# KABARAK UNIVERSITY

Education in Biblical Perspective

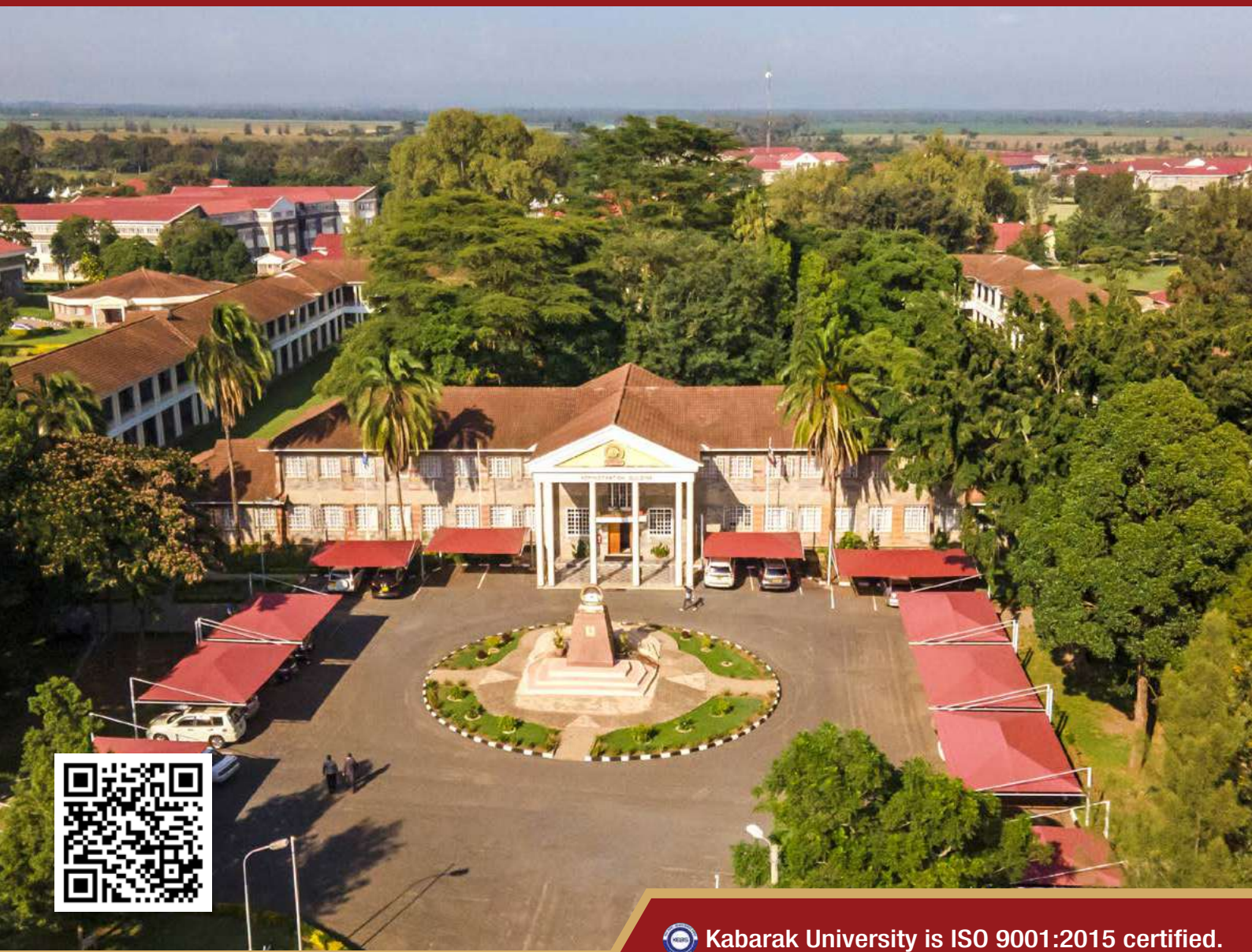
**DIRECTORATE OF RESEARCH, INNOVATION AND OUTREACH**

## 16TH INTERNATIONAL RESEARCH CONFERENCE

## SCHOOL OF SCIENCE, ENGINEERING AND TECHNOLOGY, 2026

**23RD - 24TH JUNE**

## PROGRAM AND BOOK OF ABSTRACTS



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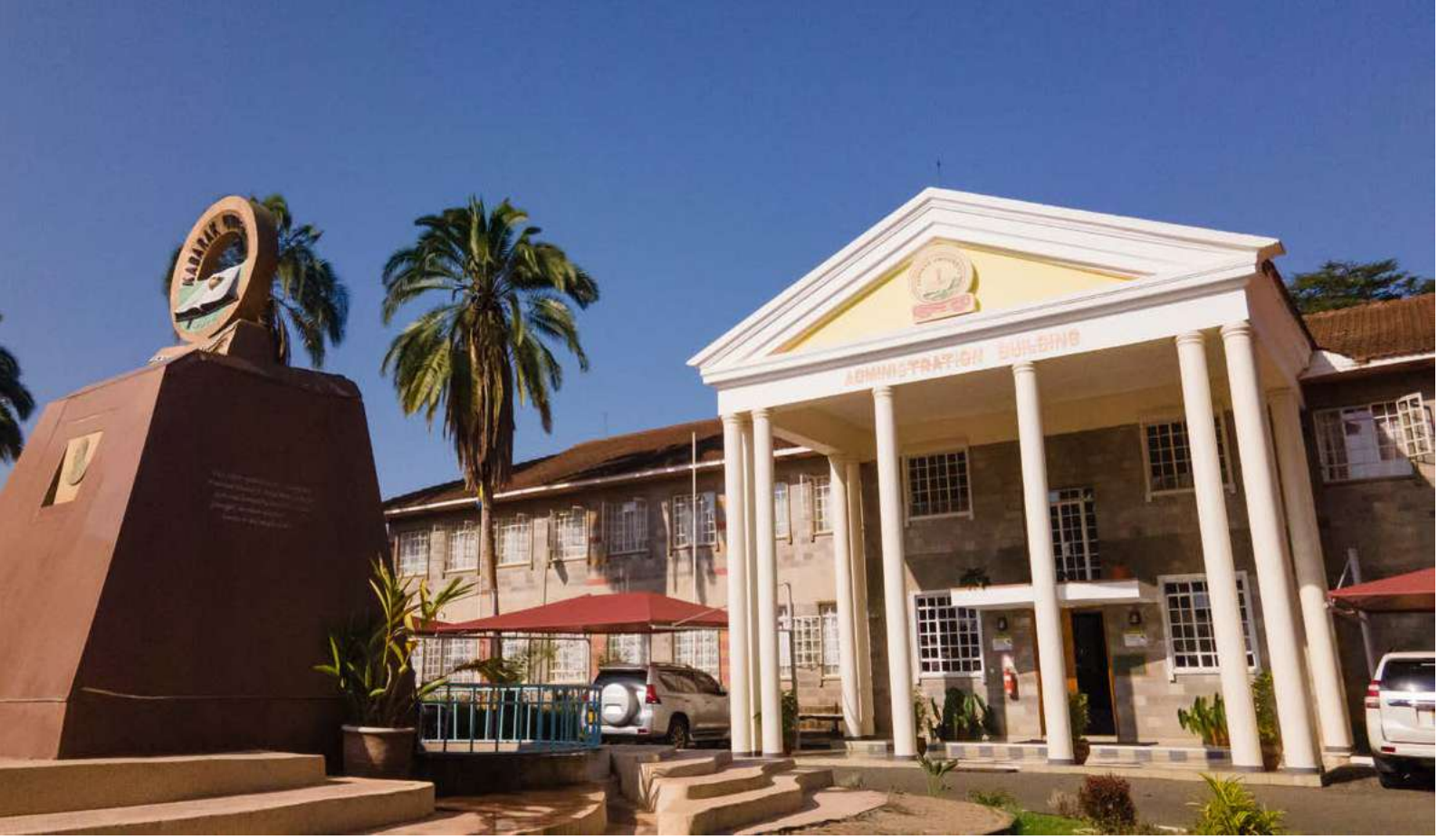

# KABARAK UNIVERSITY

## About Us

Kabarak University is a Chartered institution of higher learning that provides holistic Christian-based quality education, training, research and outreach activities for the service of God and humanity. The University was established in the year 2000 by the 2nd President of Kenya, H.E. Hon. Daniel T. Arap Moi, who was also the founding Chancellor. This was as a result of his visionary idea of setting up a Christian University that would meet the demand for higher education in Kenya and offer quality education based on strong moral principles.

## Vision

To become a centre of Academic Excellence founded on Biblical Christian values.

## Mission

To provide holistic quality education, research and community outreach based on Biblical Christian values.

## Philosophy

To provide quality education in Biblical perspective that transforms lives.

## Core Values

- Integrity
- Excellence and Professionalism
- Patriotism and Being Mindful of Others
- Innovativeness and Creativity

*Education in Biblical Perspective*

# KABARAK UNIVERSITY

## 16TH INTERNATIONAL RESEARCH CONFERENCE

## SCHOOL OF SCIENCE, ENGINEERING AND TECHNOLOGY, 2026

Conference Theme:

*Sustainable Futures through Science, Technology and Community Innovation*

# PROGRAM
# AND
# BOOK OF ABSTRACTS

**JUNE 2026**

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## Prof. Henry Kiplangat, PhD, MBS, OGW

## VICE CHANCELLOR, KABARAK UNIVERSITY

t is my great pleasure and honour to welcome you to Kabarak University and to our **16th International Research Conference for the School of Science, Engineering and Technology**. We are deeply honoured by your presence and grateful that you have joined us from different institutions, regions, and countries to share knowledge, exchange ideas, and collectively explore solutions to the pressing challenges facing our world today.

I am sincerely grateful to our speakers whose expertise, experience, and thought leadership continue to inspire innovation and transformative action in science, technology, and sustainable development.

This conference comes at a critical moment. Across the globe, societies are grappling with climate change, environmental degradation, energy insecurity, food system vulnerabilities, public health challenges, and rapid technological transformations. These challenges are complex, interconnected, and demand solutions that are innovative, evidence-based, and inclusive. The theme of this year's conference, **Sustainable Futures through Science, Technology and Community Innovation,** is therefore timely and relevant. It recognizes that sustainable development cannot be achieved through technological advancement alone. Rather, it requires a synergistic approach that combines scientific excellence, technological innovation, and meaningful engagement with communities. Sustainable futures emerge when research moves beyond laboratories and classrooms to create practical solutions that improve lives, protect ecosystems, and strengthen economies.

This perspective is reflected in the three sub-themes that will guide our discussions during this conference. Sustainability begins within communities. Around the world, and particularly across Africa, local communities possess valuable indigenous knowledge, practical experiences, and innovative approaches that can complement scientific research in addressing environmental and energy challenges.

As we pursue the global Sustainable Development Goals, we must recognize that local ownership is essential for lasting impact. Whether it is renewable energy deployment, ecosystem restoration, climate adaptation, sustainable agriculture, water conservation, or circular economy initiatives, communities must remain at the center of solution design and implementation.

This conference provides an opportunity to showcase successful locally-led innovations and to strengthen partnerships between researchers, policymakers, industry actors, and communities in creating resilient environmental and energy futures.

We are living in an era characterized by unprecedented technological advancement. Artificial Intelligence, Big Data Analytics, the Internet of Things, Cloud Computing, Remote Sensing, and Digital Platforms are transforming every sector of society.

These technologies present immense opportunities for sustainable development. They can optimize energy systems, improve environmental monitoring, enhance disaster preparedness, support precision agriculture, strengthen healthcare delivery, and enable evidence-based decision-making. However, we must also ensure that technological progress remains ethical, inclusive, and environmentally responsible. Green ICT and responsible AI development must prioritize equity, transparency, sustainability, and human well-being. As scholars and innovators, we have a responsibility to shape technologies that serve humanity while protecting our planet. I encourage participants to explore how emerging digital technologies can be harnessed to accelerate sustainable development across Africa and beyond.

Scientific discovery remains the foundation upon which technological and societal progress is built. Advances in the physical, biological, and mathematical sciences continue to unlock new knowledge and innovative solutions to some of humanity's greatest challenges.

From biotechnology and biodiversity conservation to materials science, renewable energy technologies, computational modelling, data science, and mathematical innovation, research in these disciplines continues to expand the frontiers of knowledge and create pathways toward sustainable development. The strength of this conference lies not only in the quality of research that will be presented but also in the diversity of perspectives represented here. Meaningful innovation thrives when scholars, practitioners, policymakers, entrepreneurs, and communities come together to exchange ideas and co-create solutions.

I therefore encourage all participants to actively engage in the discussions, challenge conventional thinking, establish new collaborations, and explore innovative approaches that can generate tangible impact beyond this conference.

I wish to express my sincere appreciation to our partners, sponsors, presenters, and all participants whose dedication and hard work have made this event possible.

I am confident that the discussions, presentations, and collaborations emerging from this conference will generate new insights, strengthen partnerships, and contribute significantly to the realization of sustainable futures through science, technology, and community innovation. I wish you fruitful deliberations, productive networking, and a successful conference.

**Prof. Henry K. Kiplangat, PhD, MBS, OGW**
**Vice Chancellor, Kabarak University**

# Prof Peter Rugiri

## DEAN, SCHOOL OF SCIENCE, ENGINEERING & TECHNOLOGY

It is my great pleasure and honor to welcome you all to the 16th International Research Conference of the School of Science, Engineering and Technology at Kabarak University.

On behalf of the School of Science, Engineering and Technology, I extend a very warm welcome to our distinguished keynote speaker, **Dr. Nelson Maara**, whose expertise and contributions to research, innovation, and sustainable development continue to inspire scholars and practitioners across various disciplines. We are privileged to have you with us today and look forward to your insights as we explore pathways towards a more sustainable future.

I also wish to sincerely welcome our Vice-Chancellor, members of the university management, our invited guests, researchers, industry representatives, development partners, faculty members, students, and all participants joining us both physically and virtually. Your presence reflects a shared commitment to advancing knowledge and finding practical solutions to the challenges facing our communities and the world at large.

This year's conference theme, ***Sustainable Futures Through Science, Technology and Community Innovation,*** could not be timelier. Around the globe, societies are grappling with complex challenges including climate change, energy insecurity, environmental degradation, technological disruption, and socio-economic inequalities. Addressing these challenges requires more than isolated efforts; it calls for interdisciplinary collaboration, innovative thinking, and meaningful engagement with communities.

As a School, we believe that science, engineering, technology, and innovation are powerful tools for transforming society. However, sustainable development can only be achieved when these tools are combined with community participation, indigenous knowledge systems, sound policy frameworks, and responsible stewardship of resources. This conference therefore provides an important platform for researchers, innovators, policymakers, industry leaders, and community stakeholders to share knowledge, exchange ideas, and co-create solutions that can make a lasting impact.

The conference objectives resonate strongly with our institutional mission. Over the next two days, we shall promote interdisciplinary scientific research for sustainable development, foster meaningful discussions on sustainable solutions, strengthen community-led innovation systems, and document successful models that can be replicated and integrated into policy and practice.

The conference tracks reflect the breadth of expertise represented here today. From locally-led solutions for sustainable energy and environmental futures, to advances in physical, biological and mathematical sciences, and emerging opportunities in Green ICT and AI-driven solutions, the discussions and presentations promise to generate new knowledge and inspire transformative action.

As scholars and innovators, we have a responsibility not only to generate knowledge but also to ensure that our research contributes meaningfully to society. The future we envision must be one where scientific excellence, technological advancement, environmental sustainability, and community well-being go hand in hand.

I therefore encourage all participants to engage actively in the presentations, panel discussions, networking sessions, and collaborative exchanges. Let us use this opportunity to build partnerships, strengthen research networks, and identify innovative solutions that can contribute to sustainable development locally, nationally, and globally.

As I conclude, allow me to thank the Directorate of Research, Innovation and Outreach, the organizing committee, our partners, presenters, reviewers, and all those who have worked tirelessly to make this conference possible.

Once again, I warmly welcome you to Kabarak University and to the 16th International Research Conference of the School of Science, Engineering and Technology.

I wish you fruitful deliberations and a successful conference.

**Prof Peter Rugiri**
**Dean, School of Science, Engineering and Technology**

## KEYNOTE SPEAKER

### Dr. Maara Tanui Nelson

CECM, Water, Environment, Energy, Climate Change and Natural Resource, Nakuru County

Dr. Maara Tanui Nelson is an accomplished natural resource management expert, environmental leader, and policy practitioner with over two decades of experience in academia, environmental governance, and sustainable development. He currently serves as the County Executive Committee Member (CECM) for Water, Climate Change, Environment, Energy, and Natural Resources in Nakuru County, where he provides strategic leadership in environmental conservation, climate resilience, water resource management, and sustainable development initiatives. Dr. Maara holds a Doctor of Philosophy (PhD) in Natural Resource Management from Egerton University, a Master of Science (MSc) in Natural Resource Management from Egerton University, and a Bachelor of Science (BSc) in Forestry from Moi University. His doctoral research focused on the use and propagation of selected medicinal plants in Eldama Ravine and Esageri Divisions of Koibatek District, Kenya. Before joining county government, Dr. Maara served as a Lecturer in the Department of Natural Resources at Egerton University from 2000 to 2022, where he taught, mentored students, and conducted research in natural resource management, forestry, and environmental sustainability. His expertise spans forest management, water project management, environmental policy development, climate change adaptation, and sustainable resource utilization.

A respected professional leader, Dr. Maara served as the National Secretary of the Forestry Society of Kenya (2016–2020) and previously chaired the Mau Forest Conservation Committee (2008–2015), contributing significantly to forest conservation and ecosystem restoration efforts in Kenya. Dr. Maara is widely recognized for his commitment to environmental stewardship, sustainable development, and public service. His work continues to influence policy and practice in natural resource management, climate action, and environmental governance at both county and national levels.

KABARAK UNIVERSITY

# PROGRAM AND ABSTRACTS FOR CONFERENCE ON ENVIRONMENT AND ENERGY TECHNOLOGY

## SUB-THEME 1: *LOCALLY- LED SOLUTIONS FOR A SUSTAINABLE ENERGY AND ENVIRONMENTAL FUTURE*

**CHAIR: Dr. Eliud Michura**

**Rapporteur: Dr. Rose Sagwe**

## PROGRAM

## DAY 1: 23RD 2026

**Link:** *https://kabarak-ac-ke.zoom.us/j/88277529856?pwd=RzYxbTB5pRqmbWXOim4bmmJgwXhEdb.1*

| DAY 2 (C) \| Tuesday, 23rd June 2026 \| School of Science, Engineering & Technology – Official Opening (Sawia Auditorium) | | |
|---|---|---|
| 8:00 – 9:00 AM | **Guests Arrival & Registration** | School Officials |
| 8:30 – 9:00 AM | **Guests Courtesy Call to the VC** | University Boardroom |
| 9:00 – 9:10 AM | Kenya National Anthem, East African Community Anthem, Kabarak University Anthem | School of Music & Media |
| 9:10 – 9:20 AM | **Devotional Thought & Opening Prayers** | Rev. Justus Mutuku, Ag. University Provost |
| 9:20 – 09:25 AM | Remarks, Dean School of SET | Prof Peter Rugiri |
| 9:25 – 9:30 AM | Remarks, DVC (A&R) | Prof. John N. Ochola |
| 9:30 – 9:50 AM | **Welcome Remarks and official opening by the Vice-Chancellor** | **Prof. Henry K. Kiplangat, PhD, MBS, OGW** |
| 9:50 – 10:30 AM | **Keynote Speaker** | **Dr Maara Tanui Nelson** ***(CECM – Water & Environment – Nakuru County)*** |

| | | |
|---|---|---|
| 10:30 – 11:00 AM | **Panel Discussions/Q&A** | Dr. Michael Walekhwa (Moderator) |
| 11:00 – 11:10 AM | **Appreciation** | **Prof. Henry K. Kiplangat, PhD, MBS, OGW** |
| *11:10 – 11:40 AM — Networking Tea Break* | | |
| *Paper Presentations as per School Program* | | |

| TIME | TITLE OF THE PAPER | NAME OF THE PRESENTER |
|---|---|---|
| 2.30 – 2.50 PM | **Abstract 1**: Assessment of barriers to effective e-waste management in hotels in Naivasha sub-county, Kenya | Kopejo Joseph Makibia<br>Kabarak University<br>jkopejo@kabarak.ac.ke |
| 2.50 – 3.10 PM | **Abstract 2**: Quantitative assessment of benzene, toluene, and xylene in Nakuru town borehole water | Boaz Wekesa<br>Kabarak University<br>boazwekesa@kabarak.ac.ke |
| 3.10 – 3.30 PM | **Abstract 3**: Sources, Distribution and Seasonal Variations of Microplastic-Related Chemical Pollution in Lake Naivasha Ecosystem, Kenya | Nicodemus Onunga Omwancha<br>Kabarak University<br>nomwancha@kabarak.ac.ke |
| 3.30 – 3.50 PM | **Abstract 4:** Evaluating agrisilviculture as a climate change mitigation strategy in cassava production: insights from western Kenya for Sub-Saharan Africa. | Davis Simiyu Masibo<br>Egerton University<br>1187624@student.egerton.ac.ke |
| 3.50 – 4.10 PM | **Abstract 5** The Environmental Soldier Programme as a model for sustainable defense: Tactical asset as an environmental steward through strategic greening | Brenda Jerotich Kimutai<br>Kabarak University<br>bkimutai@kabarak.ac.ke |

## DAY TWO: 24TH JUNE 2026

**CHAIR: Dr. Sellah Kebenei**

**Rapporteur: Dr. Mary Kuria**

**Link:** *https://kabarak-ac-ke.zoom.us/j/88277529856?pwd=RzYxbTB5pRqmbWXOim4bmmJgwXhEdb.1*

| DAY 2\| Wednesday, 24th June 2026 \| School of Science, Engineering & Technology (2N | | |
|---|---|---|
| **Time** | **Activity** | **Responsibility** |
| 8:30 – 9:00 AM | Arrival & Registration | School Officials |
| 9:00 – 9:10 AM | **Devotional Thought & Opening Prayer** | Rev. Justus Mutuku, Ag. University Provost |
| 9:10 – 9:20 AM | Opening remarks by Dean of the School | Prof. Peter Rugiri |
| 9.20 – 9.40 AM | **Abstract 6:** Evaluating the effects of charged *Prosopis juliflora* biochar on the growth performance of *Calliandra calothyrsus* in Marigat sub-county, Kenya. | Jane Chepkonga<br>Kabarak University<br>cjepsergon@kabarak.ac.ke |
| 9.40 – 10.00 AM | **Abstract 7:** Lithium Geochemistry and Spatial Variability in Menengai Geothermal Brines, Kenya: Implications for Critical Mineral Recovery and Reservoir Hydrogeochemistry | Vincent Osango<br>Kabarak University<br>vincentosango@kabarak.ac.ke |
| 10.00 –10.20 AM | **Abstract 8:** Determinants of adoption of climate smart agriculture among small-holder farmers: A review of empirical literature | Chepkoech Cheruiyot<br>Kabarak University<br>chepkoech@kabarak.ace.ke |
| *10.20–10.40 AM* | *BREAK* | |
| **DAY 2\| Wednesday, 24th June 2026 \| School of Science, Engineering & Technology (2N** | | |
| 10.40 –11.00 AM | **Abstract 9:** Adoption of Energy-Efficient Lighting: Practices and Potential among Small-scale Traders in Kenyan Market Centres | Danice Awinda,<br>Kabarak University<br>dawinda@kabarak.ac.ke |
| 11.00 –11.20 AM | **Abstract 10:** Command-and-control vs. market-based instruments: A comparative analysis of plastic bag mitigation strategies in Nairobi and Nakuru city. | Brenda Jerotich Kimutai<br>Kabarak University<br>bkimutai@kabarak.ac.ke |
| 11.20 11.40 AM | **Abstract 11:** Thermodynamic and fluid dynamics simulation model to analyze geothermal heat transfer into waste oil - fueled glass recycling furnace for improved energy efficiency. | Kennedy M. Anyona<br>Kenyatta University<br>morangaanyona9@gmail.com |

# ABSTRACTS FOR CONFERENCE ON ENVIRONMENT AND ENERGY TECHNOLOGY

## 1. ASSESSMENT OF BARRIERS TO EFFECTIVE E-WASTE MANAGEMENT IN HOTELS IN NAIVASHA SUB-COUNTY, KENYA

**Kopejo Joseph Makibia[1], Dr. Danice Awinda[2], Dr. Edwin Akumu[3]**
Email: jkopejo@kabarak.ac.ke

### ABSTRACT

Electrical and electronic waste (e-waste) is one of the fastest-growing waste streams globally, with serious environmental and public health implications. In Kenya's hospitality sector, there is limited understanding of the challenges hindering its effective management. The purpose of this study was to assess barriers to effective e-waste management among hotels in Naivasha Sub-county. Using a mixed methods research (MMR) design, the study targeted the 86 classified hotels within Naivasha, offering at least accommodation and meals, from where a stratified sample of 69 hotels was chosen, in addition to 5 purposively selected key informants. Quantitative data was collected using structured questionnaires, while qualitative data was collected using a key informant interview guide alongside direct observation in the sampled hotels, and the municipal dumpsite. Quantitative data was analyzed descriptively with the help of the Statistical Package for Social Sciences (SPSS version 30), and inferentially and results interpreted at 95% confidence level. Qualitative data was analyzed thematically and the outcomes of the two analyses triangulated for clear conclusions. The study identified the most prevalent barriers to be: limited access to licensed e-waste recyclers, inadequate infrastructure, lack of training, cost of e-waste disposal, limited awareness, lack of enforcement, and lack of clear policies and procedures. Pearson's correlation showed that were significantly negatively correlated with effective e-waste management, indicating that increased barriers hinder effective e-waste management and remained a significant negative predictor, when subjected to regression analyses. Additionally, through coefficients analysis, barriers had a strong and highly significant positive influence. The study therefore concluded that barriers were the strongest, most influential and systemic predictor of effective e-waste management, and recommended addressing existing barriers, through targeted strategies. These findings will support evidence-based policy interventions, guide environmentally sustainable e-waste management in the hospitality industry, contributing to broader environmental conservation efforts, and provide a foundation for further research.

**Key Words:** *E-Waste, E-Waste Generation, E-Waste Management, Barriers to E-Waste Management, Naivasha Sub-County.*

## 2. QUANTITATIVE ASSESSMENT OF BENZENE, TOLUENE, AND XYLENE IN NAKURU TOWN BOREHOLE WATER

**Boaz Wekesa *, Caroline Chepkirui, and Eliud Michura.**
KABARAK UNIVERSITY
*Corresponding Author: boazwekesa@kabarak.ac.ke

### ABSTRACT

Benzene, toluene, and xylene (BTX) are among the emerging pollutants in groundwater posing adverse risks to public health because of their high environmental mobility, persistence, and documented carcinogenic and neurotoxic effects. Many urban aquifers are contaminated and often go undetected until concentrations

approach or exceed regulatory limits, underscoring the need for consistent monitoring. Hence, this study focuses on a quantitative assessment of BTX in the groundwater resources of Nakuru town. A total of 20 boreholes from 9 stratified regions of diverse land-use zones across the town were sampled. The BTX compounds were concentrated using headspace solid phase microextraction (HS-SPME), then quantified by gas chromatography–mass spectrometry (GC-MS). Benzene levels were below the analytical detection limit. Toluene ranged from 0.118 µg/L to 0.181 µg/L, while xylene ranged from 1.072 µg/L to 2.168 µg/L. The detected levels of toluene and xylene were below the WHO maximum contaminant level (MCL), 700 µg/L for toluene, and 500µg/L for xylene. Zonal clustering and co-occurrence patterns of detected compounds suggest contributions from industrial zones, the petroleum infrastructure zone, the sewage treatment zone, and the garages concentrated zone. These findings will inform stakeholders in water and public health about the safety and quality of drinking water sources, pollution control, and serve as a baseline for future investigations into emerging hydrocarbon contaminants in groundwater systems. Continuous monitoring of these pollutants is recommended to avert groundwater quality challenges resulting from rapid urbanization in Nakuru and other growing towns.

**Keywords:** *Benzene, toluene, xylene, and groundwater quality.*

## 3. SOURCES, DISTRIBUTION AND SEASONAL VARIATIONS OF MICROPLASTIC-RELATED CHEMICAL POLLUTION IN LAKE NAIVASHA ECOSYSTEM, KENYA

**Nicodemus Onunga Omwancha[a], Eliud Michura [a], Rose Nyakemiso Sagwe[a],**
KABARAK UNIVERSITY
Email: nomwancha@kabarak.ac.ke

## ABSTRACT

Microplastic-associated chemical pollution poses a growing threat to freshwater ecosystems, yet studies in African lakes remain limited. This study investigated the sources, distribution, seasonal dynamics, and bioaccumulation of plastic-related compounds in water, sediment, and fish tissues from Lake Naivasha and its inflowing rivers (Malewa and Gilgil) in Kenya. Samples were collected during dry (Mid-February, 2026) and rainy (end of march, 2026) seasons and analyzed using LC-MS/MS-Orbitrap. Eighteen compounds linked to plastics were identified. These include building blocks such as monomers, additives like plasticizers (especially phthalates and adipates), slip agents made up of fatty acid amides, antioxidants, and breakdown products from plastics such as PET and polyolefins. A few of the compounds were also related to surfactant-type amines. During the rainy season, dibutyl phthalate and erucamide dominated the chemical profile (>50% contribution to variation between sites, SIMPER), indicating rainfall-driven mobilization and transport via runoff especially for plastic additives from packaging materials into water bodies. In the dry season, concentrations increased significantly, particularly in water, with surfactants (dodecyl sulfate and stearamide) becoming dominant due to reduced dilution. Fish tissues (Nile tilapia and African catfish) showed clear bioaccumulation, with high levels of erucamide (up to 15,470.38 × $10^7$), dibutyl phthalate, and terephthalic acid, confirming trophic transfer into the aquatic food web. These findings demonstrate strong seasonal and compartment-specific dynamics of plastic-derived chemicals and highlight potential risks to ecosystem and human health through fish consumption. The statistical results from heatmaps, NMDS plots, SIMPER analysis, and correlation tests show clear differences between locations and seasons. During the rainy season, rainfall carries these chemicals into water bodies, spreading them widely but unevenly across sites. In the dry season, the pollutants build up more, especially in lake water and sediments. The study provides critical baseline data for evidence-based management of plastic pollution in Lake Naivasha, a Ramsar wetland of international importance.

**Keywords:** *Antioxidants, Monomers, additives, Microplastics, Polyolefins, plasticizers, Plastic additives, Seasonal variation, Lake Naivasha, Phthalates, Erucamide, Kenya.*

## 4. EVALUATING AGRISILVICULTURE AS A CLIMATE CHANGE MITIGATION STRATEGY IN CASSAVA PRODUCTION: INSIGHTS FROM WESTERN KENYA FOR SUB-SAHARAN AFRICA.

**Davis Simiyu Masibo, Prof. Paul Mackenzi, Dr. Dickson Lubanga, Egerton University**
Corresponding author: 1187624@student.egerton.ac.ke

### ABSTRACT

Cassava is one of the most widely cultivated crops globally and is considered drought-resistant in Kenya. However, its cultivation releases a substantial amount of carbon, exacerbating climate change and its impacts. This study aimed to assess the role of Agri-silvicultural practices in reducing the carbon footprint of cassava production, contributing to Kenya's efforts in climate change mitigation, and promoting climate-smart agricultural practices in dryland areas such as Teso. The study conducted a comparative analysis of carbon emission levels between two cassava production systems: conventional and agro-silvicultural. The data were analysed using R-Studio version 2025. The statistical tests included two-sample t-tests on total carbon emissions between the two farming systems. The study revealed that the conventional cassava farming system emits significantly more carbon than agroforestry systems, mainly due to its high usage of synthetic farm inputs such as pesticides, fertilisers, and tractors for tillage, as well as the large amount of carbon generated from fossil fuel combustion. The t-test analysis showed a mean difference between the two systems ($t = -9.25$, $df = 7.83$, $p < 0.001$), indicating a significant difference ($p < 0.001$) in emissions between them. The Agri-silvicultural system had a mean of 1250 kgCO2e/ha, which was lower than the conventional farming system's mean of 1860 kgCO2e/ha. The means ranged from -762.68 to -457.32, with a 95% confidence interval, confirming that the conventional system consistently emitted higher levels than the Agri-silvicultural system. This study provides actionable insights for landowners, policymakers, and climate advocates in designing sustainable agricultural systems aimed at enhancing climate change mitigation and adaptation. It could encourage farmers to adopt the Agri-silvicultural farming system more widely, promoting sustainability by improving soil health, moisture retention, fertility, and conserving essential soil microorganisms.

**Keywords**: *Carbon emissions, greenhouse gases, climate change, agroforestry, conventional system*

## 5. EVALUATING THE EFFECTS OF CHARGED *Prosopis juliflora* BIOCHAR ON THE GROWTH PERFORMANCE OF *Calliandra calothyrsus* IN MARIGAT SUB-COUNTY, KENYA.

**Jane Chepkonga, Caroline Chepkirui, Rose Sagwe**
Kabarak Univewrsity
Corresponding author: cjepsergon@kabarak.ac.ke

### ABSTRACT

Agricultural productivity in Kenya's Arid and Semi-Arid Lands (ASALs) continues to be constrained by soil degradation, declining soil fertility, moisture stress, and the widespread invasion of *Prosopis juliflora*. These challenges significantly reduce fodder production and threaten agro-pastoral livelihoods in Marigat Sub-County, Baringo County. This study aims to evaluate the effects of charged *Prosopis juliflora* biochar on soil properties and the growth performance of *Calliandra calothyrsus* under ASAL conditions. Specifically, the study will assess the impact of charged biochar on soil physical properties, determine its effects on soil chemical properties, and evaluate its influence on the growth performance of *Calliandra calothyrsus*. The study will adopt an experimental research design using a Randomized Complete Block Design (RCBD). It will be conducted in Marigat Sub-County due to the high invasion of *Prosopis juliflora* and declining soil quality in the area. Three treatments will be applied: no biochar (control), uncharged *Prosopis* biochar, and nutrient-charged *Prosopis*

biochar. Each treatment will be replicated three times, resulting in nine experimental plots. Each plot will measure 5 m × 5 m with a 1 m buffer zone between plots to prevent cross-contamination. Seedlings will be planted at a spacing of 1 m × 1 m, giving 25 seedlings per plot. Soil physical and chemical properties, as well as plant growth parameters, will be measured using structured data collection instruments. Data will be analyzed using SPSS version 25.0 and Microsoft Excel. Descriptive statistics, including means and frequencies, will summarize soil properties and plant growth parameters. Inferential analysis will be conducted using Analysis of Variance (ANOVA) to determine significant differences among treatments. Where significant differences occur, Tukey's Honestly Significant Difference test will be applied at a 95% confidence level. Correlation and regression analyses will further examine relationships between biochar treatments, soil properties, and plant growth performance. The findings will provide empirical evidence on the potential of charged *Prosopis juliflora* biochar as a practical soil amendment for improving soil quality, enhancing fodder tree growth, and strengthening climate-resilient agroforestry systems in ASAL regions.

**Key words:** *Biochar, Prosopis juliflora, Soil fertility Calliandra calothyrsus, Arid and Semi-Arid Lands (ASALs)*

## 6. THE ENVIRONMENTAL SOLDIER PROGRAMME AS A MODEL FOR SUSTAINABLE DEFENSE: TACTICAL ASSET AS AN ENVIRONMENTAL STEWARD THROUGH STRATEGIC GREENING

**Brenda Jerotich Kimutai, Dr Danice Otieno Awinda**
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Email: bkimutai@kabarak.ac.ke

### ABSTRACT

As global military forces increasingly recognize climate change and land degradation as threat multipliers, the traditional boundary between national defense and environmental conservation is blurring. This paper evaluates the **Environmental Soldier Programme (ESP)** within the Kenya Defence Forces (KDF) as a pioneering framework for integrating ecological restoration into military operations. Using a mixed-methods approach, the study examines the ESP's impact on three key areas: regional biodiversity recovery, watershed protection, and the enhancement of military soft power within local communities. By leveraging military logistical capabilities and disciplined labor for large-scale reforestation and soil conservation, the program significantly accelerates the rehabilitation of degraded ecosystems. Furthermore, the integration of environmental stewardship into military culture fosters a dual-competency identity among personnel, improving institutional morale and public perception. The ESP provides a scalable model for other sub-Saharan defense forces. A military-led environmental strategy is not merely a corporate social responsibility initiative but a critical component of long-term national security and climate resilience.

**Keywords:** *Environmental Soldier Programme, military operations, environmental stewardship, sustainable defense, climate resilience*

## 7. LITHIUM GEOCHEMISTRY AND SPATIAL VARIABILITY IN MENENGAI GEOTHERMAL BRINES, KENYA: IMPLICATIONS FOR CRITICAL MINERAL RECOVERY AND RESERVOIR HYDROGEOCHEMISTRY

**Vincent Osango, Jackson Kitetu, Carolyne Chepkirui**
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### ABSTRACT

Lithium is strategically significant because it is crucial for lithium-ion batteries, electric vehicles, and grid-scale energy storage solutions as the world moves toward renewable energy systems. Since the discovery of geothermal brines, geothermal has emerged as a potential low carbon geothermal source of lithium, however, the lithium geochemistry of Kenyan geothermal systems is still not known in detail even though the country has a great geothermal potential in the East African Rift System. The geothermal field of Menengai was therefore studied, and lithium concentration obtained in the geothermal brines using Flame Atomic Absorption Spectrophotometry (FAAS). Thirty samples of the brine were collected from 10 production wells with three replicates analysed for each sample after acidification with ultra-pure $HNO_3$ and filtration through 0.45 µm membranes, at 670.8 nm. Descriptive statistics, one-way analysis of variance (ANOVA), Tukey HSD, skewness, kurtosis and effect size estimation were used in statistical analyses. The range of dissolved lithium levels was 0.254-3.080 mg/L with a mean concentration of 1.671 ± 0.852 mg/L and a standard deviation of 50.97%, this is a high geochemical variability beyond analytical uncertainty. Inter-well variability was highly significant ($F(9,20) = 60.32$, $p < 0.001$; $\eta^2 = 0.961$), with MW01A recording the highest concentration (2.971 ± 0.104 mg/L) and MW09 the lowest (0.425 ± 0.148 mg/L). The bimodal distribution of lithium concentrations indicated two hydrogeochemically different fluid populations related to fluid-rock interaction and meteoric dilution along structural discontinuities and reservoir compartmentalization. Lithium was found in all the wells but in very low amounts compared to the generally accepted economic extraction limit of 50 mg/L. This study also constitutes the first statistically sound geochemical baseline of geothermal lithium occurrence in Kenya, laying the groundwork for reservoir characterization studies, lithium direct extraction feasibility studies and critical mineral policy development.

**Keywords:** *Geothermal brine, lithium concentration, hydrogeochemically, Menengai geothermal field, renewable energy, Kenya.*

## 8. DETERMINANTS OF ADOPTION OF CLIMATE SMART AGRICULTURE AMONG SMALL-HOLDER FARMERS: A REVIEW OF EMPIRICAL LITERATURE

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### ABSTRACT

Climate change has threatened agricultural productivity, food security, and rural livelihoods among smallholder farmers especially in developing countries. Climate-smart agriculture (CSA) has emerged as a sustainable approach to increasing agricultural productivity, building resilience to climate change, and reducing greenhouse gas emissions. Despite the stated benefits of CSA practices, adoption among smallholder farmers remains relatively low in many parts of Sub-Saharan Africa. This paper reviews the existing literature on the determinants of smallholder farmers' adoption of climate-smart agriculture practices. The review analyses recent studies published between 2022 and 2026 specifically on socioeconomic, institutional, technological,

and environmental factors influencing adoption. The findings state that education level, household income, access to extension services, access to credit facilities, farm size, climate information, access to market, and government support significantly influence smallholder farmers' decisions to adopt. Institutional factors such as access to agricultural training, policy frameworks, and membership to a farmer organization were found to play an important role in promoting adoption of CSA technologies. However, barriers such as high initial costs, limited technical knowledge, and limited climate information continue to hinder widespread adoption. The review also identifies research gaps related to localized empirical studies and the long-term sustainability assessment of climate-smart agriculture interventions. The study concludes that strengthening institutional support, improving farmer awareness, facilitating access to agricultural financing, and promoting locally adaptable CSA technologies are essential for increasing adoption among smallholder farmers and promoting sustainable agricultural development.

**Key words:** *Climate-smart agriculture, smallholder farmers, adoption, climate change, empirical review*

## 9. ADOPTION OF ENERGY-EFFICIENT LIGHTING: PRACTICES AND POTENTIAL AMONG SMALL-SCALE TRADERS IN KENYAN MARKET CENTRES

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## ABSTRACT

Globally, studies have highlighted the environmental, economic, and social benefits of replacing high-emission lighting sources (such as kerosene lamps and incandescent bulbs) with cleaner alternatives like LED lights and solar-powered lamps. However, despite growing research in this field, limited attention has been given to the impact of this transition on small scale traders, who form a significant part of the economy in many developing countries. This study examined solar energy absorption and access patterns among traders in a likely semi-rural Kenyan context, focusing on demographics, primary lighting sources, and bulb/device preferences. The study adopted a cross-sectional descriptive survey design targeting microenterprises in Kenya. The study was conducted in trading centres within four counties—Kericho, Nakuru, Baringo, and Kisumu—where economic activity is visibly concentrated. The sample size for the study was 384 small-scale traders, with each county contributing 96 small-scale traders. Data was collected using structured questionnaires administered face – to – face, observation checklist, key informant interview guide and focus group discussion guide. Qualitative data was analyzed thematically while quantitative data was analyzed descriptively using percentages and inferentially using Chi-square. The sample shows a marked gender imbalance, with females comprising 87.7% (335 respondents) versus 12.3% males (47), suggesting that more women are engaged in small-scale trading and manage lighting for cooking, childcare, and evening tasks—common in off-grid communities. Education levels are dominated by secondary completion (57.9%, 221 respondents), followed by primary (28.0%, 107), tertiary (9.2%, 35), and none (0.5%, 2), with minor missing data (4.5%); this profile aligns with East African trends (50-60% adult secondary rates) and supports adoption of user-friendly solar tech, though primary-only groups may need simplified maintenance training. Primary lighting sources highlight solar dominance at 88.0% (336 respondents using solar lamps/systems), far outpacing grid electricity (8.6%, 33), "other" sources (2.1%, 8), candles (0.5%, 2), and negligible kerosene lamps or generators (0.3% each). The chi-square results revealed a significant rate of adoption of solar lamps by small scale traders. This reflects robust off-grid solar penetration in sub-Saharan Africa, displacing health-risky kerosene (reducing respiratory issues and weekly costs of ~$1-2/household) amid unreliable grids. Frequently used lighting devices favor LEDs (65.2%, 249), rechargeable torches (24.1%, 92), and fluorescent tubes (8.4%, 32), with rare incandescent use (0.3%) and minimal missing data (1.8%). LED prevalence pairs efficiently with solar (low wattage, 10,000+ hour lifespan), enabling 4-6 hours of nightly use and 80% cost savings over kerosene, while torches address portable needs like farming. Overall, results affirm solar's scalability for energy poverty alleviation and gender-specific challenges, though gender skew limits male perspectives,

and "other" sources warrant further probing for hybrids. Targeted interventions could boost tertiary education uptake and rainy-season reliability.

**Key words:** *Energy-efficient lighting, small scale traders, solar-powered lamps, Kericho, Kisumu, Baringo, Nakuru, off-grid communities*

## 10. COMMAND-AND-CONTROL VS. MARKET-BASED INSTRUMENTS: A COMPARATIVE ANALYSIS OF PLASTIC BAG MITIGATION STRATEGIES IN NAIROBI AND NAKURU CITY

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### ABSTRACT

This paper seeks to compare and contrast policy bans on plastic bags with localized market-based approaches, such as taxes and levies, in two cities. In this case, Nairobi is the primary administrative hub, while Nakuru is a rapidly growing commercial and agricultural hub. In 2017, Kenya implemented one of the world's most stringent bans on single-use plastic carrier bags. Despite high initial compliance, urban centers continue to face challenges from the persistence of illicit bags and the emergence of non-regulated plastic packaging. The study concludes that a ban is insufficient for the complete eradication of plastic. A hybrid model, retaining the ban on retail carriers while introducing tiered taxes on industrial primary packaging, is recommended to address the specific socio-economic realities of Nairobi and Nakuru.

**Keywords:** *Plastic bag ban, plastic taxes and levies, market-based instruments, circular economy*

## 11. THERMODYNAMIC AND FLUID DYNAMICS SIMULATION MODEL TO ANALYZE GEOTHERMAL HEAT TRANSFER INTO WASTE OIL - FUELED GLASS RECYCLING FURNACE FOR IMPROVED ENERGY EFFICIENCY.

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### ABSTRACT

Recycling is an essential component of an environmental conservation program by controlling waste materials from accessing various channels into the ecosystem. Waste glass engenders unembellished environmental challenge, mainly due to the impulsiveness conditions in the mass waste state. With snowballing environmental pollution, there is need to reduce solid waste in order for the protection of future generations. Recycling of waste glass is one alternative measure to reduce the influx of solid waste into the environment. Out of the five hierarchies of waste management, reduce, reuse, recycle, recover, and landfilling, recycling is the best alternative measure for melting glass. Geothermal energy is a clean, sustainable, and renewable resource. Embracing and direct use of geothermal energy in Kenya is a key approach for empowering waste control, enhancing environmental protection, and improving energy utilization. In the study, geothermal energy from a power plant or from dormant wells was simulated using numerical model through experimental tests to verify its potential to enhance waste oil in the melting of waste glass. The objective of this study was to create a thermodynamic and fluid dynamics simulation model to analyze geothermal heat transfer into waste oil - fueled glass recycling furnace for improved energy efficiency. The finite difference technique of algebraic

analysis was utilized during the procedure to regulate the conditions in the glass recycling process. The data that was gathered was used to test and validate the development of the simulation model and supply the necessary conditions for the recycling of glass. MATLAB was used for the analysis of this data, and SolidWorks was used for designing the experimental model and simulation.

**Key Words:** *Thermodynamic, fluid dynamics, simulation model, geothermal heat transfer, waste oil – fueled, glass recycling and improved energy efficiency.*

# PROGRAM AND ABSTRACTS FOR COMPUTER SCIENCE AND IT CONFERENCE

## SUB-THEME 2: *EMPOWERING SUSTAINABLE FUTURES THROUGH GREEN ICT & AI-DRIVEN SOLUTIONS*

## DAY 1: 23RD JUNE 2026

**Chair: Dr Dismas Ombuya**

**Rapporteur:**

**Link:** *https://kabarak-ac-ke.zoom.us/j/88277529856?pwd=RzYxbTB5pRqmbWXOim4bmmJgwXhEdb.1*

| TIME | TITLE OF THE PAPER | NAME OF THE PRESENTER |
|---|---|---|
| 2.30 – 2.50 PM | **Abstract 1**: A Self-Assessment Model for Assessing Information Security Maturity in Healthcare Facilities in Kenya: A Systematic Literature Review and Gap Analysis | **Caroline Ngetich**<br>Kabarak University<br>**cjepkosgei@kabarak.ac.ke** |
| 2.50 – 3.10 PM | **Abstract 2**: Leveraging Blockchain to Strengthen Fraud Prevention and Data Integrity in Digital Financial Transfers | Kevina Brenda Mbati<br>Kabarak University<br>kbrenda@kabarak.ac.ke |
| 3.10 – 3.30 PM | **Abstract 3**: An artificial intelligence conversational agent with integrated analytics for antenatal care health education | Wilbon Cheruiyot Langat Kabarak University |
| 3.30 – 3.50 PM | **Abstract 4:** A literature review on explainable AI ensemble model for multi-class classification of malaria and sickle cell anemia: critical data elements, associated challenges and the role of machine learning & explainability | Waliaula Mabonga,<br>Kabarak University<br>smabonga@kabarak.ac.ke |
| 3.50 – 4.10 PM | **Abstract 5:** A Hybrid CNN-LSTM Architecture for Structural and Contextual Feature Extraction in Phishing Email Detection | Laban Kipkorir<br>Kabarak University |

## DAY TWO: 24TH JUNE 2026

**CHAIR:**

**Rapporteur:**

**Link:** *https://kabarak-ac-ke.zoom.us/j/88277529856?pwd=RzYxbTB5pRqmbWXOim4bmmJgwXhEdb.1*

| | | |
|---|---|---|
| 8.30 AM | Devotion and opening prayer: | |
| 9.00 AM | Opening remarks from the Dean School of Science Engineering and Technology | |
| **TIME** | **TITLE OF THE PAPER** | **NAME OF THE PRESENTER** |
| 9.20 – 9.40 AM | **Abstract 6:** Cybersecurity Frameworks for Sustainable Digital Financial Institutions in AI-Enabled Environments: A Systematic Literature Review | **Elisha Omondi**<br>Kabarak University<br>**eedwine@strathmore.edu** |
| 9.40 – 10.00 AM | **Abstract 7:** An assessment of the data integrity status of dispensed drugs. A study of Homabay County Referral Hospital. | Jacob Orage<br>Rongo University<br>**hopeleze@gmail.com** |
| 10.00 – 10.20 AM | **Abstract 8:** Intelligent Tracking Model for Stolen Android Devices with Multi-User Authentication and Predictive Recovery Support | |
| *10.20 – 10.40 AM* | *TEA BREAK* | |
| **10.40 – 11.10 AM** | **Abstract 9:** Design of Hybrid Gated Recurrent Unit with eXtreme Gradient Boosting Model Optimized through Bayesian Optimisation for Flood Prediction | Lilian Chepng'eno Ng'eny<br>Kabarak University<br>**lngeny@kabarak.ac.ke** |
| 10.40 – 11.00 AM | **Abstract 10:** ERP Security Vulnerabilities, System Integrity, and Sustainable ICT in AI-Enabled Environments: Evidence from GWASCO and KEWASCO | Dennis Boera Onchwari<br>Rongo University |
| 11.00 – 11.20 AM | **Abstract 11**: KalenjinAI: Low-Resource Swahili–Kalenjin Neural Machine Translation via QLoRA for Sustainable Digital Inclusion and Indigenous Language Preservation | |
| 11.20 – 11.40 AM | **Abstract 12:** Cybersecurity Frameworks for Sustainable Digital Financial Institutions in AI-Enabled Environments: A Systematic Literature Review | |
| 11.40 – 12.00 PM | **Abstract 13:** A machine learning-based model for simplifying consumer decision making in online marketplaces | Victor K. Rotich<br>Kabarak University<br>vkipkirwa@kabarak.ac.ke |
| 12:00 – 12:20 PM | **Abstract 14:** Evaluating the Usability of a Face-Based Hybrid Authentication Models | Salihu Umar Suru<br>Kebbi State University of Science and Technology- Nigeria<br>salihuumarsuru@gmail.com |

# ABSTRACTS FOR CONFERENCE ON COMPUTER SCIENCE AND IT, 2026

## 1. A SELF-ASSESSMENT MODEL FOR ASSESSING INFORMATION SECURITY MATURITY IN HEALTHCARE FACILITIES IN KENYA: A SYSTEMATIC LITERATURE REVIEW AND GAP ANALYSIS

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### ABSTRACT

The rapid digitalization of health services has on the one hand, enhanced service delivery, data availability, and efficiency. On the other hand, this has brought forth a plethora of cybersecurity challenges, especially in low- and middle-income countries such as Kenya, where resources, technical expertise, and security infrastructure are critically wanted (WHO, 2021). Current information security maturity models, including the ISO/IEC 27001, NIST Cybersecurity Framework, COBIT, and HITRUST, offer a framework for effective risk management and governance (Dlamini et al., 2021). However, despite their theoretical benefits, they have proven to be complex, expensive, and require specific expertise to effectively implement. Moreover, they lack health-specific and operational environment applicability. This paper aims to conduct a systematic review of existing information security maturity models, their applicability in a health environment, and their limitations. It has identified a number of critical gaps in the existing literature, including a lack of health-specific applicability, lack of non-expert applicability, lack of self-assessment, and failure to take cognizance of socio-technical issues in low- and middle-income countries. Empirical evidence from various healthcare facilities in Kenya showed low levels of security maturity in various areas, including administrative, technical, and physical safeguard areas. The low levels of security maturity were noted in various areas, including governance structures, incident response, and security culture. The need for a simplified self-assessment security maturity model for various healthcare facilities in Kenya is imperative. The self-assessment will help various healthcare institutions in Kenya assess their security levels without requiring much expertise and financial resources.

**Keywords:** *Information security maturity, healthcare cybersecurity, maturity models, self-assessment, Kenya, LMIC, research gaps*

## 2. LEVERAGING BLOCKCHAIN TO STRENGTHEN FRAUD PREVENTION AND DATA INTEGRITY IN DIGITAL FINANCIAL TRANSFERS

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### ABSTRACT

The rapid expansion of digital financial transfer systems has improved transaction efficiency and financial inclusion. However, these systems continue to face significant challenges, particularly in fraud prevention and data integrity, due to their reliance on centralized architectures and fragmented security controls. This study will aim to develop a blockchain-based model to strengthen fraud prevention and enhance data integrity in digital financial transfers. The study will adopt the Design Science Research (DSR) methodology to guide the identification of system vulnerabilities, the definition of solution objectives, and the design and evaluation of the proposed model. The proposed solution will utilize blockchain technology, incorporating distributed

ledger architecture, consensus mechanisms, and smart contracts to ensure secure, transparent, and tamper-resistant transaction processing. The model will be demonstrated through simulated transaction scenarios, including multi-account transfers and fraud detection cases. The evaluation will assess the extent to which the proposed system improves fraud prevention by enabling real-time transaction validation and reducing opportunities for unauthorized manipulation. It will also examine how the system enhances data integrity by ensuring immutability and consistency of transaction records across participating nodes. Furthermore, the decentralized nature of the system is expected to support transparency and reduce reliance on centralized control, thereby improving trust within the financial ecosystem. The study is expected to demonstrate that blockchain technology provides a robust and scalable approach to addressing persistent security and integrity challenges in digital financial transfer systems. The findings will contribute to the development of more secure, transparent, and reliable financial infrastructures.

**Keywords:** Blockchain, Fraud Prevention, Data Integrity, Digital Financial Transfers, Distributed Ledger

## 3. AN ARTIFICIAL INTELLIGENCE CONVERSATIONAL AGENT WITH INTEGRATED ANALYTICS FOR ANTENATAL CARE HEALTH EDUCATION

**Wilbon Cheruiyot Langat[1], Moses Thiga[2], Pamela Kimeto[1] and Peter Rugiri[1]**
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## ABSTRACT

In recent years, countries in sub-Saharan Africa have invested significantly in maternal healthcare facilities and technologies to improve the quality of care for expectant women. Despite these efforts, maternal morbidity and mortality remain high due to limited access to effective antenatal care (ANC) health education. Insufficient ANC education hinders awareness of proper pregnancy practices such as nutrition, avoidance of harmful substances, and self-care, increasing the risk of undetected complications including gestational diabetes and pre-eclampsia. Delayed interventions may also result in missed immunizations and screenings, exposing mothers and infants to preventable health risks. Access to quality ANC health education is constrained by poverty, long distances to healthcare facilities, inadequate information, shortages of healthcare personnel, and limited resources. Existing technologies, including Mum-Care, Rosie, Baby-Bump, PROMPTS, and Mom-Connect provide ANC support but lack integrated data-driven analytics for decision support. The development of an artificial intelligence-driven prototype that provides instant, multilingual, confidential, and personalized ANC education to multiple expectant mothers simultaneously from their homes. By incorporating predictive analytics and user engagement metrics, the system delivers tailored health information, monitor behavioral trends, identify potential risk indicators, and support early intervention. Healthcare providers will also benefit from analytics to assess user interactions, identify knowledge gaps, and predict high-risk cases. The study adopts the design thinking methodology. During the Empathize stage, disproportional purposive sampling and proportional stratified random sampling used to select 21 ANC experts and 150 expectant mothers, respectively. The prototype is developed using rapid prototyping and evaluated through a goal-based evaluation technique. The AI-driven ANC education system is expected to improve maternal knowledge, enable early risk detection, and enhance antenatal health outcomes.

***Keywords:*** *Artificial Intelligence, Conversational agents, Natural Language Processing, Integrated analytics.*

## 4. A LITERATURE REVIEW ON EXPLAINABLE AI ENSEMBLE MODEL FOR MULTI-CLASS CLASSIFICATION OF MALARIA AND SICKLE CELL ANEMIA: CRITICAL DATA ELEMENTS, ASSOCIATED CHALLENGES AND THE ROLE OF MACHINE LEARNING & EXPLAINABILITY

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### ABSTRACT

Malaria and sickle cell anemia remain two of the most serious and interconnected public health issues in Sub-Saharan Africa, particularly in areas like Western Kenya where both illnesses are common. Because these diseases have multiple clinical symptoms in common, including fever, anemia, tiredness, and jaundice, their coexistence complicates diagnosis significantly. In resource-constrained healthcare settings, this overlap is exacerbated by limited access to trustworthy diagnostic equipment, fragmented patient records, and insufficient clinical data. As a result, misdiagnosis and delayed treatment of mono- and co-infections are widespread, posing significant hazards to patient outcomes. This literature review looks at the important data items needed for accurate malaria and SCA diagnosis, as well as how machine learning (ML) and explainable artificial intelligence (XAI) can aid with the diagnostic issues. The review summarizes existing research on demographic, clinical, and laboratory data elements used to diagnose malaria and SCA and identifies major barriers to their effective use, such as data incompleteness, heterogeneity, class imbalance, and limited interoperability within health information systems. It also examines the expanding significance of machine learning algorithms such as Random Forest, Support Vector Machines, Gradient Boosting, and deep learning models in detecting complicated patterns in clinical data for disease classification. Ensemble learning approaches are given special emphasis, as they combine numerous predictive models to improve accuracy, resilience, and generalizability in complicated diagnostic contexts. Furthermore, the paper investigates the role of explainable AI techniques, such as SHAP and LIME, in addressing the "black box" character of many ML models. By giving interpretable insights into model predictions, XAI improves transparency, clinician trust, and the usability of AI-based decision-support technologies. The analysis highlights a key need in current research: the absence of integrated multi-class diagnostic frameworks capable of identifying malaria infection, SCA-related disease, co-infection, and non-related febrile illnesses.

The findings emphasize the need of context-aware, explainable ensemble models that rely on readily available clinical data and can work effectively in low-resource situations. The report closes by presenting future research initiatives aimed at establishing cost-effective, interpretable AI diagnostic tools that can improve clinical decision-making and health outcomes in malaria-SCA co-endemic areas.

**Keywords:** *Explainable AI, ensemble learning, malaria, sickle cell anemia, multi-class classification, clinical data, diagnostic challenges, machine learning, SHAP, healthcare informatics.*

## 5. A HYBRID CNN-LSTM ARCHITECTURE FOR STRUCTURAL AND CONTEXTUAL FEATURE EXTRACTION IN PHISHING EMAIL DETECTION

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### ABSTRACT

Phishing remains one of the most persistent cybersecurity threats, targeting individuals and organizations through deceptive email communications designed to steal sensitive information. Traditional rule-based and blacklist-based detection systems have proven insufficient in addressing the increasingly sophisticated and adaptive nature of modern phishing attacks. Recent advancements in artificial intelligence and deep learning have provided new opportunities for enhancing phishing detection mechanisms. This study proposes a hybrid deep learning architecture combining Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks to improve phishing email detection by capturing both structural and contextual features embedded within email content. The CNN component is responsible for extracting spatial patterns such as suspicious URL structures and header anomalies, while the LSTM component models sequential linguistic dependencies within email text. The proposed model is trained and evaluated using publicly available phishing and legitimate email datasets. Experimental results demonstrate that the hybrid CNN-LSTM architecture achieves superior performance compared to standalone deep learning models. The findings highlight the importance of integrating structural and contextual analysis for effective phishing detection in modern cybersecurity environments. The proposed approach contributes to the development of intelligent email security systems capable of detecting increasingly sophisticated phishing attacks.

**Keywords:** *phishing detection, deep learning, CNN-LSTM, cybersecurity, email security, machine learning.*

## 6. CYBERSECURITY FRAMEWORKS FOR SUSTAINABLE DIGITAL FINANCIAL INSTITUTIONS IN AI-ENABLED ENVIRONMENTS: A SYSTEMATIC LITERATURE REVIEW

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### ABSTRACT

The rapid digital transformation of financial institutions has significantly expanded the cyber-attack surface, particularly within sustainable digital financial ecosystems operating in data-intensive environments. This study presents a systematic literature review of cybersecurity frameworks applicable to sustainable digital financial institutions, with specific attention to emerging AI-enabled operational contexts. Although Artificial Intelligence (AI) is not foregrounded in the title, its role is critically examined within the review to assess how intelligent systems influence threat detection, adaptive defense mechanisms, automated compliance monitoring, and risk analytics. Using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, this study systematically identifies, screens, and synthesizes peer-reviewed research published between 2014 and 2025 across major academic databases. A structured inclusion–exclusion protocol was applied to ensure methodological rigor, transparency, and replicability. The analysis evaluates existing cybersecurity frameworks against sustainability principles, regulatory alignment, resilience capabilities, and scalability within digital financial infrastructures such as fintech platforms, digital banks, and cooperative financial systems. Findings reveal that while traditional governance-based frameworks emphasize compliance and risk management, emerging AI-integrated models demonstrate enhanced predictive threat intelligence, anomaly detection, and adaptive response capabilities. However, challenges remain in areas such

as explainability, ethical AI deployment, regulatory harmonization, and long-term sustainability integration. The study proposes a synthesized conceptual framework that integrates sustainability, cyber resilience, and AI-driven security orchestration to guide policymakers, researchers, and financial technology practitioners toward secure and sustainable digital finance ecosystems.

**Keywords:** *Sustainable Digital Finance, Cybersecurity Frameworks, Artificial Intelligence in Cybersecurity, PRISMA Systematic Review and Digital Financial Institutions.*

## 7. AN ASSESSMENT OF THE DATA INTEGRITY STATUS OF DISPENSED DRUGS. A STUDY OF HOMABAY COUNTY REFERRAL HOSPITAL

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### ABSTRACT

The integrity of data in the supply and distribution of public health commodities, particularly human medicinal drugs, is crucial for ensuring safety, efficacy and trust within the healthcare system. Recognizing this, our study evaluates the current status of data integrity in dispensed drugs at Homabay County Referral Hospital. Key aspects assessed include Attributability, Legibility, Contemporaneous Recording, Originality, and Accuracy factors vital for reliable drug management. Using a purposive and snowball sampling approach, 54 stakeholders including pharmacists, doctors, nurses, procurement officers, hospital administrators and patients were engaged through interviews and observations to gather comprehensive insights across all departments. The findings reveal notable weaknesses in several data integrity attributes, culminating in an overall score of 59.5%. Specifically, contribution levels varied: Attributability (23%), Legibility (43.3%), Contemporaneousness (55.75%), Originality (47%), Accuracy (42%), Completeness (38%) and Consistency (16.7%). Statistical analysis using Chi-Square tests demonstrated a significant association ($p < 0.001$) between these attributes and the current data integrity status. The results underscore the urgent need for targeted interventions to enhance data quality, ultimately strengthening drug security and fostering a paradigm shift toward more transparent and reliable healthcare data management.

**Key Words**: *Data Integrity, Drug Supply Chain, Healthcare Data Management, Pharmaceutical Records, Data Quality Assessment.*

## 8. INTELLIGENT TRACKING MODEL FOR STOLEN ANDROID DEVICES WITH MULTI-USER AUTHENTICATION AND PREDICTIVE RECOVERY SUPPORT

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### ABSTRACT

Smartphone theft and loss continue to present major cybersecurity, privacy, and financial risks due to the increasing dependence on mobile devices for communication, digital transactions, identity management, and storage of sensitive information. Although existing recovery solutions such as Google Find My Device and similar commercial platforms provide basic device recovery functionalities, their effectiveness remains limited

under real-world theft conditions due to reliance on continuous internet connectivity, enabled GPS services, and single-user authentication mechanisms. This study proposed and evaluated an intelligent Android device recovery model integrating multi-user authentication, offline tracking resilience, stealth-based monitoring, and lightweight machine learning-based trajectory prediction. The study adopted a Design Science Research methodology involving problem identification, framework design, prototype implementation, and performance evaluation. The proposed framework was implemented within an Android environment using Kotlin, Firebase Firestore, Google Maps API, and FIDO2/WebAuthn passkey authentication technologies. A K-Nearest Neighbors predictive subsystem was integrated to analyze historical movement behavior and estimate probable future device trajectories during recovery operations. The system further incorporated offline location caching, delayed cloud synchronization, trusted contact recovery support, and heatmap-based movement visualization. Evaluation findings demonstrated improved operational resilience, authentication reliability, predictive recovery support, and tracking continuity compared to conventional smartphone recovery systems. The integrated predictive subsystem achieved acceptable trajectory estimation accuracy with low Root Mean Square Error (RMSE) values, while offline synchronization mechanisms improved recovery continuity during unstable network conditions. The findings further established that collaborative multi-user recovery significantly strengthened recovery accessibility and operational flexibility under compromised access scenarios. The study concludes that integrating predictive analytics, collaborative authentication, and offline operational resilience significantly enhances smartphone recovery effectiveness under real-world-oriented conditions and contributes meaningfully to contemporary intelligent mobile security research.

**Keywords:** *Android Device Recovery, Multi-User Authentication, Predictive Analytics, Smartphone Tracking, K-Nearest Neighbors.*

## 9. DESIGN OF HYBRID GATED RECURRENT UNIT WITH EXTREME GRADIENT BOOSTING MODEL OPTIMIZED THROUGH BAYESIAN OPTIMISATION FOR FLOOD PREDICTION

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### ABSTRACT

Flood prediction continues to be a major global concern a due to the difficulty of standard models in capturing the intricate non-linear dynamics and temporal relationships present in hydrological systems. The design factors for a hybrid Gated Recurrent Unit (GRU) and eXtreme Gradient Boosting (XGBoost) model optimized by Bayesian Optimization (BO) for flood prediction and mitigation strategies are examined in this literature review. The study consolidates theoretical frameworks, empirical data, and methodological strategies from 25 peer-reviewed researches published between 2014 and 2025. Key findings indicate that Gated Recurrent Unit designs excel in capturing temporal dependencies with less computational cost relative to conventional recurrent networks, whereas eXtreme Gradient Boosting effectively manages non-linear interactions and incorporates built-in regularization to mitigate overfitting. Bayesian Optimization is a sample-efficient technique for hyperparameter tuning in high-dimensional spaces, especially beneficial for hydrological applications with limited computational resources. The review highlights significant research deficiencies, such as inadequate incorporation of primary hydrological data, insufficient investigation of Gated Recurrent Unit with eXtreme Gradient Boosting synergistic frameworks, and the necessity for improved model interpretability. This synthesis lays the theoretical and methodological groundwork for creating a hybrid model specifically designed for Kenya's Nyando River Basin, where frequent flooding calls for reliable forecast systems.

**Keywords:** *Gated Recurrent Unit, eXtreme Gradient Boosting, Bayesian Optimization, hybrid model, flood prediction*

## 10. ERP SECURITY VULNERABILITIES, SYSTEM INTEGRITY, AND SUSTAINABLE ICT IN AI-ENABLED ENVIRONMENTS: EVIDENCE FROM GWASCO AND KEWASCO

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### ABSTRACT

This study assessed Enterprise Resource Planning (ERP) security vulnerabilities affecting system integrity in public water utilities, focusing on Gusii Water and Sanitation Company (GWASCO) and Kericho Water and Sanitation Company (KEWASCO). Using a mixed-methods approach, data were collected from 39 ERP-engaged staff through questionnaires, interviews, system-log analysis, and observations. Findings indicate that ERP data integrity performance averaged approximately 60%, significantly below the 90–100% benchmark expected for high-integrity enterprise systems. Key vulnerabilities were identified in data accuracy and completeness (65%), metadata integrity (55%), and cross-module consistency (60%). Additional weaknesses were observed in audit trails, access control, and insider threats, including shared credentials, incomplete logs, and delayed access revocation. The results demonstrate that ERP vulnerabilities are systemic, arising from both technical limitations and governance weaknesses. The study concludes that current ERP environments are insufficient to guarantee data reliability, auditability, and accountability, and recommends strengthening access control, audit logging, and user governance practices.

**Keywords:** *ERP security, data integrity, access control, audit trails, insider threats, public utilities.*

## 11. KALENJINAI: LOW-RESOURCE SWAHILI–KALENJIN NEURAL MACHINE TRANSLATION VIA QLORA FOR SUSTAINABLE DIGITAL INCLUSION AND INDIGENOUS LANGUAGE PRESERVATION

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### ABSTRACT

Kalenjin, a major Nilotic language spoken by over 6 million people in Kenya's Rift Valley, remains absent from modern generative AI systems and translation tools. This linguistic exclusion creates a digital divide, limiting mother-tongue education, cultural preservation, and equitable access to information in rural communities. I developed KalenjinAI — the first neural machine translation system for Swahili to Kalenjin — as a practical step toward closing this gap. Using Meta's NLLB-200 (600M distilled) model and QLoRA fine-tuning on a locally curated parallel corpus (28,101 training sentences), an initial 5-epoch run achieved a training loss of 11.14 on consumer 8 GB VRAM hardware. A second retraining run for 24 epochs (8 hours overnight) significantly improved performance, reaching a final training loss of 2.78. Human evaluation confirmed better fluency, including accurate translation of number words that previous versions failed. The model is deployed as a live public web application at https://kalenjinai.xyz with a built-in feedback loop for community-driven data collection. This low-compute, open approach exemplifies green AI and sustainable digital innovation: it requires no cloud resources, runs on modest hardware, and empowers indigenous language speakers. The work aligns with Kenya Vision 2030, SDG 4 (Quality Education), and SDG 10 (Reduced Inequalities), demonstrating how efficient AI can drive community-led sustainable development in East Africa.

**Keywords:** *Generative AI, African Languages, Low-Resource NLP, QLoRA, Sustainable Digital Inclusion.*

## 12. CYBERSECURITY FRAMEWORKS FOR SUSTAINABLE DIGITAL FINANCIAL INSTITUTIONS IN AI-ENABLED ENVIRONMENTS: A SYSTEMATIC LITERATURE REVIEW

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### ABSTRACT

The cyberattack surface has grown dramatically due to financial institutions' rapid digital transformation, particularly within sustainable digital financial ecosystems operating under data-intensive conditions. With a focus on developing AI-enabled operational settings, this paper offers a thorough literature assessment of cybersecurity frameworks relevant to sustainable digital financial institutions. The role of artificial intelligence (AI) is rigorously explored in the evaluation to evaluate how intelligent systems impact threat detection, adaptive defense mechanisms, automated compliance monitoring, and risk analytics, even if AI is not highlighted in the title. This study systematically finds, filters, and synthesizes peer-reviewed material published between 2014 and 2025 across major academic databases using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) technique. To guarantee scientific rigor, transparency, and reproducibility, a standardized inclusion-exclusion protocol was used. A total of 56 articles were initially identified, of which 34 peer-reviewed studies were finally included after the PRISMA screening process. The literature search was conducted across major academic databases including Scopus, Web of Science, IEEE Xplore, ScienceDirect, and Google Scholar, covering publications from 2014 to 2025. The review identifies major cybersecurity frameworks applied in digital financial institutions and evaluates how artificial intelligence technologies enhance threat detection, cyber resilience, and fraud prevention. The findings reveal that existing frameworks remain largely compliance-oriented and lack adaptive AI-driven mechanisms for emerging digital finance ecosystems. This study contributes to the literature by synthesizing cybersecurity, artificial intelligence, and sustainability perspectives and proposing an integrated conceptual framework for secure and sustainable digital financial institutions. The analysis evaluates existing cybersecurity frameworks against sustainability principles, regulatory alignment, resilience capabilities, and scalability within digital financial infrastructures such as fintech platforms, digital banks, and cooperative financial systems. Findings reveal that while traditional governance-based frameworks emphasize compliance and risk management, emerging AI-integrated models demonstrate enhanced predictive threat intelligence, anomaly detection, and adaptive response capabilities. However, challenges remain in areas such as explainability, ethical AI deployment, regulatory harmonization, and long-term sustainability integration. The study proposes a synthesized conceptual framework that integrates sustainability, cyber resilience, and AI-driven security orchestration to guide policymakers, researchers, and financial technology practitioners toward secure and sustainable digital finance ecosystems.

**Keywords:** *Sustainable Digital Finance, Cybersecurity Frameworks, Artificial Intelligence in Cybersecurity, PRISMA Systematic Review and Digital Financial Institutions.*

## 13. A MACHINE LEARNING-BASED MODEL FOR SIMPLIFYING CONSUMER DECISION MAKING IN ONLINE MARKETPLACES

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### ABSTRACT

The rapid growth of online marketplaces and the increasing volume of product information have created significant challenges for consumers in making informed purchase decisions. Consumers are often faced with information overload, unreliable reviews, and difficulty in identifying suitable products and trustworthy vendors.

This negatively affects decision quality and overall user experience. Although existing machine learning–based recommendation systems provide some level of support, they often lack contextual understanding and fail to address complex decision-making scenarios. This study aims to develop a hybrid model that integrates machine learning with a rule-based system to streamline consumer decision-making in online marketplaces. The study investigates the limitations of existing decision-making models to facilitate the design and implementation of a machine learning–based solution. A mixed-methods research design is adopted, combining quantitative analysis of consumer behaviour data with qualitative insights from user experiences. The proposed model analyses consumer behaviours and product data while incorporating contextual factors such as budget constraints and vendor credibility to improve recommendation relevance. The proposed model will be evaluated using both system performance metrics and user-cantered measures of usability and satisfaction. The findings are expected to demonstrate the effectiveness of the model in improving decision accuracy, reducing cognitive overload, and enhancing overall consumer experience in online marketplaces.

**Keywords:** *Machine Learning, Recommender Systems, E-commerce, Consumer Decision-Making, Hybrid Models, Explainable AI, User Experience*

## 14. EVALUATING THE USABILITY OF A FACE-BASED HYBRID AUTHENTICATION MODELS

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## ABSTRACT

Usability remains a critical challenge in authentication system design, particularly for mechanisms that aim to enhance security without imposing excessive cognitive or interaction burdens on users. While face-based graphical authentication schemes have shown promise in improving memorability, they often suffer from usability limitations when deployed in real-world, multi-user environments. This paper presents a usability evaluation of a face-based hybrid authentication prototypes that integrates graphical face recognition with textual and object-based authentication elements to balance usability, memorability, and security.

A controlled within-subject experimental design was employed, involving 30 participants, each of whom interacted with six authentication models, including three proposed hybrid models and three representative baseline schemes. Usability was assessed using standardized Likert-scale measures covering ease of use, ease of understanding, authentication speed, GUI Layout presentation and overall user satisfaction. Both descriptive and inferential statistical analyses were conducted, including one-way ANOVA, post hoc Tukey HSD comparisons, and Chi-Square tests of independence, to examine differences and associations across models.

The results demonstrate statistically significant differences in perceived usability among the evaluated authentication models ($p < 0.001$). The proposed hybrid models consistently achieved higher usability ratings than traditional face-based and object-based schemes, with large effect sizes indicating meaningful practical improvements. Post hoc analyses further revealed that models incorporating structured face categories and hybrid interaction mechanisms significantly outperformed purely graphical approaches. These findings highlight the importance of hybrid design strategies in mitigating usability challenges associated with face-based authentication systems.

The paper contributes empirical evidence to human-centered authentication research and offers practical design insights for developing usable and secure authentication mechanisms suitable for deployment in multi-user environments.

**Keywords**: *Face-based authentication · Hybrid authentication · Usability evaluation · Human–computer interaction · Graphical passwords*

# PROGRAM & BOOK OF ABSTRACTS FOR PURE AND APPLIED SCIENCE CONFERENCE

## SUB-THEME 3: *CONTEMPORARY RESEARCH ADVANCES IN PHYSICAL, BIOLOGICAL AND MATHEMATICAL SCIENCES*

### DAY 1: 23rd JUNE 2026

**Chair: Prof. Christopher Maghanga**

**Rapporteur: David Maina**

**Link:** *https://kabarak-ac-ke.zoom.us/j/88277529856?pwd=RzYxbTB5pRqmbWXOim4bmmJgwXhEdb.1*

| TIME | TITLE OF THE PAPER | NAME OF THE PRESENTER |
|---|---|---|
| 2.30 – 2.50 PM | **Abstract 1**: Design and Characterization of a Panchromatic Natural Dye Cocktail for Enhanced Light-Harvesting in Dye-Sensitized Solar Cells | Archibald M.K Kipkembo<br>Kabarak University |
| 2.50 – 3.10 PM | **Abstract 2**: On EP And Generalized EP Equivalent Operators | Caroly Wafula Wekesa<br>Maasai Mara University<br>cwekesa.0064@student.mmarau.ac.ke |
| 3.10 – 3.30 PM | **Abstract 3**: Analysis of phase shift and energy gap dependence on Fermi momentum in nuclear systems with large neutron excess | Murila Musungu<br>Kabarak University<br>- |
| 3.30 – 3.50 PM | **Abstract 4:** Study of Electronic Structure and Lattice Dynamical Properties of $Bi_2Te_3$ and $BiK_3Te_3$ Materials Using First-Principles Calculations for Thermoelectric Applications | David Maina<br>Kabarak University |
| 3.50 – 4.10 PM | **Abstract 5:** Spontaneous Fusion Theoretical Considerations, Physical Limits, and Implications for Nuclear Energy Research | Peter Tanui<br>Kabarak University<br>petertanui@kabarak.ac.ke |

# ABSTRACTS FOR PURE AND APPLIED SCIENCE CONFERENCE

## 1. DESIGN AND CHARACTERIZATION OF A PANCHROMATIC NATURAL DYE COCKTAIL FOR ENHANCED LIGHT-HARVESTING IN DYE-SENSITIZED SOLAR CELLS

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### ABSTRACT

As global energy demand accelerates, sustainable green energy solutions are a multifaceted priority. According to Michael Grätzel, solar energy incident on Earth far exceeds global daily requirements; however, capturing this energy efficiently and sustainably remains a challenge. While silicon-based photovoltaics dominate the market, Dye-Sensitized Solar Cells (DSSCs) offer a compelling, low-cost, biodegradable alternative. A primary bottleneck in DSSC performance is the narrow spectral response of individual natural dyes compared to synthetic ruthenium complexes. This study investigates the synergistic potential of four locally sourced botanical sensitizers: Bloodleaf (*Iresine herbstii*), Black Jack (*Bidens pilosa*), and Potato Tree berries (*Solanum erianthum*). Natural pigments were isolated via solvent extraction using ethanol and methanol. Optical characterization was performed via UV-Vis Spectrophotometry to evaluate absorbance and Light Harvesting Efficiency (LHE) while FTIR was used to identify critical anchoring groups (carboxyl and hydroxyl units). Initial data indicates that Bloodleaf and Potato Tree berries provide strong anthocyanin-based absorption in the 500–680 nm region, while Black Jack response spans 400–500 nm range. These experimental parameters serve as the foundation for numerical modeling using the Transfer Matrix Method (TMM) to optimize a panchromatic cocktail. It is anticipated that the optimized blend will bridge individual spectral gaps, yielding superior short-circuit current density and power conversion efficiency. This research demonstrates that strategic combinations of invasive and common plant species can effectively mimic expensive synthetic sensitizers, supporting the shift toward fully organic, biodegradable solar technology.

**Keywords:** *Panchromatic Natural Dye, DSSCs, dye extraction, modelling, characterization*

## 2. ON EP AND GENERALIZED EP EQUIVALENT OPERATORS

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### ABSTRACT

Classical studies of metrically equivalent operators are typically formulated in terms of adjoints and are therefore largely restricted to invertible settings. However, many practical applications—particularly in signal processing, image reconstruction, tomography, deconvolution, and signal recovery—involve singular or non-invertible operators. This motivates the development of a broader equivalence framework capable of accommodating closed-range operators beyond the invertible case. In this paper, we introduce a new equivalence relation based on the projection structure of EP (equal projection) operators and the class of star–dagger (SD) operators.

Two closed-range operators and are said to be **EP-equivalent** if

$$T^{\dagger}T = S^{\dagger}S,$$

and we prove that this condition defines a well-structured equivalence relation. We undertake a systematic investigation of its algebraic and structural properties, examining in particular its relationship with established operator classes, including EP operators, hypo-EP operators, and SD operators. Our analysis shows that classical metric equivalence is recovered precisely when the operators belong simultaneously to both the EP and SD classes.

The notion of EP-equivalence is further generalized in two directions: first, through **EP(n)-equivalence**, defined by

$$T^{\dagger}T^{n} = S^{\dagger}S^{n},$$

and second, through **EP(n,m)-equivalence**, defined by

$$(T^{m})^{\dagger}T^{n} = (S^{m})^{\dagger}S^{n}.$$

For each generalized relation, we analyze the induced algebraic structure, local spectral behavior, and stability under similarity transformations within the closed-operator norm topology.

From an applied perspective, projection-based equivalence captures the geometric structure of recoverable signal subspaces. In particular, the condition $T^{\dagger}T = S^{\dagger}S$ guarantees coincidence of effective reconstruction subspaces, thereby promoting monotonicity and stability in iterative solution schemes. These structural results suggest potential applications in reliable reconstruction and filtering methods arising in signal and imaging problems. The analysis is carried out within the framework of EP and SD operator theory, employing spectral and perturbation techniques. We also indicate how reconstruction models informed by learning principles may benefit from enforcing projection-preserving constraints associated with these equivalence classes. By systematically developing and studying these projection-based equivalence relations, this work advances the structural theory of closed-range operators and provides a rigorous foundation for further research linking functional analysis, inverse problems, and computational signal processing.

**Keywords:** *EP Operators, Closed-Range Operators, SD Operators, Equivalent Operators*

## 3. ANALYSIS OF PHASE SHIFT AND ENERGY GAP DEPENDENCE ON FERMI MOMENTUM IN NUCLEAR SYSTEMS WITH LARGE NEUTRON EXCESS

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### ABSTRACT

Understanding the properties of nuclear matter with large neutron excess is a fundamental problem in nuclear physics and has important implications for astrophysical systems such as neutron stars. In particular, the interplay between nucleon–nucleon scattering and pairing correlations plays a key role in determining the microscopic behavior of dense nuclear matter. This study investigates the dependence of scattering phase shift and pairing energy gap on Fermi momentum in neutron-rich nuclear matter within the $^{1}S_{0}$ interaction channel. The analysis is based on theoretical formulations derived from nucleon–nucleon interaction models using an exponential potential, with phase shifts obtained via the Born approximation and the energy gap evaluated using the Bardeen–Cooper–Schrieffer (BCS) formalism. Numerical calculations were performed for Fermi momentum values in the range $0.1 \leq k_F \leq 1.6$, and the resulting data were analyzed graphically to establish

functional relationships. The results indicate that the phase shift increases approximately linearly with increasing Fermi momentum, while the energy gap increases rapidly at low momentum and gradually saturates at higher values. The maximum energy gap obtained is approximately 1 MeV. These behaviors are consistent with microscopic nuclear matter predictions and reflect the transition from weak to saturated pairing regimes. The study confirms that Fermi momentum is a key parameter governing scattering and superfluid properties in neutron-rich nuclear matter.

**Keywords:** *Nuclear Matter, Phase Shift, Energy Gap, Fermi Momentum, Neutron Stars, Pairing Interaction*

## 4. STUDY OF ELECTRONIC STRUCTURE AND LATTICE DYNAMICAL PROPERTIES OF $Bi_2Te_3$ AND $BiK_3Te_3$ MATERIALS USING FIRST-PRINCIPLES CALCULATIONS FOR THERMOELECTRIC APPLICATIONS

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### ABSTRACT

A first-principles investigation of the electronic and lattice dynamical properties of $Bi_2Te_3$ and $Bi_2K_3Te_3$ compounds has been carried out using the plane-wave pseudopotential technique based on density functional theory (DFT) as implemented in *Quantum ESPRESSO*. To accurately capture relativistic effects associated with the heavy Bi atoms, spin–orbit coupling (SOC) was explicitly included in the calculations. Structural optimization yielded equilibrium lattice parameters of $a = 4.16$ *Å* and $c = 28.96$ *Å* for $Bi_2Te_3$ and 10.48 *Å* $BiK_3Te_3$, in close agreement with previous theoretical results. Band structure and density of states (DOS) calculations reveal that $Bi_2Te_3$ has no band gap or is metallic whereas $BiK_3Te_3$ is a semiconductor with indirect band gap of 1.10 eV. This shows that spin-orbit coupling causes band overlap making the structure to behave like semimetal or topological material. The narrower band gap of $Bi_2K_3Te_3$ suggests superior low-temperature thermoelectric performance compared to $Bi_2Te_3$. Phonon dispersion and phonon density of states (PDOS) analyses confirm the dynamical stability of both compounds and indicate phonon softening in $Bi_2K_3Te_3$, associated with the inclusion of potassium atoms. These findings provide valuable insights into the electronic and vibrational behavior of Bi–Te–based compounds for thermoelectric and optoelectronic applications.

**Keywords:** *$Bi_2Te_3$, $BiK_3Te_3$ Density Functional Theory (DFT), Spin–Orbit Coupling (SOC), Lattice Dynamics*

## 5. SPONTANEOUS FUSION THEORETICAL CONSIDERATIONS, PHYSICAL LIMITS, AND IMPLICATIONS FOR NUCLEAR ENERGY RESEARCH

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### ABSTRACT

Spontaneous fusion refers to the hypothetical process in which nuclear fusion occurs without externally applied high temperature, pressure, or electromagnetic confinement. Unlike thermonuclear fusion, which requires extreme conditions to overcome the Coulomb barrier, spontaneous fusion has been proposed to arise from quantum tunneling, lattice confinement effects, or exotic nuclear interactions under specific condensed matter configurations. This paper critically examines theoretical models that could support spontaneous fusion,

evaluates experimental claims, and assesses the physical plausibility of sustained fusion reactions under low-energy conditions. The study integrates concepts from quantum mechanics, nuclear physics, and condensed matter physics to evaluate whether such processes are consistent with established physical laws. Recent research in low-energy nuclear reaction (LENR) studies continues to report anomalous heat and nuclear signatures; however, reproducibility remains a major challenge. Current evidence suggests that while quantum tunneling permits rare fusion events at low energies, no reproducible mechanism has been demonstrated for sustained energy-producing spontaneous fusion. The paper concludes that spontaneous fusion remains speculative and requires further experimental validation and theoretical development.

**Keywords:** *Spontaneous Fusion, Quantum Tunneling, Nuclear Fusion, Low-Energy Nuclear Reactions, Coulomb Barrier.*

## COMMITTEE MEMBERS

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