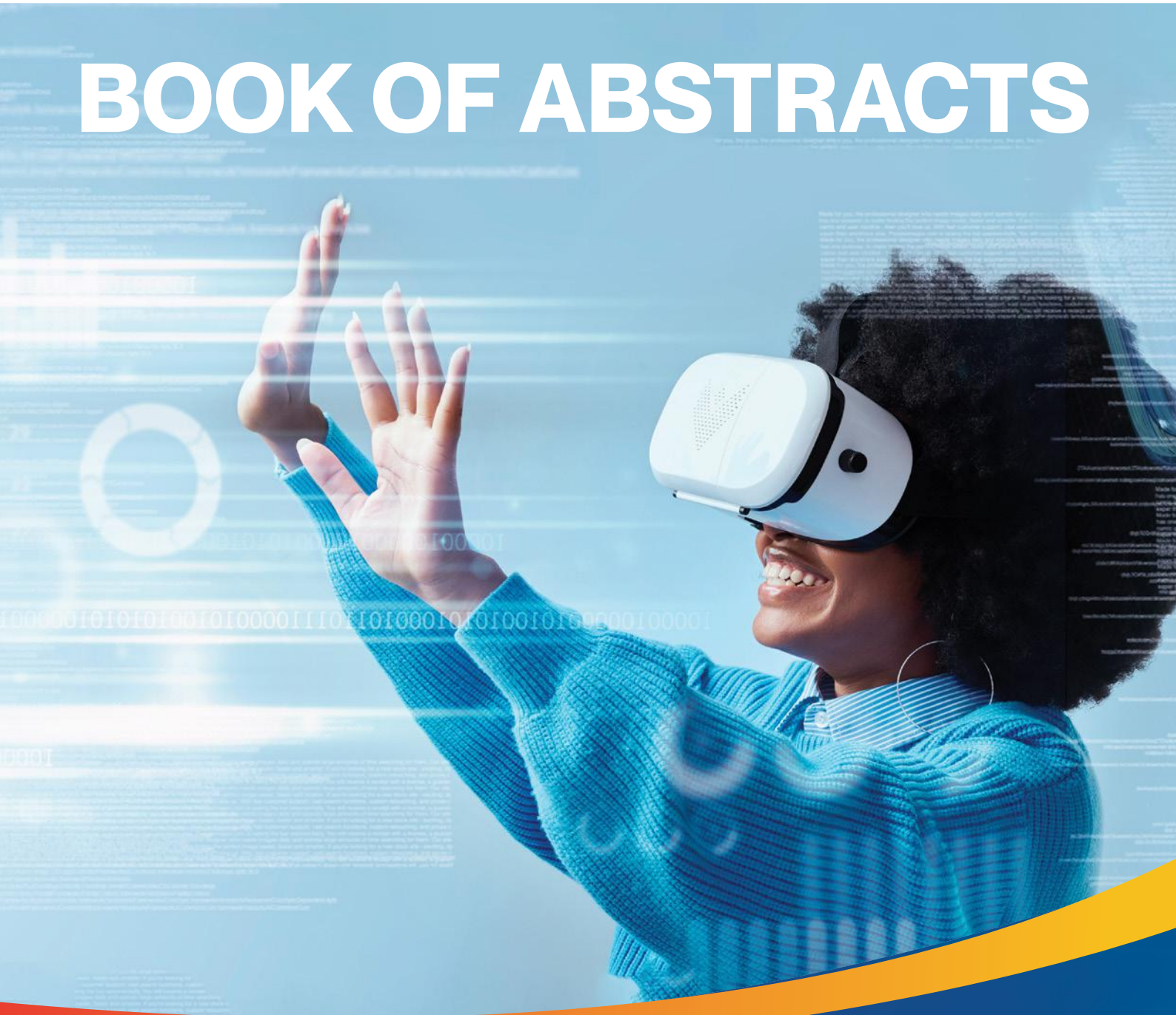
11th UNESCO Africa Engineering Week &
9th African Engineering Conference

African Scientific Research and Innovation Council

UGANDA INSTITUTION OF PROFESSIONAL ENGINEERS

BOOK OF ABSTRACTS



THEME

Leveraging Engineering Innovations and Technology to Accelerate Africa's Socio–Economic Transformation

Foreword

This is 11th UNESCO–Africa engineering week & 9th African engineering conference 2025 (Kampala, Uganda) being organised jointly by UNESCO and the Federation of African Engineering Organisations (FAEO) and hosted by the Uganda Institution of Professional Engineers (UIPE). The conference is being organised under the theme "Leveraging Engineering Innovations and Technology to Accelerate Africa's Socio–Economic Transformation". It is further synthesised into five sub-themes namely; Innovative Engineering for Industrialization and Economic Growth; Sustainable Infrastructure, Transport, and Urban Development; Renewable Energy and Climate–Resilient Engineering Solutions; Engineering Innovations in Agriculture, Water, and Food Security; and Engineering Capacity Building and Engineering Education for Africa's Future.

The conference affirms Africa's commitment towards engineers and academics responsible for research, development, innovation, training and policy makers by providing such an important platform that enables them showcase their abilities. Through this conference we are able to exchange and debate ideas on capacity building, innovation, sustainable infrastructure, water and food systems. The conference enables us to design concrete actions to improve training, research and innovation towards local, regional and international perspective with regard to the continent's sustainable development and socio-economic transformation.

The prevailing world economic order presents Africa with new challenges and opportunities which necessitates strengthening of Africa's human and institutional capacities in teaching research science-based subjects, engineering, technology and innovation so as to harness available resources, create youth employment, achieve industrial and socio-economic development and inclusive growth across the continent. Africa's young population especially in sub-Saharan Africa is growing very fast. The continent needs to create opportunities and avenues for this population to thrive and drive Africa's agenda. In spite of this resolute, climate change and its adverse effects on basic needs of health and nutrition, food security, energy access and efficiency, water availability and environmental sustainability, urban migration, pose threats to Africa's resilience. These are the discussions that this conference is premised on to try and find solutions tailor made for Africa

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The expected outcome of 11th UNESCO–Africa engineering week & 9th African engineering conference 2025 is to showcase achievements and innovations from African scientists and engineers. And also, to demonstrate the extent Africa has moved in engineering research and innovation for achieving Socio–Economic Transformation.

Thank you for attending the conference.

Eng. Dr. Jimmy Byakatonda

Chairman, Conference Editorial Committee

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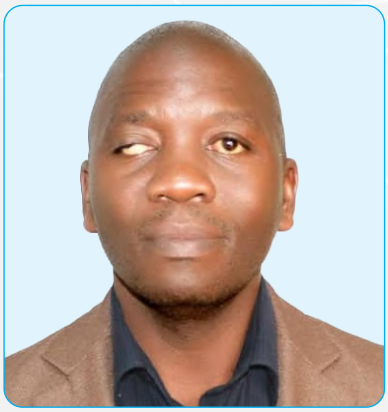
Profiles of Editors

Eng. Dr. Jimmy Byakatonda
Editor in Chief

Eng. Dr. Jimmy Byakatonda is a practicing Engineer and researcher in Irrigation Engineering and Water Management at the department of Biosystems Engineering, Gulu University, Uganda. He currently participates in collaborative projects with both government, private sector and other international partners. Currently he is having joint research collaborations with University of Trier in Germany and University of New South Wales of Australia together with consultancy projects in water resources assessment.

He is passionate about research on water management under scarcity. He has vast experience with building forecasting models using Artificial Neural Networks (ANN) a class of AI. His PhD studies were drought prediction using Artificial Neural Networks. He has both national and international experiences having worked on development projects in Malawi, Botswana, Zimbabwe and in the Netherlands. He supervises both undergraduate and graduate research students. Eng. Dr. Jimmy Byakatonda is also is a reviewer in a number of journals such as Atmospheric research, Forestry and Agricultural meteorology, Meteorological applications etc.



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Eng. Dr. Jotham Ivan Sempewo is a professional engineer with over 25 years of experience in project planning, training, capacity development, research, and consultancy. His expertise spans Project Management in Water and Energy Systems, Climate Change, Active Mobility, Asset Management, Urban Infrastructure, Hydrology, Hydropower, and Dams.
He holds a PhD in Civil Engineering from the University of Birmingham, UK, and an MSc in Municipal Water and Infrastructure from the UNESCO-IHE Institute for Water Education, the Netherlands.

Dr. Sempewo has extensive experience in both academia and professional practice, including engagements with government parastatals and numerous donor-funded projects supported by KfW, AfD, USAID, and the World Bank. His academic and research roles include serving as a Graduate Teaching Assistant at the University of Birmingham (UK), a Research Fellow at the Patel School of Global Sustainability, University of South Florida (USA), and a Research Associate at the Water Engineering and Development Centre (WEDC), Loughborough University (UK). He has also contributed to prestigious international research projects in the Netherlands, Germany, USA, and the UK.

He is a Registered Engineer with the Engineers' Registration Board and a corporate member of the Uganda Institution of Professional Engineers and the of Uganda. In addition, he serves as an Editorial Board Member for the IWA Water Practice and Technology Journal and is a reviewer for several leading international journals.

Eng. Dr. Martin Kalibbala

Martin Kalibbala holds a PhD in Environmental Engineering (Saitama University, Japan), Master of Science in Water Resources Engineering and Bachelors of Science in Civil Engineering (University of Dar es Salaam, Tanzania). He holds international and regional work experience (work, research and study) in Holland, Japan, France, South Sudan, Kenya, Rwanda and Tanzania. Currently, Martin works at the National Water and Sewerage Corporation (NWSC) – Kampala Water, as Manager Performance Management and Staff Development (April 2024 – present). Prior, he worked at NWSC as Manager Training and Capacity Development (January 2009 – April 2021) and Manager Asset Management (May 2021 – March 2024). More details of his experience are as depicted below:

Over 22 years of experience of managing construction projects in water supply systems, structural projects, drainage systems and other engineering–related projects: i.e. design, construction supervision, feasibility studies, projects financial appraisals, projects management & cost containment, appraisal of contractors' payment certificates, preparation of engineering reports, preparation of engineering project operation and maintenance (O&M) manuals, O&M of schemes, etc.

17 years of experience of managing donor funded projects and development partners' relations.

15 years' experience in technical vocational education and capacity development (CD) initiatives.

12 years of developing and reviewing practical training occupational standards, assessing competence based skills, development of ATPs, skills certification, diagnostic skills testing, quality assurance of ATPs and occupational standards, curriculum development, setup of training/resource centers, etc.

Over 12 years' experience of managing training and capacity building initiatives: i.e. designing courses, training needs assessments, training plans, etc.

8 years of experience in CD strategic planning, and development of long term (5–Year) CD plans, including vocational training plans for development partners and government institutions like NWSC.

17 years of experience in educational research, university lecturing, research & publishing journals.

7 years of experience in managing vocational training and resource centers in "technical and vocational education and training" (TVET) Projects, while working with development partners, plus strategic planning, sourcing of funding, collaboration with multiple stakeholders & institutions.

9 years of experience as University external reviewer of PhD and Masters research works.

6 years of experience as senate member at University (academia management) level.

7 years of experience in curriculum review using the problem–based learning approaches at University/ Campus level.

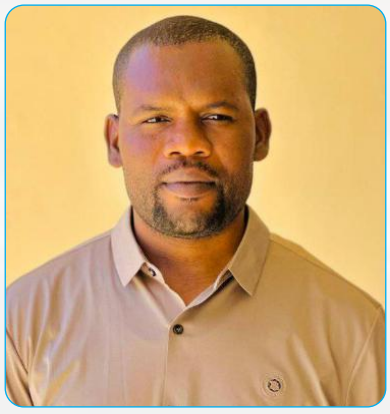
Eng. Dr. Rachel Namuli

Eng. Dr. Rachel Namuli is an electrical engineer with 21 years experience in engineering consultancy. She has a Bachelor of Science in Electrical Engineering from Makerere University Kampala, a Master of Science in Energy from Heriot Watt University, United Kingdom and a PhD in Electrical and Computer Engineering from Concordia University, Montreal. Her expertise is in feasibility study, design and construction supervision of power distribution lines, feasibility study, design and supervision of renewable energy installations, design and supervision of electrical installations in buildings, carrying out power audits of facilities, and project management in the electricity sector.

She has worked on rural electrification projects in various districts in Uganda as a distribution engineer and project manager. She has also worked as a design and supervision consultant on various high rise building projects, and carried out power audits for a number of organisations. She is a team leader on most of the projects undertaken, often providing guidance, technical expertise, monitoring progress and reporting to clients, ensuring project deliverables are attained. Outside of work, Eng. Namuli is passionate about travelling, seeing new places and experiencing different cultures and environments.

Dr. Mohammed Kyari

Dr. Mohammed Kyari is presently occupying the position of Senior Scientific Officer Coordination at the African Union, Scientific, Technical and Research Commission (AU/STRC) and has 17 years of post-graduation experience in science and technology policy and the environment. He has B.Sc Physics from University of Maiduguri, Nigeria, M.Sc. in Environmental Pollution Controls and Ph.D in Heat Treatment of Waste and Disposal both from University of Leeds, United Kingdom.



Dr. Mudi Bashir

Dr. Mudi Bashir is a Programme Officer with the African Union Scientific, Technical and Research Commission (AU-STRC/ASRIC), where he supports research coordination, scientific journals, and continental conferences. Dr. Bashir has Lectured in the Department of Public Administration, University of Maiduguri, Nigeria. He holds a Ph.D. and Master's degree in Public Administration from the University of Maiduguri, where he also earned his B.Sc. in the same discipline. His teaching and research focus on governance, policy, accountability, and development administration, areas in which he has contributed significantly through publications and academic service.

Eng. Dr. Sandra Cecilia Muhirirwe

Eng. Dr. Sandra Cecilia MUHIRIRWE is a lecturer at the Department of Civil and Environmental Engineering at Kyambogo University. She has over 12 years of experience in civil and environmental engineering research with a focus on water treatment, climate change adaptation, sustainable water resource management, and sanitation services in displacement settings. Additionally, Sandra has led multi-stakeholder initiatives bridging government, development partners, and communities, with a strong focus on science-policy support, systems strengthening, and capacity development. Sandra holds a PhD in Engineering Science, us a professional engineer registered with the Uganda Institution of Professional Engineers (UIPE) and the Engineers' registration board of Uganda (ERB).

Eng. Dr. Robinah N. Kulabako

Robinah Kulabako holds a BSc. Civil Engineering degree from Makerere University, an MSc. in Environmental Engineering from University of Manchester (UK), a Technical Licentiate degree of Engineering (Hydraulic Engineering) from the Royal Institute of Technology (KTH) in Stockholm, Sweden and a Doctor of Philosophy (Land and Water Resources Engineering) that was undertaken in a sandwich programme between Makerere University, Kampala, Uganda and KTH.

She is currently a senior lecturer and head of the Department of Civil and Environmental Engineering, School of Engineering, Makerere University, Kampala, Uganda. She lectures and supervises both undergraduate and graduate students (MSc and PhD) in the field of Environmental Engineering. Dr. Kulabako has more than 25 years expertise in water supply, wastewater management, water/wastewater quality monitoring and assessments, sanitation and solid waste management.

She has participated in both locally and internationally funded research and consultancy projects in these areas. Dr. Kulabako has over 50 publications in peer-reviewed impact factor journals, book chapters and conference proceedings. Dr. Kulabako is a corporate member of the Uganda Institute of Professional Engineers (UIPE) and registered Civil Engineer with the Engineers' Registration Board. She currently serves as a member of the Infrastructure-Water and Environment Working group, a committee of UIPE.

9A-1000-2025

Sub-Theme 1

Structural Mapping and Prospects Identification in Otio oil field, Niger Delta

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Abstract:

This research presents a detailed structural mapping and prospects identification study of the Otio Field located in the Niger Delta. The study integrates 3D seismic data and well logs to delineate subsurface structures and assess the hydrocarbon potential of the field. Five key horizons were evaluated using petrophysical analysis, revealing porosity values ranging from 18% to 27%, water saturation levels between 20% and 31%, and Net-To-Gross ratios of 59% to 96%. Time-depth structure maps were generated for each horizon, allowing for the identification of two prospects, namely the North-Eastern and South-Eastern prospects. The North-Eastern prospect was ranked higher due to its larger estimated hydrocarbon volume, with Sand E2 identified as the most promising reservoir based on volumetric analysis. This study underscores the importance of integrating seismic and petrophysical data for effective exploration and field development, providing a basis for future drilling decisions in the Otio Field. The research method started with the subsurface evaluation of the “Otio Field” integrating well log data from the field and seismic data spanning the field. The databases used for this project are three Dimensional (3D) seismic cube, base map, six well data in LAS format and check shot data for only one well. The results show the identified hydrocarbon bearing zones are Sands D, E1, E2, H and J as interpreted from gamma-ray and resistivity logs. The sand correlation across the field showed uniform sand development from well to well. The checkshot is interpreted as good because of the absence of outliers or spurious values. The plot is a gentle slope that eventually steepens because of compaction of the underlying units that causes Two-Way Time (TWT) to decrease. The results from the structural Interpretation, sixteen faults (F1-F16) were interpreted across the field as seen on seismic section. Faults in the field trend in the East-West (E-W) direction with majority of them dipping north except for faults F4 F6, F7 and F9 dipping south. In the conclusion, the 3D structural analysis of Otio Field in the Niger Delta enhanced understanding of its structural styles and hydrocarbon traps. Eight reservoirs were identified, with five hydrocarbon-bearing sands (D, E1, E2, H, J) mapped, consisting of sands sealed by shales.

Keywords:

Niger Delta | structural mapping | seismic interpretation

9A-1001-2025

A transition towards resilient communities-Safe drinking water for rural households in Uganda

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Abstract:

Safe water coverage in Africa is still low with approximately 30% of the entire population in need of clean water. The situation is even dare in rural communities with up to 50% of the population underserved. In the rural communities of Uganda alone, there are communities who have no access to any form of water supply systems. These communities rely on surface runoff from ground surfaces during a rain downpour. The water collected is the one available to meet the entire household demand. This water is generally unsafe for human consumption by any standard owing to the catchments from where it is collected. With influx of refugees in Uganda, this has put even more pressure on the host communities. Gulu university with support from UNSW developed a UV-LED integrated with a filtration system to cater for these underserved refugee host communities in Uganda. Due the high level of turbidity, the water is taken through a primary and secondary filter before it is allowed to get in contact with the UV-LED reactor. The efficacy of this intervention was tested before piloting in the communities. Laboratory results showed that the filtration system was able to reduce the turbidity by 99.3%. The UV-C was also able to reduce the e-coli load from 210 mpN to 0.3 mpN (reflecting a 99.8% removal efficiency). The effectiveness of the UV-LED is dependent on the contact time with water. Following these positive results, four units were installed at three primary schools and a health centre among the refugee host communities. Following the pilot coupled with quarterly monitoring of the system, some lessons were learnt. There was need to increase the flowrate to meet the increased demand. Also, the water in the final water collection tank was warm to the dislike of the school children. For this reason, we were able to upgrade the UV-LED reactor from point of use to industrial scale. This enabled us to increase the flowrate while at the same time increasing the contact time with the UV-LED. In addition, coolers were installed in the classrooms. With this noble intervention, the schools have reported reduced incidences of waterborne diseases for children in the boarding section. The energy cost on boiling water for the school children has also been eliminated. The later has also reduced on deforestation and hence carbon sequestration.

Keywords:

Densification | Water treatment | UV treatment | Humanitarian Engineering

9A-1002-2025

Dual-Mode Smart Waste Bin with Sensor-Based Sorting and Waste Compacting for Manual and Automatic Operation

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Abstract:

This paper presents the design and implementation of a solar-powered, dual-mode smart waste management system capable of detecting, classifying, and compacting four categories of solid waste: metal, plastic, wet waste, and paper. The system employs inductive, capacitive, moisture, and ultrasonic sensors to achieve detection accuracies of 89%, 90%, 91%, and 92%, respectively. Integrated with a GSM-based SIM800C module, the system transmits real-time bin status via SMS to waste collection personnel, eliminating the need for internet connectivity and improving deployment feasibility in off-grid or rural locations. It supports both manual and automatic modes, enhancing user adaptability. Additionally, a built-in compacting and heating unit processes plastic waste, reducing its volume by up to 60%, thus extending bin capacity and facilitating recycling. Experimental validation over a 30-day testing period demonstrated 97% operational reliability. The proposed system offers a cost-effective, sustainable, and scalable solution for modern waste management, particularly in resource-constrained settings.
Keywords: Waste Management, Waste Sorting, GSM Communication, Dual-Mode Operation, Waste Compacting, inductive proximity sensor.

Keywords:

Waste Management | Waste Sorting | Dual-Mode Operation | inductive proximity sensor. | Waste Compacting

9A-1003-2025

Leveraging ILGCS-AG: Accelerating Cost-Effective Geothermal Exploitation in Uganda's discovered field

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Abstract:

The global transition towards electric mobility (e-mobility) is accelerating, driven by technological advancements and environmental imperatives. While Africa currently accounts for a small fraction of global Electric Vehicle (EV) sales, the continent is poised for a significant shift, motivated by the urgent need to reduce reliance on fossil fuel imports, manage a growing vehicle market, and leverage abundant renewable energy resources. Uganda has emerged as a pioneer in this transformation on the African continent, with its journey starting as far back as 2009. The nation's transport sector, like in most African countries, faces substantial challenges, including severe air pollution, an inefficient public transport system reliant on end-of-life imported vehicles and significant economic drain from fuel and vehicle imports. This paper examines Uganda's strategic approach to leveraging e-mobility for sustainable urban development, and an enabler for socioeconomic transformation by reducing import dependency and enhancing citizen well-being. It provides a synthesis of Uganda's foundational policy and strategic documents and recent progress reports, providing a comprehensive assessment of the nation's e-mobility trajectory. Uganda has demonstrated tangible progress, with combined annual EV production capacity exceeding 10,000 units in 2024. Significant strides have been made in public transport electrification, including the launch of electric bus services and the commencement of an electric standard gauge railway project. EV Charging infrastructure is expanding rapidly, with over 30 DC Fast Chargers and 134 battery swapping stations operational across the country in 2024. These efforts have attracted over USD 160 Million in investment, created over 10,000 direct and indirect jobs, and avoided over 270,000 Metric Tonnes of CO2 equivalent emissions between 2022 and 2024. Uganda's integrated and locally-driven e-mobility strategy offers a compelling model for other African nations seeking to address urban challenges, foster economic growth, and achieve environmental sustainability through innovative engineering and policy frameworks.

Keywords:

E-Mobility | Sustainable Transport | Sustainable Infrastructure | Urban Development | Urban Development

9A-1004-2025

Efficiency of Avocado Seed Extract as Natural Coagulant in Sustainable Purification of Drinking Water

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Abstract:

There is an increasing need for affordable water treatment solutions especially in developing countries and natural coagulants as alternatives to conventional chemical coagulants with their attendant environmental and health implications, low effectiveness in low temperatures, high procurement cost, large sludge volumes and pH effects. An experimental study was conducted on efficiency of avocado seeds powder as a natural coagulant for drinking water purification. Avocado seeds contain bioactive compounds like tannins with known coagulating properties. A suspension of 5g/l of avocado seed extract prepared and used on raw untreated water samples from Lake Bunyonyi. Results showed optimum avocado seed extract dosage of 0.35mg/L reduced turbidity from 12.8 to 4.5 NTU, with removal efficiency of 65% and is in line with the Ugandan National Water Quality Standard for potable water. Colour was reduced from 30 to 13 PCU with removal efficiency of 57%. The pH of the treated water ranged from 7.0-7.4 for all samples while sludge volume was comparably very low. The avocado seed can be used as a natural coagulant at concentration and dosage comparable to conventional chemical coagulants. These findings suggest that avocado seed extract is a viable, eco-friendly, and cost-effective coagulant for rural household water purification systems.

Keywords:

Avocado seed | Natural coagulant | Potable water | Optimum dosage

9A-1005-2025

Empirical Insights and Technical Stakeholder Perspectives: AI for Effective Decision-Making in South Africa's Water Management Sector

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Abstract:

South Africa's water management sector faces escalating challenges from climate change, population growth, and fragmented governance. This study investigates strategic stakeholder perceptions of artificial intelligence (AI) as a tool for effective decision-making, focusing on five thematic domains: Key Challenges in Water Management (CWM), Impacts of Climate Change and Population Growth (ICCPG), AI for Effective Decision-Making (AIEDM), Recommendations for Improving AI Tools (RIAIT), and Data Privacy and Security (DPS). A structured digital questionnaire using a five-point Likert scale was administered to thirty-five professionals across engineering, planning, policy, and civil society sectors. Purposive sampling ensured strategic-level representation. Quantitative analysis using SPSS v30 included descriptive statistics, reliability testing (= 0.929), Pearson correlations, and multiple regression modelling. Findings reveal significant relationships between ICCPG and all predictor domains, with CWM (r = 0.756) and DPS (r = 0.697) emerging as the strongest predictors. Technically trained stakeholders demonstrated high alignment between climate/data concerns and systemic water challenges. The relatively lower influence of AIEDM and RIAIT suggests cautious optimism toward AI, tempered by concerns around implementation feasibility and ethical safeguards. To address the "black-box" problem, which is the difficulty in understanding or explaining how AI systems arrive at their decisions, particularly deep learning, the study advocates for the integration of Explainable AI (XAI) to enhance transparency and stakeholder trust. These insights align with South Africa's National Water Act and Water and Sanitation Master Plan, underscoring the need for integrated governance, digital literacy, and inclusive stakeholder engagement to support AI-enabled water resilience.

Keywords:

Artificial Intelligence (AI) | Water Resource Management | Climate Change | Stakeholder Perceptions | Explainable AI (XAI) | Decision-Making | Data Privacy

9A-1006-2025

Poster Presentation

Assessment and design of a sustainable washbay model with water recycling system for Uganda's washing bays: a case study of Kampala and Wakiso districts:

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Abstract:

With rapid urbanization and increasing vehicle ownership in Uganda, commercial car wash bays have proliferated, particularly in Kampala and Wakiso districts. These facilities consume substantial volumes of water (up to 22,000 liters daily per wash bay) and discharge untreated, chemical-laden wastewater, exacerbating water pollution and scarcity. This study proposes a sustainable wash bay model incorporating water recycling to mitigate freshwater depletion and environmental contamination while aligning with Uganda's regulatory framework. The model integrates oil-water separators, CX sand filters, diaphragm pumps, and storage tanks to treat and reuse greywater. The proposed system could reduce freshwater demand by recycling up to 80% of used water while minimizing operational costs and regulatory non-compliance risks. Adopting water-recycling technologies in wash bays addresses Uganda's water management systems.

Keywords:

Water recycling | car wash bays | environmental pollution

9A-1054-2025

MECHANICAL PROPERTIES OF CEMENT CONCRETE, ADDITION OF FLY ASH TO IMPROVE PERFORMANCE

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Abstract:

Abstract: The cement industry is among the largest contributors to global carbon dioxide emissions, a potent greenhouse gas responsible for climate change. The widespread use of concrete also poses serious environmental concerns. By covering the fertile topsoil, concrete damages the earth's most productive layer. Moreover, the creation of hard, impermeable surfaces increases surface runoff, which can intensify soil erosion, water pollution, and flooding. In recent years, numerous studies have explored sustainable alternatives in concrete production. Particular attention has been given to the incorporation of fly ash, an industrial by-product, into green concrete formulations. Research has examined its influence on critical properties such as strength and fracture toughness. Additional investigations have focused on the transport properties of high-volume fly ash concrete exposed to elevated temperatures, as well as the effect of curing temperature on the strength development of fly ash–recycled concrete aggregate blends. These studies highlight the potential of fly ash as a viable substitute for cement, especially considering the vast quantities currently disposed of as waste each year. Cement remains one of the most widely used construction materials worldwide, yet its production significantly accelerates carbon dioxide emissions. Consequently, the search for alternative low-carbon binders has become a central focus in materials science and sustainable engineering. Fly ash, given its availability and waste-reduction potential, stands out as one of the most promising solutions. At the same time, Industry 4.0 offers a transformative opportunity for sustainable development, particularly in regions such as Africa. Emerging digital technologies—including artificial intelligence (AI), big data, cloud computing, robotics, the Internet of Things (IoT), and the Internet of Everything (IoE)—can be leveraged across sectors such as energy, transport, health, and construction to accelerate progress toward the United Nations Sustainable Development Goals (SDGs). For engineering practitioners, harnessing these digital innovations is not only timely but essential to advancing both environmental sustainability and economic growth.

Keywords:

Fly ash | Fracture toughness | Compressive strength

Sub-Theme 2

9A-1007-2025

Governance Fragmentation and Implementation Deficits in Durban's Sustainable Transportation Transition

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Abstract:

Durban, South Africa's third-largest metropolitan economy, faces a critical sustainability impasse where rapid urbanization intersects with three compounding transportation crises: Transportation constitutes 28% of metropolitan GHG emissions due to entrenched fossil fuel dependence, low-density spatial development perpetuates automobile-centric mobility patterns while undermining public transport viability, and institutional fragmentation across 34 municipal entities creates governance paralysis in implementing integrated solutions. These systemic failures manifest in worsening traffic congestion, deteriorating air quality, and mobility poverty affecting 65% of low-income households. Despite extensive policy frameworks, e.g. Green Transport Strategy 2020-2050 and technological innovations, critical knowledge gaps persist regarding the governance-infrastructure-behaviour nexus in complex African urban contexts, implementation barriers causing the "planning-implementation gap" in low-carbon transitions, and scalable solutions for secondary Global South cities where institutional capacity constraints differ fundamentally from primary cities. Current literature inadequately addresses how polycentric governance systems can overcome path dependencies to deliver transformative change. This systematic review diagnoses these interconnected failures through political ecology and sustainability transitions frameworks. We critically synthesise empirical evidence to establish how institutional misalignment, funding discontinuities, and uncoordinated land use-transport planning perpetuate unsustainable mobility patterns. This analysis reveals that catalytic interventions require simultaneous advancement across four dimensions namely: 1)Metropolitan-scale governance integration enabling cross-departmental coordination, 2) Strategic infrastructure prioritization targeting network effects (e.g., BRT optimization increasing throughput 22%, cycling corridors capturing 15-30% mode share), 3) Behaviour change programs leveraging modal choice elasticities, and 4) Standardized monitoring frameworks tracking decarbonization metrics. The Buffelsdraai reforestation project exemplifies how nature-based solutions can complement but not substitute systemic reforms. This research establishes that Durban's transition requires dismantling institutional siloes through metropolitan transport authorities with statutory powers. It provides diagnostic frameworks applicable to secondary cities confronting similar governance fragmentation and implementation deficits across the Global South.

Keywords: Transportation governance, Implementation deficit, Sustainable mobility transitions, Institutional barriers, Climate-responsive infrastructure, Decarbonization pathways, Urban political ecology, Global South secondary cities

9A-1054-2025

Sustainable Infrastructure, Transport, and Urban Development: Case Study of Masdar City

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Abstract:

Masdar City, developed in the United Arab Emirates, is a pioneering example of sustainable urban planning in an arid environment. Conceived as a carbon-neutral city, it integrates renewable energy systems, compact urban design, and pedestrian-focused transport. This paper critically evaluates Masdar's strategies, their evolution since inception, and their relevance for African urban development. Using site analysis, project documentation, and performance data, the study identifies achievements, challenges, and transferrable best practices. Results show significant reductions in carbon emissions, optimized resource use, and enhanced livability metrics, while also revealing socio-economic and technical constraints. The insights offer a framework for African cities to adopt contextually appropriate, climate-resilient infrastructure and transport systems.

Keywords:

Urban planning | sustainable development | renewable energy | Masdar City | climate-resilient infrastructure | sustainable transport

9A-1009-2025

Developing a framework for enhancing the performance of local road works contractors in Kenya

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Abstract:

Road construction is vital for economic growth and service delivery, yet many projects face delays, cost overruns, low completion rates, and substandard quality, undermining infrastructure goals and contractor sustainability. This study investigated the persistent performance challenges of local road works contractors in Kenya, despite substantial investment in road infrastructure under the national development agenda. The research aimed to: evaluate contractor performance; identify key influencing factors; assess relationships between these factors and performance outcomes; and develop an enhancement framework. A mixed-methods design combined surveys of National Construction Authority-registered contractors across the regional clusters. Regression analysis revealed non-significant statistical links between contractor performance and the attendant predictor variable. However, their positive coefficients implied a supportive, if less pronounced, relationship with contractor performance. The study thus concluded that the performance of local road contractors in Kenya is generally suboptimal, particularly in terms of schedule and cost management, with many projects experiencing delays and budget overruns. The resulting performance enhancement framework recommended: strengthening capacity through training and certification; improving financing and equipment access; streamlining regulations; implementing robust monitoring systems; and fostering stakeholder collaboration. Adoption of this framework is expected to enhance contractor performance, support a more competitive and sustainable construction industry, and improve Kenya's infrastructure delivery outcomes.

Keywords:

Contractor performance | Road construction | Project management | Infrastructure development | Kenya

9A-1010-2025

Cost-effective Resilient Rural Bridges –A Case Study of Masonry Stone Arch Bridges in Kasese District, Western Uganda.

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Abstract:

Climate change poses an increasing threat to Uganda's road infrastructure, with frequent flooding and bridge washouts making replacement and new constructions costly. This study evaluates the cost-effectiveness and climate resilience of stone arch bridges compared to reinforced concrete alternatives. Using a case study approach comprising site visits, stakeholder interviews, structural, construction and maintenance costs analysis, the research highlights the viability of stone arch bridges for rural settings. Findings reveal that stone arch bridges achieve over 79% to 90% initial construction cost savings for short spans and demand significantly less maintenance of 58% life cycle cost for over 30 years in comparison to Reinforced Concrete bridges. While not ideal for long spans or heavy traffic, they excel in low-load rural environments. Key advantages include long-term durability, reduced lifecycle costs and resilience to climate-related stresses. However, their wider adoption is limited by a shortage of trained professionals and the exclusion of stone arch bridge design in engineering curricula. The study recommends integrating this approach into infrastructure policy to enhance rural connectivity and promote sustainable, climate-resilient road construction in rural Uganda and with comparable contexts.

Keywords: Rural roads, Masonry stone arch bridges, Cost-effective construction

Rural roads | Masonry stone arch bridges | Cost-effective construction

9A-1011-2025

Strength, Sustainability, and Design Applications of Bambusa vulgaris in Uganda

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Abstract:

Bambusa vulgaris, a fast-growing bamboo species abundant in Uganda, offers significant potential as a sustainable construction material due to its quick regeneration, high biomass yield, and competitive mechanical properties. This study presents a comprehensive evaluation of the mechanical properties and material sustainability of Bambusa vulgaris grown in Uganda's Lake Victoria agroecological zone. Mechanical testing, conducted according to BS ISO 22157:2019 and ASTM D1037-12, assessed bending, tensile, shear, and compressive strengths parallel to the fibres, alongside corresponding moduli of elasticity. The influence of moisture content on the strength and stiffness properties and node presence on compressive strength was evaluated. Results revealed characteristic bending strength values comparable to C16 timber, with mean compressive strengths reaching 33 MPa. Results indicate that bamboo offers significantly higher strengths than the equivalent timber class. However, the lower strength/stiffness to density ratio makes timber a better choice than bamboo for lightweight construction. Correlation analyses confirmed the typical trend of increasing material strength with decreasing moisture content, though some variations in the bending strength suggest further investigation. The results also indicate that the presence of nodes decreases the compressive strengths, although the effect is not significant. Embodied carbon analysis using a modular bamboo housing design demonstrated a significant 74.2% reduction in embodied carbon emissions compared to conventional construction materials and practices in Uganda, underscoring bamboo's potential contribution to climate-friendly building practices. Despite promising findings, limitations include narrow scope of life cycle assessment stages considered and smaller sample sizes. The study recommends broader environmental impact assessments, further investigations into the factors affecting the different strength and stiffness properties, and supports the integration of Bambusa vulgaris into local building codes to encourage its uptake as a renewable, low-carbon alternative in Ugandan construction.

Keywords:

Bambusa vulgaris | mechanical properties | sustainable construction | sustainable construction

9A-1012-2025

Seismic Vulnerability Assessment of Existing Buildings: A case study of Senate Building in Makerere University

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Abstract:

This study assessed the seismic vulnerability of existing buildings at Makerere University. This study evaluated the seismic vulnerability of existing buildings at Makerere University with focus on Senate Building as a representative structure for mid-rise buildings in the University. Despite Uganda's classification as a low seismic zone, historical earthquakes have exposed significant infrastructure vulnerabilities particularly in educational institutions. The lack of specific guidelines for existing buildings within the Ugandan code, coupled with the varied and often vulnerable nature of existing construction and limited seismic data in Uganda, makes predicting the seismic vulnerability of existing buildings challenging thereby creating a critical gap in disaster preparedness. The research employed a quantitative methodology combining building inventory classification, structural modeling and fragility curve development. Nonlinear static pushover analysis using SeismoStruct assessed structural capacity with eigenvalue analysis identifying ductility limitations. Ground motions from the PEER NGA database were scaled to Kampala's seismic hazard spectrum. Fragility curves were developed using the Capacity Spectrum Method and they quantified the probability of exceeding limit states. Results indicate that Senate building has a total base shear of 4800 kN thereby resisting more lateral force before failure than high rise buildings. However, Senate building reaches the Significant Damage limit state at lower drift values when compared to high rise buildings thereby suggesting brittle behavior. Results also indicate that Senate Building showed moderate resilience with Near Collapse at 0.56g. These findings highlight the urgent need for retrofitting existing buildings in Makerere University particularly for mid-rise buildings and advocate for updating the current seismic code to address seismic vulnerability assessment of existing buildings. This research provides a framework for seismic risk mitigation in Ugandan educational institutions thereby informing retrofitting strategies, policy development, and emergency planning. It bridges a critical gap in regional seismic vulnerability assessments and contributes to global earthquake engineering practices by highlighting the importance of tailored vulnerability evaluations for older building stocks.

Keywords:

Seismic Vulnerability | Capacity curves | Fragility Curves

9A-1013-2025

Semi-Autonomous Robotic Boat, With Lora Data Acquisition

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Abstract:

Keeping waterways safe can be very challenging, especially in large areas inside countries but also across waterways that borders countries, illegal activities in waterways may be harmful and can damage the aquatic environment. Illegal trading, as well as smuggling tobacco, cannabis, and alcoholic drinks are also problematic. Additionally, armed groups can also use the waterways to smuggle goods and infiltrate into neighbouring countries, leading to violence and insecurity. To address these issues, countries are deploying police and military patrols. Unfortunately, this system uses a lot of personnel that could be deployed in other activities. However, technology can be used to solve those problems efficiently, all the time and in real-time. The main goal of the project is the development of a prototype of a robotic boat that can accurately perform surveillance in real-time. This robot boat is controlled remotely by a radio communication technique that enables long-range data transmissions. It is capable of moving in all directions and is equipped with multiple sensors to facilitate the movement and avoidance of collisions during its autonomous movement. To design and develop a robust and efficient semi-autonomous surveillance boat equipped with advanced features such as a high-resolution camera, ultrasonic sensors, and GPS tracking capabilities for surveillance, on the other hand, the stability of the boat itself while moving on water, and the communication between the transmitter and receiver during the remote control and the data transmission. LoRa is one of the powerful radio communication techniques that enables Long-Range, low-power wireless data transmission, is a spread spectrum modulation technique that uses license-free radio frequency bands to create long-range communication links. The semi-autonomous robotic boat is expected to perform a real-time surveillance hance enhance security on the waterways effectively and efficiently.

Keywords:

Robotic boat | LoRa module | Surveillance | semi-autonomous

9A-1014-2025

Unlocking Project Efficiency Through Artificial Intelligence: A Case for Transforming Construction Management in South Africa

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Abstract:

South Africa's construction sector faces chronic inefficiencies, including delays, budget overruns, and low productivity. Artificial Intelligence (AI) has emerged as a transformative tool globally, demonstrating measurable improvements in project scheduling, risk management, and cost prediction. However, local adoption remains limited. This study investigates the perceptions, barriers, and readiness factors influencing AI integration in South African construction project management. A survey of twenty-two professionals across engineering, contracting, and project management was conducted. Results reveal strong recognition of AI's potential to enhance scheduling and budgeting (77.3% agreement) but limited organisational readiness: only 45.5% reported a digital strategy, 38.1% adequate IT infrastructure, and 18.2% active collaboration with external innovators. Key barriers include digital skills shortages (72.7%) and high implementation costs (54.5%). The findings align with international literature on AI adoption challenges while exposing South Africa's unique contextual constraints. Recommendations highlight skills development, pilot projects, and supportive policy frameworks to accelerate responsible AI adoption. The study contributes to the Africa Engineering Week theme by demonstrating how AI, when contextualised, can strengthen infrastructure delivery and socio-economic transformation.

Keywords:

Artificial Intelligence | Construction Project Management | South Africa | Digital Transformation | 4IR | Infrastructure Efficiency

9A-1015-2025

Assessing the effectiveness of biotechnical slope stabilization methods in landslide prone areas

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Abstract:

This research was conducted in Kasika village with a main aim of assessing the effectiveness of the different biotechnical slope stabilization methods in landslide prone areas. The study was triggered by the increasing challenge of slope instability in the area which led to loss of lives and destruction of community infrastructure such as roads, the study aimed at coming up with sustainable and environmentally friendly measures of stabilizing the slopes in the area because most traditional slope stabilization techniques are environmentally intrusive and climatically unadaptable. The study was conducted basing on three objectives that is to evaluate the slope susceptibility of the slopes to landslides in the landslide prone areas , to determine the factor of safety of the slope before failure and to assess the effectiveness of the biotechnical slope stabilization techniques. The study used (Analytical Hierarchy Process) AHP to come up with the landslide susceptibility map and Morgenstern price method of slices to determine the factor of safety of the slope before failure under saturated and normal soil conditions. The study found out that the endangered slope was unstable and prone to landslides and recommended the use of the biotechnical slope stabilization method of brush layering with bamboo live cuttings (Oldenia Alpina) to stabilize the slope.

Keywords:

Landslide Susceptibility Mapping | Weighted Overlay Analysis | Morgenstern Price Method | Brush Layering | Oldenia Alpina | iotechnical Slope Stabilization Methods | Landslide Causative Factors

9A-1016-2025

21st Century Full Spectrum Automated Road Condition Assessment - An Evolution from Opinion to Factual State of the Art

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Abstract:

Given that all road agencies, world-wide, have constrained budgets, maintaining the requisite standards must be achieved with the lowest cost and highest benefit. This requires the collection and analysis of road pavement data so that optimal maintenance and rehabilitation strategies can be identified, prioritized and implemented through the agency's Road Asset Management System (RAMS). Network level road condition surveys are an essential and integral component of any RAMS with the accuracy of these assessments being critical to the validity of the systems output in terms of priority, optimisation and financial budgets and the allocation of technically and economically appropriate remedial interventions. This notwithstanding, the status quo in many countries in the world is that the vast majority of road network level condition evaluations are STILL dependent on undertaking physical visual assessments, i.e. the use of people, resulting in subjective assessments with questionable remedial interventions based on opinion rather than fact. Semi-automated data collection using surveillance vehicles equipped with cameras and profiling equipment, is now the norm in many countries, but this still depends on physical input and subjective analysis by human interpretation. Whilst this is an improvement over completely manual methods, it is still a subjective evaluation and, more importantly perhaps, neglects to address the pavement structural condition except for visual inspection. Technology now exists, and is rapidly being utilized around the world, that replaces human subjectivity with objective unbiased and technically correct interpretations of the full depth condition of a road pavement. By integrating road surface measurement systems – e.g. rutting, cracking, roughness etc, with traffic speed deflectometer and ground penetrating radar an automated, continuous full spectrum pavement evaluation can be carried out with then resulting condition data now being factually measured and not based on human opinion. This Paper aims to provide a critical discussion on the evolution of road condition assessments from being completely subjective, to being objective, relevant and factual, together with a proposed way forward strategy towards establishing state of the art autonomous network and project level road condition data collection and evaluation that is fit for purpose in the 21st Century.

Keywords:

Pavement condition | Structural assessment | Automated data collection

9A-1017-2025

Bending Capacity of Reinforced Masonry Beams with Different Reinforcement Arrangements and Geometric Configurations

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Abstract:

Reinforced masonry (RM) beams are underutilised in Uganda, despite their potential as cost-effective alternatives to reinforced concrete. This study investigates the flexural performance of RM beams with various reinforcement configurations and spans through finite element analysis (FEA). The analysis considered unreinforced, centrally reinforced, bottom-reinforced, and stirrup-confined RM beams across spans from 900 mm to 3600 mm. Findings indicate that bottom reinforcement and stirrups significantly enhance flexural strength and ductility, while unreinforced beams are inadequate for longer spans. Fully reinforced beams perform optimally across all modelled spans. The finite element results align with existing experimental findings, validating the model. Notably, RM beams can reduce construction costs by 20–30% and construction time by up to 25% compared to traditional reinforced concrete. These results advocate for the adoption of RM technology as a sustainable solution for structural applications in developing countries, supporting Sustainable Development Goals (SDGs) 9 and 11.

Keywords:

Reinforced masonry beams | Flexural capacity | Finite element modelling | Three-point bending test

9A-1018-2025

Evaluation of Guidance, Navigation, and Control Algorithms for Hydrogen-Powered Multi-Aircraft Systems

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Abstract:

This paper presents a modular digital-twin framework to compare inner-loop attitude controllers: geometric PD ("PID"), discrete Linear-Quadratic Controller (LQR), and a move-penalized linear Model Predictive Controller (MPC)—for a heavy-lift T30-class quadcopter intended for hydrogen propulsion study. Twin couples 6-DoF rigid-body dynamics, actuator mixing, and motor/ESC lag, a bus-level electrical model, and stochastic wind (Ornstein–Uhlenbeck) with look-ahead guidance on a sharp lawnmower survey. To isolate controller effects, we equalize task difficulty by autotuning a single scalar per controller so that the achieved cross-track Root-Mean-Squared-Error (RMSE) falls in a target band of 2.6 ± 0.25 m; the tuned controllers then run identical 600 s simulations under the same wind seed and retimed speeds. On the equalized run, PID and LQR meet the band (2.45 m and 2.55 m), while MPC settles at 3.13 m, given its move penalty and finite horizon. All three deliver survey-class power with mean bus power within the same tolerance (≈ 4.8 kW) and peaks remaining in the 7–8 kW range. The energy per meter travelled favours MPC, with it reduced by ≈ 2.3% versus PID/LQR at the cost of relaxed lateral accuracy. A 10-seed Monte-Carlo with frozen scales shows the same trade: PID/LQR remain in-band in 90%/80% of seeds while MPC misses the target but consistently lowers energy per meter travelled, with similar mean power but gentler peaks. For hydrogen-electric UAVs, these metrics map directly to propulsion co-design; energy per meter travelled informs hydrogen mass and range, peak power sets stack/buffer sizing, and actuator smoothness affects balance-of-plant transients (Aslam et al., 2023). The results show that the controller choice is also an energy-management knob: PID/LQR when survey tolerance dominates; MPC-style penalization when endurance and BoP smoothness matter.

Keywords:

digital twin | guidance | navigation and control | heavy-lift multirotor | hydrogen-electric propulsion | predictive control model

9A-1019-2025

Leveraging electric mobility to build smart sustainable cities in Africa: A case study of Uganda

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Abstract:

The global transition towards electric mobility (e-mobility) is accelerating, driven by technological advancements and environmental imperatives. While Africa currently accounts for a small fraction of global electric vehicle (EV) sales, the continent is poised for a significant transformation, motivated by the urgent need to reduce reliance on fossil fuel imports, manage a rapidly growing vehicle market, and leverage abundant renewable energy resources. Uganda has emerged as a pioneer in this transformation on the African continent, with its journey starting as far back as 2009. Like many African countries, Uganda's transport sector , faces numerous challenges, including severe air pollution, an inefficient public transport system reliant on end-of-life imported vehicles, and substantial economic drain from fuel and vehicle imports.

This paper examines Uganda's strategic approach to leveraging e-mobility a tool for sustainable urban development, and as an enabler for socioeconomic transformation by reducing import dependency and enhancing citizen well-being. It synthesizes foundational policy documents, strategic frameworks, and recent progress reports to provide a comprehensive assessment of Uganda's e-mobility trajectory. As of 2024, Uganda has achieved a combined annual EV production capacity exceeding 10,000 units. Significant advances include the launch of electric bus services and the commencement of an electric standard gauge railway project. The country's charging infrastructure is expanding rapidly, with over 30 DC fast chargers and 134 battery-swapping stations operational nationwide. These efforts have attracted over USD 160 million in investment, created over 10,000 direct and indirect jobs, and avoided over 270,000 metric tonnes of CO2-equivalent emissions between 2022 and 2024. Uganda's integrated and locally-driven e-mobility strategy offers a compelling model for other African nations seeking to address urban challenges, foster economic growth, and achieve environmental sustainability through innovative engineering and policy frameworks.

Keywords:

e-mobility | Sustainable Transport | Sustainable Infrastructure | Urban Development

Poster Presentation

9A-1020-2025

Durability Properties of Ambient-Cured Metakaolin Stabilized Compressed Earth Blocks

Authors: Edmond Didier Medongou Tejiogho[1], Isaac Sanewu[2], Christopher Kanali[3] and François Ngapgue[4]

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Abstract:

The engineering and durability performance of metakaolin-stabilized compressed earth blocks (CEBs) remained underexplored despite their potential as sustainable materials. In this study, durability properties of the blocks were assessed at 28- and 180-days curing. The blocks were stabilised with metakaolin contents (CEB_MKX) ranging from 0% to 19%, in increments of 2% and cured at mean ambient temperature of 26±0.2oC. The constituent materials use to produce the blocks were characterized in terms of their mineralogical, chemical, microstructure, mechanical and physical properties. Metakaolin was obtained through calcination of kaolin at 700°C for 3 hours and it was activated to metakaolin binder using a 12M solution of sodium hydroxide. Secondly, five CEB samples for each metakaolin content were tested for physical, mechanical, and thermal properties according to the African Standard for Compressed stabilized earth blocks. It was established that the optimum metakaolin content is 11%. The results show that abrasion resistance of CEB_MK11% (2.73 cm/g) was significantly higher than that of non-stabilized CEBs (0.35 cm/g), demonstrating improved surface wear resistance. CEB_MK11% blocks had progressive mass loss during wetting-drying cycles, exceeding the 15% limit after 5 cycles and reaching 17.18% after 12 cycles, indicating moderate durability loss due to weakened bonding. In the capillary absorption test, CEB_MK11% blocks reached a maximum absorption of 3.42 g/cm, which was slightly higher than that for the CEB_OPC8% blocks of 3.12 g/cm after 72 hours. CEB_MK11% blocks absorbed water faster at early stages, indicating higher capillarity, but both stabilized blocks showed similar trends in water uptake over time. Erosion drip tests revealed no visible surface erosion for both stabilized CEBs, though moisture depth penetration was 29.5% higher in CEB_MK11% (21.1 mm) than in CEB_OPC8% (16.3 mm), suggesting slightly lower water ingress resistance. However, all DP values remained below 90 mm, revealing good durability against dripping action, according to the New Zealand's Materials and Workmanship for Earth Buildings standard. Under heavy water spray (0.5 bar), CEB_MK11% showed an erosion rate of 38.5 mm/h (class EI2), higher than that of CEB_OPC8% (3.9 mm/h, class EI1), but far superior to unstabilized CEBs, which eroded completely (>120 mm/h, class EI5). Therefore, metakaolin stabilization of the blocks enhanced resistance to wetting-drying cycles, capillary water absorption, and erosion, significantly improving the durability of the CEBs. These findings highlight metakaolin as a promising sustainable alternative to cement-based stabilizers, offering enhanced strength and durability for masonry applications.

Keywords:

sustainable materials | stabilized blocks | capillary absorption test

9A-1021-2025

Research on performance of technology transfer in the construction industry of Kenya

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Abstract:

Technology transfer in the construction sector lags behind other industries, yet it is vital for achieving Kenya's Vision 2030 and the Sustainable Development Goals. Globalization offers opportunities for local firms to acquire new technologies from foreign firms and academia, primarily through joint ventures, subcontracting, and management contracting. This study examined the level of technology transfer in Kenya's construction industry, its determinants, and the correlation between transfer levels and influencing factors. Using a cross-sectional design, the study targeted local construction firms that had engaged in technology transfer as transferees in projects with foreign contractors since 2018, covering all 70 registered projects. Four explanatory variables were considered: Technology Transfer Environment, Transferor Characteristics, Transferee Characteristics, and Learning Environment. Quantitative analysis revealed that the Transfer Environment and Transferor Characteristics significantly predict technology transfer levels. The study concludes that improving these two areas can advance knowledge, enhance project performance, and boost economic growth. It recommends an integrated model, informed by global best practices, emphasizing legal reforms, institutional strengthening, relationship building, capacity development, and incentives to promote effective technology transfer. These measures aim to foster innovation, improve efficiency, and ensure long-term competitiveness in Kenya's construction industry.

Keywords:

Technology Transfer | Construction Industry | Kenya | Transferor Characteristics | Transfer Environment

9A-1022-2025

FEM analysis of the effect of Geometrical Radius on the force capacity of Unreinforced Masonry walls under Out-Of-Plane monotonic loading

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Abstract:

The susceptibility of Out-of-Plane (OOP) failure in Unreinforced Masonry (URM) walls during natural hazards such as earthquakes and high winds has been widely documented. This failure mode poses significant structural and safety risks, highlighting the need for further research. While curved wall construction has gained global acceptance due to its architectural and functional appeal, it is quite evident that the existing design considerations are primarily tailored to straight and orthogonal wall geometries, leaving the flexural behaviour of curved URM walls analytically underrepresented. This gap necessitates the use of crude approximations in practice, often resulting in conservative or unreliable performance predictions that constrain innovation in form and material optimization.

Keywords:

Curved Masonry walls | Finite Element Modelling | Out-Of-Plane loads

9A-1023-2025

Engineering-based rapid visual screening for seismic safety of school buildings in Uganda: a pathway to resilient and inclusive urban development

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Abstract:

Western Uganda, located within the East African Rift System, is one of the most seismically active regions in the country. Despite increasing urbanization and the critical role schools play in socio-economic transformation, several school infrastructures in this region remain highly vulnerable to seismic hazards. This study presents a rapid visual screening framework to assess the seismic safety of school buildings across three major urban cities: Fort Portal, Hoima, and Mbarara. The study aims to identify key structural vulnerabilities, quantify seismic risks, and inform gender-responsive disaster risk reduction strategies. Whilst peak ground acceleration of up to 0.26g is predicted for a 475-year return period, mean annual economic losses exceeding US$71million are estimated across Uganda. Results from the 100 classrooms inspected show that whilst 35% of the buildings are safe, 59% require retrofitting and 6% pose critical seismic risks. Common deficiencies include unsupported parapets, weak roof connections, poor materials, and inadequate foundations. The findings underscore the need for seismic-code update and enforcement, cost-effective retrofitting strategies, and integration of seismic risk mitigation into national development planning. As schoolgirls are disproportionately affected by disaster-induced disruptions, improving seismic resilience of school infrastructure in Uganda's growth corridors will promote safer, sustainable, and inclusive school environments.

Keywords:

Sustainable infrastructure | earthquake hazard and risk | seismic resilience | gender-responsive disaster risk reduction | rapid visual screening | development | Uganda

9A-1022-2025

Ethical Engineering Innovation and Infrastructure Development Integrity through the Indigenous African Governance Framework of Ubuntu-Botho.

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Abstract:

For centuries, indigenous African people abandoned their traditional ways of doing things in favour of foreign Eurocentric cultures imposed by colonization. Eurocentric and indigenous African ways are environmentally and culturally different. Eurocentric cultures are influenced by environmental scarcity, while indigenous Africans are influenced by abundance. Despite being self-governed since the 1960s, many African nations and their professionals, like in engineering, failed to transform, but continue using their former colonizers' cultural governance models and practices, not aligned to the indigenous African cultural environment. In South Africa, infrastructure (roads, buildings, etc.) is seen as constructed without following the engineering cultural considerations, the practice principles of safety and reliability (quality), thereby causing harm to humanity. Based on the already undertaken Royal Bafokeng Nation (RBN) case study, their Ubuntu-Botho-centered governance. Using qualitative methods and approaches, this study analyses the existing case study's outcomes application to the engineering profession. The paper, like in the case study, analysis employs indigenous knowledge systems methodology to review the philosophical Ubuntu-Botho's four pillars of spiritual soul, culture, governance, and operational excellence pillars and their mechanisms in governing the engineering sectoral and functional structures and processes, as an alternative to foreign models and a mechanism to decolonise indigenous African professionals' mind and thought in the creative, innovative development and the engineering environmental transformation.

Keywords:

Ubuntu-Botho | Spiritual Governance | Ubuntu-Botho-Based Engineering Governance System Framework | Ubuntu-Botho-Based Engineering Good-Ethical-Moral Code of Practices | Indigenous African Knowledge & Compliance System (IAKCS)

Sub-Theme 3

9A-1024-2025

esign and Simulation of Distributed Solar Photovoltaic Power Plants with Artificial Intelligence and Power Line Communication-Based Energy Management System

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Abstract:

Western Uganda, located within the East African Rift System, is one of the most seismically active regions in the country. Despite increasing urbanization and the critical role schools play in socio-economic transformation, several school infrastructures in this region remain highly vulnerable to seismic hazards. This study presents a rapid visual screening framework to assess the seismic safety of school buildings across three major urban cities: Fort Portal, Hoima, and Mbarara. The study aims to identify key structural vulnerabilities, quantify seismic risks, and inform gender-responsive disaster risk reduction strategies. Whilst peak ground acceleration of up to 0.26g is predicted for a 475-year return period, mean annual economic losses exceeding US$71million are estimated across Uganda. Results from the 100 classrooms inspected show that whilst 35% of the buildings are safe, 59% require retrofitting and 6% pose critical seismic risks. Common deficiencies include unsupported parapets, weak roof connections, poor materials, and inadequate foundations. The findings underscore the need for seismic-code update and enforcement, cost-effective retrofitting strategies, and integration of seismic risk mitigation into national development planning. As schoolgirls are disproportionately affected by disaster-induced disruptions, improving seismic resilience of school infrastructure in Uganda's growth corridors will promote safer, sustainable, and inclusive school environments.

Keywords:

Artificial intelligence | microgrids | photovoltaic forecasting | power line communications | renewable energy management

9A-1025-2025

Generation Demand Balance Analysis for Uganda-Vision 2040

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Abstract:

Uganda's Vision 2040 establishes a target of 52 GW of installed electricity generation capacity by 2040, an objective that demonstrates a significant divergence from current growth projections. This study utilises a quantitative methodology, employing econometric and time-series models to forecast electricity demand, peak loads, and installed capacity through 2040. Sector-specific consumption data from 2013-2023, alongside key socio-economic drivers, were used to develop log-linear regression models for energy demand and a harmonic regression model for peak demand. Under the base-case scenario, 2040 annual energy demand is projected to reach approximately 14,320 GWh, with a peak demand of 2,291 MW, and an installed capacity of 3,381 MW. These forecasts account for only 6% of the Vision 2040 capacity target. This substantial mismatch between the ambitious national objective and data-driven projections underscores the critical need for evidence-based planning to mitigate the risks of stranded assets, financial inefficiency, and unsustainable development. The findings advocate for a phased, demand-driven approach to generation expansion to ensure a reliable and economically viable energy future for Uganda.

Keywords:

Generation-Demand Balance | Electricity Forecasting | Uganda Vision 2040 | Econometric Modelling | Energy Policy | Sustainable Development | Sub-Saharan Africa

9A-1026-2025

A Peer-to-Peer Energy-Sharing System for Smart Electricity Utility Meters

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Abstract:

Uganda's power sector transition from a postpaid to a prepaid electricity metering system resulted in improved revenue for utilities and significantly lowered administration costs. Whereas this system is functionally operational, it lacks a mechanism for direct transfer of purchased electricity units between customers, leading to inefficiencies and limited consumer flexibility. This paper presents the development, implementation, and testing of an IoT-enabled peer-to-peer (P2P) energy-sharing model that allows for direct transfer of energy units. Developed using a mixed-methods approach, the prototype employs an ESP32 microcontroller, a secure token-based vending platform via a centralized server, and bidirectional data exchange between meters. Experimental evaluation demonstrated ±5% metering accuracy, reliable credit transfer, and automatic load reconnection. The approach addresses a key service gap by enabling surplus unit sharing without utility intervention, promoting collaborative consumption, and enhancing energy equity. Beyond technical performance, the system supports Sustainable Development Goals (SDGs) 7, 8, 9, 10, and 12 by improving access, economic inclusivity, and resource efficiency. This work provides a scalable framework adaptable to other sub-Saharan African contexts and offers utilities an opportunity to enhance customer satisfaction while fostering innovation in decentralized energy distribution models.

Keywords:

Energy sharing | pre-paid metering | Electricity billing | Peer-to-Peer | IoT-based electricity metering | Energy token transfer

9A-1027-2025

Evaluating the Techno Economic Impact of Private Sector Driven Expansion of the Transmission Grid

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Abstract:

Uganda's escalating electricity demand and constrained public funding have prompted regulatory reforms enabling private sector participation in transmission infrastructure (Electricity Regulatory Authority [ERA], 2023; Ministry of Energy and Mineral Development [MEMD], 2022). This paper evaluates two priority projects—i.e., the Mbale–Bulambuli–Kween project and the Nkenda–Hoima–Fort Portal 220 kV upgrade—within the 2023 Independent Power Transmission (IPT) framework (ERA, 2023). Using Uganda Electricity Transmission Company Limited's (UETCL) Grid Development Plan 2018–2040 as a baseline (UETCL, 2018), detailed network models were developed in DIgSILENT Power Factory (DIgSILENT GmbH, 2024) to compare a 2027 base case against private-investor scenarios. Technical metrics include system losses, voltage profiles, and equipment loading; the economic analysis uses Net Present Value (NPV), Internal Rate of Return (IRR), and payback period under conservative tariff and cost assumptions (World Bank, 2023). Results indicate the Mbale corridor reduces system losses by ≈0.78 percentage points, improves voltage profiles, and yields a positive NPV with an approximate six-year payback. In contrast, the Nkenda–Hoima upgrade achieves only ≈0.23 percentage-point loss reduction, suffers from low utilization, and produces a negative NPV under current demand projections (UETCL, 2023). We recommend prioritizing private investment in the Mbale corridor while re-scoping Nkenda with phased implementation or alternative financing; strengthened evaluation criteria and improved demand forecasting are necessary to align IPT with Uganda's grid resilience goals (MEMD, 2022; World Bank, 2023).

Keywords:

Uganda | transmission grid | Independent Power Transmission (IPT) | private sector | techno economic evaluation

9A-1028-2025

Optimizing railway energy reliability using wind energy harvester with FLC-MPPT: a case study of Addis Ababa light rail transit

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Abstract:

In Addis Ababa, Ethiopia, the Addis Ababa Light Rail Transit (AALRT) provides vital transportation connectivity but faces frequent power outages that compromise energy reliability. This paper explores the feasibility of harnessing wind energy generated by moving trains along the AALRT corridor, leveraging natural wind resources. Unlike large-scale wind farms, the study investigates the integration of small-scale wind turbines to power railway auxiliary systems, employing advanced control strategies to enhance reliability and sustainability. The research focuses on designing a Fuzzy Logic Control (FLC) based Maximum Power Point Tracking (MPPT) system to optimize energy extraction from Wind Energy Harvesting Systems (WEHS). With the AALRT's average speed at 20 km/h, the project aims to capture both train-induced and natural wind for power generation, optimizing energy conversion through FLC-MPPT by controlling the Tip Speed Ratio and Pitch angle. The paper concludes with practical recommendations for deploying integrated small-scale WECS along railway corridors and managing wind power conversion. It also suggests future research directions to advance wind energy harvesting technologies, providing valuable insights for engineers and stakeholders in enhancing railway energy resilience and promoting sustainable transportation.

Keywords:

Railway Transportation | Wind Energy Harvesting | AALRT | MPPT | Power Electronics | Energy Reliability

9A-1029-2025

Investigating the technical feasibility of plastic waste conversion to fuel using pyrolysis

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Abstract:

With the increasing plastic pollution worsening Africa's environmental and climate crises, existing pyrolysis research overlooking scalable, low-cost solutions for mixed plastics, this research addresses this gap by developing a simple modular pyrolysis system and using locally sourced catalysts to convert plastic waste into fuel. Plastic waste was sorted using recycling codes (HDPE, LDPE, PP and PS), cleaned and shredded. A cylindrical metallic reactor with a rocket stove improved heating efficiency and plastic breakdown into liquid fuel, usable byproducts like combustible gas (syngas), and char residue. Heating was done in anoxic conditions to yield 70 – 96% liquid oil, with PP achieving the highest yield (96%). Locally sourced sugarcane bagasse ash was tested as a cheaper catalyst vs. activated carbon to boost fuel quality and cut energy use. Emissions tests showed safe levels of CO and NOx that fell within acceptable limits. This work highlights a promising way to reduce plastic pollution and create useful energy in Africa, but requires better tools and support to scale up.

Keywords:

Plastic waste | Pyrolysis | Bagasse-ash | Activated-carbon | sustainable

9A-1030-2025

Design and Simulation of an Automatic Generation Control (AGC) System for Real Time Power Balance of Uganda's Power Grid.

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Abstract:

This study presents the design and simulation of an Automatic Generation Control (AGC) system designed to enhance real-time power balance within Uganda's power grid. The work addresses the challenges of manual frequency regulation, load and generation imbalance, and cross-border power exchange instability. The study focuses on Uganda's generation mix, incorporating major hydropower plants like Isimba, Karuma, Nalubaale, and Bujagali Hydropower plants, mini-hydros, grid connected solar PV, cogeneration (Bagasse), and thermal. It also accounts for the Kenya-Uganda tie-line to ensure realistic grid representation. Furthermore, the study accounts for economic dispatch which considers the capacity-based power plants, cascade operation and economic merit order where the lowest cost generators are considered first. A model of the AGC system was developed in MATLAB/ Simulink, with performance evaluated across five operational scenarios. These are the normal operating conditions, the AGC maintained system frequency within ±1% of the nominal 50 Hz. During simulated disturbances including a 100 MW load fluctuation, an 8 MW tie-line backflow from Kenya, a 50 MW loss of generation from the mini-plants, and a generator unit trip at Isimba power plant, the AGC exhibited rapid response capabilities. It dynamically adjusted generation outputs and deployed spinning reserves, effectively restoring system equilibrium and preventing cascading failures. It puts into account the economic dispatch principles, enhances frequency stability and reduces the response time during grid disturbances. Notably, it ensured adherence to Uganda's scheduled 50 MW power export obligations to Kenya while supporting real-time operational efficiency. These outcomes support the AGC's potential in improving grid resilience, facilitating renewable energy integration, and advancing Uganda's engagement in the East African Power Pool (EAPP).

Keywords:

Automatic Generation Control (AGC) | Frequency stability | Realtime power balance. | Tie-line power flows

9A-1031-2025

Regulating Beyond the Grid: Harnessing Big Data Analytics for Sustainable and Inclusive Off-Grid Energy Systems

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Abstract:

Pay-as-you-go (PAYG) solar operators generate high-frequency operational data, yet regulators rarely use these streams to guide oversight. This paper analyses twelve months of transaction data from two PAYG portfolios in Uganda and Rwanda (over 115,000 customer accounts; 2019) to propose regulator-ready indicators for off-grid electrification. Datasets from both companies were cleaned, harmonised, and analysed with Microsoft Excel and Python to generate critical insights for regulatory actions. Village-level coverage maps from customer GPS clusters reveal where access concentrates. Account- and product-status series show sharp contractions, including a 12.6% fall in Rwanda and a 36.6% drop in Uganda, while product-segmented balances highlight concentration in a few product lines and uneven repayment gains. Portfolio-at-risk (PAR) analyses clarify arrears migration: one portfolio shows growth in PAR90+ despite overall contraction, while the other shifts toward shorter-dated arrears alongside declining active service. The analysis is intentionally non-comparative; each portfolio is read as a distinct case to highlight both visibility and opacity in available data. Critically, the truncated datasets omit payment completions in Rwanda and access reconnections in Uganda, limiting differentiation between maturations and write-offs. We argue that indicators such as spatial coverage, account updates, product balances, and PAR trends can ground proportionate, real-time regulation, and extend to mini-grids, commercial, and grid-tied systems wherever sensor-based monitoring is feasible.

Keywords:

Off-grid electrification | PAYG solar | big data | regulation | real-time oversight

9A-1032-2025

GLISSA: A GenAI-Augmented Framework for Real-time Situation Awareness of power Infrastructure based on Crowd Sourced Data

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Abstract:

Monitoring critical infrastructure (CI) like national power networks in developing countries is hindered by the limited coverage and high cost of traditional data collection methods (e.g., sensors, SCADA), making real-time situational awareness difficult during service disruptions. In contrast, social media platforms like X (formerly Twitter) offer a rich but underutilized source of real-time user-generated data. However, its unstructured, noisy, and diverse nature challenges traditional AI methods. This paper proposes a fully automated pipeline leveraging Generative AI (GenAI), specifically Large Language Models (LLMs), to extract and synthesize actionable insights from social media. The system includes Twitter API-based data ingestion, LLM-driven filtering and classification, geolocation inference, and visualization. A case study in Uganda validates its ability to detect power disruption events, addressing crowd-source data challenges.

Keywords:

Infrastructure Monitoring | GenAI | LLMs | Social Media Analytics | Real-Time Systems | Uganda

9A-1033-2025

An algorithm for failure detection of a power mosfets in non-isolated boost dc-dc converters for Photovoltaic (PV) power systems.

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Abstract:

Considering the intermittent nature of power generated by photovoltaic (PV) panels and the faults posed by the entire PV power systems, an algorithm for power switch failure in DC-DC converters is proposed herein. This algorithm does not necessitate an extra MOSFET or sensor. It utilizes the use of overcurrent at the slope of the input inductor as an indication of failure to the system. This method proved to be cost-effective and simple compared to the traditional methods of adding extra MOSFET/sensor or designing a monitoring software for failure detection. The algorithm was tested under different scenarios and validated using both simulation and experimental phenomena. The results show a promising future for the reliability of power MOSFET for the incorporation of DC-DC converters to the PV power system.

Keywords:

MOSFET Failure | DC-DC Converters | PV Power System

9A-1034-2025

Unlocking Clean Aviation in Africa: Challenges to localising Hydrogen Aviation Propulsion in South Africa

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Abstract:

The global aviation industry has adopted ICAO's Long-Term Aspirational Goal (LTAG) to achieve net-zero emissions by 2050. Hydrogen fuel cell propulsion is recognised as a key enabler of zero-emission aviation. While South Africa has strong potential for green hydrogen production due to its renewable energy resources, the country does have challenges in localising hydrogen aviation propulsion technologies. This paper explores these challenges through the CSIR's H2UAV project, which is a hydrogen powered long-endurance unmanned aerial vehicle (UAV) designed to localise aviation hydrogen propulsion expertise, demonstrate hydrogen propulsion feasibility, and support a roadmap toward decarbonisation in aviation. Challenges identified include underdeveloped regulatory frameworks, limited early-stage funding, infrastructure inefficiencies, and a shortage of aerospace product development expertise. This study draws on global hydrogen aviation trends and proposes mechanisms for overcoming these obstacles in emerging economies like South Africa to boost the implementation of low carbon aviation propulsion technologies

Keywords:

Hydrogen fuel cells | Technology development | Aviation

9A-1035-2025

A Mathematical Model of a Commercial Fuel Cell for Evaluating Efficiency Under Varying Ambient Conditions

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Abstract:

Long-endurance aviation propulsion is currently dominated by carbon-based fuels. However, due to climate change, which is largely attributed to carbon dioxide (CO2) emissions from human activities, aviation contributes approximately 4 %, a more climate friendly fuel is sought. Hydrogen (H2), particularly in proton exchange membrane (PEM) fuel cells, offers a promising carbon-neutral alternative. To assess its viability, a mathematical model of a commercial fuel cell was developed to evaluate efficiency under varying ambient conditions representative of Africa climates and at high-altitude scenarios.

Keywords:

Fuel cells | hydrogen | global warming

9A-1036-2025

Forecasting Low-Frequency Oscillations Using PMU Data and LSTM Networks in the Southern African Power System

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Abstract:

Phasor Measurement Units (PMUs) have become a vital tool in enhancing the observability and control of modern power systems. While widely used globally for both monitoring and control, PMUs in South Africa are mainly utilized for monitoring purposes. Integrated into a Wide Area Monitoring System (WAMS), PMUs provide real-time, time-synchronized measurements of voltage and current phasors at high resolution—far exceeding the capabilities of traditional SCADA systems. This study leverages PMU data for predictive analytics using machine learning. A Long Short-Term Memory (LSTM) neural network, a class of Recurrent Neural Network (RNN), is trained to forecast the damping behavior of low-frequency oscillations. Historical data from five PMUs installed in the South African transmission network are used, with 19 training cases featuring 20-second frequency data windows preceding known oscillation events. Events are labeled as positively damped (1) or negatively damped (0). The trained LSTM model is tested on five unseen events and achieved approximately 80% classification accuracy in distinguishing positively damped from negatively damped oscillations. These results demonstrate the potential of LSTM networks in early detection and characterization of electromechanical instability using PMU frequency data alone.

Keywords:

Phasor Measurement Unit | LSTM | Low-Frequency Oscillations | Wide Area Monitoring | Machine Learning | Power System Stability

Poster Presentation

9A-1037-2025

Analyzing Distribution Network Performance Gaps and Challenges to Scale Up Modernization: A Case Study of Kampala West Region

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Abstract:

This paper analyzes Uganda's electricity distribution network performance gaps and modernization challenges using Kampala West region's Kitala feeder as a case study. Industry standard reliability indices (SAIDI, SAIFI, CAIDI), modernization maturity assessment, and network simulations identified high outage durations, frequent interruptions, and significant feeder losses. Modernization interventions including protection coordination, network reconfiguration, reconductoring, parallel circuits, and distributed generation significantly improved reliability and reduced losses. Cost-benefit analysis using NPV and payback period metrics highlighted the most economically viable interventions. The study recommends targeted interventions with optimal NPV and payback period values, replicable to similar urban feeders. Policy formulation and regulations supporting 100% distribution network modernization are essential to achieve reliable electricity supply and support Vision 2040 goals.

Keywords:

Distribution networks | SAIDI | SAIFI | modernization | Uganda | cost-benefit analysis | reliability indices

Sub-theme 4

9A-1038-2025

Advancing Flood Susceptibility Mapping in Lake-Watersheds Using AI-driven Geospatial Workflows

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Abstract:

Lake Tana and its surrounding regions experience frequent flooding, necessitating improved susceptibility mapping to mitigate risks and enhance resilience. This study applies data-driven machine learning techniques to assess flood susceptibility utilizing data sets commonly used in large-scale river basin studies. A comprehensive flood inventory of approximately 2,080 flooded locations was compiled alongside 14 predictive variables. The predictive features include elevation, slope, distance to Lake, maximum precipitation and topographic wetness index. The models tested include Random Forest (RF), Support Vector Machine (SVM), Artificial Neural Network (ANN), and Convolutional Neural Network (CNN). Model performance was validated using the Kappa score and the area under the receiver operating characteristic curve (AUC). Results indicate that all models perform exceptionally well, with a minimum AUC of 0.87 for the testing dataset. RF consistently outperformed other models, achieving an AUC of 0.96 for the flood inventory and predictor variables. Elevation and distance to Lake Tana emerged as the most critical influencing factors. This study underscores the effectiveness of machine learning-based flood susceptibility mapping for Lake Tana and its surrounding watersheds, provided that a reliable flood inventory is available. The findings support data-driven approaches in flood risk assessment and offer valuable insights for disaster preparedness.

Keywords:

Flood susceptibility | Lake Tana Basin | Machine Learning

9A-1039-2025

Food Security in Nigeria: Engaging Diverse Models

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Abstract:

This article seeks to alleviate food insecurity in Nigeria by deploying diverse models that have significantly improved agricultural productivity. The summarized model studies spanned over three decades (1993 – 2025). The technologies are: Accuracy of feel measured texture in Alfisol soil, quantitative and qualitative yield determinant techniques, the Global DALYs 136 countries Hidden Hunger Indices and Maps, Irrigation systems evaluation for off-season Olericulture, Integrated harvesting techniques for African eggplant (Solanum macrocarpon), FFM+ programme in Nigeria, Rapid-Sanitary and Phytosanitary Assessment Tool for engineers. These were discussed and way forward recommended. What is needed is alleviating food insecurity commitment through leveraging agronomic technologies and engineering innovations to accelerate Africa's socio-economic transformation.

Keywords:

Agronomic | Models | Food | Poverty

9A-1040-2025

Adaptive irrigation system based on evapotranspiration and soil moisture sensing for precision agriculture

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Abstract:

Agriculture in Uganda faces mounting pressures from escalating food demand, climate variability, and declining freshwater availability, with irrigation alone accounting for over 80% of total freshwater withdrawals. To address the limitations of conventional evapotranspiration (ET) controllers—which often depend on expensive meteorological instrumentation—this study proposes a cost-effective, sensor-minimal approach that utilizes only ambient temperature and relative humidity measurements from a DHT11 sensor, combined with soil moisture sensing. ET estimation is performed using a Sugeno-type Adaptive Neuro-Fuzzy Inference System (ANFIS) trained via a hybrid learning algorithm that integrates least-squares estimation for linear parameters with gradient descent for nonlinear membership function tuning. The ANFIS model, achieving a mean absolute error of 0.035 and a coefficient of determination (R) of 0.988, was implemented in MATLAB to generate ET values in real time. These values are evaluated alongside in-field soil moisture readings by an ESP32 microcontroller to determine optimal irrigation scheduling. The system incorporates both automatic and manual control modes, accessible through a MATLAB-based PC graphical user interface and an Android mobile application via Wi-Fi, enabling responsive and scalable deployment. This architecture delivers a precise, affordable, and adaptable irrigation management solution suitable for resource-constrained agricultural environments in Uganda.

Keywords: ; ; ;

Evapotranspiration | precision agriculture | adaptive irrigation | ANFIS

9A-1041-2025

Assessment of Groundwater Quality and Faecal Contamination Risks Beneath the Qoboza Klaaste Building, University of Johannesburg

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Abstract:

This study investigates the physicochemical and microbiological quality of groundwater beneath the Qoboza Klaaste (Q/K) building, Doornfontein Campus at the University of Johannesburg (UJ), South Africa, and whether it is suitable for human consumption. Groundwater ingress is a persistent structural and resource concern, exacerbated by legacy mining impacts and urban sewer infrastructure. Groundwater samples were analysed against the South African National Standards (SANS 241:2015) for potable water. Physical parameters (pH and electrical conductivity) were found to be compliant, whereas turbidity exceeded acceptable limits in 8 out of 15 samples. Microbiological tests revealed consistent detection of Total Coliforms and E. coli, indicating faecal contamination. Acid Mine Drainage (AMD) was not a significant factor; sewer line leakage was identified as the primary source of contamination. Untreated groundwater is unsuitable for human consumption but may be safely repurposed for non-potable applications. Recommendations include sump infrastructure upgrades, routine water quality monitoring, and disinfection strategies to mitigate health risks and enable potential reuse. Q/K Groundwater, if not treated it can be used for flushing toilets and watering gardens

Keywords:

Groundwater quality | Urban hydrogeology | Infrastructure risk | Parameters

9A-1042-2025

OSIKANI Farm Solution: Optimized Solar-Integrated Knowledgeable Agricultural Node for Innovation-A Low-Cost, Remote-Controlled Smart Farming System for Sustainable Small-scale Farming

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Abstract:

This work presents the OSIKANI Farm Solution, developed to address persistent challenges in small-scale farming such as labor shortages, unreliable power supply, and inefficient use of resources. The system was built from locally sourced materials and incorporated a 60 W solar panel, rechargeable lithium battery, high torque DC motors, sensors, relays, and a GSM module for mobile alerts. A dedicated mobile application enabled both remote and manual control. Automated functions included irrigation, weeding, and chemical application, triggered by real-time sensor data. Results obtained from the performance testing conducted for six hours, three hours on solar power and three hours on battery. The system achieved 90% efficiency under solar power and 75% on battery. Functional success rates included 92% for remote weeding, 88% for automated irrigation, 94% for data transmission, and 95% for the security alarm. The results indicates that, the OSIKANI Farm Solution reduces manual labor, optimizes water and energy usage, and enhances productivity. Its reliance on renewable energy and low-cost components makes it a sustainable and scalable precision farming tool for smallholder farmers in both rural and urban settings.

Keywords:

Solar-powered farming | automated irrigation | GSM farm alerts | precision agriculture | small-scale farming technology | renewable energy agriculture

9A-1043-2025

Bio techno-economic evaluation of a maggot facilitated waste management system: a regenerative agriculture approach

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Abstract:

Uganda's organic waste, constituting of 70-80% of municipal solid waste, poses significant environmental and public health challenges through current disposal methods that contribute to greenhouse gas emissions and land degradation. This study examines the effectiveness of Maggot Facilitated Waste Management System (MFWMS) utilizing Black Soldier Fly Larvae (BSFL) to transform organic waste into high-protein animal feed (42% crude protein content) and organic fertilizer. Our bio-techno economic assessment at Women Income Network Uganda, a local NGO promoting maggot farming among women and youth, demonstrated BSFL's capacity to process 60-70% of organic waste within 14 days. As of 2023, the facility received and processed up to 25.95 tons of organic waste, producing about 686 kg of maggots and 6.523 tons of compost. The maggots are used as animal feed for poultry, pigs, and fish, while the compost is used as fertilizer for crops. Socially, the project empowers women and youth by providing new economic opportunities and fostering community engagement. The system also enhances public health by reducing the spread of pathogens and improving sanitation. Environmentally, the MFWMS supports Uganda's commitment to reducing its carbon footprint and aligns with national development plans and several United Nations Sustainable Development Goals (SDGs), including Zero Hunger, Decent Work and Economic Growth, Responsible Consumption and Production, and Climate Action. The research concludes that the MFWMS is a scalable, adaptable, and sustainable solution for organic waste management in Uganda. By integrating this system, Uganda can achieve significant environmental, economic, and social benefits, paving the way for a cleaner, greener, and more prosperous future. This study provides valuable insights for policymakers, agricultural practitioners, waste managers, and investors, advocating for the adoption of innovative waste management strategies to address the pressing challenges of organic waste.

Keywords:

Organic waste | Maggot Facilitated Waste Management System | Sustainability

9A-1044-2025

Enhancing Mechanical Strength: Agricultural Fiber Composites

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Abstract:

Agricultural biodegradable-fillers is cost and environmentally efficient substitute to synthetic-fillers for material engineering applications. Mechanical strengths were therefore studied for agricultural fiber-composites that were made with different amounts of kenaf stem (KS), tamarind shell (TS) and resin (RS). Composites had varied percentage weights of KS (10 - 30%), a mix of TS (10%) and RS (60%). Tensile and impact strengths were carried out in respect to ASTMD3039 (2014) and ASTMD256 (2023) standard protocols respectively. Results indicated a significant correlation between kenaf filler composition and material strengths of the hybrid-composites. Composite of 20%KS possessed the most significant optimal mechanical performance compared to other hybrids. Hybrid composite tensile strength increased from 32.5MPa for 10%KS composite to 38.8MPa for 20%KS hybrid composite when compared with pure epoxy resin (check) 17.8MPa for 100%RS. The impact strength optimally and significantly increased from 2.55J for 10%KS composite to 4.48J for 20%KS composite, compared with check epoxy resin 1.06J for 100%RS. These results indicate significant improvements in hybrid composites mechanical strengths for material engineering applications to accelerate Africa's socio-economic transformation.

Keywords:

Agriculture | Waste | Mechanic | Hybrid | Enhancement | Kenaf | Transformation

9A-1053-2025

Innovative and Sustainable Water Engineering for Agricultural irrigation in Sub-Saharan Africa: A Systematic Review of Irrigation Technologies and Their Productivity Impacts under Water Scarcity

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Abstract:

This paper aims to review existing studies on innovative and sustainable water engineering for agricultural irrigation technologies and their productivity impacts under water scarcity in Sub-Saharan Africa (SSA). This study analyzed and reviewed 50 articles and reports on agricultural irrigation technologies using a systematic literature review, PEO, PRISMA, SALSA and impact-effectiveness frameworks methodologies. Data sources included Scopus, Web of Science, AGRIS, Google Scholar, and ScienceDirect and institutional repositories for instance FAO, World Bank. The findings indicate that although a wide range of irrigation technologies are being implemented in different ecological and socio-economic settings in Sub-Saharan Africa, including drip and solar-based systems, and traditional and natural systems, notable research gaps were identified such as sustainability landscape of irrigation research is still very much characterised by substantial structural and content-related gaps, omission of the behavioral and perceptual aspects of adoption, governance and institutional arrangements, digital and remote-recording practices are making inroads in irrigation systems. The study suggests that technical success is commonly limited by socio-institutional and environmental factors, including under-financing, poor training, and policy fragmentation. The study aggregates empirical evidence and maps implementation challenges, offering a timely policy-relevant basis to rethink strategies for irrigation in SSA. It provides a much-needed typology and a set of principles to help guide researchers, practitioners and decision-makers toward sustainable, scalable and climate-smart irrigation solutions for the region. In addition, the findings will be useful for policymakers, industry stakeholders, and educators in developing effective agricultural irrigation technologies.

Keywords:

Sustainable irrigation | water engineering | Sub-Saharan Africa | smallholders | systematic review | water productivity | climate adaptation

9A-1045-2025

Poster Presentation

Enhancing Water Use Efficiency in Ugandan Smallholder Farms: A Sensor-Based Irrigation Approach for Climate-Resilient Agriculture

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Abstract:

Water scarcity poses a significant threat to agricultural productivity and food security for smallholder farmers across Uganda. This paper explores the practical application of sensor-based irrigation systems as a climate-smart solution to improve water use efficiency and enhance crop yields. Our research, centered on maize in Luwero district, demonstrates that integrating soil moisture sensors with solar-powered irrigation can dramatically reduce water consumption while boosting crop growth. These findings highlight a scalable technological intervention to support sustainable agriculture in water-stressed environments within the region.

Keywords:

sensor-based irrigation | water use efficiency | climate-resilient agriculture | smallholder farming | Uganda | Climate smart agriculture

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Standalone IOT-Based Drip Irrigation System with Mobile App Control for Water Efficiency

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Abstract:

Smallholder farmers in rural areas often struggle with inefficient water usage due to limited access to automated irrigation systems and unreliable internet connectivity. This project presents a cost-effective, IoT-based drip irrigation system controlled via a smartphone app. At the core of the system is the ESP32 microcontroller, which is configured to operate in Access Point (AP) mode, allowing it to create its own Wi-Fi hotspot. Communication between the ESP32 and the mobile application is handled through the lightweight MQTT protocol, ensuring fast, reliable, and low-power data exchange. Farmers connect directly to this hotspot using a custom mobile application developed in Java with Android Studio, eliminating the need for internet service. The app provides a simple user interface for monitoring soil moisture levels and controlling the irrigation pump, either manually or based on moisture thresholds. Field test results demonstrated the reliability and responsiveness of the system. The system achieved 98.5% uptime during a 10-day test period, operated with an average response time of 3 seconds when soil moisture dropped below 500 ADC, and responded to mobile app irrigation toggles in an average of 1.2 seconds. Additionally, the system can be switched on and off remotely through the app, presenting a high level of flexibility. This system is affordable, easy to deploy, and specifically designed for the needs of smallholder farmers. It promotes smart agriculture by combining local wireless connectivity, MQTT-based communication, mobile control, and automated irrigation, all without relying on expensive infrastructure or recurring data costs.

Keywords:

IoT irrigation | Drip irrigation system | Smart farming | Mobile app irrigation control

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Sub-Theme 5

Engineering the future: mentorship for young students and graduates in career, personal, and professional progression in Africa: case study Kenya

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Abstract:

Engineering is fundamental to sustainable development, innovation, and economic growth in Africa. However, the continent continues to face significant challenges in cultivating the next generation of engineers, particularly among youth. In Kenya, many students lack exposure to engineering practice, guidance in career planning, and mentorship from industry professionals. These gaps contribute to low enrolment in STEM (Science, Technology, Engineering, and Mathematics) disciplines and a mismatch between academic knowledge and industry needs. The Institution of Engineers of Kenya (IEK), through its Future Leaders Committee (FLC), has pioneered a comprehensive mentorship program that seeks to inspire, educate, and empower students and young graduates across secondary schools and universities. This paper aims to examine how mentorship programs, particularly those led by professional bodies such as the Institution of Engineers of Kenya (IEK), contribute to the academic, personal, and professional growth of students and graduates in Kenya. It explores the impact of the FLC's mentorship initiatives using a descriptive case study methodology. The study draws data from over 15 learning institutions across Kenya through surveys, interviews, and document analysis. Findings reveal that mentorship significantly increases interest in STEM careers, enhances students' self-confidence, builds critical soft skills, and encourages peer mentorship. Notably, awareness of engineering as a career and understanding of professional pathways improved markedly among both high school and university participants. The study highlights key areas for strengthening the program, including integration with national education policy, digitization of mentorship delivery, and expansion to underserved regions. It also documents the replicability of this model, which has already influenced mentorship structures in universities and grassroots communities. The paper concludes that mentorship is a vital strategy in developing Africa's future engineering Leaders by recommending the institutionalization of mentorship as a national strategy for professional and personal development in Kenya and Africa.

Keywords:

Mentorship | engineering education | STEM | youth empowerment | professional development | career guidance | Kenya | sustainable development | institutional collaboration | gender inclusion | digital mentorship

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Engineering a Global Future: COREN's Pathway to the Washington Accord and Lessons for Africa

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Abstract:

The global engineering landscape is increasingly defined by harmonized accreditation systems that promote international mobility and recognition. This paper examines the Council for the Regulation of Engineering in Nigeria's (COREN) strategic journey toward securing membership in the Washington Accord (WA)—a critical milestone that would place Nigerian engineering qualifications on par with global standards. Drawing on a recent survey of engineering educators and institutional assessments, the study analyzes COREN's implementation of Outcome-Based Education (OBE), the structural reforms undertaken, and the multifaceted challenges encountered, including infrastructural deficits, policy bottlenecks, and faculty adaptation. The paper highlights COREN's success in securing provisional WA status in 2023 and underscores the importance of independent accreditation, faculty development, and international collaboration. It concludes by offering practical lessons and recommendations for other African countries seeking similar recognition, emphasizing the need for data-driven reforms, sustainable funding, and strong industry-academia linkages to achieve globally competitive engineering education.

Keywords:

Washington Accord | Outcome-Based Education (OBE) | Engineering Accreditation in Africa | International Mobility of Engineers

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Bridging the Skills Gap: Rethinking Project-Based Training in Technical and Vocational Education in Uganda

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Abstract:

As Africa works to build an engineering workforce ready for the future, Technical and Vocational Education and Training (TVET) institutions are key players. However, assessments conducted at six TVET institutions in Uganda uncovered significant skills gap in weak implementation of project-based training. This paper presents evidence from five national examination series (November 2023 - May 2025), using on-site inspections, interviews, and photographic evidence to explore training gaps and institutional challenges. The findings showed many recycled projects, suboptimal learning conditions, material shortage and limited supervision. A concerning case involved over 40 diploma students wiring a dilapidated kiosk, though the exercise followed curriculum, it did not demonstrate real-world complexity and compliance with engineering standards. The study also revealed that students often follow procedural steps without understanding the underlying science limiting their imagination. Rigid curriculum is an obstacle to creativity and contextual learning which result in graduates who hold academic credentials but lack real-world competence. This means they struggle to solve problems on their own. To bridge this gap, the paper proposes increased funding for practical training, strict enforcement of originality and technical standards, partnerships with industries, enhanced engagement with industry mentors and continuous professional development for trainers. Project-based training must go beyond academic formality to cultivate innovation, ethical engineering and workforce readiness. By rethinking how student projects are designed, supported and supervised, Uganda and Africa can better equip engineering professionals to drive sustainable development and industrial transformation.

Keywords:

Project-based Learning | Technical and Vocational Education | Engineering Skills Development

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Integrating Sustainable Indigenous Practices in African Engineering Education: A System Dynamics Approach

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Abstract:

This study presents a multi-country System Dynamics model for integrating Indigenous Environmental Practices (IEPs) into engineering education in Kenya, Ghana, Nigeria, and South Africa. Using Vensim-style stock-flow constructs implemented in simulation, the model captures interactions among Indigenous Knowledge Content, Institutional Capacity, Student Engagement, and Curriculum Inclusivity. A 10-year simulation compares a baseline scenario with an intervention combining enhanced educator training and accelerated policy adoption. Results indicate that the intervention raises the Curriculum Inclusivity Index by an average of 0.18 across countries at year 10, with South Africa and Kenya showing the largest gains. Sensitivity analysis highlights educator training rate as a high-leverage policy variable. The paper outlines policy implications, offers validation and calibration steps, and provides recommendations for embedding IEPs in African engineering curricula.

Keywords:

Indigenous Environmental Practices (IEPs) | System Dynamics (SD) | engineering education | decolonization | curriculum inclusivity | indigenous knowledge systems (IKS)

9A-1051-2025

Enhancing Employability through Industry-Led Site Management Training in Uganda's Technical Colleges

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Abstract:

Africa's socio-economic transformation hinges significantly on the availability of technically skilled graduates who are not only knowledgeable but also job-ready. Between 2019 and 2022, I led the review, update, and delivery of practical training in Construction Site Management across five Uganda Technical Colleges (UTCs), under a European Union funded programme delivered through UNABSEC and UIPE. This paper presents key insights from this initiative, assessing its effectiveness in bridging the industry-academia gap and equipping students with critical site-level skills including site layout planning, work scheduling, quality assurance, and risk management. Results show a marked improvement in students' readiness for the construction sector, with over 80% demonstrating improved comprehension in at least four modules, while qualitative feedback highlighted improved confidence and industry relevance. The findings underline the transformative value of integrating industry-led training into technical curricula.

Keywords:

Technical Training | Construction Management | Employability | Industry-Academia Collaboration | Uganda

9A-1054-2025

Building Engineering Human Capital as the Catalyst for Unlocking Africa's Industrial Future

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Abstract:

Science, technology, and innovation (STI) are essential for modern economic growth, with the ability to create value through STI a key differentiator between developed and developing nations. Data from newly industrialized nations show that engineering capacity is a major driver of STI-led industrial value creation, and that engineering human capital is the primary engine for engineering capacity. However, Africa's engineering human capital is hindered by a critical shortage of skilled engineering talent. UNESCO estimates that an additional 2.5 million engineers are needed in Sub-Saharan Africa to meet its development and industrialization goals. Yet, structural bottlenecks, including knowledge gaps, skills mismatches, and weak innovation and entrepreneurial ecosystems continue to impede progress. These challenges stem from outdated and misaligned curricula disconnected from industrial value chains, insufficient mechanisms for rapid workforce conversion, and the underutilization of Africa's vast engineering diaspora. Using Uganda as a case study, this paper presents a practical approach for developing the continent's engineering human capital. Over the past four years, Uganda has implemented a strategy which has upskilled over 10,000 engineers in key industrial value chains. The engineering human capital development initiatives are supported by targeted investments in STI infrastructure for hands-on training, prototyping, and industrial-scale manufacturing. Uganda's approach demonstrates that strategic investments in engineering human capital can unlock Africa's industrial potential, accelerate socioeconomic transformation, and position the continent as a competitive player in the global manufacturing and innovation landscape.

Keywords:

Engineering Human Capital | Skilling | Industrialization | Science | Technology and Innovation (STI) | Diaspora Engagement

The Role of Competency-Based Frameworks in Advancing Engineering Professionalism in Africa: Insights from the Engineering Council of South Africa's Alinment with International Engineering Alliance Standards

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Abstract:

Science, technology, and innovation (STI) are essential for modern economic growth, with the ability to create value through STI a key differentiator between developed and developing nations. Data from newly industrialized nations show that engineering capacity is a major driver of STI-led industrial value creation, and that engineering human capital is the primary engine for engineering capacity. However, Africa's engineering human capital is hindered by a critical shortage of skilled engineering talent. UNESCO estimates that an additional 2.5 million engineers are needed in Sub-Saharan Africa to meet its development and industrialization goals. Yet, structural bottlenecks, including knowledge gaps, skills mismatches, and weak innovation and entrepreneurial ecosystems continue to impede progress. These challenges stem from outdated and misaligned curricula disconnected from industrial value chains, insufficient mechanisms for rapid workforce conversion, and the underutilization of Africa's vast engineering diaspora. Using Uganda as a case study, this paper presents a practical approach for developing the continent's engineering human capital. Over the past four years, Uganda has implemented a strategy which has upskilled over 10,000 engineers in key industrial value chains. The engineering human capital development initiatives are supported by targeted investments in STI infrastructure for hands-on training, prototyping, and industrial-scale manufacturing. Uganda's approach demonstrates that strategic investments in engineering human capital can unlock Africa's industrial potential, accelerate socioeconomic transformation, and position the continent as a competitive player in the global manufacturing and innovation landscape.

Keywords:

Engineering professionalism | Competency-based frameworks | Graduate attributes | Professional registration | ECSA | IEA | Africa

Reimagining Academic Equivalence: Pathways, Principles and Practices for Substantial Recognition in African Engineering Contexts

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Abstract:

As Africa advances its industrialisation and knowledge-based development goals, anchored in continental strategies such as Agenda 2063: The Africa We Want, there is a growing need for transparent, credible and context-responsive recognition systems of engineering recognition. These aspirations are reinforced by regional policy frameworks such as the African Continental Free Trade Area (AfCFTA), which highlights human capital mobility as a driver of intra-African trade and development. This paper presents insights from International Engineering Alliance (IEA) workshops on substantial equivalence, with a particular focus on academic equivalence and emerging pathways for recognition. Drawing on global frameworks such as the Washington, Sydney, and Dublin Accords, and their alignment with the IPEA, APECEA, IETA, and AIET agreements, the study examines the conceptual, procedural, and risk-based foundations of recognising diverse and non-traditional qualifications. The African context is characterised by legacy qualifications, transnational mobility, and rising demand for work- and competency-based education models. Through analysis of structured dialogues and case-based discussions from IEA capacity-building activities, the paper proposes principles for regulators, accreditation bodies, and professional societies. These include prioritising outcomes over processes, applying risk-calibrated rigour, and strengthening peer-reviewed quality assurance to foster cross-border trust. The paper also explores the implications of “academic equivalence without a degree,” highlighting the tension between equitable mobility and public safety. It concludes with recommendations for African stakeholders to shape inclusive recognition systems that strengthen local practice while aligning with global norms.

Keywords:

Substantial equivalence | academic recognition | engineering mobility | African regulators

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