to match the needs of labour market leading low employment particularly for the youth. Inorder to turn around the current situation the EAC has adopted an Action Plan that pursue proactive policies to bring about rapid structural change. The Plan sets broad strategic intervention that will guide implemention of activities over the next 5 years. My paper will focus on the key policy interventions including improving the competitiveness of priority regional value chains; promoting of local content policies; building resilience of Micro, Small and Medium Enterprises (MSMEs); leveraging the AfCFTA & global value chains; shifting to green industrialization pathways; optimizing infrastructure & logistics networks for spatial growth & agglomeration; and leveraging the adoption of 4IR among others.

Keywords: manufacturing, manufacturing value add , value chainss, transformation and industrialization,

1. Introduction

The manufacturing sector in East Africa is a major pillar for economic development in the region contribution to at least 9 percent of the GDP. The Manufactured Value Added (MVA) growth and remains a key policy concern in the region. MVA growth has slowed down in recent years, from 5.3 % between 2005 and 2010, to 4.6 % between 2010 and 2015, falling short of the 10% annual growth rate envisaged in the EAC Industrialization Policy and Strategy. Due to the slow pace of MVA growth relative to GDP, the share of manufacturing in GDP has been contracting, from previously more than 10% a decade ago to less than 8% raising doubts about structural transformation-through industrialization- which is key to sustained economic development in the long-run. The share of manufactured exports as a share to total exports shares are below 50 percent for all East African Countries except Rwanda implying a greater need for faster growth of manufactured exports in the total exports baskets. An encouraging development however is that the case of manufactured exports, the destination is mainly to EAC or Sub-Sahara Africa signifying attractiveness of regional integration for manufacturers. This contrasts with commodity and agricultural exports, which mainly target the rest of the World. An important implication of the lack of structural transformation in East Africa is that the economies are not creating significant employment opportunities to match the needs of labour market leading to general unemployment particularly in the category of the youth. The policy makers have to strive to pursue proactive policies that can bring about rapid structural change by tapping into sectors that are strategic to the region.

2. Binding Constraints to Industrialization

The following are some identified binding constriants need to be overcome for real progress to be made towards industrializing the region:

(i) **Addressing gaps in the Institutional Coordination and governance frameworks:** These are manifested by the lack of implementation of viable strategies, policies and systems of coherent laws and regulations to guide the industrialisation efforts. There are further inadequacies in institutional capabilities to chart a viable visons, coordinate and backstop the process of industrialisation;

(ii) **Reducing shortages of essential industrial skills:** due to the underdevelopment of human capital, there are shortages of industrial sector skills similarly; industry is also challenged by weak work ethics, relatively low level of labour force regulation, poor skills mix and productivity. In addition, critical masses of technological capacities, which are needed to catalyse sustainable development, are lacking. Lastly, a demand driven education system tailored to meet the region's industrial needs is lacking.

(iii) **Building quality infrastructure:** Infrastructure challenges have significantly constrained accelerated development in all EAC Partner States, although the impact of these constraints has varied across the Partner States. The region's railway network is antiquated and unable to meet the demands of a 21st century economy. While the state of the region's roads can be described as fair, specific road infrastructure constraints relate to inadequate investment in capacity and maintenance of existing roads and inadequate but improving regional legal and regulatory frameworks to enable coordination of roads development initiatives. The cost of power remains a challenge.

(iv) **Financing for Industrialization progrmmes and access to affordable finance:**The public debt burden experienced by EAC Partner States implies that less-and-less resources will be made available for productive activities including industrialization interventions. This is likely worsen an alreday bad situation where industry both at regional and national level often get minimal budgetary allocation.

(v) **Access to finance** remains one of the major factors constraining Micro, Small and Medium Enterprises (MSME) growth and

(vi) **Fragmented Markets:** The region has small, fragmented, and underdeveloped markets among others.

3. EAC Industrialization Strategy, 2012-2032

The EAC has developed a regional Industrialization Policy and Strategy (2012-2032) to enhance production and productivity, and accelerate the structural transformation of its economies. The results of the Strategy are to be achieved through, inter alia, diversifying the manufacturing base and raising local value-added content of exports to at least 40% by 2032; strengthening institutional frameworks; expanding trade in manufacturing; and transforming MSMEs into viable and sustainable business entities.

3.1. Determination of the EAC Priority Regional Sectors

In the development of the Strategy the region set out to identify industries that are competitive in local, regional and selected international markets. These industries dubbed, ""Strategic Regional Industries". These were defined as innovative industries to be promoted based on comparative and competitive advantages of the region and which contribute to attainment of at least four of the following

a) fostering of complementarities or enhancing collaborative production in the region,
b) large investments which may require pooling of resources to ensure that economies of scale are achieved,
c) contributing to realisation of backward and forward linkages in the value chains with regional dimensions,
d) contributing to employment generation in the region; and
e) having presence in at least more than one Partner State.

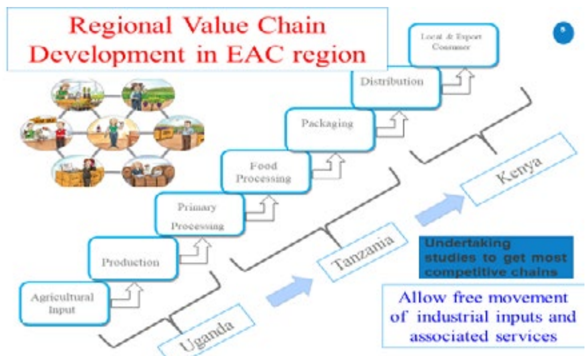


Fig 1: Regional Agro Value Chain in the EAC

3.2. Identification of the Regional Industries

The region used framework developed by UNIDO (Fig. 2) for identifying industrial development priorities. The framework that has been used in selecting target regional industries is based on two dimensions: attractiveness and feasibility.

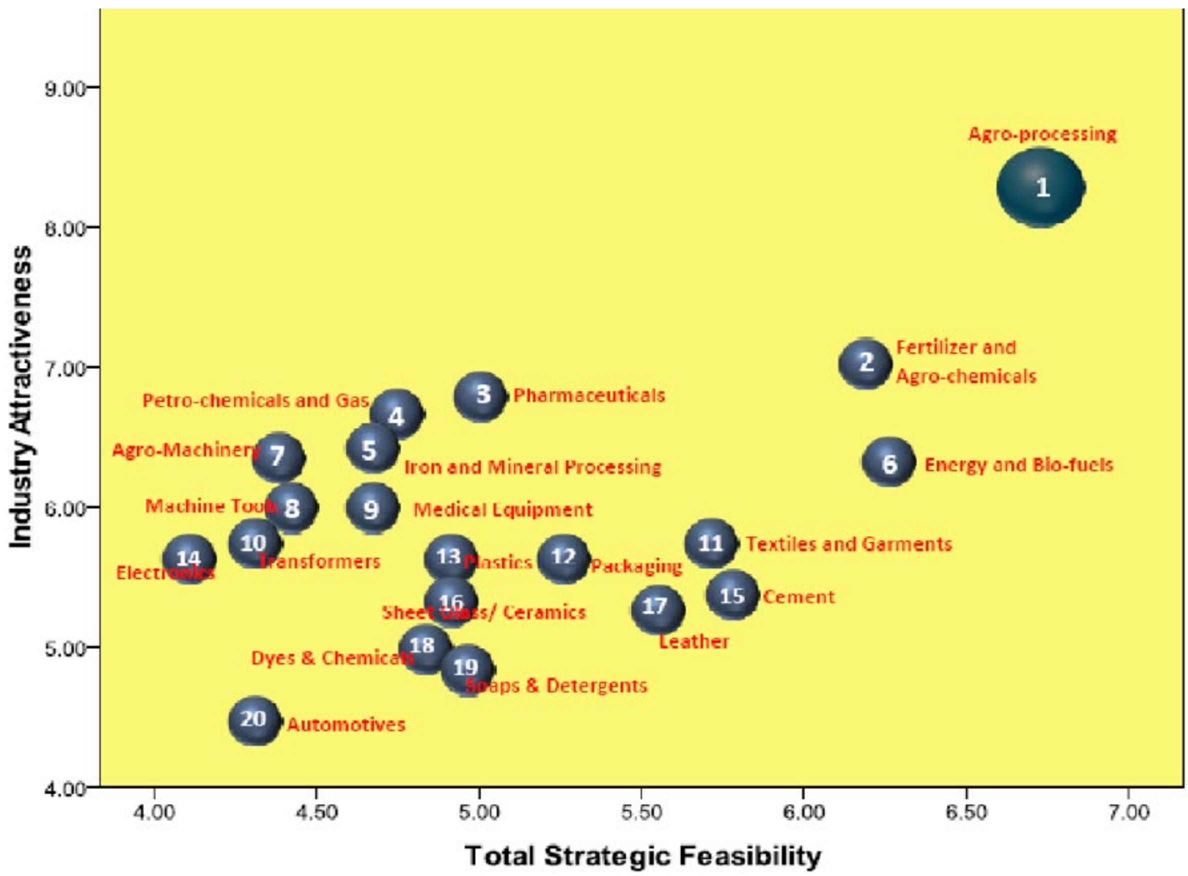


Fig 2: Graphical Illustration on the Attractiveness and Strategic Feasibility of a Targeted Industry

From Fig. 2 above, it is clear that agro-processing, fertilisers and agro chemicals, iron/steel and metals, energy projects (ethanol) and textiles registered the highest scores on attractiveness and strategic feasibility, and therefore have the greatest potential for growth within the region.

3.3. Identified Strategic Regional Industries Basing on the above analysis and broad consultation with stakeholders, the six industries below have been selected as the ones with potential comparative advantage within the region;

a) Agro-processing
b) Fertilisers and agrochemicals;
c) Pharmaceuticals;
d) Iron-ore and other mineral processing;
e) Petro-chemicals and gas processing;; and
f) Energy and bio-fuels.

3.4. Proposals to Accelerate Structural Transformation of Industrialization in the region

a) Exploit the opportunities in the dynamic EAC market: All EAC Partner States present a very high concentration of export markets. On the other hand, the EAC is a very dynamic market where demand for manufactured goods is growing annually at 16%, and at double digits for all the 20 most demanded manufactured products of the region. At the same time, the EAC Partner States are together losing market share on the vast majority of these. The region is an important market for medium and high tech products, where EAC firms have been more successful. Firms should continue to take advantage of this.
b) Shift, in the medium and long term, from resource-based and low-tech sectors, to a larger share of medium and eventually high-tech sectors: Three of the six priority sectors are classified as medium and high tech (fertilisers and agrochemicals, pharmaceuticals, and energy and bio-fuels).
c) **Upgrade smartly within sectors/value chains**: The short term should focus more on upgrading within sectors/value chains, that is, undertaking processing activities to add value to agricultural products or goods with currently low prices.
d) **Strengthen forward and backward linkages to boost industrial and overall economic growth**: The very low levels of forward and backward linkages of the manufacturing sectors of EAC Partner States should be boosted by a) increasing the capacities of MSMEs to provide the products required by larger (exporting) firms in terms of product type, quality, quantity, price and reliability; and b) increasing local content by putting in place local content policies/preferential procurement schemes.
e) **Develop and promote post-primary education programmes (TVET and university programmes)** catered to supplying the manufacturing sector with a range of Selected policy recommendations highly-skilled workers. This may require starting new skills training programmes or reforming existing ones to minimise the skills gap. In order to ensure skills mismatches are mitigated to the extent possible, strong involvement of the private sector is encouraged, not only in the initial design/restructuring of such programmes is required, but through continuous collaboration and dialogue.
f) **Attract foreign and domestic investments into the manufacturing sector** to ensure EAC firms can exploit the emerging regional market for manufactured goods.
g) **Direct limited public resources to applied research and various forms** of specialised extension services in order to support the development of technology and innovation.
h) **Strategically ease access to a selected set of capital goods and inputs** required for production, without hampering the growth of national/regional producers of the same.
i) **Introduce dedicated policies for long-term financing, matching grants**, ex-post rewarding schemes and other to encourage private investors.

3.5. The key strategic thrusts to drive growth should focus on:

(i) Spatial developent of key economic corridors (regional approaches)
(ii) Cities and Urban centers as new sources of growth for industrialization and rural transformation (mainly national)
(iii) Harnessing the opportunities of the Fourth Industrial revolution (4IR)(re-skiling of workforce and skilling of youth to adapt to technological frontier
(iv) Regional approach to Global Value Chain Integration (GVC)- regional coordination for targeted FDIs, coherent policy & investment incentives, making regional value chains work

4. Conclusions and Recommendations

To enable the growth of the Industrial Sector the region has adopted an Action Plan for 2021-2027 whose theme is "Recovery and Binding Resilience for sustainable Industrial Growth". The broad Programmatic Intervention Areas to guide generation of specific action and activities to be implemented in the period 2021-2027 include:

a) Improving the competitiveness of priority regional value chains to boster intra-EAC trade
b) Developing a regionally coherent and harmonized policy framework for Local Content for regional value creation and supply chains development
c) Supporting the private sector and SMEs resilience for accelerated growth and recovery of the Industrial Sector
d) Leveraging the AfCFTA and GVCs for export growth and rapid Industrial Sector Tranformation
e) Shifting to Green Industrialization Pathways and anchoring sustainability to achieve SDGs
f) Improving Policy Coordination and Building Capacity for Industrial Policy Management
g) Optimizing Infrastructure & Logistics Networks for Spatial Industrial growth and Agglomeration
h) Stregnthening colloboration in R&D, Technology Tranfer and adotion of Fourth Industrial Revelotion (4IR) technologies

Elaboration of Strategic Actions

4.1. Improving the competitiveness of priority regional value chains to bolster intra-EAC trade

What is required here is to develop and implement the Regional Value Chains Action Plans for specific sectors. Explore the scope for establishment of a regional or national investment and financing facility (special purpose vehciels) to support the development and production of essential industrial inputs and intermediate goods industries focusing on the strategic regional value chains of priority to EAC. Industrial inputs and intermediate goods industries are by their nature capital intentisive and require scale economies to become competitive and efficient. Undertake market opportunity assessment study for the essential industrial inputs and intermediate products currently being imported into the region including existing production capacities to gauge the products and activities with greatest feasibilities and identify arange of policy intruments to be deployed to promote such industries. Organize value chain specific round tables/forum to create a platform for continuous policy dialogue and monitoring the competitiveness challenges in the sectors and prepare Investment Roadmaps for the priority regional targeting attraction of FDIs and profiling of investment opprtunities

4.2. Developing a regionally coherent and harmonized policy framework for Local Content for regional value creation and supply chains development

Conduct a mapping study on the scope and opportunities for value addition (value creation) through local content policy tool, identify the sectors with most promising potential and prepare a local content policy framework to support leveraging of such opportunities (demand side of the equation) and Develop a regional wide suppier development and linkage programme focusing on training of suppliers on requirements from multi-national compnaies, financing, exporting, quality, costing, and strategies for integrataio into regional and global supply chains.

4.3. Supporting the private sector and SMEs resilience for accelerated growth and recovery of the Industrial Sector

Mapping of information requirements for small and medium enterprises. Cluster approach to be used to gather relevant information for SMEs and a register of potential service providers prepared. Develop a regional SME Information Portal linking similar nation information sources to enhace access to comprehensice regional information on trade, investment, partnerships, procurement opprtunties etc. Provide tailored techhical assiatnce towards upgrading of production and business processess and acess to approproate technology and organize Regional SME Investment symposium creating opportunity to expore business partnerships within the region, market their products, and promote policy dialogue.

4.4. Leveraging the AfCFTA and GVCs for export growth and rapid Industrial Sector Transformation

The African Continental Free Trade Area (AfCFTA) agreement will create the largest free trade area in the world measured by the number of countries participating. The pact connects 1.3 billion people across 55 countries with a combined gross domestic product (GDP) valued at US$3.4 trillion. The actions include: Develop EAC sector specific roadmaps for participation in the AfCFTA in colloboration with private sector . The roadmaps will lay out the sectors that can harness opportunities in the continental market, comparative strengths, pecularities of targeted markets , capacity gaps to participate, policy challenges and draw a detailed action plans. Others include to devclop capacities of enterprises in the targeted value chains to comply with AfCFTA rules of origin applicable including their capacities to meet the continental standards and Support the promotion of linkages of SMEs to regional (continental) multinational corporation through activities such as SME-FDI linkage forum, buyer-seller platforms, private-private investmnet parnerships agreements etc among others.

4.5. Shifting to Green Industrialization Pathways and anchoring sustainability to achieve SDGs

In many countries, industrial production and consumption patterns outpace the renewal capacity of natural resources and governments' capacity to manage waste products. These trends in resource use and energy consumption indicate that current forms of industrial production are not sustainable in the long run, and risk undermining the social and economic development benefits achieved thus far. This calls for a shift toward green and more sustainable approaches needed to satisfy the needs of the present – without comprising the needs of future generations. The greening of industries by governments is a proactive way to decouple environmental pressures from economic growth.

4.6. Improving Policy Coordination and Building Capacity for Industrial Policy Management

In the EAC Region, the capacity and performance of the public sector that deals with industry related matters is generally low, and as a result, implementation of industry related policies and strategies has in some cases been inadequate, constrained by several factors, including poor governance and ineffective monitoring and evaluation frameworks. In addition Partner States often do not have up-to-date and reliable data of industrial establishmnets and real time information of production. The situation not only curtails the prospects for an evidence based policy making but also seriosly limits the design of a credible investment proposal that can be developed and marketed to potential investors.

4.7. Optimizing Infrastructure & Logistics Networks for Spatial Industrial growth and Agglomeration

Economic corridor development is an integrative strategy and effective tool that enables industrial spread, creates jobs, upgrades infrastructure, aligns infrastructure development with urban and social agglomerations, unifies domestic markets, and links production centers with global value chains. Likewise, economci corrodors can serve as a tool to foster decentralized development away from the country's city and creates markets in the lagging regions. As EAC Partner State begin the transition to middle income status, it it critical that the countries, exploit the full potential of their various regions and finding new sources of growth that can sustain a higher growth trajectory. Corridir development ensures a holistic development and can become new drivers for structural transformation and regionally balanced development

4.8. Strengthening collaboration in R&D, Technology Transfer and adoption of Fourth Industrial Revolution (4IR) technologies

The impact of Industry 4.0 - the next phase in the digitization of the manufacturing sector driven by computing power, connectivity, and new forms of human-machine interaction - will be wide and profound. It offers exciting opportunities for African manufacturers and small and medium enterprises to create new business models and integrate into global value chains. Key areas of policy focus to enbale the region harness opportunities under Fourth Industrial Revolution include: Develop national strategies for integration of 4IR technologies into the national economy. Conduct situatioal assessment of EAC readiness for fourth industrial revolution technologies (4IR technologies)- which sectors can integrate, what gaps exists, what support is needed by business, and an action plan for integrating 4IR in manufacturing, SMEs, education, Agriculture etc. The region is to forge and foster regional, and global collaboration for access, adoption, adaption and deployment and tranfer of 4IR capacities and technologies. Conduct training and skilling of workforce and youth to effectively deploy and harness the emerging opportunties under 4IR with focus on priority regional value chains and build necessary infrastructure to support wide application of 4IR technologies including digital infrastructure among others.

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[Photo Courtesy]

In Pictures

4th ACEK Conference themed: Engineering the Future: Driving Innovation and Navigating the Industry 4.0–5.0 Transition.

IEK and Kirinyaga University MoU signing

IEK and ACTOM MoU signing

IEK courtesy visit to Principal Secretary for Industry – Dr. Juma Mukhwana

IEK Engineers Golf Day – Winner. Eng. Kennedy Wandera

IEK courtesy visit to Cabinet Secretary for Water, Sanitation and Irrigation – Eng. Eric Mugaa

2025 Devolution Conference: IEK Side Event

IEK Special General Meeting – scheduled 22nd August 2025

The **African Journal of Engineering Research and Innovation (AJERI)** Scientific Conference 2025 took place on 24 -25 July 2025 at Kenyatta University, bringing together engineers, researchers, and innovators under the theme **"Engineering for Transformation."**

IEK, the Institution of Engineers of Kenya, recently visited Mutito Boys' High School in Kitui County as part of their Newspapers in Education (NiE) program, aiming to promote STEM education and engineering careers among students. An IEK delegation, led by President Eng. Shammah Kiteme, visited the school on or around July 10, 2025, engaging with students to foster interest in engineering

The conference was officially opened by **Prof. Waceke Wanjohi, Deputy Vice-Chancellor (Academic)**, representing the **Vice-Chancellor, Prof. Paul K. Wainaina.** The Institution of Engineers of Kenya (IEK) was represented by **Eng. Jacton Mwembe, Hon. Secretary,** who delivered remarks on behalf of **IEK President Eng. Shammah Kiteme.** Eng. Mwembe encouraged participants and the wider engineering community to make the AJERI Journal a daily go-to resource for cutting-edge insights, research, and innovation in engineering. He was accompanied by other members of the IEK Council, including **Eng. Harrison Keter (1st Vice President), Eng. Christine Ogut (2nd Vice President), Eng. Jeniffer Korir (Hon. Treasurer), Eng. Collins Changole (Chair, South Rift Branch),** and **Eng. John Nyaguti,** reflecting the Institution's strong support for the advancement of engineering research.

Innovations in Fertilizer Application and Drone Technology

(Photo Courtesy)

Food security is an important component of the global sustainable development. As the world populations continues to rapidly grow, it is becoming increasingly important to produce enough food and provide this population's access to it. While traditional fertilizers have over the years helped farmers boost yields, they come with a number of limitations that may render them unsustainable overtime.

Traditional fertilizers come in both organic and inorganic forms where the organic fertilizers are derived from animal and plant matter while inorganic fertilizers are potassium, nitrogen and phosphorus-based. Organic fertilizer improves the soil nutrient and are slow to release, thereby allowing plants to make optimal use of the available nutrients. Inorganic traditional fertilizers promise faster outcomes as they are measured for accurately. However, the use of these traditional fertilizers has posed significant challenges to farmers like difficulty in precise application and the markedly slower outcomes of the organic fertilizers.

While inorganic fertilizers address these shortcomings to some extent, their overuse over the years have raised serious concerns on their contribution to soil, water pollution and air pollution. Agriculture remains a key casualty of environment degradation and climate change, thus more than ever, there is a need for sustainable solutions to keeping the population fed while innovating and adopting sustainable solutions.

Best Management Practices (BMPs)

Best Management Practices (BMPs) in the context of fertilizer use refer to the optimal use of fertilizer that encourages increased nutrient uptake and production while reducing their impact on the environment. It is anchored on the Nutrient BMPs, otherwise known as the 4Rs—Right rate, Right timing, Right source, and Right placement of the fertilizers. Innovations in fertilizer application use this framework to create a system that reduces the negative effects of agricultural production on surface and ground water resources.

Innovations in fertilizer application

Microdosing

Microdosing is a strategic fertilizer placement technique that leverages the concentration of nutrients at the base of the plant to accelerate root growth which enhances faster uptake of native soil nutrients. To microdose, farmers apply small doses of fertilizer, as little as a pinch, the planting hole or wait to weeks to apply the pinch at the base of the plants. This method revives soil nutrients and is highly applicable in areas that have experiences land degradation. It is also relatively cost-effective as it can be utilized by small-scale farmers.

Deep Banding

Of the three plant macronutrients Nitrogen (N), Phosphorus (P) and Potassium (K), Nitrogen tends to be the most mobile, therefore traveling in between the soil layers. Phosphorus and Potassium on the other hand are relatively immobile as they are held on soil particles and do not leach into deeper layers. This way, the top layers of the soil may be heavily fertilized, but these two nutrients may not be used by the plant simply because they are not available for uptake at the root level. Deep banding solves this problem by placing these immobile nutrients in concentrated bands 5 to 8 inches (13-20 cm) below the soil surface, often using GPS guidance to align with planting rows.

Smart Fertilizers

Smart fertilizers refer to advanced formulations that are capable of slowly releasing nutrients into the soil and crop. The release is determined by factors such as soil moisture and temperature. This controlled release mechanism ensures that plants receive the right amount of nutrients at the right time instead of bombarding them with many different nutrients that they may already have.

Precision Agriculture

Precision agriculture makes use of the 4R framework to apply the correct amount of the right fertilizer to crops, at the time and place that the crops needs is most. In order to be precise, this method of agriculture draws from data analytics, remote sensing, and automated systems to optimize nutrient management. Waste and surface run-off have been a challenge when it comes to fertilizer application, but by using soil sensors, drones, and GPS technology, farmers can accurately apply fertilizers and nutrient solutions in the specific areas of their field that need them most. This method is cost-effective and also reduces the negative environmental impact of fertilizers.

Drone Technology

Drones are quickly becoming an integral part on the technology forward agricultural industry. The application of drone technology in agriculture is diverse, ranging from aerial surveillance, mapping, land inspection, monitoring, checking for diseased or rotting crops to fertilizer application. The use of drones in fertilizer application is a smart farming technique that promises more precise application. It is faster and highly efficient in areas whose terrain would be challenging for heavier machinery. It is also cheaper as compared to using small aircrafts for administering fertilizer.

The smart capabilities of the drones enable them to quickly collect crop data and map out the areas that need fertilizer and the specific fertilizer that is needed. Their precise application ensures there is no waste and reduces chances of soil compaction.

Conclusion

Food security is an important factor of sustainable development and social stability. How to keep the population fed while also ensuring that the agricultural resources and the environment is not depleted remains a critical concern for the future of agriculture. Advancements and innovation in fertilizer application should meet the triple goals of increasing crop yields, reduce environmental impact, and contribute to global food security.

Linear Infrastructure in and Around The Nairobi National Park: Reducing Wildlife Deaths

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Globally, the Nairobi National Park (NNP) is the only one that exists within a capital city. It is therefore a souvenir of great production economically since inception in 1947. However, because of the ongoing urbanization and a highly rapid development of supportive linear infrastructure in and around it, the morbidity and mortality of its wildlife is an existential risk (Fernando et al.,2019). Countless studies have been done to document the contributing factors including; human-wildlife conflict, road-kills, ultra-fine particulate matter pollution, name it. Little has however been done on the side of policy tool to help reduce the wildlife deaths due to the operation of the linear infrastructure like; Standard-Gauge Railways, Nairobi Express Way, Southern Bypass Road, Athi-River- Namanga Road, Old Namanga Road and Magadi Road. This research will use an integrative review method to analyze, discuss and quantify the historical wildlife deaths to mop up policy problem evidences. This then will inspire framing of a policy solution proposal for reducing the deaths and coming up with an implementation framework to mitigate effects of ecological trap wrought by the liner infrastructure (Nyumba et al.,2021). Should the concerned stakeholders adopt the policy concept, the eminent death of the Nairobi National Park from the impact of the infrastructure will be averted. Transportation and policy planners will be called upon to remain steadfast in preserving the pride of NNP.

Key words: Infrastructure, Wildlife, Deaths

Linear infrastructure, as the name suggests, is a development constructed in a linear manner that can cover long distances on land surface. This may include; roads and rail lines, power and communications lines, oil and natural gas distribution lines, border and other types of fencing, canals and irrigation ditches, and more, all which fragment wildlife habitats. Mostly they are considered as the lifeblood of urban environments and the critical connectors of cities or metropolis, hence allowing people, goods and information to move back and forth, while also delivering resources from remote locations to the population centers that rely on them. Because of its linearity, it creates an intriguing set of political, technical and social debates. Whereas commercial, urban and residential projects have localized impacts and are easier to quantify, linear infrastructure on the other hand, traverses' multiple locations (local, regional, and even international borders), and may sometimes cross protected lands and sensitive landscapes like the case of the Nairobi National Park henceforth known as NNP (AfricaGeographic,2023), where it is feared to impact the welfare of wildlife due to the artificial formation of an 'ecological trap'. The latter being a situation where animals' mobility become curtailed due to fear, they become confined hence losing freedom for food search and mating partners. They may even die eventually leading to biodiversity loss (Ament et al.,2008).

The NNP, located 7km South of CBD, is a priceless asset, particularly because of its ecosystem services to the city residents. Since its inception in the mid-1940s, a lot of transport infrastructure projects have been implemented in the vicinity. As a result, its vulnerability to the operations of these linear infrastructure remains a constant threat. In fact, records on wildlife kills are growing day by day. At the national level, a study by (Ogutu et al.,2016) recorded a striking trend where the rates of wildlife population decline between 1977 and 2016 averaged about 68.1% (1.7% per year) across all the 18 wildlife species analyzed. For NNP, an analysis on the population dynamics of 11 ungulate species established that the continued fragmentation of the lands by linear infrastructure is closing their migratory corridors onto Athi-Kaputiei Plains which denies them food resource since they are left confined to smaller rangeland spaces (Ogutu et al.,2013).

To reduce the continuing wildlife deaths, a policy solution is needed with a clear implementation framework as a commitment to future generations. NNP is a protected area. It is very essential for the city's biodiversity conservation. In fact, it is meant to maintain the functioning of natural ecosystems, acting as a refuge for species as well as to maintain ecological processes threatened by the intensely changing landscapes around Nairobi. Globally, there is an increasing concern about urban pollution more particularly associated with emissions from vehicle exhausts. Even though today's cars use lead-free gasoline, their exhausts remain the major contributors to atmospheric nitrogen pollution in the form of emissions of Nox which affects the welfare of terrestrial wildlife. Atmospheric deposition of nitrogen by traffic pollution is harmful. In addition, automobiles release heavy metals to the environment which are dangerous to life, because they disrupt ecosystems. This is the reason as to why their critical load levels must not be exceeded (Hettelingh et al.,2001).

The NNP is neighbored or crossed through by; the Standard-Gauge Railways, Nairobi Express Way, Southern Bypass Road (Kahumbu,2011,12), Athi-River- Namanga Road, Old Namanga Road and Magadi Road, see Figure 1.

Figure 1 Linear Infrastructure in and around Nairobi National P

Conservationists approximate that the NNP is a home to more than 100 species of mammals, about 60 species of reptiles and amphibians, and over 500 species of plants and birds within its land-space measuring approximately 117 km^2. The diversity of species found here adds to its uniqueness of being within a city environment. A part from the elephants, it houses four of the 'Big Fives'; lions, leopards, rhinoceros and buffalos. Through the park, phase II of Kenya's Standard-Gauge Railways has a 6.7-kilometre bridge snaking along its southern boundary, with an average height of 18 metres. It is highly suspected that the fragmentation of the park will impact its biodiversity and animal movement. Kenya has 24 national parks and NNP is the oldest hence most affected by development challenges. It is treasured heritage of conservation of 'wild nature' for national prosperity and a symbol of national pride. As part of the National Park System, it aims to protect the local ecosystem, improve ecosystem services, restore biodiversity and improve people's livelihood.

The fact that NNP is within a rapidly developing urban environment exposes it to a multiplicity of threats such as; a changing weather pattern, and land-use changes. This has resulted in the decline of species population, and a consequential loss in their biodiversity, as well as habitat loss due to developmental fragmentation occasioned more specifically by linear infrastructure. For example, the Standard Gauge Railway (SGR) and Southern by-pass are two major developments that have been built right through the park (Githaiga and Bing,2019). . Strikingly, Southern Bypass Road construction caused the hiving-off of more than 300 acres of the parkland amidst the protests from the concerned conservationists. Equally, the park inner roads have also fragmented the ecosystem hence hampering the free movement of animals which have also enhanced road-kill threat. The latter has seen cheetahs being killed on some of these roads. The SGR on its part took up parkland (Kari ,2017) that has disrupted the animals' wellbeing because of noise pollution which continue to affect, the rhino, antelopes, and the wild dog. These animals prefer to move far from people and the presence of SGR right in the heart of their abode is an invasion of their only safe space.

This paper aims to document the infrastructure effect (IE) on NNP's wildlife. Using previous studies 'synthesis, a quantification of the magnitude and spatial extent of infrastructure impacts on the abundance species is outlined. Linear infrastructures are vital to human development, but they may also have negative impacts on wildlife populations. Infrastructure construction and use affect wildlife through various processes, with habitat destruction and fragmentation, and increased mortality being the most obvious. They may degrade the surrounding habitat through chemical and noise pollution and the creation of habitat edges. In addition, they may pose a barrier to species' movement, potentially limiting gene flow between conspecifics and reducing access to important food resources. The effect may extend to several kilometers into the surrounding environment. Commonly known as the impact zone which in road ecology is known as the road effect zone. Other scholars have before expanded the term to infrastructure effect zone to encompass all forms of linear infrastructures like power, pipe lines, paved roads, railways and unpaved roads. For instance, power line collisions and electrocutions have been identified as one of the main avian mortality causes. Paved roads are known to have higher effects, because they are often wider and are more intensively used. The characteristics of the surrounding habitat may also influence the effect, for example, closed habitats, like forests, are more often affected by edge effects while on the other hand, noise and air pollution impact open habitats.

The impact though differ between species; low reproductive rates and long generation times could be skewedly impacted by infrastructure collisions and deaths as their populations recover more slowly than populations of species with high reproductive rates. Additionally, species with large home ranges are more likely to encounter infrastructure that increases their vulnerability. Physiologically, home range size and reproductive rate are related to body size, therefore, large species are more at risk from infrastructure-effect. Comparatively, small species are abundant in infrastructure verges because of changes in the vegetation or because their larger predators are less abundant. On the other hand, carnivores may be more affected than herbivores as they generally have larger home ranges and lower reproductive rates.

Whereas dependency contexts have been used to analyze the impacts of linear infrastructure on biodiversity, aggregated biodiversity indicator perspectives are also helpful. Countless studies have investigated the interplay between species traits and infrastructure impacts, but none so far has been attempted the case of NNP.Some of these have used expert opinions to categorize species specific IEZs for various types of infrastructure. As earlier stated, NNP is a home of species of various taxa, meaning that, a trait based meta analytical approach to map the impacts of linear infrastructure across all is not possible. Therefore, this paper assesses the size and spatial extent of linear infrastructure impacts on the abundance of terrestrial wildlife in NNP from earlier studies.

Digging through peer reviewed literature in the ISI Web of Science and Google Scholar using search term, disturbance, relevant materials were collected. This facilitated the documentation of the intensity of disturbance. The material to be included was guided by its relevance to the NNP ecosystem which limited the extraction into the database. The impact analysis was not restricted to species traits, neither did the study look at the effect size outwards of the park. From the extracted data, it was found that, the section of SGR that runs from Mombasa through Nairobi to Naivasha Industrial Park in Enoosupukia and ends in Narok town, was completed in August 2019.This stretch has about a 6.7km portion running through the NNP.

The main objective of the line is to help handle the long-distance hauls from Mombasa Port to Malaba Border Post facilitating the shift of freight loads from the highways to rail. In infrastructure terms, the SGR facility is categorized as a National Class I railway with a range of safety measures from the design and operation covering issues like; speed limits, installation of high guard fence, safety buffers and earth embankments. In addition, it has; bridges, underpasses, culverts and flyovers constructed especially within the NNP to aid the free movement of wildlife (Conversations ,2021). In fact, within NNP, an acoustic noise barrier was installed to reduce noise disturbance. Understanding the impacts of linear infrastructure disturbances on wildlife populations is an important task for ecologists in the face of ecosystem-level changes caused by such developments. The whole idea is to preserve wildlife population persistence depending on the 'severity' of the impact of the expected disturbance (Russell et al.,2020). This depends primarily on the 'intensity' of disturbance, defined as the strength of the disturbing force.

Given that the freight flow of the line is mostly in bulk cargos in containers carrying; coal, fuel oil, petroleum products, and cement, its impact on welfare of the wildlife is monumental. A part from the cargo-droppings, the SGR line caused; huge excision of parkland which of course has led to a loss in wildlife habitat, and disturbance of the forest ecosystem (Ambani and Mulaku,2021). The latter provides an important watershed ecosystem service for wildlife water supply and air cleaning through carbon sequestration. Other associated externalities also include; acoustic pollution such as; noise and vibration which continue to affect some sensitive receptors such as the David Sheldrick Wildlife Sanctuary. There is a growing environmental concern emanating from shipment of freight containers through protected areas. In fact, the issue of sustainability is at the forefront of global consciousness in the transport sector.

Figure 2: Trapped and scared animals near SGR (Source, Nation Media Group file by Mutanu)

In 2019, Bernardine Mutanu, a correspondent scribe with the Nation Media Group, in an online article titled,' *Death of Nairobi National Park: Why wildlife risks being wiped out',* lamented on the agony of wildlife due to SGR's installation through the park. In figure 2 above, she reckoned that the animals got stuck on one side of the standard gauge railway for days. It is situations of this nature which calls for policy intervention in line with the globally best practice guidelines like Protected Area Management that can help. This has called attention to Kenya government's vision for sustainable freight transport practices. Such measures include; use of rail system which has a lower carbon footprint and can handle larger volumes of goods, optimization of delivery routes, to eliminate unnecessary miles traveled, use of electrically powered trucks, use of recyclable and biodegradable packaging materials to minimize waste generation, promotion of the concept of collaboration and consolidation to help in reducing congestion. Although much is still needed to avoid unintended consequences of developments supporting the same initiative. By and large, freight logistics in Kenya is today leveraging technology such as the Internet of Things (IoT), artificial intelligence (AI), and data analytics to help optimize supply chain operations for greater efficiency and waste reduction. The deployment of real-time tracking systems has enabled efficient planning and resource allocation.

As earlier stated, NNP has park roads and is also neighbored by the; Nairobi Express Way, Southern Bypass Road, Athi-River- Namanga Road, Old Namanga Road and Magadi Road. It is acknowledged that, road construction does normally have tremendous impact on the ecological resources since it involves the opening up of the earth surface. This emits dust emissions and pollution from burning of the fuels from the heavy equipment. On commissioning stage, further air pollution ensues again which affect the animal health quite a bit. This arises from the contamination of run-off water with oil or petrol droppings from vehicle engines which has led to deterioration of water quality in the park. The roads within the park have a direct habitat loss. And the adjacent road networks continue to facilitate invasion of weeds, pests and pathogens many of which are not indigenous as well as a variety of edge effects.

Ecologists have argued that, the impact of road construction includes displacing animals and plants that may not be recovered. With careful planning, roads can pass through parks successfully (Caro,2015). Although some species thrive on the roadsides, however, some of them are weedy species which are alien and can move to other areas at a fast rate as they are not impacted by the disturbed ecosystem. This causes human-wildlife conflict due their spreading out to the communities in which they end up invading farms. In other instances, this also results in increasing farming costs resulting from purchase of pesticide control chemicals that also to some extent pollute underground water. Even though the design of these roads was done in such a way that all ecological impacts were put into consideration and negative effects eliminated as much was possible, the Environmental Impact Assessment (EIA) recommendation alone is not a panacea to resolving all ecological impacts of linear infrastructure. The impacts are mostly associated with pollution, degradation of biodiversity and depletion of natural resources within the park. This the reason as to why, road agencies always work hard to protect the ecosystem by documenting in prior, all the environmental issues pertaining to road infrastructure provision and use. To this end, they promote use of sustainable road construction materials, and clean fuel to power engines. In Kenya, there are several instruments facilitating this vision, that include; Environmental Impact Assessment (EIA), National Environmental Management Authority (NEMA), The Environmental Management and Coordination (Air Quality) Regulations-2024, Suppression of Noxious Weeds Act, Water Pollution Act, Noise Legislation Act and Biodiversity Conservation Strategy.

The linear infrastructure in and around the NNP has created an ecological trap prone to microplastics (Bess et al.,2023) and other airborne nitrogen pollutants (Bobbink et al.,2003). All these airborne pollutants need not exceed critical load levels (Burns et al,2003; De Vries and Bakker,1996). Animals have fallen into an 'ecological trap' merely by being confined in the space at the expense of their fitness (Navinder et al.2024). This is maladaptive behavior has been caused by human-induced changes in the park through fencing, closing migratory corridors, building of roads and railways all together called infrastructure in this discussion. When the infrastructure was built, the animal cues that rely on habitat features, sound, light, and smell, for habitat selection, navigation, foraging, and mate choice were interfered with. The cues aim to increase animal survival instincts for reproduction, and ultimately their fitness. Such alterations have disturbed the ecosystem, meaning the persistence of animal populations within the park is threatened. The park has become an "ecological trap". In fact, it is a perfect trap, because of three reasons; (i) it is fenced making it fit in the description of severe trap since it is the the only preference left for the animals (ii) this renders individual fitness in the trap habitat to be lower, and (iii) animals must actively move into the trap habitat as they have no other option (Navinder et al.,2024).

Because of lack of mortality data associated with the 'ecological trap' problem, there could be a masking effect caused by the linear infrastructure on animal populations in two forma: (i) past massive mortality, causing local extinctions, or (ii) strong barrier effects due to the inability or reluctance of individuals to traverse the infrastructure corridor. In 2009, Dr. David Western, a respected ecologist stated that, NNP exhibited a negative but non-significant downward trend in animal population decline (Western et al.,2009). Nonetheless, to unravel the true effect of the linear infrastructure's ecological trap problem in detail, there is need for long-term mortality data collection with information on the abundance of the focal species, their genetic patterns and movement behavior. When mortality rates increase in the park, we shall be witnessing a population depletion effect and ultimately extinctions of some species hence loss of biodiversity. exclusionary fences linked to crossing structures along roads or railways.

The mitigation prioritization should not be directly linked to mortality counts solely because like in the NNP, there is no dedicated framework for documenting the deaths attributed to the linear infrastructure which could be at times based on polluted forage (Ammann et al.,1999). A case in point is when the roads or the railway imposes a strong barrier effect on animal movement leading to eventual starvation and death (Angold,1997). In fact, some animal species are unable to transpose the infrastructure corridor as it represents an insurmountable physical obstacle due to avoidance behavior. And other species tend to avoid crossing gaps in vegetation, particularly those caused by roads that have fragmented the habitats. Ecologists often cite examples such as that several small mammal species are known to avoid open areas, probably due to predation risk, and even dirt roads may represent deterrent features for animal movement. Additionally, some other species avoid the vicinity of infrastructures, thereby intensifying the habitat loss and barrier effects. Such avoidance behaviors can have important repercussions on accessing resources, including mates or food.

In conclusion, it can be said that, the value of NNP may be eroded very soon if there are no proper plan to protect the wildlife from the effect of linear infrastructure development. This calls for more detailed future research needs to address the wildlife-linear infrastructure interactions to better understand how the mortality patterns (including the lack of mortality) relate with the spatial patterns of species and landscape connectivity. Manuals are already there to guide development in protected areas (Dudley,2008). Policy makers can agree on use of a standard protocol that can be integrated in infrastructure-related research to measure species occurrence and abundance in control and impact sites (Krief et al.,2020). Impact sites should be in the vicinity of the studied infrastructure (where vicinity is a distance not superior to half of the focal species home range) and control sites should be far from any other infrastructure that may cause a positive or negative effect on the focal species population (i.e., controlling for similarity of relevant environmental factors).Moreover, a great concern should also be dedicated to understanding the animal movement behavior toward the different infrastructures and incoming vehicles, as well as species responses to mitigation alternatives in the face of climate change (Ogega et al.,2019). Today, an array of tracking devices is available and their cost is decreasing substantially, bringing the animal movement discipline toward a feasible solution.

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The Rise of Young Engineers in Kenya's Agri-Food Revolution

Over and above every human need, food has to be the most basic without which nations cannot fully function and develop in any capacity. The human body is nourished and sustained by food. Not just any type of food but that which speaks to every part of the cell structure and essence of the soul.

While we all hail and pedestal it, we must understand that food does not just come to be of its own but by intentionally and diligently applied labor. With love and care for each seed that goes into the ground, each drop of water applied in irrigation, and the kind of models a farmer decides to adopt in their food production.

The food production chain goes longer and further that most can imagine. More than the crops we see and celebrate in its ripe season ready for harvest on farms, is the sweat and capital of men dedicated not only to feed themselves but to contribute positively to humanity.

Time was in the past when farm land was seen as more than just an asset, more that just a treasure but life itself for from it, all life is sustained. This is not to mean that the perspective has changed, but to emphasize the essence of the resource and its interlock with life.

Now that that is out of the way, let's explore Kenya's agri-food sector. Like most nations Kenya has agriculture as its economic backbone contributing to over half of the GDP and employing 60% of Kenya's workforce. To maintain this and further grow the sector, it is expedient for all of us, not only farmers, to understand the value of every micro step and stage in the food value chain. From sowing to reaping, every condition in between plays a crucial role in ensuring sustainable nutrition of the populous.

While the agrarian revolution still continues to see excellent innovations and growth, the essence of the basics must not be understated. Early in the days, without soil, water and sunlight harvest was just but a dream. But by innovation, engineers have managed to come up with ways that override these basics.

Technologies like hydroponics that depend on nutrient-rich water as a growing medium, greenhouse technology that involves creating a controlled environment for cultivating crops that would otherwise not see the light on day in uncontrolled environments, fertigation which involves applying water-soluble fertilizers through an irrigation system and many other such technologies have appealed to the Kenyan youth who otherwise stigmatised agriculture and viewed it as a labour for the less priviledged and elderly.

A new generation of young engineers and agripreneurs has emerged as a result of this agricultural transformation, which have let to food production optimisation using data-driven techniques like the Internet of Things (IoT), increasing productivity and efficiency, and incorporating technology and mechanisation into farming practices.

With these technologies, agriculture continues to find relevance amidst young engineers who would otherwise settle for white collar jobs, which in the recent past have also seen a significant decline.

For this reason, engineering disciplines like agricultural engineering, which is dedicated to applying scientific knowledge and mechanisms in agriculture have gained traction for the reasons that agriculture has shifted from being a labour-intensive toil to a fairly enjoyable venture.

Living in a generation that is highly data driven with constant interaction with gadgets and devices, modules and courses like computer programming have made it possible to automate most aspects of the food production chain making it efficient and effective through the entire process.

A potential shift towards a more inventive, technologically advanced, and sustainable agriculture sector has also seen the rise of urban farmers who refuse to be limited by lack of farmland. Therefore, involving young engineers is essential to boosting food security, promoting economic growth, and creating a resilient future for Kenya's agrifood systems.

Emmah is a NEMA-certified environmental engineer. She possesses a strong background in sustainable development, renewable energy, and environmental management. With a Bachelor's degree in Environmental and Biosystems Engineering and ongoing Master's studies, her skills encompass but are not limited to EIA/EA (Environmental Impact Assessment and Environmental Audit), water resource management, and biodigester design. She has a proven track record of leadership, having managed teams for transport feasibility study projects and various innovation challenges. Her diverse professional experience includes research and preparing success reports for regenerative agriculture projects and research on captive power generation. With these she has honed her skills in research, data analysis, and project management.

Design Considerations for Plumbing Systems in Smart City Buildings

'A Case Study of National Construction Authority Centre for Construction Industry Development at Konza Technopolis'

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Abstract

Smart cities and building investments are growing due to rapid urbanization internationally. These buildings demand comprehensive plumbing system design due to their innovative design and upkeep methods. Engineers are faced with design challenges on the factors to consider for the utilities to gain the smart city's approval and to benefit the facility users and owners. Knowledge of these design factors accelerates project design timelines and reduces cost overruns. The purpose of this paper is to highlight the elements influencing plumbing system design in Kenyan smart buildings, focusing on the Center for Construction Industry Development (CCID) project in Konza Technopolis. Non-systematic review of literature was utilized for its dependability and simplicity. This involved extensive examination of literature, laws, guidelines, and standards with emphasis on smart city initiatives. Key findings were that the Kenya Vision 2030 and Global Sustainable Development Goals (SDGs) of environmental preservation and utility efficiency are achieved through adoption of low carbon footprint materials and use of resource-efficient fixtures and smart systems such as leak detection systems. Information from the country's rules, regulations, and standards is vital in guaranteeing the safety, inclusivity, security, and efficacy of plumbing systems. The integration of intelligent features, such as automated monitoring and control systems, enhances maintenance efficiency and overall system performance. They also enhance visitor and staff satisfaction as well as prolonging plumbing system's lifespan. From the findings, a multifaceted approach to smart city building's plumbing system design is recommended to guide future smart city buildings for efficiency, compliance, sustainability and satisfaction.

Keywords: Smart buildings; plumbing system design; design factors

Introduction

Researchers have delved into the smart building concept for several decades. A commonality in all the studies is that adoption of smart building concepts is still low globally. However, these buildings also offer numerous benefits in increased energy efficiency, sustainability, and data-driven insights.

The smart building concept first emerged in the 1980s. However, a standard definition on what exactly entails a smart building is yet to be found (Omar, 2018). Related to this fact, the perpetual technological advancements make it possible to incorporate many systems in a smart building. A good example is the plumbing system, which is a basic and important system in a building designed by considering several elements.

In this paper, we introduce the factors to consider when designing plumbing systems for smart buildings, based on our research and direct involvement in the design of the proposed Center for Construction Industry Development (CCID) project at Konza Technopolis. CCID project reveals how systems in smart buildings can attain efficiency and sustainability in line with Sustainable Development Goals (SDGs) and Kenya's Vision 2030.

Smart Buildings - Overview

The smart building concept first emerged in the US, but has since spread across the world due to its environmental and economic benefits. There are several cases of smart building practices in Africa. For instance, South Africa's Cape Town has a smart water metering system. Another example is the smart waste management system in Kigali, Rwanda. Such models have not only put the cities on the world map but also enhanced their livelihoods.

Kenya has made strides in waste management, traffic management, and e-governance. Sensors embedded in waste bins monitor waste levels for better management of waste collection. Garbage trucks are therefore saved from unnecessary trips to collect the waste. Monitoring smart systems help identify areas where waste is normally high.

On the e-governance front, Kenya has had remarkable achievements. These milestones have helped various government departments operate faster and more efficiently. Consider things like permit applications, remittances to the KRA, and business registrations – online portals have transformed the management of processes.

An efficient transport system contributes to a more sustainable environment and a smarter city. The achievements of the country on this front are a testament that there is always something one can do towards achieving this goal.

Factors considered in the design of Plumbing System for Smart Buildings

Engineers and other stakeholders in the building services space ought to double their efforts towards designing and implementing plumbing systems in smart buildings and cities due to limited and scarce information. According to (Rameshwar et al, 2020), there are 11 concepts desired in a smart building as summarized in the figure 1 overleaf. These include building materials, occupant comfort, resource use efficiency, and monitoring & control.

However, there is limited information on how some of these concepts relate to plumbing systems. There are also no manuals, technical guidelines, except those used for conventional plumbing systems.

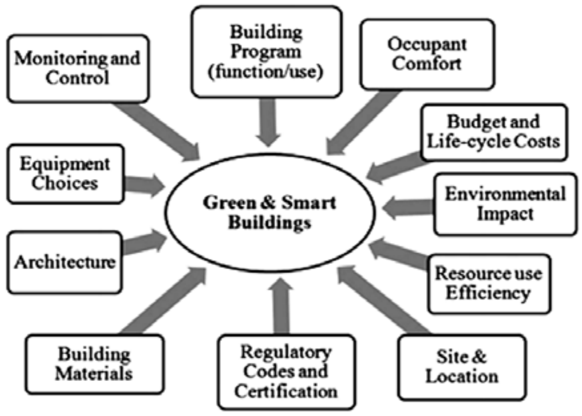

Fig 1: Concepts covered by green smart building

Smart plumbing systems are markedly different from the conventional options because of features that promote conservation and improved user experience. These features include leak detection, remote monitoring & control, water temperature control, and usage analytics. As the infographic on smart buildings shows, plumbing, one of the systems in a smart building, has evolved from a mere network of pipes and fixtures to an integral part of the technological and infrastructural solutions that are central to smart buildings.

The Center for Construction Industry Development (CCID) is a smart building development within Konza, a major flagship of Kenya's Vision 2030. When complete, Konza will be a state-of-the-art city equipped with advanced infrastructure, ICT sector, and business friendly systems. So far, investors have already committed over USD 800 million to the city development. CCID is expected to have functions for capacity building/training centers, research and innovation, information center, residences, plant & equipment unit, conference facility and NCA headquarters/ offices as a standard smart building, the CCID building adheres to the smart city development principles, which revolve around integration of modern systems and sustainable practices.

Like any other design within a smart building, a smart plumbing system design must meet several user requirements. In line with this, it is paramount to match standards of the internal plumbing design with the user requirements (Omar, 2018). By virtue of its high standards, a smart building can also elicit expectations from the user about safety, energy efficiency, and user comfort provided by the system (Ghansah et al., 2021). The building owner also has goals to be met for instance, energy efficiency and users' comfort (Pašek & Sojková, 2018).

Designing the plumbing system for a smart building requires attention to specifics considering the uniqueness of materials and technologies compared to conventional plumbing (Ghansah et al., 2021). That's where codes, standards and specifications come in.

Materials and Methods

The proposed Center for Construction Industry Development (CCID) at the Konza Technopolis is a National Construction Authority (NCA) project designed for interdisciplinary construction related research and a hub for knowledge, technology transfer and research diffusion to the construction industry and other allied sectors.

The main components of the CCID plumbing system are sanitary fittings, internal plumbing and external water reticulation, rainwater harvesting installations and water leak detection system. The plumbing system design for the CCID building at the Konza Technopolis met specific smart building specifications. As the project engineers, we focused on addressing important elements including energy efficiency, user safety, design standards, and cost.

Project site evaluations and analysis formed part of the data collection approach, helping identify water usage patterns and decide on the ideal system layout. A major consideration was the building's need for automated systems close collaborations with Architects and other project stakeholders to ensure the seamless integration of the plumbing system with the rest of the smart building's infrastructure. Snowballing method was deployed for non-systematic review of literature in this study.

Results

The plumbing system at the CCID building in Konza successfully considered several crucial factors other than the normal considerations in the code of practice as detailed below namely sustainability; rules, regulations, & standards; monitoring & control; and system lifecycle costs.

Sustainability

Sustainability is a key design requirement for a plumbing system in a smart building. It entails environmental preservation and utility efficiency. The two components of sustainability are achieved through adoption of low carbon footprint materials and use of resource-efficient fixtures & smart systems like leak detection systems.

On environmental preservation, selection of piping material was based on the evaluation of the piping materials carbon foot print via the Life-Cycle Assessments of the suitable piping materials within the project locality. The findings were that pipework and fittings for water distribution from the storage tanks to sanitary were done in CPVC material with final pipe connections being in special flexible rubber hoses with angle regulating valves to basin taps, and connected directly to fittings in case of flush valves for toilets and urinals. Pipework and fittings for water harvesting downpipes to storage tanks were done in High density Polyethylene (HDPE) material because of their advantages over other pipes. For instance, they have less effect on exposure to ultraviolet (UV) rays, are easy to install, corrosion resistant, cost effective, and available locally.

On utility efficiency, Konza Technopolis guidelines require non-residential buildings, mixed-use, and multifamily 4 stories or more to reduce water use 40% below the baseline that is derived from conventional fixtures. We designed the system for minimal water consumption by using water-efficient fixtures. For instance, the proposed smart tap for the wash hand basin working at 5.7 liters per minute for 10 seconds results in an annual water bill saving of Kshs. 127,764.00. The water usage per fixture and the resultant savings in all the fixtures as per tables 1 and 2 overleaf were within the acceptable limit. The water closet was at 27.2%, wash hand basin taps at 12.9%, and urinals at 8.4%.

Table 1: Daily water volume requirements per fixture

Sanitary Fitting	Daily Water storage rate in Litres (CIBSE Guide G)	Number of fittings	Daily Water demand by the fittings	Proportion of the Fitting's water demand to the estimated daily demand 90,750 Litres
Water Closet	180	137	24,660	27.2%
Wash hand basin-Taps	90	130	11,700	12.9%
Urinals	110	69	7,590	8.4%

Table 2: Annual water saving per selected fixture

Sanitary Fitting	Water usage volume in Litres for the specified Fitting	Water usage volume in Litres for Base-line fitting	% Water saving by the proposed fitting	Fitting's water demand per day (table 1)	Fixture's daily Water saving	Annual Water saving (Litres) (6 days per week)	Annual Water bill saving in Kshs (70kshs per 1000 Litres)
Water Closet	Smart flush valve with 3 Litres flush volume	Cistern fitting with 6 Litres flush volume	50%	24,660	12,330	3,846,960	269,287.20
Wash hand basin-Taps	Smart tap 5.7 Litres per minute for 10 seconds	Delay push button tap 5.7 Litres per minute for 20 seconds	50%	11,700	5,850	1,825,200	127,764.00
Urinals	Smart flush valve with 0.003 Litres per second volume flow	Cistern fitting with 0.008 Litres per second volume flow	40%	7,590	3,036	947,232	66,306.24

Rules, Regulations, and Standards

The rules, regulations, and standards of a plumbing system design are legal requirements set out by the NCA and related major bodies and authorities to ensure the proper performance, safety, sustainability, and reliability of plumbing systems. These elements must align with the relevant laws in Kenya and the global best practices. Under this category, our design focused on the safety, inclusivity, security, and efficacy of the plumbing system.

Inclusivity is a crucial plumbing system design aspect that looks into how accessible and usable the system is to all users regardless of their background, age, or capability. Article 27 of the Kenyan constitution under the Bill of Rights guarantees Equality and Freedom from Discrimination. Section 1 (C) of Article 54 of the Kenyan Constitution requires for the user-friendliness of public infrastructure to people living with disability.

According to the Persons with Disabilities Act no. 14 of 2003, clauses 21 and 22, persons with disability are entitled to a barrier- free and disability-friendly environment to enable them to have access to buildings, roads and other social amenities, and a proprietor of a public building shall adapt it to suit persons with disabilities.

In our plumbing design, the key component was ensuring inclusivity in the selection of sanitary fixtures therefore all the water closets were fitted with the Arabic showers and there was provision of people with disability (PWD) toilet fixtures in all washroom areas.

In addition, the Konza Technopolis design guidelines require the plumbing design for smart buildings to safeguard the safety and security of the users. These guidelines require all private and public buildings to harvest and provide on-site storage for feeding gravity building gray water systems.

Safety was guaranteed by ensuring that sanitary fixtures are made of impermeable, non-corrosive material, have a smooth non-absorbent surface and be constructed and fitted so as to discharge through a trap, into a soil pipe or waste pipe, as the case may be.

The Konza Technopolis sustainability design guidelines as well as The National Building Code section 244. (1) requires provision for rainwater harvesting in buildings. Rain water harvesting was considered for the building for water conservation purposes and to conform to Konza Technopolis design guidelines and the building code.

We aligned our design with the standards outlined by the KEBS and NCA. We met KEBS standards (KS EAS 12: 2014) in the delivery of clean water. By saving water through the technologies, we have explained earlier and using eco-friendly materials, we ensured that this plumbing system adhered to the NEMA's Environmental Management and Co-Ordination Act, 1999 (Act No 8 of 1999).

Our design strictly adhered to the environmental requirements and building standards in Kenya. It also aligned to the constitutional requirements on inclusivity and non-discrimination. The conformance to rules, regulations, and standards is key in the system compliance and approval.

Monitoring and Control

The plumbing system for a smart building should have monitoring and control capability covering maintenance efficiency and overall system performance. For instance, incorporating smart meters leads to higher water efficiency and increased longevity of the plumbing system.

According to Konza Technopolis guidelines, sustainability is captured in several ways. As a green field city, Konza's building codes will require a private or public building of any type/use to monitor its energy and utility consumption. This requirement will utilize solar photovoltaics, water and rainwater harvesting requirements. There was an overall enhancement in system maintenance in terms of efficient handling of issues and less likelihood of system disturbances or anomalies arising. Smart meters were part of the design for plumbing and smart appliances/fittings were used in the CCID building design.

On smart meters, the plumbing design is capable of closely tracking water consumption in the building in real-time, showing how the water is being used in different sections at any given time. The smart meters provide insightful data that can prompt reduction in water consumption in the building through improved consumption management. Regarding the water leak detection design, we used an automated system that can continuously check the pressure and flow of water in the building. Whenever the system detects any form of water leakage, it alerts the building management for response. This design will also potentially lead to a reduction in water wastage.

System Life Cycle Costs

This factor concerns the total cost of owning the plumbing system for smart buildings. The initial costs, operating costs, and maintenance costs are key in this respect. According to the Konza Technopolis guidelines on infrastructure energy efficiency, all new infrastructure, including but not limited to traffic lights, street lights, and water and wastewater pumps, should achieve a 15% annual energy reduction below an estimated baseline energy use for this infrastructure. The baseline is calculated with the assumed use of lowest first-cost infrastructure items.

We needed to identify the feasible plumbing system for the facility by analyzing whether an up-feed system or down feed system is suitable based on the lifecycle costs of each system. The design adopted the up-feed plumbing system arrangement (water boosted from underground tank to sanitary fittings) for the purpose of controlled and regulated supply to fitting at required pressure and flow. Booster pumps are demand driven (variable frequency drive/flow controlled) to minimize power use. This plumbing approach was guided by a lifecycle cost model developed which revealed the up-feed system to be marginally economical over the entire life of the system.

The total lifecycle cost for the up-feed water distribution system at Kshs 10,736,263.67 was marginally (11%) lower than that of the down-feed water distribution which was Kshs 11,898,932.12. The choice of up-feed system also conformed to the Konza Technopolis Architectural guidelines on the need for low pitch roof of maximum 2% which would not have been achieved with the roof storage tanks in place.

Building Program (Function/Use)

The quality and quantity of water in a smart building are critical design elements. The Konza Technopolis guidelines on the building program, though not directly, touch on the water quality and quantity to use. On water quantity, the guidelines require buildings and their systems to reduce water usage by 30% below the baseline through strategies such as plant species/density/ microclimate, irrigation efficiency (i.e.: drip).

An additional point can be achieved by reducing water consumption 50% through above strategies and including captured rainwater, reuse, recycled wastewater, use of water treated by a public agency, and use of non-potable water sources (storm water, foundation drain water etc.). The CCID building will provide a conducive environment to support interdisciplinary basic and applied construction related research as well as provide a hub for knowledge, technology transfer and research diffusion to the construction industry and other allied sectors.

With this in mind, our plumbing design incorporated both potable and non-potable water supplies. The potable water is from the mains supply with supplementary rainwater and recycled wastewater from Konza Technopolis.

Discussion

The factors considered in design of Plumbing System for CCID Smart Building are as in the figure 2 below:

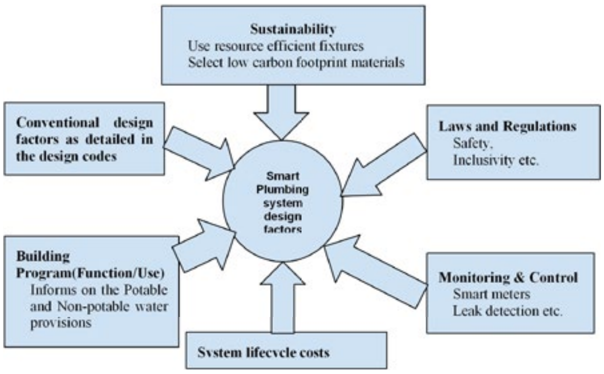

Fig 2: Factors Considered in design of Plumbing System for a Smart Building

The plumbing system design for the Center for Construction Industry Development (CCID) project in Konza Technopolis shows the need to adopt newer evolving standards that are an improvement to conventional plumbing standards. While the British Standards and other conventional standards for plumbing are robust, the increasingly complex requirements of smart buildings can make the application of these standards inadequate in some aspects.

Conventional standards emphasize on the performance, safety, and other basic requirements of plumbing systems, leaving out factors that are key for complex smart buildings, for example. Take the case of BS 6700:2006 and the design specifications as defined in the 2018 International Plumbing Code (ICC, 2017) which are silent on the integration of **monitoring and control** elements like **smart metering and water leak detection systems in design of plumbing systems.** Conventional building standards focus on routine maintenance. We see a shift in the plumbing system for the CCID, where smart technologies would encourage the **predictive** maintenance concepts.

The CCID project goes ahead to demonstrate technologies that enhance **sustainability** in plumbing systems. Enhanced sustainability through optimized water consumption is evidenced through the use of resource-efficient fixtures. Conventional standards like BS 6700:2006., BS EN 806-2-2005 and 2018 International Plumbing Code (ICC, 2017) have no information on the application of adjustable water flow in smart taps and other resource efficient fixtures. The choice of materials according to these conventional standards is solely on the conventional factors such as functionality and safety. They do not consider the criticality of carbon footprint in materials.

According to the triple constraint theory as in the Edwin Njoroge, & Muchelule Yusuf. (2020) study, Cost is one of the three critical factors of any project/system. As determined in our research, cost should not be constrained to the installation. This factor extends to the entire lifecycle of the project, in what is called the lifecycle cost of the system. Like for any other system, the plumbing system design should be assessed on the basis of the life cycle cost. Conventional standards like BS 6700:2006., BS EN 806-2-2005 and 2018 International Plumbing Code (ICC, 2017) are silent on the **system life cycle cost** element. Our plumbing system design for the CCID project applied the lifecycle cost analysis, settling on the upfeed water distribution system because it was 11% more affordable.

On **laws and regulations**, there are emerging requirements across system designs, ranging from inclusivity and safety to security and efficacy of the system. A plumbing system in a smart building should adhere to the respective Kenyan laws and KOTDA guidelines. The BS 6700:2006., BS EN 806-2-2005 and 2018 International Plumbing Code (ICC, 2017) are not explicit on these aspects of the design, for instance on the use of Arabic showers and inclusion of People with Disability (PWD) fixtures in the design.

Such gaps need to be addressed to serve the dynamic nature of plumbing systems in smart buildings such as the CCID. There is need for plumbing standards that incorporate the role and relevance of advanced technologies such as leak detection and smart taps. As new smart cities emerge and buildings such as the Center for Construction Industry Development (CCID) project in Konza Technopolis come up, there is a growing need for plumbing design standards that accommodate innovative solutions such as resource-efficient fixtures and real-time water monitoring.

Conclusion

The CCID project in Konza Technopolis has reiterated the need to improve existing plumbing design standards to align with the needs of smart buildings. Yes, BS EN 806-2:2005, BS 6700:2006 and other existing standards cover important aspects such as functionality and safety, but they are inadequate for emergent building requirements such as sustainability and advanced technologies.

Notable gaps for plumbing system design factors are the lack of lifecycle cost analysis and low carbon footprint materials. There are also no provisions for leak detection, smart metering, and resource-efficient fixtures. Therefore, design of plumbing systems for smart city buildings need to consider other factors beyond the conventional standards as identified in this paper.

As we immerse ourselves in the new era of advanced urban development, engineers have a critical role in making smart cities a reality. The infrastructure in smart cities has its unique demands, including advanced plumbing design. As seen in the case of the CCID project in Konza Technopolis, it is possible to meet these demands by adhering to the factors outlined.

Acknowledgement

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(Photo Courtesy)

The Role of Tractors in Modern Agriculture from Global Icons to Kenya's Fields: Ford and Massey Ferguson

By Joseph Anvar Alot
Policy Research and Partnerships Manager, IEK

Early Experimental Tractors and Newer Version

The tractor is not just a piece of machinery. It is agriculture's most transformative invention. An engine that replaced centuries of backbreaking labor with mechanized power. With every turn of its wheels, the tractor shortens farming cycles, improves yields, and underpins modern food security. Today, tractors are so central to agriculture that their absence in a farming system almost guarantees low productivity. Yet their journey from the smoke of early steam engines in Europe to the maize fields of Kenya tells a remarkable story of engineering innovation, adaptation, and resilience.

From Steam to Steel. A Short History of the Tractor

The first tractors emerged in the late 19th century as steam-powered traction engines. Heavy and cumbersome, they were more akin to locomotives than farm tools. Their immense weight compacted soil, they consumed vast amounts of water and fuel, and they required skilled operators. Despite their inefficiency, they marked the beginning of mechanized agriculture. The breakthrough came with the internal combustion engine in the early 20th century. Smaller, lighter, and far more efficient, petrol and later diesel tractors made mechanization practical. In 1917, Henry Ford introduced the Fordson, the world's first mass-produced tractor. Just as the Model T democratized the car, the Fordson made mechanization affordable for the ordinary farmer. By mid-century, Harry Ferguson's invention of the three-point hitch later incorporated into the Ford 8N, revolutionized tractors again. The hitch allowed implements to be safely and efficiently attached, creating a flexible and standardized system that remains the global norm.

Meanwhile, Massey Ferguson, formed in 1953, became another engineering powerhouse. Its rugged machines, notably the MF 35, 135, and 165, earned a reputation for durability, adaptability, and simplicity. They could be repaired in village workshops, handled diverse implements, and delivered reliable performance even in harsh conditions. These engineering innovations turned tractors into indispensable, multipurpose farm tools.

Inside the Machine-The Engineering of Tractors

For engineers, the tractor is a masterpiece of applied mechanics. Its power comes from an internal combustion engine, most commonly a four-stroke diesel unit, which delivers high torque at low revolutions per minute, a necessity for heavy pulling. The engine's output is transmitted through the powertrain: a system of clutch, gearbox, differential, and final drives. The clutch regulates engagement, the gearbox controls torque and speed, and the differential allows wheels to rotate at different speeds when turning. Together, they provide precise control for operations ranging from slow ploughing to rapid haulage. One of the tractor's most critical innovations is the Power Take-Off (PTO) shaft, which transfers rotational energy to implements. At standardized speeds of 540 or 1000 rpm, the PTO allows tractors to operate sprayers, harvesters, mowers, and balers. In effect, the PTO transforms the tractor into a mobile power unit capable of running an entire suite of farm machinery. The hydraulic system powers the three-point hitch and other linkages, allowing tractors to lift, lower, and control mounted implements. Steering systems, ranging from basic mechanical to advanced hydrostatic, give maneuverability even in tight field conditions. Safety is ensured by the braking system, typically a combination of foot-operated service brakes and hand-operated parking brakes, with modern models including braking on all four wheels.

These subsystems, engine, powertrain, PTO, hydraulics, steering, and brakes work as an integrated whole, embodying engineering precision designed to withstand continuous heavy-duty use.

The African Journey of Tractors in Kenya

Tractors entered Africa through colonial farming estates, primarily for large-scale cash crop production. Post-independence, the challenge became how to adapt mechanization to smallholder farming systems that dominate African agriculture.

In Kenya, tractors were initially concentrated in the Rift Valley's commercial farms. Over time, county governments, cooperatives, and private entrepreneurs began to extend tractor services to smallholder farmers. Unlike in Europe or North America, where individual tractor ownership is common, Kenya's model is often mechanization-as-a-service farmers hire tractors during peak planting and harvesting windows.

This model makes sense economically: over 70% of Kenyan farmers cultivate less than three hectares, making outright tractor ownership uneconomical. Yet with access to hire services, they benefit from timely ploughing, reduced labor costs, and increased yields.

Ford and Massey Ferguson tractors dominate because they strike a balance between durability, availability of spare parts, and ease of repair. In rural Kenya, a tractor's true value is measured by uptime, not horsepower, and these brands offer proven reliability.

Makueni County provides a strong example of how counties can integrate mechanization into agricultural transformation. While the county is widely recognized for its fruit processing plant, it has also invested in tractor hire services to support smallholder farmers. In a semi-arid region where rainfall is unpredictable, the ability to prepare land quickly after rains is critical. Makueni's county-supported tractor services have enabled farmers to reduce the time between rainfall and planting, improving harvest reliability. Coupled with cooperative-led management, these tractors have become shared community assets rather than underutilized private machines. The Makueni model illustrates how counties can use mechanization not just to increase yields, but also to strengthen value chains from production to processing ensuring that agriculture contributes more meaningfully to rural economies.

Besides Makueni, several other counties across Kenya are heavy in agriculture and play a critical role in feeding the nation. In the Rift Valley, Uasin Gishu and Trans Nzoia are considered the country's grain basket, producing large volumes of maize and wheat alongside dairy farming, while Kericho, Bomet, and Nandi thrive in tea production, maize, and livestock. Nakuru is well-known for potatoes, pyrethrum, cereals, and dairy, further cementing the region's role as Kenya's food hub. In Central Kenya, Murang'a, Nyeri, Kirinyaga, and Kiambu lead in coffee, tea, rice, dairy, horticulture, and emerging avocado exports, while Meru and Embu in Eastern Kenya contribute through miraa, coffee, macadamia, and bananas. Western counties such as Kakamega and Bungoma dominate sugarcane and dairy, Kisii and Nyamira excel in bananas, tea, and coffee, while Migori and Siaya combine sugarcane, maize, and fishing. At the Coast, Kilifi and Kwale focus on coconuts, cashew nuts, and horticulture, while Taita Taveta produces bananas, horticulture, and livestock through irrigation farming. Across all these regions, tractors and mechanization are transforming agriculture by reducing reliance on manual labor, increasing efficiency in land preparation, and enabling farmers to expand cultivation, thereby boosting yields and food security.

Tractors and Devolution

Looking ahead, counties across Kenya have an opportunity to strengthen agricultural mechanization as part of their devolution journey. County-managed tractor hire schemes can provide affordable access to smallholder farmers who may not have the means to own machinery, while public–private partnerships with established tractor brands such as Ford and Massey Ferguson can ensure a steady supply of durable models, alongside training and maintenance support. Youth groups and SACCOs can be engaged to manage tractor fleets, creating employment and enhancing accountability in service delivery. At the same time, digital platforms and mobile apps can be used to schedule services more efficiently, ensuring farmers receive timely support during critical planting and harvesting windows. Together, these measures would allow counties to harness mechanization in driving Kenya's food security agenda within the devolved governance framework.

How Tractors Have Revolutionized the Food System

The impact of tractors on agriculture is measurable and profound. They reduce the time required for land preparation by up to 70%, improve planting precision, and increase yields significantly. Beyond field operations, tractors also provide crucial logistics support—transporting harvests, inputs, and even construction materials in rural areas. Mechanization also reduces drudgery, allowing rural labor to shift toward higher-value activities such as irrigation management, post-harvest handling, and agribusiness. With the adoption of conservation implements like subsoilers and rippers, tractors contribute to soil and water conservation practices essential for sustainable farming in fragile ecologies.

Why Ford and Massey Ferguson Still Lead in Kenya

Ford's legacy, from the Fordson to the 5610 and 6610 series, lies in building durable, fuel-efficient machines with simple designs that Kenyan mechanics can repair easily. Through New Holland, the Ford DNA continues in modern models that balance performance with accessibility. Massey Ferguson's MF 135, 240, 375, and 385 models, on the other hand, have become synonymous with Kenyan farming. Affordable to run, adaptable across different farm sizes, and backed by a strong spare-parts network, they remain the workhorses of both county hire schemes and private contractors. For Kenyan farmers, the choice is not simply between red and blue, but between tractors with proven track records of uptime, serviceability, and return on investment.

The global tractor industry is moving toward electrification, automation, and data-driven farming. In Kenya, while electric tractors may be some years away, digital integration is already becoming relevant. Fleet management software, GPS guidance, and predictive maintenance systems are emerging, making mechanization more efficient and accountable. The trajectory is clear: tractors in Africa will remain diesel-powered for the near future, but increasingly data-enabled, ensuring better service delivery, reduced downtime, and more sustainable use of resources.

The tractor is more than an agricultural machine; it is an engineering achievement that has reshaped societies. From Ford's early mass-production models to Massey Ferguson's rugged icons, tractors have provided farmers with the most critical input of all: control over time. In Kenya's devolved governance era, tractors are also policy tools, linking county strategies to farmer outcomes. Whether ploughing Makueni's semi-arid fields or hauling maize in the Rift Valley, tractors continue to be the silent drivers of Kenya's food security and rural transformation. For engineers, they stand as enduring proof of how design, mechanics, and innovation can intersect to solve humanity's oldest challenge: feeding itself.


(Photo Courtesy)

Refrigeration Revolution: Rural Food Processors Powered by Solar-Powered Coolers

By IEK Correspondent

The most promising way to overcome the energy market's volatility and surpass the slow grid expansion is through renewable-powered cooling, which provides a workable solution to the cooling-food-energy nexus and increases the viability of agribusiness's economic growth. Perishable produce can be stored and distributed, rural communities can be empowered, and food waste can be decreased for the benefit of producers and consumers by using renewable energy sources like solar and wind to power cooling.

According to The Global Energy Alliance for People and Planet (GEAPP), one of the biggest challenges they aim to solve is the reliance on costly and polluting diesel generators, which are often the only option for refrigeration in off-grid areas. The World Bank further estimates that smallholder farmers, many of whom lack access to the electrical grid, produce 75% of the agricultural output in sub-Saharan Africa. Therefore, if farmers have access to refrigeration, they frequently rely on pricey diesel-powered cold storage.

Solar-refrigeration systems' technical features

Photovoltaic (PV) panels, which turn sunlight into electricity, a storage battery to store extra energy, and the cooling unit itself make up the majority of solar refrigeration systems. Since it determines performance in different atmospheric conditions, these components' efficiency is crucial.

SunDanzer, for example, is a company that has created a portable cooling system on a small scale specifically for the Kenyan dairy industry. The system consists of a photovoltaic refrigerator (PVR) that cools a chest refrigerator using solar power. This technology can store energy in the form of a battery, phase-change materials (substances that can store and release large amounts of energy), or a combination of the two. Freezing phase-change material into "milk packs" is evaluated by SunDanzer. Farmers use the portable milk packs to keep collected milk cold in sterile aluminium milk containers while they transport it to dairy processing facilities in the morning because they maintain their cold temperature throughout the night.

Why employ refrigeration powered by solar energy?

- Economic impact: Over time, solar-powered refrigeration can result in significant cost savings. The operational savings become apparent as fossil fuel usage is decreased and electricity costs are eliminated, even though the initial investment may be substantial.
- Social impact: Improving food security and availability has a significant effect on the community. Perishables that are regularly preserved improve food safety and nutrition, two important aspects of public health.
- Impact on the environment: In addition, these systems increase resistance to environmental threats. Communities that use solar refrigeration become less vulnerable to fluctuations in energy prices by reducing their dependence on non-renewable resources.

Adoption-related obstacles

Notwithstanding the alluring advantages of solar refrigeration, a number of obstacles prevent its widespread use. Many people who live in remote areas with low incomes may find the initial costs of the technology intimidating. Many communities may not be able to take advantage of these systems because of the entry barrier caused by this financial burden.

Additionally, knowledge of system maintenance and technological literacy are still required. Premature system failures and the loss of solar refrigeration investment could result from community members lacking the skills necessary to operate and maintain such systems. For these technologies to be sustainable and successfully incorporated into community practices, education and training initiatives must be implemented alongside their installation.

Conclusion

These systems can improve food security in isolated areas by utilizing renewable energy, guaranteeing that communities have access to safe and fresh produce. Solar refrigeration stands out as the world shifts to sustainable solutions in many areas because of its many benefits, which range from improving environmental health to improving economic conditions.

Investing in solar technologies can also help areas that have historically been left out of energy supply chains make the transition to energy independence. The possible effects on nearby communities are still significant, even though the obstacles related to expenses and upkeep need to be resolved. Sustained support for the advancement of solar energy can result in extensive educational programs that enable people and communities to make efficient use of this technology and guarantee that they are prepared to maintain and run these systems in the long run.

Encouraging this paradigm change will be crucial to creating resilient, self-sufficient communities that are ready to prosper in the face of global issues like climate change and food security. Every sphere of society should support and invest in this endeavour.

How Smarter Transportation Can Save Perishable Produce

By IEK Correspondent

Introduction

As the world grapples with climate change, rising populations, and food insecurity, one question persists: ***"How can we ensure that the food we grow reaches our tables in good condition?"***

Fruits, vegetables, meat, and dairy products are among the most vulnerable perishable foods. A fresh harvest can become a financial loss due to a small delay, a malfunctioning cold room, or a truck with inadequate insulation; And that is an expense we cannot bear in a nation where millions of people already suffer from hunger.

Globally, 30% to 40% of perishable food is lost after harvest. Most of the loss occurs during storage and transportation. In Kenya, it is even higher, with more than 40% of perishables never making it to the consumer. This is not only a food problem but also an energy, climate, and human problem.

The good news? There is a solution, and it lies in engineering smarter, cleaner, and more reliable transport systems for our food.

Smart solutions from the field

Engineers and innovators are stepping up all over the world. Close to five litres of diesel is now saved daily in South Africa by solar-powered refrigerated trucks with battery backups and ingenious insulation, and they pay for themselves in less than two years. Elsewhere, particularly in Europe and Asia, AI-powered logistics systems are being used to optimize delivery routes and reduce the energy needed to keep food fresh. These smart systems not only save fuel but also help maintain ideal temperatures, reducing spoilage on the go. There is also the use of smart packaging: tiny sensors in crates and pallets that monitor freshness, temperature, and humidity in real-time. Studies from TransportWorks and arXiv show that when this data is connected to a logistics network, food loss can drop dramatically.

The cold chain challenge

The lack of adequate cold chains, systems that keep food chilled from the farm to the market, is a major contributor to food waste and rising emissions in much of sub-Saharan Africa and parts of Asia, according to a recent Food and Agriculture Organization (FAO)-United Nations Environment Programme (UNEP) video.

Less than 10% of perishable food is lost in wealthier nations like the United States of America and Germany because of robust cold chains. However, food frequently deteriorates before it even reaches the market in places like Kenya, where refrigeration is sporadic and diesel-powered trucks predominate.

A promising cold storage project in Rwanda failed because of inadequate operator training, unstable energy, and poor technical alignment. It is imperative for countries investing in cold chain infrastructure to consider its long-term sustainability.

Kenya's cold chain awakening

In Homa-Bay County, the UNEP partnered with farmers to roll out an off-grid cold room powered by solar energy and backed by ice-based thermal storage. Since its launch, the community has seen post-harvest losses drop by over 30%, especially for fish and vegetables.

Up in Kiambu County, the Africa Centre for Sustainable Cooling and Cold-chain (ACES) is piloting a community hub model. Farmers there can access refrigerated trucks, solar storage, and even training in best practices for handling perishable produce. Importantly, everything is traceable, from the farm gate to the market.

Meanwhile, private companies like Cold Solutions Kenya are stepping in. At their facility in Tatu City, smallholder farmers can rent cold storage space or hire reefer trucks as needed. This is a game changer for producers who once relied on open pickups or boda bodas.

Many rural areas are, however, facing significant challenges since reliable electricity is still a problem and there is a shortage of cold-chain technicians. Additionally, without external support, startup costs for small businesses can be high.

Engineering a more secure future

This is the intersection of food engineering and practical applications. Future food security in Kenya hinges on both what we can grow and what we can preserve.

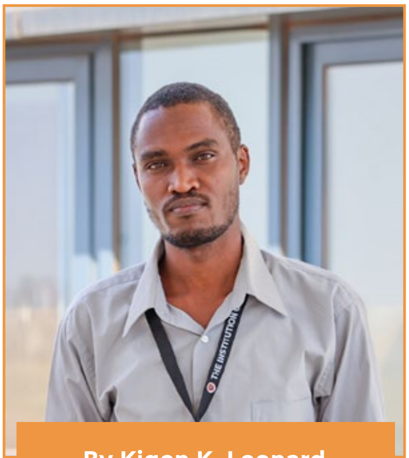
Increasing harvests is not enough; we also need to protect them. This entails making investments in items such as:

- Smart insulation
- Energy-efficient refrigeration
- Decentralized cold storage
- Internet of Things system that track freshness and alert handlers in real-time

There is, however, more to sustainable cold chains than just coolers and trucks. The goal is to provide rural farmers with better markets in an equitable manner. They also relate to nutrition, ensuring that fresh food maintains its quality. Additionally, they focus on reducing carbon emissions and waste in the face of climate change.

The road ahead

Both Kenya's Vision 2030 and the Agriculture Transformation Strategy focus on the need for post-harvest management and climate-smart practices. However, turning strategy into action takes more than policy; it takes engineering. We need to scale up solar-powered refrigeration, invest in smart transport, and train the next generation of cold-chain specialists (the engineers, technicians, and logistics experts) who will build the backbone of Kenya's food system.



By Kigen K. Leonard
Graduate Mechanical Engineer
Assistant Publications Officer, IEK

Smart Dairy: The Future of Milk Handling and Processing

Introduction

Food engineering in the context of dairy involves the application of principles—mechanical, biochemical, thermal, digital—to transform raw milk into safe, nutritious, and desirable products.

In Kenya, Small scale famers contribute over half of national milk production.

Food engineering innovations helps to unlock opportunities for post-harvest loss reduction, safety enhancement, and value addition. These technological strides both respond to local challenges and signal a broader transformation in dairy value chains.

Kenya produces approximately 5.8 billion liters of milk as of the year 2023, around 5 billion from five million dairy cows. However, at that time only about 40% of the milk underwent value-adding processing, with the rest sold raw in informal markets

Milk spoilage, and lack of cooling infrastructure mean farmers lose up to 30% of product before it reaches markets.

In the capital city of Kenya, Nairobi, it's believed that 90% of the milk being consumed by the residents has undergone some sort of adulteration. To address these challenges, Kenya's Ministry of Agriculture aims to increase value-addition to 60% by 2025 through improved processing capacity and machinery access.

Milk Pasteurization & Cooling Innovations

This refers to use of controlled temperatures such as use of solar powered heaters for the small-scale farmers. This process creates a uniform heating, and offers LED guides and temperature sensors to ensure proper pasteurization. This allows farmers have reduced spoilage, longer shelf life, and better prices on treated milk

Most milk processing industries in the Kenyan milk processing sector manufactures 50–500 litres pasteurizers and chillers for cooperatives, operating on electricity, LPG, steam, or biogas. Some units have solar cooling options for off-grid regions. These innovations embody system engineering: thermal control, logistics optimization, IoT integration, and financial transparency.

Packaging Machines and Systems

This marks the final phase in the production of milk and its by-products. Before packaging, the milk must first be approved by the Quality Control (QC) department to ensure it meets high quality standards.

At the beginning of the packaging process, thorough inspections are conducted—this includes checking the integrity of seals, date labeling, and packet quality. All findings are documented for traceability purposes.

Quality Control personnel collect product samples for both microbiological and chemical analysis. Some of these samples are stored at room temperature, while others are kept in cold storage, replicating the same conditions under which the milk is stored for market distribution. These samples are closely monitored throughout the product's shelf life to ensure ongoing quality and safety. The machines used for packaging of milk are;

Filpack Machines

These are machines which pack milk in polyethylene packaging paper. There are various brands of packs namely; Gold Crown pack which is yellow in colour, KCC Fresh pack which is green in colour. The packs are in sizes of 200 ml and 500 mls.

In the process of packaging the expiry date of the product, code of the machine and the operator's code are all printed on the packs for traceability.

Filmatic Machines

These are machines which package milk in plastic bottles of 1 liter, 2 liters, and 3 litres; the milk is of various brands.

Nimco Machines

These machines pack fresh milk and fermented products in brik packs. For Fresh milk; it is packaged in 500 ml and 1000 ml packs and for Fermented products; it is packaged in 250 ml and 500 ml packs.

Fermentation Tanks & RO Water Treatment

Kenyan suppliers provide fermentation tanks calibrated for yogurt, cheese, and probiotic drink processing—ensuring consistent texture and flavors. They also supply reverse osmosis (RO) water systems (500–2,000 LPH) to ensure that water used in dairying is free from contaminants.

Yogurt & Ice Cream

Engineered fermentation using controlled tanks ensures consistent probiotic yogurt, flavored milk, and sour milk (Mala). Engineering controls of temperature, pH, and fermentation time ensure product safety and sensory appeal. Yoghurt-cap filling machines streamline packaging for retail and cooperative sales.

Ice Cream

While dominated by large players like Brookside (which produces UHT milk, yogurt, butter, ice cream, and ghee across East Africa). Food engineering here supports local formulations (including lactose-free and vegan options), small-batch freezing, stabilizer systems, and hygienic handling.

Sustainability & Circular Economy

Many processing units now use solar, biogas, LPG, or steam power, mainly industrial boilers thus reducing dependence on costly grid electricity, especially in off-grid rural areas. These sustainable innovations lower operational costs and carbon footprints.

Packaging & Plastic Waste Reduction

Milk ATMs (dispensing units) enable consumers to refill reusable containers via pressurized hygienic systems. This reduces single-use plastics and packaging waste, while improving affordability and access

Advantages of Milk Processing and its Impacts on Economy & Health in Kenya

i. Greater income for farmers: Processed milk (fermented or pasteurized) fetches up to KSh 90/L, compared to raw milk at ~KSh 45/L

ii. Reduced wastage and spoilage, through chilling, pasteurization, and logistics innovation.

iii. Improved public health, via safer milk supply with pathogen reduction and adulteration prevention.

iv. Economic empowerment for smallholder farmers and cooperatives through new valueadded income streams.

v. Environmental benefits, including reduced plastic waste and adoption of renewable energy solutions.

Key Dairy Infrastructure	Number	Percentage of Total (Where Applicable)
Processors >20,000L/day	24	48% of defined-capacity processors
Processors <20,000L/day	26	52% of defined-capacity processors
Mini Dairies	238	-
Cottage Operations	278	-
Cooling Plants >5,000L	185	27% of cooling plants
Cooling Plants <5,000L	502	73% of cooling plants
Dairy Cooperatives	862	-

Source: Farmerstrend.Co. Ke and Kenya Dairy Board

Challenges in the milk Processing industries

i. High upfront cost of equipment, though pay-as-you-go financing, staged installations, and NGO outreach help mitigate this

ii. Technical training: many farmers need training in hygiene, equipment maintenance, and operation.

iii. Regulatory frameworks: the Dairy Industry Bill (2024) is pending, with aims to standardize safety, quality control, and traceability across the value chain

iv. Adoption speed: smallholders may resist technology uptake without demonstration of clear benefit and ease of use.

Conclusion

Food engineering helps to reshape Kenya's dairy industry—from collection to cooling, pasteurization to packaging, data capture to product innovation. Through scalable technologies like Milk ATMs, portable pasteurization, digital farm tools, and energy-efficient processing systems, Kenya is moving from raw-milk reliance toward processed, safe, and nutrition-rich dairy products.

Key goals—to increase value addition from ~40% to 60%, reduce losses, and double production to 10 billion litres—are well supported by these engineering solutions. Continued collaboration between government, universities, tech startups, cooperatives, and donors will be vital to scale advancements, train users, and enforce standards. Over the coming decade, the fusion of food engineering and dairy innovation positions Kenya to become a vibrant hub of dairy transformation, with improved incomes, enhanced food safety, expanded product diversity, and stronger economic resilience.

Kigen K. Leonard is a graduate mechanical engineer with a strong foundation in engineering principles and a forward-looking focus on innovation across the engineering, and energy. His professional interests also extend to agricultural research and livestock production, driven by a strong passion for advancing technology in food and energy systems to support rural development and food security.

Currently serving as the Assistant Publications Officer at the Institution of Engineers of Kenya (IEK), Kigen has successfully overseen the publication of 15 editions of engineering journals since 1st January, 2023. Through this role, he has contributed significantly to the dissemination of technical knowledge and the promotion of engineering excellence.

Aquaculture and Fish Farming Technologies:
Examining the Role of Engineering in Sustainable Aquaculture, including innovations like motorized boats, feeding systems and water quality management

By IEK Correspondent

A report by World Wide Fund for Nature Kenya (WWF-Kenya) puts the number of people dependent on small-scale fisheries at 2.5 million. This number includes the fishermen themselves, fish traders, processors, and their families, as well as those involved in peripheral activities within the fisheries sector. This report alone demonstrates how small-scale fisheries are crucial for livelihoods, food security, and economic sustenance. If done correctly, aquaculture can easily be a major source of food to sustain our country's growing population. Aquaculture goes well beyond fish farming, as it also incorporates shell fish and aquatic plants farming in a controlled environment.

Aquaculture in Kenya: Status and Challenges

Aquaculture in Kenya can be categorized into two broad divisions, that is, freshwater aquaculture and mariculture. Freshwater aquaculture can further be categorized into warm fresh water aquaculture which focuses on tilapia farming and cold fresh water aquaculture whose dominant species in the rainbow trout. Earthen and lined ponds, dams, and tanks form the bulk of the Kenyan aquaculture systems. Cage culture is an emerging type of aquaculture that involves farming fish in mesh enclosures that are suspended existing water bodies. The cages make use of the free-flowing water current for oxygen and waste removal.

While freshwater aquaculture has progressed over the years as compared to mariculture, it still grapples with unique challenges which inhibits production. One such challenge is the low pond productivity which is usually as a result of low-quality seeds. Most people are only beginning to wake up to the potential of aquaculture, hence it is a relatively new venture, but despite this willingness, they lack statistical data to guide them. While there are training and extension opportunities, there is still a need for information dissemination and technology transfer to farmers backed by research unique to their aquaculture methods and systems. On top of the technical know-how, farmers need credit services and there is a general need for change of perception of aquaculture which is not yet believed to be a profitable enterprise.

Examining the Role of Engineering in Sustainable Aquaculture

The most basic role of engineers is to find lasting solutions to the world's problems. Dwindling food supply to an ever-increasing world population is an emerging problem the world now faces and well-engineered and optimized aquaculture may just be the answer to the food security challenge. Not only is it cost-effective as compared to dairy and poultry farming, but fish are also an excellent protein source. Fish also tend to mature much faster. Engineering plays a huge role in sustainable aquaculture when it comes to design, construction, and maintenance of systems that support fish farming and ensures high yields.

Motorized Boats

Some of the things that have negatively shaped the perception of traditional fish farming is its labor-intensive nature. Coupled with little to no technical backing and unorganized feed distribution, which results in high costs, many prospective investors struggle to see it as a worthwhile investment. Motorized boats put these issues to rest, the automated ones especially, are highly efficient and can deliver feed at allotted times. They are especially important for large farms and offshore cages. Motorized boats come in different types and functionalities like automated feeding, transport, cleaning and maintenance vessels.

Feeding Systems

Most fish species have specific dietary requirements. Aquaculture feeding systems innovations now incorporate precision feeding systems that administer fish feed in multiple doses at scheduled times throughout the day. These systems are highly efficient as they do not need the farmer to personally distribute this food especially when the farm is large.

Water Quality Management

Water management is one of the key components of an effective water culture system. Aquatic organisms tend to be very particular about the environment that they grow in. Engineers come up with systems that monitor factors such as water temperature and pH, oxygen and ammonia levels. Factors such as water salinity greatly determine overall fish health, therefore engineers need to constantly ensure that these parameters are optimal to prevent fish stress, and in the worst-case scenarios, fish mortality.

Conclusion

Aquaculture has a great potential to be a key food security, job creation and environment sustainability driver. Engineering innovations play a critical role in achieving these goals by reducing production costs, improve efficiency, and enhancing the economic viability of aquaculture operations, making them more sustainable and profitable.

By Michael Waweru, MPRSK
Marketing and Communications Officer, IEK

The Silent Crisis of Why Kenya's Food System is a National Security Risk

Every day, millions of Kenyans eat food whose journey they cannot trace. From the farm to the market stall, there are often no records of where it came from, how it was handled, or whether it met basic safety standards. In a good year, this invisibility goes unnoticed. In a bad year, it can become a national crisis.

In 2004, this gap in knowledge killed 125 Kenyans and made hundreds more seriously ill after they consumed maize heavily contaminated with aflatoxin, a poisonous chemical produced by mold that grows in damp grain. Some samples of maize sold in local markets were found to have aflatoxin levels as high as 46,400 parts per billion, which is thousands of times above the safe limit set for human food (10 parts per billion).

The tragedy wasn't just that the maize was contaminated. It was that no one knew where the bad grain came from or where it had gone. Like a disease spreading through an invisible network, the poisoned maize circulated through markets across the country while authorities scrambled in the dark, unable to trace its path or stop its spread.

The Three Faces of Food Danger

Kenya's food system faces threats that most people never think about, but every engineer would recognize as classic system failures:

Equipment failure equivalent: Natural contamination, like the aflatoxin that devastated Kenya in 2004. When maize isn't dried properly or stored in humid conditions, microscopic molds move in like squatters in an abandoned building. They multiply rapidly and produce toxins that cause liver cancer and stunt children's growth. It's a predictable failure mode that happens when the right conditions align: heat, moisture, and poor storage.

Operator error equivalent: Food adulteration and shortcuts. When proper equipment fails, say, when there's no refrigeration some operators resort to dangerous workarounds. Think of traders using bleaching agents to make rotten meat look fresh using sodium metabisulfite commonly known as "dawa ya nyama", or adding formaldehyde (yes, the stuff used to preserve dead bodies) to fish to keep it from spoiling. It's like bypassing safety systems to keep a machine running it might work short-term, but the long-term consequences are catastrophic.

Malicious attack equivalent: Deliberate contamination

Just as hackers infiltrate digital systems, bad actors could target food networks. Imagine someone intentionally poisoning grain silos or introducing harmful chemicals into milk processing plants. Without proper monitoring and tracing systems, such attacks could cause massive damage before anyone realizes what's happening.

This is not theoretical. In the 1960s in Japan, powdered milk and candies were deliberately poisoned with arsenic, killing children and eroding public trust in national food systems.

The lesson is clear: **a food chain is as vulnerable as a computer network.** A single breach at the wrong node can ripple into mass casualties, economic disruption, and national panic. In a country where maize silos and milk tankers move daily without tamper-proof safeguards, the potential impact is enormous.

The Engineering Problem: No System Monitoring

Any engineer who is worth their salt knows that complex systems need monitoring. You can't manage what you can't measure, and you can't fix what you can't find. Yet Kenya's food system operates like a factory with no gauges, no alarms, and no way to trace problems back to their source.

This isn't just a theoretical concern. In well-monitored systems like those in Europe and America, when contaminated food is detected, authorities can quickly identify exactly which production batch is affected, trace it back to its source, and forward to see where it's been distributed. The response is surgical remove the bad product while leaving everything else untouched.

Without this capability, Kenya faces the equivalent of having to shut down an entire power grid when just one transformer fails. When food contamination is discovered, authorities often have no choice but to ban entire categories of products or shut down whole supply chains, punishing innocent farmers and traders along with the guilty parties.

The Missing Foundation: Small-Scale Producers

Here's where Kenya's challenge gets interesting from a systems perspective. Over 70% of the country's food comes from smallholder farmers, people working plots that might be smaller than a typical factory floor. These aren't industrial operations with quality control labs and computer systems. They're individual operators, often working with basic farming tools and limited resources.

But here's the thing: any engineer knows that a system is only as strong as its weakest component. If you're building a monitoring network and 70% of your inputs come from unmonitored sources, your entire system is compromised from the start.

The solution isn't to replace these small producers they're the backbone of the food system and often more efficient per acre than large operations. Instead, the challenge is designing a monitoring system that can integrate thousands of small-scale inputs without overwhelming them with complexity or costs.

Think of it like designing a sensor network where most of your sensors have limited power, processing capability, and connectivity. You need lightweight solutions that can operate in harsh conditions and aggregate data effectively.

Designing for Kenyan Conditions

This is where the engineering gets creative. You can't just copy a system designed for different conditions and expect it to work. Kenya's food networks operate differently from European or American systems. Instead of products moving through refrigerated trucks on highways, you might have produce traveling by bodaboda through dusty rural roads. Instead of centralized processing facilities, you have thousands of small operations scattered across the countryside.

The Security Engineering Perspective

From a national security standpoint, food systems are critical infrastructure, just like power grids or communication networks. A successful attack on the food supply could cause more casualties and economic damage than many conventional threats.

Consider the scenario analysis: If contaminated grain were to enter storage facilities serving major urban areas, or if chemicals were introduced into dairy distribution networks, the impact could be devastating. Without traceability systems, the response would be chaotic, and authorities would struggle to contain the threat, leading to widespread panic and potentially catastrophic economic consequences.

But with proper monitoring in place, even a deliberate attack becomes manageable. The system can quickly isolate the affected products, trace the contamination source, and communicate targeted warnings to the public. It's the difference between a controlled shutdown and a system-wide failure.

Communication as a Control System

Here's something that might not be obvious: traceability isn't just about collecting data it's also about how you communicate when problems are detected. This is like designing alarm systems that provide useful information rather than just panic.

The communication protocol needs to be as carefully engineered as the monitoring system itself:

- **Precise messaging:** Instead of vague warnings that could trigger mass panic, provide specific actionable information exactly which products to avoid, how to identify them, and what to do if you've already consumed them.
- **Multi-channel distribution:** Use every available communication method: radio, TV, SMS, social media, local community networks to ensure the message reaches both urban tech users and rural populations who might rely on word-of-mouth.
- **Feedback loops:** Monitor how the public responds to warnings and adjust the communication strategy accordingly, just like tuning a control system based on system response.
- **Proportional response:** Scale the communication intensity to match the actual risk level, avoiding both underreaction and over-reaction.

The Bottom Line

Kenya stands at a critical decision point. The current approach, essentially running a complex system with no monitoring or control mechanisms, leaves the country vulnerable to both accidental failures and deliberate attacks. The 2004 aflatoxin outbreak was a preview of what can go wrong when systems operate without proper oversight.

But the opportunity is equally clear. A well-designed traceability system could transform Kenya's food sector from a liability into a strategic asset. Kenyan smallholder farmers could access premium export markets by proving their products meet international standards. Consumers could buy food with confidence. And the country could build resilience against both natural disasters and security threats.

Technology exists. The need is evident. What's required now is the will to build something that works for Kenya's unique conditions not just copying solutions designed for other contexts but engineering a system that turns the country's food network from a vulnerability into a source of strength.

The question isn't whether Kenya can afford to build this system. After experiencing what happens when it doesn't exist, the real question is whether Kenya can afford not to.

Engineering Accessibility in Nairobi City by Road Transport Infrastructure in The Face of Climate Change Dilemma

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Globally, climate change continues to present a monumental dilemma in all sectors of the economy. In the urban road transport system, it has become a norm that short distances between places end up consuming longer hours of travel by motorists on rainy days. This prolongation of travel time is occasioned by flooding risks. This makes places inaccessible. Accordingly, this study aimed at improving the accessibility of Nairobi city neighborhoods during wet weather. This informs the reason for use of the term, "engineering accessibility" which simply means to reduce travel time during wet weather between destinations. The study leverages the theory of infrastructure resilience in an attempt to extract developmental data in terms of mapping in the GIS Software environment, the incremental strides in road network lengths and tracing the incremental building footprints over the time scales covering years; 2000,2010,2020 and 2024.Secondly, rainfall data was sourced from KMD open source database that assisted in the development of flood map profile over the same time scale in HEC-RAS software. In the year 2000, built up area covered,50km squared, and the road network totaled 9630km.The worst flood depth recorded around Ojijo road in the period was 0.63m. In 2024,built up area was 83km2,road length was 14,720 and the flood depth at the same location was 1.83.This was the worst as exhibited in figure 2.In conclusion, the study has highlighted the need to mainstream resilience in storm water drainage system by deploying a continuous action plans.

Key words: Accessibility, Engineering, Resilience

Introduction

The ongoing global climate change dilemma is the severest challenge facing our planet Earth during this 21st century (Feulner,2015). It does impact negatively the urban transportation systems calling to attention the need for embedment of resilience practices in all transport infrastructure (Ji et al.,2022). Most implicated are cities in developing nations where transportation systems often get overwhelmed with every occurrence of extreme weather event like has been severally witnessed in Nairobi, the capital city of Kenya (Nyarieko et al.,2019). In Nairobi, the subject location of this study, mobility and accessibility, the "ying-yang" of every transport system, are always impeded by the onset of pluvial floods (Owuor and Mwiturubani 2022). At such times, the travel time, travel cost, travel options, comfort and safety, all become distorted. Therefore, mainstreaming resilience in urban transport infrastructure is not only an urgent matter but is also a necessity. Accomplishing this will help in the improvement of performance of the city transit system towards optimality and equally, will also facilitate in the achievement of a smooth connectivity between places. It is always the poor connectivity between places that renders nearer distances to demand for an extended travel times much to the discomfort of every traveler.

Whereas it is known that, urban transportation systems (public transport, private transport, pedestrian and cycling) are susceptible to disturbances from the impact of climate change, many city authorities, Nairobi included, are yet to mainstream resilience to reduce disruption consequences. The delay to act as argued by Greenham et al., (2023), has seen the problem of traffic congestion grow to a chronic level resulting in poor-quality mobility services that we are witnessing. As a result, the movement of people and goods is greatly affected and the accessibility of places is at its lowest. Embedding of resilience systems can boost the efficiency of the urban transportation systems to be able to absorb and maintain changes as they occur, see Figure 1.

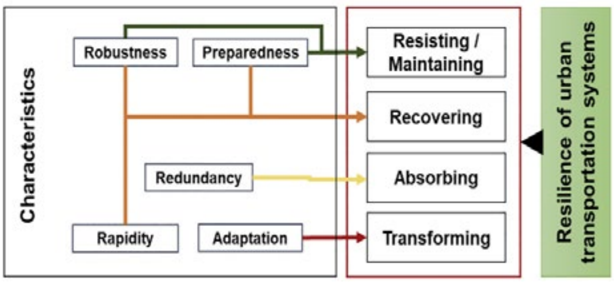


Figure 1: Urban transport system adaptive readiness to resiliently adjust to disruptive forces

The devastation among the citizens arising out of extreme weather events, for example, the occurrence of heavy rains and floods in Nairobi are expected to widen social inequality should the inaction persist (Winter et al.,2024). In the prediction scenario by the Intergovernmental Panel for Climate Change (IPCC) GCMs (Global Circulation Models), Kenya most likely will experience adverse climate changes between now and the year 2100. The existing GCMs projections as per grid resolution of 200 × 200 km indicate that rainy seasons are likely to become wetter especially the short rains that normally fall between October and December every year. Enhanced rainfall intensity events may result to flooding events in frequency and severity. Accordingly, the National Climate Change Action Plan, is mulling low carbon climate-resilient pathway (Lagat et al.,2021), in which the transport infrastructure must be "climate proofed". The latter means "designed, constructed and operated in a way that accounts for anticipated risks and opportunities that result from climate change, ensuring that infrastructure investments are not compromised in the future."

From the prediction vision, it is evident that the issue of urban flooding, worsened by the combined impact of rapid urbanization and climate change in Nairobi needs further documentation, which to the best of our knowledge is lacking. Therefore, this paper is aimed at developing an elucidation for Nairobi city's flooding risk to inform policy discussion on how to mainstream resilience in the development of urban transport infrastructure. For sometimes, news media activities toward flood-related transportation damage in Nairobi have always illuminated the agony motorists endure. In fact, it has always been expected that such highlights are meant to offer valuable insights to the city authorities to enhance flood mitigation strategies in road transportation systems as per the articulation by Xiaohui et al., (2024). However, what is worsening the situation of Nairobi is the rapid spread of urban sprawl outwards that continues to propagate unplanned development (Mwaniki et al.,2015). In terms of flood risk, Nairobi has been experiencing a record-breaking rainfall in the recent past. This, however, is not surprising given the fact that, East Africa region where Kenya belongs in the African continent, is prone to climate and weather extremes with a highly variable climate, and population exposure leading to high vulnerability (Oguge et al.,2021).

There are five stations from which Nairobi rainfall data are recorded; Moi Air Base (M.A.B), Dagoreti, Wilson, JKIA and Kabete. From the data, consistently in the recent past, an anomalous rainfall patterns are being recorded (Kilavi et al.,2018). Based on the Emergency Events Database (EM-DAT), floods in Nairobi have frequently caused damages to water systems, roads, communications, and buildings; the costs of treatment for waterborne diseases which calls for a deeper understanding on how to prepare for the risk. So far, the government, through Kenya Metrological Department (KMD), is using weather/climate forecasts and advisory bulletins with early warnings to sensitize the public. It needs to be noted that, Kenya is mulling the use of Flood Risk Early Warning Systems (EWS) which have the potential to help mitigate the impact of flood events which have been only prototyped operationally in the Nzoia river basin in Western Kenya. Until then, engineering the accessibility in Nairobi during wet weather must be investigated urgently. To engineer accessibility is simply to have a system of detecting flood risk hotspots along Nairobi's roads so that motorists make prior plans on alternative routes for arrival to destinations.

Flood risk has increased dramatically in over the past half-century, more especially in Africa (Padi et al.,2011). In the previous studies, scholars have deployed GIS based approaches (Rashiq et al.,2022) to conduct flood risk zonation. Such methods do explore the utility of spatial group fuzzy Analytic Hierarchy Process (AHP), a multi-criteria decision-making analysis and fuzzy overlay analysis. The ranking of flood risk maps that are usually produced help in showing the floodiness hotspots to help in crisis management (Hasanloo et al.,2019).

In the city of Addis Ababa, Ethiopia, identification of urban flooding risk hotspots was done to engineer accessibility. The researchers used three GIS-based frameworks for identifying urban flooding risk hotspots for residential buildings and urban corridors. They overlayed a map of potentially flood-prone areas [estimated through the topographic wetness index (TWI)], a map of residential areas and urban corridors [extracted from a city-wide assessment of urban morphology types (UMT)], and a geo-spatial census dataset. In addition, they used a maximum likelihood method (MLE) to estimate the threshold used for identifying the flood-prone areas (the TWI threshold) based on the inundation profiles calculated for various return periods within a given spatial window. Secondly, they deployed Bayesian parameter estimation to estimate the TWI threshold based on inundation profiles calculated for more than one spatial window. This assisted in generating a map of potentially flood-prone areas which was overlaid with the map of urban morphology units, to delineate residential and urban corridors, to highlight the urban flood risk hotspots (Jalayer et al.,2014). From the foregoing, Nairobi (see Figure 1) can improve its neighborhood accessibility based on the flood risk zonation.

Data, Study Area and Method

In this paper, we explore the spatial phenomenon of urban development in space and time. The decadal time scales considered cover the years; 2000,2020,2020 and 2024. Nairobi is the capital city of Kenya. Its annual average rainfall ranges between 800 - 1200 mm. There is a constant 12 hours of daylight. Average daily temperature ranges from 29˚C in the dry season to 24˚C throughout the year. Its areal coverage measures about 703.9 square kilometers with a population of 4,906,000.

Figure 1. The study area

We began by plotting of the flooding risk over Nairobi City County areal plan. HEC-RAS version 6.7 and Arc-GIS Pro 1.2 softwares were deployed. First, Flood Risk Map for each time scale was developed using HEC-RAS, and the result was exported to Arc-GIS Pro for presentation. This was to enable a proper appreciation. Next, the profile of road network development (arterials, feeders, local neighborhood roads that include; estates, and parks) was traced. Arc-GIS Pro was deployed to trace backwards the density of road development from 2000 building up to 2024.This helped in picking the road network total length for each window of time. For building footprints over each time window, the same Arc-GIS software was used to extract plinth areas to present how the development footprints have been changing from the year 2000.The three mapping processes for flood risk, road network and building footprints gave the data for analyzing flood risk zonation.

The flood hazard that motorists are exposed to is defined by the extent and depth of inundation. The magnitude of a flood hazard can be expressed by its area of coverage in any corridor. The potential damage of a given flood hazard is dependent on the number of motorists plying the corridor at the time of flooding event hence their vulnerability to the subject flooding. The function of flood hazard, exposure and vulnerability of road users within the city road network referred to as the flood risk in this study.

The flood risk that denies the motorists their accessibility to places causes discomfort. The discomfort can be in terms of extended time of the journey. This is estimated using Flood Depth which in this study is taken as the average per year will be used to demonstrate the vulnerability of motorists. A case example is what happened on 29th November,2024 after a heavy downpour in Nairobi when cars were submerged along Ojijo road in the Parklands neighborhood (sample this from this YouTube clip, https://youtu.be/t3b_A0pVvZE?si=kRgb4jai_IxuRtGw, together with Figure 2.

Figure 2: Flood risk along Ojijo road in Parklands

This study has created Flood Depth (m) using the Ojijo road case, Total Road length and built-up area for the last two half decades.

Table 1: Extracted Flood Depths (m), road lengths (Km) and built up (Km2) area in Nairobi

Year	Flood Depth (m)	Road Length (km)	Built up area Km^2
2000	0.63	9630	50
2010	1.10	11,698	67
2020	1.72	13,645	79
2024	1.83	14,720	83

From the above, the study developed in Ms Excel, two regression equations for correlating Flood Depth and Road Length, and second one, correlating road length to built-up area;

Flood Depth (m) = 0.002 x (road length) -1.7636 (1)

Road Length (Km) = 0.0066 x (Built up area) – 11.635 (2)

From the above, it is possible to estimate the likely increase in road length with every new development which extends the impermeability. Secondly the flood risk estimation everywhere, can then be estimated over time using GIS generated flood maps to help in raising the inhabitant's awareness. This means the city's planning and development control unit is a crucial resilience lever for flood risk mitigation and or adaptation to climate change. Once this is made active by updating the risk level as development continues, the city will be engineering the accessibility of places despite the climate change dilemma.

RESULTS

From the GIS software, the following plots presented in figures; 3,4,5 and 6 were generated to illuminate the aspects of building footprint growth over the years, and the increments in length of the road network. And the deployment of HEC-RAS software equally assisted in generating flood risk map over the similar timescales covering the whole city with a CBD caption.

Building Foot Print

2000

Building Foot Print

2010

Building Foot Print

2020

Building Foot Print

2024

Figure 3: *Building footprint profile*

Road Network

2000

Road Network

2010

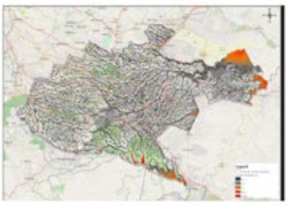
Road Network

2020

Road Network

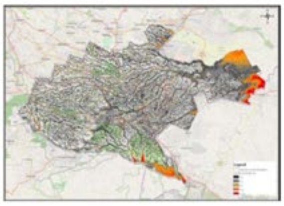
2024

Figure 4: *Road network profile*



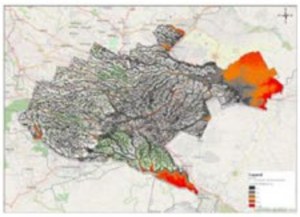
Flood Risk-whole city

2000



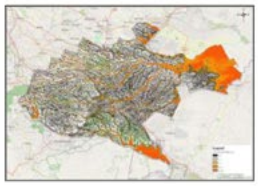
Flood Risk-whole city

2010



Flood Risk-whole city

2020

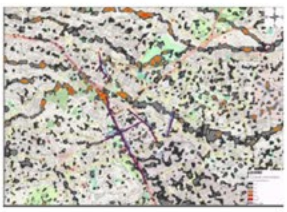


Flood Risk-whole city

2024

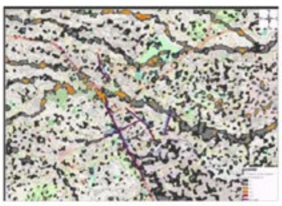
innovative Urban Flood Risk Index (FRI) to quantify and assess flood risk at the sub-catchment level, providing a tool for evidence-based planning and resilient infrastructure development.

Figure 5: *Flood Risk profile*



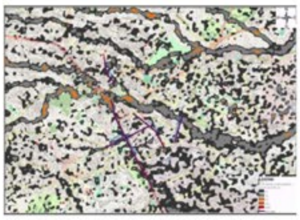
Flood Risk-CBD

2000



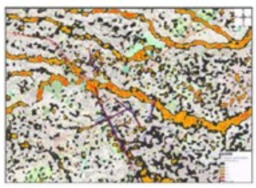
Flood Risk-CBD

2010



Flood Risk-CBD

2020



Flood Risk-CBD

2024

Figure 6: *Flood Risk profile over the CBD*

Discussion

The plots are clearly showing that as the city continues to grow its roads and buildings, the flood risk is also increasing. Inferentially, the pluvial flood over the increasing impermeable surface will continue to pose a challenge to road transport. This will be compounded with the uncertainty presented by the variability of climate change impact which influence the rainfall events. This then calls attention to concerted climate action by everyone around mitigation and adaptation measures. The CBD flood risk map is more informative and confirmatory. The ponding along Moi Avenue will continue to pose a big challenge in terms of slowing down traffic flow. The spillover effect usually creates a grid lock. To address this, a major overhaul of the drain system along Kenyatta Avenue, Moi Avenue, Om Mboya and the River Road is urgently needed to increase the speed of storm runoff evacuation.

Conclusion

The increasing frequency of extreme weather events over Nairobi poses ever greater challenges urban resilience and the motorists' quality of driving by denying them ease of accessibility to places. Engineering the accessibility therefore has become a necessity. This requires that the city authorities to consider investing in urban resilience practices by working with flood risk professionals to routinely develop informative maps which can be shared in real time using Artificial Intelligence platforms, even as they consider improving the climate proofing of the drainage infrastructure. This study had aimed to elucidate the possibility of this thinking by providing some empirical insights of the impact of infrastructure growth trend on the flood risk quantification. Theoretically, this has used the Ojijo road flood depth changes history to provoke the urgency to respond to climate change dilemma. Practically, the pinpointed flood zone hotspots can be used to scope for the drainage infrastructure repairs using the framework in Figure 1.

Acknowledgments

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A flooded road in T Mall roundabout, Langata.

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, 536th, 537th and 538th council accepted the following members under various membership categories as shown below;

Membership Class	Number Accepted - 536th Council	Number Accepted - 537th Council	Number Accepted - 538th Council	TOTAL
Fellow	2	4	4	10
Corporate	2	88	97	187
Graduate	116	49	57	222
Graduate Engineering Technologist	35	13	8	56
Graduate Engineering Technician	10	10	6	26
Student	43	18	14	75
TOTAL	**208**	**182**	**186**	**576**

During the period, we had 10 members who transferred from the class Corporate to Fellow member 187 from Graduate to Corporate member. In addition, we had 222 graduates, 56 graduate engineering technologists,26 graduate engineering technicians and 75 students were accepted as members.

Gender Data

Class	Male	Female	Percentage (Male)	Percentage (Female)
Fellow	6	4	60%	40%
Corporate	142	45	76%	24%
Graduate	170	52	77%	23%
Graduate Engineering Technologist	38	18	68%	32%
Graduate Engineering Technician	21	5	81%	19%
Student	44	31	59%	41%
TOTAL	**421**	**155**	**73%**	**27%**

Summary

Gender	No	Percentage
Male	421	73%
Female	155	27%
	576	**100%**

538TH APPROVAL

FELLOW

S / NO	NAME	MEMBER NUMBER
1.	Edwin Mogeni Keago	F.6442
2.	Lucy Wanjiku Mutinda	F.5863
3.	Jeniffer Jelagat Korir	F.4736
4.	Mathews Ondiek Amuti	F.4800

CORPORATE

S/ NO	NAME	MEMBER NUMBER
1.	Aggrey Meshack Obondo	M.10638
2.	Ahmednur Billow Maalim Kassim	M.6570
3.	Allan Mogoi Gisanga	M.7552
4.	Aloyce Ogana Kona	M.7204
5.	Angela Khana Mangi	M.10357
6.	Angela Mukuhi Kamau	M.10882
7.	Ann Wanjiku Nguca	M.6914
8.	Anne Mutheu Mulei	M.9451
9.	Arnold Aluda Kegode	M.11955
10.	Arnold Ezekiel Ngala	M.11772
11.	Benard Otieno Owinga	M.13581
12.	Benjamin Obong'o Gekara	M.13970
13.	Benson Kipyegon Komen	M.10158
14.	Benson Lumosi Aboka	M.5529
15.	Bernard Mbuli King'esi	M.8577
16.	Bethwel Hillary Otieno Mogalo	M.4166
17.	Bonface Gikundi Koome	M.6113
18.	Brenkah Mutsotso Amuhaya	M.7875
19.	Brian Kemboi Kandie	M.9017
20.	Brian Kiambi Miriti	M.11680
21.	Caroline Munyiva Mutie	M.7528
22.	Collins Otieno Omwono	M.8770

S/ NO	NAME	MEMBER NUMBER
23.	Collins Otieno Otiende	M.13034
24.	Cyprian Christopher Oliko	M.3432
25.	David Awori Olando	M.7013
26.	Dedan Gichuki Munyori	M.6581
27.	Dennis Omondi Oombo	M.14202
28.	Diana Atieno Otieno	M.9999
29.	Dickson Musyoka Ndambu	M.8457
30.	Duke Nyakondo Ombaki	M.8538
31.	Elijah Sysco Mangera	M.9111
32.	Eric Murithi Njue	M.14115
33.	Festus Irungu Thuo	M.10589
34.	Francis Muchiri Mwangi	M.13035
35.	Francis Njihia Njoroge	M.14132
36.	Gaturi Wilson Macharia	M.13521
37.	George Kamau Ndung'u	M.6427
38.	Godwin Boru Sante	M.11630
39.	Harrison Chai Tunje	M.13445
40.	Hassan Hussein Dubat	M.4313
41.	Hillary Kipkogei Saina	M.8132
42.	Ian Kipchirchir Samoei	M.13026
43.	Japhet Kibet Kirui	M.11196
44.	Jeniffer Njambi Ngugi	M.8898
45.	John Mburu Ngugi	M.13672
46.	John Muriuki Githui	M.9469
47.	John Ngatho Gichuru	M.9749
48.	Johnstone Shibonje Maleche	M.7527
49.	Jones Manoti Ratemo	M.11509
50.	Joseph Gitu Muchira	M.11006
51.	Joseph Leseiyo Parashina	M.13052

S/ NO	NAME	MEMBER NUMBER
52.	Joshua Otieno Onyango	M.6504
53.	Kelvin Nyabwari Ongwae	M.9571
54.	Kemei Cheruiyot Brian	M.11194
55.	Kihumba Kamunya Peter	M.9776
56.	Kitilit Brian Kipchirchir	M.8819
57.	Langat Chebet Evaline	M.11561
58.	Lela Mutua	M.11162
59.	Lilian Kanana Kamanja	M.9153
60.	Linda Chepchirchir Korir	M.8433
61.	Linus Papa Ekajapu	M.12069
62.	Lucas Wesonga Shikunyi	M.6734
63.	Maureen Kendi Mbae	M.7985
64.	Maxwell Fredrick Wambugu	M.11668
65.	Mercy Muthoni Maina	M.14693
66.	Michael Makau Musyoki	M.8991
67.	Michael Otieno Wajwang'a	M.11198
68.	Mijoro Ogot Bradox	M.8862
69.	Miracle Mbarire Wachira	M.7632
70.	Muchendu Duncan Kirogi	M.10422
71.	Ngugi Joseph	M.5011
72.	Nicholas Otieno Oyie	M.11843
73.	Norce Kemo Maruti	M.13573
74.	Nyagwisi Joab Ngiti	M.9275
75.	Parth Paresh Patel	M.11322
76.	Patrick Oluoch Oyugi	M.7218
77.	Peter Ndungu Maina	M.5836
78.	Phoebe Wanja Murage	M.7026
79.	Phyllis Kaptuiya Boronjo	M.14131
80.	Rael Mong'ina Nyakundi	M.13140

S/ NO	NAME	MEMBER NUMBER
81.	Raymond Leiren Lekalpure	M.11169
82.	Robert Mneria Mnyolmo	M.11757
83.	Ruth Isina Topisia	M.13843
84.	Sagana Omoke Job	M.10504
85.	Saum Wamaitha Ramadhan	M.14287
86.	Seth Ochieng Oogo	M.9788
87.	Sheila Akumu Opiyo	M.9372
88.	Solomon Wambua Mutie	M.12447
89.	Stephen Muinde Ndolo	M.9763
90.	Stephen Omboko Khasiani	M.8221
91.	Tabitha Nyaguthii Soo	M.11108
92.	Thomas Kipkoros	M.12960
93.	Victor Nabibia Wafula	M.6963
94.	Vincent Mumo Killuni	M.6662
95.	Wilfred Nyabuto Machuma	M.6329
96.	Yusuf Kipchumba Sanga	M.9557
97.	Zipporah Wangui Kimani	M.7467

537nd APPROVAL

FELLOW

S / NO	NAME	MEMBER NUMBER
1.	Andrew wahome mwaniki	F.3134
2.	Paul Christopher Kimali Kioko	F.4562
3.	Ratna Manji Hirani	F.1066
4.	Yolanda Alaka Muyonga	F.4096

CORPORATE

S / NO	NAME	MEMBER NUMBER
1.	Abigael Jeptoo Morogo	M.8511
2.	Abigail Wanjiru Muigai	M.8930
3.	Aggrey Otieno	M.6727
4.	Alex Mwongera Mbogori	M.13563
5.	Ali Abdulrahman Shariff	M.6940
6.	Annah Mutethya Mwalya	M.10079
7.	Benbrose Kilelo Ndivo	M.13259
8.	Bonface Kinyua Njeru	M.7041
9.	Boniface Musau Kilili	M.6916
10.	Boniface Onyango Juma	M.11865
11.	Brian Otieno Ondiek	M.8463
12.	Caleb Makori Ogeto	M.8943
13.	Catherine Mbinya Mule	M.12879
14.	Cheruiyot Mutai Norbert	M.13646
15.	Chrispinus Opondo	M.13977
16.	Christine Jebii Chelang'a	M.8767
17.	Daniel Kimutai Kiplagat	M.7068
18.	Deborah Jepchirchir Tanui	M.10480
19.	Dennis Gikonyo Mwangi	M.8956
20.	Doreen Nkatha Gitonga	M.10702

S / NO	NAME	MEMBER NUMBER
21.	Douglas Mwangi Kagai	M.11116
22.	Duncan Mwendwa Kivuva	M.10353
23.	Edward Ongeri Monda	M.10434
24.	Edwin Mawira Murithi	M.12355
25.	Elijah Mang'iti Ombiro	M.8620
26.	Elizabeth Nabwire Ekakoro	M.8673
27.	Emmah Waihuini Matu	M.7980
28.	Ephantus Mwaura Mungai	M.9742
29.	Ethan Murigu Karingithi	M.2972
30.	Ezra Kibet Kiptoo	M.10104
31.	Felix Manua Asuma	M.8685
32.	Felix Mwachinga Mwarema	M.13523
33.	Fredrick Maundu Mutinda	M.4133
34.	George Ochieng' Mang'uro	M.3256
35.	George Ochieng Otieno	M.8594
36.	Gerald Ngugi Kamau	M.13403
37.	Henry Oscar Odhiambo	M.10499
38.	Ismail Mohamed Osman	M.13589
39.	Itobi Newton Bariu	M.9467
40.	Jackline Muthoni Wang'ombe	M.9846
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49.	Kevin Aaron Karugu	M.9323
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56.	Magovi Anadiva Bonface	M.13152
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67.	Nelson Isiaho Mulinya	M.7952
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2	Fredrick Odhiambo Aluoch	F.3904

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2	Tabitha Muthoni Wang'ombe	M.10366

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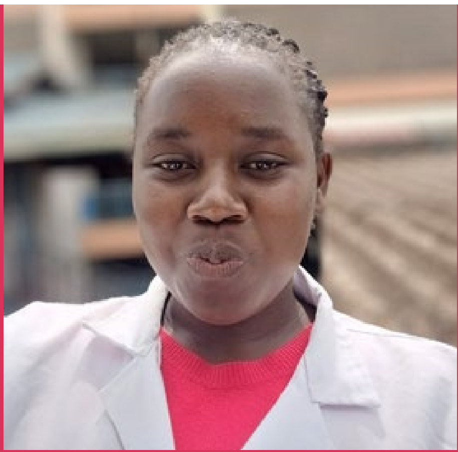
Student Voices



Name-Kimanthi prisca mwende
Institution: Kenyatta University
Course-Biomedical engineering
Year- 3rd
Age-21

Engineering Applications in Optimizing Nutrition and Efficiency in Poultry Production

Poultry farming plays a crucial role in global food security, but rising demand for meat and eggs has placed pressure on producers to improve efficiency while maintaining high nutritional standards. Engineering, particularly in the fields of agricultural, mechanical, and bio-systems engineering, has become instrumental in achieving this goal.

One key area is precision feeding systems, which use automated feeders and sensors to deliver exact quantities of feed tailored to birds' nutritional needs. These systems reduce waste and improve feed conversion ratios (FCR), a critical efficiency metric. Advanced diet formulation software also integrates data on breed, age, and environmental conditions to create optimized feed blends.

Beyond nutrition, engineering enhances overall farm efficiency. Automated climate control systems maintain optimal temperature, ventilation, and humidity, minimizing stress and maximizing growth. Robotics handle tasks like egg collection and manure removal, reducing labor costs and disease transmission.

The Integration of Internet of Things (IoT) devices and data analytics further transforms poultry farming. Real time monitoring of bird health, feed intake, and growth patterns allows for early detection of issues and data driven decision making.

Despite the benefits, challenges such as high implementation cost and the need for technical expertise remain. However, with continued innovation, engineering will play an even greater role in creating sustainable, high yield poultry systems that meet future food demands maintaining efficiency.

Name: Dorothy Doris Mutindi
Reg.: J25/4088/2021
Age :22 Years
Course: Agricultural And Biosystems Engineering
Institution: Kenyatta University

Kenya continues to evolve into a regional agribusiness powerhouse, one of the most pressing challenges is ensuring that food stays fresh from the farm to the target market. With climate change, transportation inefficiencies, and post-harvest losses threatening food security and economic growth, innovative packaging technologies are stepping in as game-changers. Smart packaging uses sensors, QR codes, indicators, and biodegradable materials to provide customers with product information, and enhance engagement. Smart packaging is fast becoming a powerful ally in the fight to keep Kenyan food fresher for longer.

According to the Kenya National Bureau of Statistics, post-harvest losses for fruits and vegetables can reach up to 45%, with cereals losing up to 30% before they reach the consumer. These losses are primarily due to poor storage, and packaging practices. In rural areas, farmers often lack access to cold chain infrastructure and modern packaging, leading to spoilage before their produce reaches urban markets or export destinations. Kenyan innovators are rising to the occasion. For example, Ujuzi Kilimo and M-Farm have begun integrating smart sensors in farming and distribution. Collaborations between universities and agri-tech startups are also fueling research into low-cost, scalable smart packaging solutions.

The Kenyan government has taken steps to promote innovation in agri-food systems through its Agricultural Sector Transformation and Growth Strategy (ASTGS). Integrating smart packaging into national food preservation policies and supporting local manufacturing of these technologies can create jobs, reduce food imports, and boost exports. As Kenya navigates its path toward food security and sustainable development, smart packaging will play a crucial role. The future lies not just in growing more food, but in preserving what we already produce. From smallholder farmers to urban retailers, smart technologies in packaging will bridge the gap between innovation and necessity, keeping Kenyan foods fresh, safe, and globally competitive.

Name: Nick otimo
Kenyatta University.
Dept of Agricultural and Biosystems Engineering.
3rd Year student.
Age: 21

Engineering Quality in Grain Milling

As the global population is projected to surpass 9.7 billion by 2050, ensuring access to safe, nutritious food becomes a critical challenge. In Kenya, where staples derived from cereals are consumed in over 80% of households, grain milling sits at the heart of food security. As the next generation of Engineers, we must lead the charge in reimagining this sector through innovations that prioritize quality, efficiency, and sustainability.

A central area for improvement is mitigating post-harvest losses from spoilage and aflatoxin contamination, which are often linked to high moisture content. By integrating automation, we can address this directly. Deploying moisture sensors and Programmable Logic Controllers (PLCs) allows milling systems to monitor grain in real-time. If moisture levels are too high, the system automatically redirects the grain for drying before milling resumes. This smart automation enhances product safety, reduces losses, and minimizes human error.

To power these systems particularly in off-grid rural areas, a hybrid solar–biogas model offers a sustainable solution. Solar panels can power operations during the day, while a communal biogas plant, fueled by local kitchen and farm waste, provides energy at night. This "waste-for-service" model allows smallholder farmers to offset milling fees, fostering a circular economy with minimal environmental impact.

Through collaboration among Agricultural, Electrical, and Mechanical Engineers, we can engineer grain milling systems that are not only efficient and safe but also sustainable and community-centered. This interdisciplinary approach is essential for building a cleaner, food secure future for all Kenyans.

Maryjoy Wendo Kitetu
BSc. Aerospace Engineering 3rd year
Age :20 years old
Kenyatta University.

Improper meat industrial processing leads to health, environmental and safety hazards which may be physical, biological and ergonomic. These facilities operate at high volumes and speeds, making them particularly vulnerable to microbial hazards thus foodborne illnesses and workplace injuries. As a result, engineers have come up with several strategic designs as measures to uphold hygiene and safety in meat processing industries throughout the product chain.

One key aspect of engineering hygiene involves the use of materials and designs that support easy cleaning and disinfection. Hygiene equipment design such as Stainless-steel equipment with smooth, non-porous surfaces is commonly used to minimize bacterial buildup. Automated cleaning systems, such as Clean-In-Place (CIP) and Steam-In-Place (SIP), help ensure consistent sanitation without dismantling machinery. The future engineering aims at developing AI Driven Pathogen Detection Equipment to make pathogen detection easier.

Airflow and water systems are also engineered to reduce cross-contamination. Proper ventilation with HEPA filters and controlled drainage systems prevent the spread of pathogens through the air and water. Temperature control systems maintain cold chain integrity, limiting bacterial growth. For ammonia leaks in the processing plant, exhaust and high roof ventilations have also been considered as in publication (DOI: 10.5829/idosi.wjdfs.2016.11.2.10598).

OSHA (Occupational Safety and Health Administration), reports that up to 30% of work-based injuries are as a result of machinery accidents. That is, rotary blades and other accidents due to malfunctioning equipment. While engineering has greatly helped in the industry, say conveyor belts, motors and deboning machines, their risks are also high. Preventive measures such as automation of these machines and use of machine guards have been implemented.

In conclusion, in compliance with OSHA, HACCP and USDA guidelines, while upholding public health standards and integrating engineering design into meat processing facilities, engineers have proved to reduce the hazards by a great margin.

Author: Kiptoo Enock, BSc. (Aerospace Engineering), J76/4834/2019
Institution: Kenyatta University
Department: Mechanical Engineering Department

Food is a basic need. It is the fuel our bodies need to give us energy. in an environment with no oxygen to act as an oxidizer to burn, boil or cook, yet still act as a laboratory for a dozen human beings, the human outpost in Low Earth Orbit (LEO)- the International Space Station (ISS), feeds its occupants in a unique way. free of gravity and the atmosphere, space and extra-terrestrial environments such as Mars will still need to provide this essential ingredient of life in one way or the other, without humans turning cannibalistic.

One solution to this is thermally treated food. Food treated by ionizing radiation. Gamma radiation is used to kill any micro-organism and still retain the flavor, nutrients and taste of the food. This also removes water content in the food. Irradiated food, is then stored in sealed packaging that occupies minimal space and alters not the taste of the food whatsoever. More so, the packaging needs to withstand the rigor of launch. The storage container should also provide room for re-moisturizing and if need be, allow for the warming of the food contained therein. Furthermore, it should act as a plate or a cup during consumption, allowing scooping using a spoon or insertion of a straw for easy sipping of drinks and beverages.

Crumbs in a spacecraft, be it the ISS, Space Shuttle or a Space Ship, pose a significant threat to the occupants and equipment on-board, therefore bread and cookies are an opportunity cost, for more nutrient dense meals that leave as little crumbs as possible while providing for the nutrient needs of occupants aboard a spacecraft.

Another viable alternative is to grow food aboard the ISS. Numerous experiments have been conducted aboard the ISS to explore feasibility the feasibility; a notable one being where lettuce have been successfully grown and consumed in the orbiting laboratory. Advantages of growing food in space is that there are no pests to deal with; or at least there have been minimal microbes in space that are known to attack plants grown in space. the lack of gravity and inconsistent exposure to sunlight brings other variables that need to be handled. experiments are ongoing to establish a sustainable human outpost, be it on the Moon, an asteroid, on Mars or an exo-planet, master of this food propagation technique has to be tested on a large scale and be proven to work. Strides are being made in the right direction.

There is enough food to last for six months on the space station, this is enough for a sing trip to Mars. this food is processed on Earth and will not be able to be a sustainable plan to have humans in planet relying on regular supply from the mother planet. More scientific efforts need to be invested in how to grow food to feed a population off the extra-terrestrial they live and work in.

PARTNERSHIP 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 November 2025.

The 32nd IEK Annual International Convention themed ***"Engineering the Future: The road map for Kenya"*** to be held from the 25th November to 28th November, 2025 in Mombasa County. The and the 4th Future Leaders Summit ***"Engineering the Future: The role of emerging engineers",*** will be held on the 25th November 2025 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:

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