



International Conference on
Science, Engineering and
Technology



Book of Abstracts

4th International Conference on
Science, Engineering and Technology

April 28-30, 2026

Thimphu, Bhutan

*Bridging Distances, Inspiring Minds: A Convergence of Global
Experts in Science, Engineering and Technology*

**4th INTERNATIONAL CONFERENCE ON SCIENCE,
ENGINEERING AND TECHNOLOGY,**

**28-30 APRIL, 2026
THIMPHU BHUTAN**

Organised by
College of Science and Technology
&
Construction Development Corporation Limited

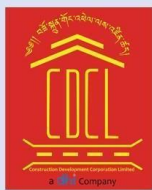
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ICSciEnTec 2026 Schedule

Venue: Namgay Heritage, Thimphu Bhutan

Day 1 (28th April 2026) Conference Opening and Keynote Address			
Time	Event	Venue	Coordinator
8:00 AM to 9:15 AM	Arrival and Registration of Participants and Guests	Conference Hall	Treasurer, Secretary, Vice Chair
9:15 AM to 9:30 AM	Arrival of Chief Guest		President, Deans, CEO (CDCL), Chair
9:30 AM to 9:50 AM	Offering of Marchang followed by National Anthem		CEO CDCL
9:50 AM to 10:20 AM	Opening Remarks by Chief Guest		
10:20 AM to 10:40 AM	Photo Session and Poster Presentation (Walk Through) *Posters will be displayed throughout the conference*	Courtyard	Media Team, Vice Chair
10:40 to 11:00 AM Tea Break			
Keynote Address			
11:00 AM to 11:30 AM	Road infrastructure and Sustainable Development (Keynote 1)	Conference Hall	Dr. Michael Henry, Professor at Shibaura Institute of Technology, Japan
11:30 AM to 11:40 AM	Question Answer Session 1		Dr. Kavi Arya, Professor at the Indian Institute of Technology, Bombay, India
11:40 AM to 12:10 PM	Networking Capability: Reimagining Engineering Education at National Scale (Keynote 2)		
12:10 PM to 12:20 PM	Question Answer Session 2		Ms. Dorji Yangki, Managing Director of the Office of the Governor, Gelephu Mindfulness City (GMC)
12:20 to 12: 50 PM	“The Mindful Engineer”: The Next Frontier of Engineering Excellence (Keynote 3)		
12:50 PM to 1:00 PM	Question Answer Session 3		
Industry and Partner Showcase			
1:00 PM to 1:10 PM	Presentation on CDCL	Conference Hall	CDCL Team
1:10 PM to 1:20 PM	ECRUL Project		Tshering Penjor, Project Manager, PMU
1:20 PM to 1:30 PM	Status & Plans for Accelerating Development of Bhutan’s Renewable Energy Resources		Head of Investment Section, DGPC
1:30 PM to 2:30 PM Lunch Break			



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2:30 PM to 4:00 PM	Commencement of Technical Sessions R1 S1 and R2 S1	Room 1 and 2	Session Chairs, Organizing team
4:00 PM to 4:30 PM Tea Break			
6:30 PM to 10:00 PM	Conference Inaugural Dinner for Invited Guests		Hosted by CST, RUB and CDCL.
End of Day 1			

Room 1

Session No: R1 S1

Track 1: Civil Infrastructure, Materials, and Sustainable Architecture

Session Chair: Ms. Dorji Tshomo Tshering, Architect, CDCL

Total Allocated time is inclusive of time for question-and-answer sessions.

Time	Paper Title	Author/s	Affiliation
2:30 PM to 3:00 PM	Visions of Balance: Circular Economy and Futures of the Built Environment in Bhutan	Oscar Gue	Royal Thimphu College and Global Sustainability Institute, Anglia Ruskin University, UK
3:00 PM to 3:30 PM	Retrofitting of Existing Urban Residential Dwellings of Bhutan for Thermal Performance	Jigme Thinley	College of Science and Technology, RUB
3:30 PM to 4:00 PM	Reconnecting Place, Memory, and Self through Adaptive Reuse: Energy Performance of a Vernacular Rammed Earth Structure in Bhutan	Sangay Wangchuk	College of Science and Technology, RUB
4:00 PM to 4:30 PM	Tea Break		
End of Day 1			



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Room 2

Session No: R2 S1

Track 2: Power Systems, Renewable Energy, and Electrification

Session Chair: Dr. Tashi, Dean of Academic Affairs, CST

Total Allocated time is inclusive of time for question-and-answer sessions.

Time	Paper Title	Author/s	Affiliation
2:30 PM to 3:00 PM	Solar Power Integration in Bhutan: A Tariff-Based Competitiveness Analysis	Chime Wangmo	Electricity Regulatory Authority, Bhutan
3:00 PM to 3:30 PM	Impact of Solar PV Integration on Power Quality of the JNEC Campus Distribution Network	Ngedup Lhamo	Jigme Namgyal Engineering College, RUB
3:30 PM to 4:00 PM	Performance Evaluation and Commissioning of a 110V, 440AH VRLA Battery Bank at Dagachhu Hydropower Plant	Thinley Dorji	Druk Green Power Corporation, Bhutan
4:00 PM to 4:30 PM	Tea Break		
End of Day 1			



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Day 2 (29th April 2026) Technical Sessions

Room 1

Session No: R1 S2

Track 1: Civil Infrastructure, Materials, and Sustainable Architecture

Session Chair: Dr. Cheki Dorji, President, CST

Total Allocated time is inclusive of time for question-and-answer sessions.

Time	Paper Title	Author/s	Affiliation
9:00 AM to 9:30 AM	Dam Break Analysis: A Case Study of the Tala Hydropower Plant Dam using HEC-RAS	Kelzang Thinley	Druk Green Power Corporation, Bhutan
9:30 AM to 10:00 AM	Improving the Strength of Cold Mix Asphalt Concrete through Numerical Optimization	Lhundup Tshomo	College of Science and Technology, RUB
10:00 AM to 10:30 AM	Daylight and Energy Performance Assessment of Passive Design Strategies in a Subtropical Commercial Building Using Honeybee Radiance in Bhutan	Leki Tshering	College of Science and Technology, RUB
10:30 AM to 11:00 AM	Tea Break		



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Room 2

Session No: R2 S2

Track 2: Power Systems, Renewable Energy, and Electrification

Session Chair: Mr. Kamal Chapagai, Lecturer, CST

Total Allocated time is inclusive of time for question-and-answer sessions.

Time	Paper Title	Author/s	Affiliation
9:00 AM to 9:30 AM	Challenges and Engineering Insights in Execution of Hydro-Electro Mechanical Works by Bhutan Hydropower Services Limited (BHSL), Bhutan	Pelden Drukpa	Bhutan Hydropower Services Limited (BHSL)
9:30 AM to 10:00 AM	Performance Evaluation of Box-Type Solar Cooker Using Reinforced Selective Coatings for Enhanced Thermal Efficiency. A Sustainable Approach for Clean Cooking in Nepal	Aaron Malla	Kathmandu University, Nepal
10:00 AM to 10:30 AM	Modeling and Simulation of 500mL Packaged Drinking Water Packaging Line	Chimi Rinzin	College of Science and Technology, RUB
10:30 AM to 11:00 AM	Tea Break		



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Room 1

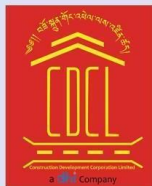
Session No: R1 S3

Track 3: Artificial Intelligence, Computing, and Digital Transformation

Session Chair: Mr. Tandin Wangchuk, Sophia University, Tokyo

Total Allocated time is inclusive of time for question-and-answer sessions

Time	Paper Title	Author/s	Affiliation
11:00 AM to 11:30 AM	Beyond Recurrence: Assessing the Computational Superiority of Generative Pre-trained Transformers over Bi-LSTMs for Dzongkha Language Modeling	Karma Wangchuk	College of Science and Technology, RUB
11:30 AM to 12:00 PM	Support Vector Machine Models With Smooth Generalized Pinball Loss	Eckart Schulz	Suraneree University of Technology, Nakhon Rachasima, Thailand
12:00 PM to 12:30 PM	DrukSerenity: A Culturally-Aware Multi-Agent Chatbot Framework for Mental Health Support in Bhutan	Sonam Eyden	College of Science and Technology, RUB
12:30 PM to 1:30 PM	Lunch Break		



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Room 2

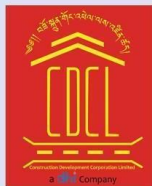
Session No: R2 S3

Track 4: Environmental Policy, Climate Science, and Engineering Education

Session Chair: CDCL

Total Allocated time is inclusive of time for question-and-answer sessions

Time	Paper Title	Author/s	Affiliation
11:00 AM to 11:30 AM	Wind Simulation in a lake Surrounded by Steep Mountains-Using Lake Suwa in Japan as an Example	Masashi Toyota	Nagano Prefectural Government Office, Japan
11:30 AM to 12:00 PM	Emerging Patterns of Precipitation Extremes in Bhutan: A Multi-Dataset Evaluation	Vasker Sharma	Jigme Namgyal Engineering College, RUB
12:00 PM to 12:30 PM	Algorithmic Modeling and Efficiency Prediction of Low-Cost Hydraulic Ram Pump	Dependra Prasad Bhandari	College of Science and Technology, RUB
12:30 PM to 1:30 PM	Lunch Break		



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Room 1

Session No: R1 S4

Track 3: Artificial Intelligence, Computing, and Digital Transformation

Session Chair: Professor Eckart Schulz, Suranaree University of Technology, Thailand

Total Allocated time is inclusive of time for question-and-answer sessions

Time	Paper Title	Author/s	Affiliation
1:30 PM to 2:00 PM	Knowledge-Action Gap and Optimism Bias in Digital Scam Prevention in the Royal University of Bhutan	Tandin Wangchuk	Faculty of Science and Technology, Sophia University, Tokyo
2:00 PM to 2:30 PM	Parameter Recovery of Vasicek Model with Kolmogorov-Arnold Networks: A Synthetic Study with Zero-Coupon Pricing Implications	Tshewang Phuntsho	Gedu College of Business Studies, RUB
2:30 PM to 3:00 PM	Tea Break		

Room 2

Session No: R2 S4

Track 2: Power Systems, Renewable Energy, and Electrification

Session Chair: Mr. Saurabh Motiwala, Solar Expert, STAR-C, International Solar Alliance

Total Allocated time is inclusive of time for question-and-answer sessions.

Time	Paper Title	Author/s	Affiliation
1:30 PM to 2:00 PM	Hydrological Uncertainty and Its Tariff Implications: Rethinking Power Purchase Pricing for Bhutan Power Sectors.	Rinzin Choden	Electricity Regulatory Authority, Bhutan



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2:00 PM to 2:30 PM	Design and Implementation of IoT Based Electrical Parameter Monitoring Module and Visualization System in JNEC Distribution Network	Dawa Choden	Jigme Namgyal Engineering College, RUB
2 :30 PM to 2:40 PM	Presentation on STAR-C Lab, CST	Mr. Saurabh Motiwala	College of Science and Technology, RUB
2:40 PM to 3:00 PM	Tea Break		

Room 1

Session: Closing Ceremony

Time	Event	Coordinator
3:00 PM to 3:10 PM	Reflection Video	Media Team
3:10 PM to 4:00 PM	Certificate Awarding Ceremony <ul style="list-style-type: none"> ● Presenters ● Poster Participants ● Volunteers 	Chair/MC/Organising team
End of Day 2		

“Our Keynote Speakers”

Michael Henry, PhD
Professor, School of Engineering
Shibaura Institute of Technology
Tokyo, Japan



Prof. Michael Henry received his B.S. in Civil Engineering from the University of Washington (Seattle, USA) in 2005, and his PhD in Civil Engineering from The University of Tokyo (Tokyo, Japan) in 2010. After obtaining his doctorate, he worked at The University of Tokyo as a researcher for almost two years before moving to Hokkaido University (Sapporo, Japan), where he worked for eight years as an assistant and then associate professor. He is currently a professor in the College of Engineering at the Shibaura Institute of Technology (Tokyo, Japan), where he carries out research on infrastructure sustainability, road asset management, and sustainable social systems.

Abstract

The world is undergoing constant change, from population growth and urbanization to deterioration of ecological systems. Sustainable development is a paradigm that aims to find balance between these often-conflicting changes. It is based on the idea that current societies need to consider short-term as well as long-term impacts of decision-making and prioritize the preservation of the environment for the well-being of both people and the planet. Road infrastructure plays a critical role in sustainable development, as it serves as the foundation for facilitating socio-economic growth by connecting people and places together, but the construction and operation of road infrastructure also carries with it serious environmental implications. It is therefore important to consider sustainability issues in the development of road infrastructure. This presentation aims to provide a basic understanding for how we can improve the sustainability of road infrastructure by (1) laying out the background and basic principles of sustainable development, (2) introducing the Sustainable Development Goals (SDGs) as a guiding framework for realizing global sustainability, (3) explaining the linkages between the SDGs and road infrastructure, and (4) showing how we can quantify the sustainability of materials used for the construction of road infrastructure. Although this presentation is given from the perspective of civil engineering, the basic concepts should be transferable to other engineering domains as well.

Kavi Arya, PhD
Professor, Computer Science & Engineering
Indian Institute of Technology
Bombay, India
Dr. Kavi Arya



Dr. Kavi Arya is Professor of Computer Science & Engineering at the Indian Institute of Technology (Bombay). He completed his B.Sc.(Hons.) in Computing Science from Imperial College and M.Sc.(Hons.)/Ph.D. in Computation from the University of Oxford. In 1988–90 he worked at IBM’s T.J. Watson Research Labs (New York) before joining IIT Bombay in 2000.

Prof. Arya is convener of the Embedded & Real-time Systems Lab (ERTS) and Principal Investigator of the e-Yantra Project, which focuses on popularising “Project Based Learning” using robotics in engineering colleges, training over 250,000 young engineers. He has served on committees such as the Technology Development Board (DST) and CDAC, and worked with Mahindra & Mahindra Group on business sustainability strategy.

Abstract

How do we create engineers who can think, build, and solve real problems in a deeply interconnected world?

This keynote presents the e-Yantra initiative at IIT Bombay as a living experiment in building engineering capability at scale. Over the past decade, e-Yantra has engaged hundreds of institutions and hundreds of thousands of students through a carefully designed ecosystem of constraints, competition, and mentorship. The talk introduces the e-Yantra Method—a framework grounded in four key principles: constraint as curriculum, apprenticeship-based learning, purpose-led problem selection, and ecosystem-level scaling. Together, these principles transform fragmented classrooms into a distributed, networked learning system where capability—not just content—is the outcome.

Dorji Yangki
Managing Director
Office of the Governor
Gelephu Mindfulness City, Bhutan



Dorji Yangki is the Managing Director at the office of the Governor of Gelephu Mindfulness City, where she works in service of His Majesty, The King of Bhutan's vision for a transformative city grounded in Buddhist mindfulness, and sustainable prosperity. She holds a Bachelor's and Master's degree in Architecture from Deakin University (1996), a Master's in Conservation from University of York (2004), and was a Loeb Fellow at Harvard University (2008). As a senior executive with a background as an Architect,

Ms. Yangki brings over 28 years of multidisciplinary experience spanning management, architecture, construction, urban policy, leadership and business development.

In Bhutan's civil service as Chief Architect and Head of the Office for Conservation of Heritage for over 16 years, Ms. Yangki has led national policy and landmark restorations including Taktsang Monastery, and Semtokha Dzong. She helped to establish Bhutan's first heritage conservation office and drafted Bhutan's foundational national frameworks such as the Traditional Bhutanese Architectural Guidelines, first Green Building Guidelines of Bhutan, Moveable Cultural Property Act and the Cultural Trust Fund. She also served as CEO of Sambhava Professional Services for over a decade, leading multidisciplinary practices across local and international contexts within the field of design and construction of the built environment. Ms. Yangki has held various prominent leadership roles including President of the Bhutan Institute of Architects and the first female Chair of SAARCH, advancing institutional strengthening and regional collaboration in Bhutan and across the Asian region.

Abstract

Engineering today is more powerful than at any point in history. We now have advanced tools and computational modelling capabilities that can perform the work of hundreds of architects and engineers, dramatically reducing time and effort. We can simulate entire cities within minutes, testing multiple scenarios and system behaviours even before a single brick is actually laid. Yet despite this extraordinary technological progress, many of the challenges we face persist. We continue to work in silos. Our systems and processes remain fragmented. Inefficiencies are not eliminated—they are often simply transferred from one layer of the system to another. The keynote presents why the future of engineering cannot be defined by technological advancements and tools alone. It lies in the emergence of “the Mindful Engineer”—an engineer who thinks, plans, and operates beyond technical numbers. Here Mindfulness is not framed in as a philosophical abstraction but rather as a practical cognitive discipline and awareness: the engineered practice of paying close attention to how systems are interdependent and do not work in isolation or in silos. It is the ability to understand how things connect: what breaks when you pull one thread, what happens downstream when a decision is made upstream – to actually see how decisions and practices are integrated across institutions, communities, environments and social systems. This perspective is particularly relevant in the context of Bhutan’s emerging development paradigm, especially the vision of the Gelephu Mindfulness City. As Gelephu evolves into a model of mindful urbanism and sustainable growth, engineering practice must similarly evolve beyond siloed execution toward integrated mindful stewardship of place, people, and purpose.

Track 01: Civil Infrastructure, Materials, and Sustainable
Architecture

Improving the Strength of Cold Mix Asphalt Concrete through Numerical Optimization

Kelden Dorji Sherpa¹ Lhundup Tshomo² Tandin Zangmo³ Namgay Om²

¹ *Project Cost and Management, Surbana Jurong India Private Limited*

² *Civil and Environmental Engineering Department, College of Science and Technology*

³ *Property Assessment and Valuation Agency, Ministry of Finance*

The growing global emphasis on sustainable development and the reduction of carbon emissions in civil infrastructure has intensified the search for environmentally friendly alternatives to conventional pavement materials. Cold Mix Asphalt Concrete (CMAC) has emerged as a viable substitute for Hot Mix Asphalt Concrete (HMAC), offering significantly lower energy consumption and reduced greenhouse gas emissions during production and construction. However, its application remains limited due to comparatively lower mechanical strength and durability, restricting its use primarily to low-traffic rural roads and rehabilitation works. This limitation highlights the need for performance enhancement to enable broader structural applications, particularly in urban and high-load environments. Opportunities exist to improve CMAC properties through the incorporation of suitable additives, though this requires systematic investigation and optimized mix design approaches capable of addressing complex material behavior. Conventional trial-and-error methods are experimentally intensive, time-consuming, and inadequate for capturing the nonlinear interactions among multiple constituents. In response, this study develops a statistically driven mix design optimization framework using Response Surface Methodology (RSM) for CMAC incorporating hydrated lime, silica fume, bitumen emulsion, and recycled polyethylene terephthalate (PET) fibres. A total of 83 mixture combinations and 128 specimens were prepared and tested in accordance with AASHTO standards, evaluating Marshall stability, flow, density, and air voids. RSM enabled the development of predictive models that capture both linear and nonlinear relationships, significantly reducing experimental effort while improving analytical precision. The optimized mixture achieved a Marshall stability of 7.36 kN, demonstrating enhanced load-bearing capacity and improved structural performance compared to conventional CMAC. While the model performs well within the calibrated range, further validation is required to assess long-term field performance and environmental durability under varying climatic and loading conditions.

Keywords: Cold Mix Asphalt Concrete, Pavement, Sustainable Pavement, Responsive Surface Methodology, Modified Cold Mix Asphalt Concrete.

Dam Break Analysis: A case study of the Tala Hydropower Plant dam using HEC-RAS

Kelzang Thinley¹ Tshewang Norbu² Pema Wangchuk³ Lhendup Namgyel⁴

^{1,2,3} *Centre of Excellence for Civil and Geotechnical Engineering Unit, Hydropower Research and Development Centre*

^{1,2,3,4} *Hydropower Research and Development Centre, Druk Green Power Corporation Limited*

Dam break flood is widely recognized as a low probability but a high impact event that can pose significant risks to downstream communities and critical infrastructures. Numerous studies have focused on the significance of dam break modelling for hazard assessment, risk mitigation and emergency preparedness planning. In this study, the Dam Break Analysis of the Tala Hydropower Plant (THP) involves a systematic approach combining data collection, hydraulic modeling, and risk assessment under different failure conditions. High-resolution 2.5-meter AW3D Digital Elevation Model served as the primary input dataset for the hydraulic modelling. The analysis employs the Hydrologic Engineering Centre-River Analysis System (HEC-RAS) to model three dam-failure scenarios under both extreme flood and normal reservoir conditions: One scenario represents THP dam failure caused by overtopping during the Probable Maximum Flood (PMF), while the remaining two scenarios simulate cascade failure of the Chhukha Hydropower Plant (CHP) and THP dams under sunny-day and Probable Maximum Flood conditions. The analysis demonstrates varying levels of flood hazard across the three simulated scenarios, with maximum breach outflows reaching 47,364.95 m³/s, 37,469.66 m³/s and 52,771.27 m³/s respectively. Downstream regions including key infrastructure such as bridges, settlements, and the Tala powerhouse Main Access Tunnel are found to be at risk, with floodwaters potentially extending into the Indian plains up to approximately 66.18 km from the dam. A sensitivity analysis performed for the study indicates that the breach elevation is a critical factor influencing the magnitude and timing of flood impacts, with lower elevations leading to more severe and rapid flooding, particularly in regions closer to the dam. The flood inundation maps generated in this study highlights the need for effective dam safety management including identifying high-risk zones, early warning systems and effective emergency response planning.

Keywords: Dam Break Analysis, Flood inundation, HEC-RAS, Probable Maximum Flood, Sensitivity Analysis, Tala Hydropower Plant

Daylight and Energy Performance Assessment of Passive Design Strategies in a Subtropical Commercial Building Using Honeybee Radiance in Bhutan

Leki Tshering¹ Sangay Wangchuk² Pema Rinzin³ Jigme Thinley⁴

Architecture Department, College of Science and Technology

The growing reliance on artificial lighting and mechanical cooling in warm-humid climates highlight the need for climate-responsive design strategies in commercial buildings. This study evaluates the effectiveness of passive design interventions in enhancing daylight performance and reducing energy consumption within a subtropical context. A generic prototype commercial building is developed for Bhutan and analyzed using climate-based daylight simulation and parametric modelling through the Honeybee-Radiance framework. Key design variables including building orientation, window-to-wall ratio (WWR), external shading devices, spatial configuration, and material strategies are systematically investigated. A comparative analysis is conducted between a baseline model, representing a conventional non-optimized design, and an enhanced model integrating comprehensive passive design strategies. Daylight performance is assessed using metrics such as Spatial Daylight Autonomy (sDA), Useful Daylight Illuminance (UDI), and Annual Sunlight Exposure (ASE). The study further investigates how improved daylighting conditions influence overall energy performance, particularly in reducing artificial lighting requirements and cooling loads. The findings demonstrate the potential of passive design interventions to significantly enhance visual comfort and energy efficiency, contributing to more sustainable commercial building practices in subtropical regions.

Keywords: Daylight Performance, Passive Design Strategies, Energy Efficiency, Honeybee-Radiance, Subtropical Climate

Reconnecting Place, Memory, and Self through Adaptive Reuse: Energy Performance of a Vernacular Rammed Earth Structure in Bhutan

Sangay Wangchuk¹ Chimi² Pema Rinzin³ Jigme Thinley⁴ Leki Tshering⁵

Architecture Department, College of Science and Technology, Royal University of Bhutan

This study investigates the adaptive reuse of a dilapidated rammed earth structure at Tandin Ney, Thimphu, Bhutan, transforming it into a low impact multifunctional contemplative retreat. Grounded in cultural continuity, material authenticity, and minimal environmental disturbance, the project reinterprets vernacular construction within the existing footprint to support mental wellbeing in alignment with Bhutan's Gross National Happiness framework. A mixed method approach combines architectural design, user perception analysis, and performance-based evaluation. Programmatic elements are integrated into the landscape to enhance contemplative engagement, while qualitative validation is conducted through surveys involving monastic and non-monastic participants. Dynamic energy simulation using Rhinoceros 3D with the Honeybee plug in evaluates thermal performance and energy demand. Results indicate an energy use intensity of 45 to 55 kWh per square meter per year, with indoor comfort achieved for 70 to 80 percent of occupied hours without active systems. The high thermal mass of the rammed earth envelope limits indoor temperature fluctuations to within ± 3 °C during seasonal climatic extremes. This finding demonstrates a strong convergence between spatial experience, cultural relevance, and environmental performance. This study proposes a replicable, performance informed model for adaptive reuse in Bhutan, illustrating how vernacular architecture can be leveraged to achieve both experiential quality and energy efficiency in climate sensitive contexts.

Keywords: Adaptive reuse, Rammed earth, Energy simulation, Thermal performance, Vernacular architecture, Bhutan

Retrofitting of existing urban residential dwellings of Bhutan for thermal performance

Jigme Thinley¹ Penden Wangchuk² Martin Hauer³

^{1&2} *Architecture Department, College of Science and Technology*

³*Energy-efficient Construction Department, University of Innsbruck, Austria*

Building and construction account for 40% of global energy consumption and one-third of carbon emissions. In Bhutan, buildings represent 52% of the total thermal demand, yet Thimphu's existing stock—characterized by archetype leaky concrete-frame and brick-infill structures adorned with expansive windows—remains thermally inefficient. While simulations suggest various retrofitting interventions, a critical gap exists in real-world validation. This research addresses this disparity by piloting retrofitting strategies on an existing residential unit to evaluate their efficacy in Thimphu's cold climate. The methodology employed a comparative approach where year-long field data collected post-intervention will be compared against OpenStudio simulations. The “Subject” room, a living area located on the first floor directly above an open stilt ground floor—a configuration highly prone to heat dissipation—was retrofitted with secondary 6mm toughened glazing and airtightness measures. An identical living room located on the floor above served as the “Control” room. Results from data logger monitoring demonstrated that the retrofitting successfully neutralized the structural “stilt-floor effect.” In winter (Nov-Feb), the subject room maintained an approximately 1°C higher mean temperature, despite it being at a disadvantage with exposed outdoor boundary condition. In contrast, the subject room performed approximately 1°C cooler in summer (June-Aug). This real-time result will be triangulated with the OpenStudio simulation to model a more comprehensive findings in terms of temperature and energy demand. The current findings prove that targeted envelope interventions can effectively transform thermally vulnerable structures into efficient environments. This study provides essential empirical validation for sustainable building practices in Bhutan, demonstrating that practical retrofitting can exceed theoretical expectations.

Keywords: Building retrofitting, OpenStudio, Sustainable construction, Performance analysis

Visions of Balance: Circular Economy and Futures of the Built Environment in Bhutan

Oscar Gue

Global Sustainability Institute, Anglia Ruskin University, United Kingdom

The circular economy concept is receiving growing international attention as nations seek to move away from linear production and consumption models and transition towards futures of human ecological balance. While this agenda has largely emerged in industrialised economies to remedy unsustainable resource use, countries such as Bhutan may engage these principles differently as they rapidly develop built infrastructure.

This research asks: how do visions of balance shape developments in the built environment? Building on 20 drawing-based interviews alongside thematic analysis of policy documents, this study identifies three key themes. First, the circular economy is adapted through local analogues. Concepts such as Gross National Happiness (GNH), mindfulness, and interdependence align with circular economy principles through a shared goal of human-ecological balance, while also creating opportunities for Bhutan to challenge unsustainable development pathways set by industrialised nations. Second, participants emphasised the creative reimagining of human-ecological boundaries, highlighting the need to address separations reinforced by the rapid adoption of modern infrastructure. Third, as the national government simultaneously promotes development and preservation, the monarchy and monastic body among other institutions play a stabilising role by situating changes within broader historical narratives. Material practices, such as the envisioned national-scale use of timber construction materials, reflect efforts to connect sustainable pasts with sustainable futures.

This research highlights how Bhutan envisions alternative futures within a globally dominant circular economy framing, contributing a distinct perspective to the global sustainability imaginary.

Keywords: circular economy, sustainable futures, built environment, sociotechnical imaginaries

Track 02: Power Systems, Renewable Energy, and
Electrification

Performance Evaluation of Box-Type Solar Cooker Using Reinforced Selective Coatings for Enhanced Thermal Efficiency: A Sustainable Approach for Clean Cooking in Nepal

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The continued dependence on solid fuels for household energy remains a critical global challenge, with approximately 2.1–3 billion people relying on biomass, coal, and kerosene for cooking, primarily in developing regions. This reliance contributes to an estimated 2.9–3 million premature deaths annually due to household air pollution, making it one of the leading environmental health risks worldwide. In South Asia, this dependence persists despite high solar availability (4–6 kWh/m²/day), highlighting a clear gap between renewable energy potential and practical adoption. Among available alternatives, box-type solar cookers offer a low-cost and sustainable solution; however, their widespread use is limited by low thermal efficiency and significant heat losses. Previous studies identify absorber surface properties as a key factor influencing performance, where increased absorptivity and reduced emissivity directly improve heat retention and system efficiency.

This study experimentally evaluates the performance of a box-type solar cooker integrated with reinforced selective coatings namely, anodized aluminum, black enamel, and black powder coating, under real climatic conditions in Kathmandu, Nepal. The system was fabricated using locally available materials, incorporating a double-glazed cover, insulated enclosure, and optimized reflectors, with temperature measurements recorded via K-type thermocouples over a 30 day period under solar insolation ranging from 400 to 800 W/m². Results indicate that coating selection significantly impacts thermal performance, with anodized aluminum achieving the highest efficiency of 62.6% under clear sky conditions and 23.8% under cloudy conditions due to enhanced absorptivity and reduced radiative losses. These findings confirm that targeted material optimization can substantially improve solar cooker efficiency, positioning such systems as practical, cost-effective, and sustainable solutions for reducing fuel dependency, lowering emissions, and advancing clean energy adoption in developing regions.

Keywords: Solar Cooking, Thermal Performance, Renewable Energy, Coatings

Impact of Solar PV Integration on Power Quality of the JNEC Campus Distribution Network

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The integration of renewable energy sources into distribution networks has become an essential component of modern smart grid development. Solar photovoltaic (PV) systems are increasingly adopted due to their environmental benefits and their ability to support localized energy generation. However, the integration of inverter-based PV systems into low-voltage distribution networks can introduce several operational challenges, including voltage fluctuations, reverse power flow, reactive power imbalance, and power quality issues such as harmonic distortion. Despite the growing interest in renewable energy deployment, limited studies have examined the impact of PV integration on institutional campus distribution networks in Bhutan.

This study aims to analyze the power quality performance of the Jigme Namgyel Engineering College (JNEC) campus distribution network with the integration of a distributed solar PV system. A simulation-based approach is employed using the Electrical Transient Analyzer Program (ETAP) to model the existing 0.4 kV campus distribution system. The PV generation system is incorporated into the network model to evaluate its influence on voltage deviation, power flow characteristics, and harmonic distortion under varying generation conditions. The simulation analysis is currently ongoing, and preliminary investigations focus on identifying potential voltage rise, reverse power flow, and harmonic distortion introduced by inverter-based PV systems. The study is expected to quantify voltage profile variations and total harmonic distortion (THD) levels across the campus distribution network before and after PV integration. The outcomes of this research will support the planned implementation of a solar PV system at JNEC and provide insights into the operational impacts of distributed PV generation on small-scale distribution networks. Furthermore, the study will contribute to identifying appropriate mitigation strategies to maintain voltage stability and improve power quality in campus-level distribution systems.

Keywords: Distributed Generation, Solar PV System, Grid Integration, Power Quality, Harmonic Distortion, Smart Grid, ETAP.

Performance Evaluation and Commissioning of a 110v, 440ah Vrla Battery Bank at Dagachhu Hydropower Plant

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Valve-Regulated Lead Acid (VRLA) batteries are important components in hydropower plants, as they provide the critical DC supply for auxiliary, protection, and emergency systems. Despite their widespread use, the reliability of these battery banks is often compromised by a lack of systematic testing after installation, leaving operators without precise data on actual capacity, internal resistance, or real-world degradation rates. Additionally, improper commissioning, such as placing new batteries on float charge without pre-commissioning inspections, can significantly shorten a battery's operational lifespan. This study establishes a baseline performance evaluation for a newly installed 110 V, 440 Ah VRLA battery bank at the Dagachhu Hydropower Plant (DHP) to ensure operational readiness. The necessity of this evaluation is underscored by the failure of the predecessor battery bank, which was installed in November 2020, it was found to have zero health capacity by December 2023. This rapid deterioration can be attributed to the lack of baseline commissioning data, which prevents a definitive technical analysis. However, the decline was almost certainly a result of a total absence of documented maintenance and diagnostic testing. Adhering to international standards such as IEEE Std. 450-2010 and IEEE Std. 1188-2005, the methodology involved three regulated charging and discharging cycles combined with precise impedance measurements using diagnostic tools such as the TORCEL 860 and Megger BITE3. The obtained results demonstrated a progressive improvement in the battery bank's health; the measured capacity increased from an initial 418 Ah to the full rated capacity of 440 Ah (100%) by the third cycle. Complementing this capacity growth/improvement, quantitative impedance analysis revealed an average reduction in internal impedance of 11.27% before discharge and 13.98% post-discharge between the first and third cycles. These findings validate the successful initiation of the battery bank and provide the necessary baseline data, ultimately enhancing the reliability and safety of the plant's auxiliary power systems. Furthermore, the recommendation to conduct proper commissioning tests of the battery banks across Druk Green Power Corporation (DGPC) is made, given that no prior documentation of bank commissioning tests is available or known.

Keywords: VRLA Battery, Commissioning Test, Capacity Test, Impedance Measurement

Modeling and Simulation of 500ml Packaged Drinking Water Packaging

Line

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A packaging line is the section of a beverage plant responsible for preparing products for distribution while ensuring product quality, safety, and presentation under high-speed production constraints. In beverage manufacturing, packaging speed, synchronization, and reliability are critical to maintaining product freshness and meeting market demand. Despite their industrial importance, packaging line configurations and operational design methodologies are often proprietary, creating a knowledge gap that limits academic understanding of system integration, simulation, and performance analysis. This study presents the modeling, simulation, and validation of a 500 mL packaged drinking water packaging line based on industrial data from Tashi Beverages Ltd. using Siemens Tecnomatix Plant Simulation. The developed model replicates key processes including filling, capping, date coding, labelling and shrink-wrapping to evaluate system performance and support decision-making. The model was validated against real plant benchmarks, achieving a simulated throughput within the acceptable and defined range of 920-1150 cases over a 7.67-hour simulation and production window, with a mean throughput of approximately 1028.4 cases over 10 simulation runs. Statistical validation showed low variability (coefficient of variation < 10%) and good relative precision, confirming the model's reliability. Experimental analysis was conducted on two critical parameters: buffer capacity and bottleneck machines' speed. Increasing buffer capacity from 1 to 500 units resulted in only a marginal throughput improvement (~1.5%, from 1022 to 1037 cases of bottles) with no statistically significant difference ($p > 0.05$), indicating an already balanced system. In contrast, reducing machine processing time from 1 s/bottle to 0.5 s/bottle increased throughput significantly from 1037 to 1438 cases, with statistical tests confirming meaningful improvement up to an optimal threshold of 0.67 s/bottle. Additionally, a supervisory PLC-based control architecture is proposed to integrate heterogeneous machine controllers using signal-level interfacing, aligned with ISA-95 principles. The results demonstrate that the developed model provides an adequate system representation and actionable insights, enabling performance optimization through targeted parameter adjustments while avoiding unnecessary system modifications.

Keywords: Digital Twin, Discrete-Event Simulation, Packaging Line Optimization, PLC-SCADA, Industry 4.0.

Hydrological Uncertainty and its Tariff Implications: Rethinking Power Purchase Pricing for Bhutan Power Sectors.

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Bhutan's Hydro Tariff Determination depends largely on the forecasted energy generation and demand. However, frequent deviation between the forecasted and actual generation due to factors such as hydrology and changing demand patterns are causing financial imbalances to both the Distribution utility namely Bhutan Power Corporation (BPC) and the consumers. The power purchase price accounts to around 60% of the total cost for BPC. This study uses comparative statistical analysis of historical data from 2022-2025 tariff period to assess the variations of power purchase price caused by differences between forecasted and actual generation and demand, with year wise and month-wise trend analysis. The analysis shows a higher power purchase cost of Nu 1.78/kWh compared to the approved average cost of Nu 1.6/kWh in 2022-2025 tariff period which have resulted in an estimated revenue loss of around Nu 3 billion to BPC. The year-wise analysis indicates that the power purchase price increased by 2% in the first year, followed by 9% and 20% in the second-year and third-year respectively. The month-wise analysis reveals a power purchase variation ranging from 5%-54% with actual DGPC generation decreasing by 1%-67% along with increased demand by 3%-10%. This variation in power purchase price is mainly driven by decreased DGPC generation (cheaper cost) resulting in purchase of energy from expensive hydropower plants such as MHP, Puna-II and Indian Power Exchange Market. The findings indicate that existing cost-plus tariff methodology and non-adoption of reconciliation method for the cost, resulted in challenges for the BPC and consumers in recovery of cost and electricity tariff instability due to the variations in power purchase caused by hydrological uncertainty and changing demand patterns. To address this, the research proposes the introduction of a Power Purchase Price Adjustment (PPPA) mechanism, differentiated power purchase prices scheme for residential and heavy industrial consumers and also encourage the energy users to install solar PV systems. This adjustment framework would allow periodic corrections based on actual generation and demand, improve cost recovery, enhance tariff stability, and support a more flexible and dynamic pricing system for Bhutan's electricity sector.

Keywords: Power purchase price, Hydrological uncertainty, Demand, BPC, PPPA, Solar PV, variations

Solar Power Integration in Bhutan: A Tariff-Based Competitiveness Analysis

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Bhutan has set an ambitious target of developing 5,000 MW of solar power capacity by 2040 as part of its broader strategy to diversify beyond hydropower-dependent electricity generation. Despite growing solar installations, the absence of a structured Feed-in Tariff (FIT) framework has meant that existing solar generation is fed into the national grid without any form of compensation, a gap that undermines long-term investor confidence and sector sustainability. This study examines the FIT derived under the tariff determination methodology recently issued by the Electricity Regulatory Authority (ERA), applying a cost-plus approach and Levelized Cost of Electricity (LCOE) analysis grounded in normative project parameters, including capital expenditure, Capacity Utilization Factor (CUF), operation and maintenance costs, and Weighted Average Cost of Capital (WACC). Financial viability was assessed through spreadsheet-based modelling tools designed to simulate realistic project economics. The analysis finds that a fair FIT for solar energy in Bhutan falls in the range of Nu. 4.00 to Nu. 5.88 per kWh considerably higher than the cost of hydropower generation (Nu. 1.60 per kWh) and the prevailing subsidized retail electricity tariff (Nu. 2.66 per unit). This gap reveals a meaningful competitiveness challenge that makes solar projects financially unviable under the current tariff structure. The study argues that bridging this gap requires a well-designed FIT policy, supported by complementary metering mechanisms such as net billing or value-based compensation schemes. Such measures, if thoughtfully implemented, could enable the sustainable integration of solar energy into Bhutan's power sector while preserving its overall financial health.

Keywords: Feed-in Tariff, Levelized Cost of Electricity, Solar Energy, Bhutan, Electricity Regulatory Authority, Renewable Energy Policy, Net Billing

Design and Implementation of IoT Based Electrical Parameter Monitoring Module and Visualization System in JNEC Distribution Network

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Electrical monitoring plays a vital role in ensuring a stable power supply and effective power management in institutional electrical systems. However, most advanced electrical monitoring systems are expensive and are primarily utilized by large industries and utility companies. Consequently, affordable and accessible monitoring platforms for small-scale applications, such as educational institutions and student learning environments, remain limited. Therefore, this paper presents the design and implementation of an Internet of Things (IoT)-based electrical monitoring module and visualization system for the Jigme Namgyel Engineering College (JNEC) campus.

The developed system was modeled and validated through simulation, including block diagram development, circuit design, and component parameter calculations. Hardware implementation utilized an ESP32 microcontroller integrated with ZMPT101B voltage and ACS712 current sensors for real-time acquisition of instantaneous electrical signals. The captured data were processed to derive RMS voltage, RMS current, and selected power quality indicators in accordance with IEEE standards. Measured electrical parameters were transmitted wirelessly via Wi-Fi to Firebase and ThingSpeak cloud platforms for real-time storage, remote monitoring, and visualization.

Experimental validation demonstrated successful acquisition and wireless transmission of electrical data with stable cloud visualization and reliable monitoring performance. The developed system provides a cost-effective, scalable, and educational platform for electrical parameter monitoring and analysis within campus distribution systems, with potential for future expansion into distributed smart energy management applications.

Keywords: Internet of Things (IoT), Electrical Parameter Monitoring System, ZMPT101B Voltage Sensor, ACS712 Current Sensor, ESP32 Wi-Fi Module, Firebase, ThingSpeak.

Challenges and Engineering Insights in Execution of Hydro-Electro Mechanical Works by Bhutan Hydropower Services Limited (BHSL), Bhutan.

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Execution of hydro-mechanical (HM) works in Himalayan hydropower projects presents significant engineering challenges due to rugged terrain, logistical constraints, climatic variability, and interface dependencies with civil structures. This paper presents practical field experiences from multiple hydropower projects in Bhutan, focusing on challenges encountered during the fabrication, transportation, and installation of HM components such as penstock ferrules and gates.

In addition, manufacturing and reclamation challenges associated with Pelton turbine runners are discussed, particularly issues related to machining integration, welding distortion, and thermal control. Engineering interventions such as modular fabrication strategies, temporary bridge modifications, adaptive transport solutions, and controlled welding techniques are highlighted.

The findings emphasize the importance of field-driven engineering decisions, proactive logistics planning, and flexibility in execution for successful implementation of HM works under challenging site conditions.

Keywords: Hydro-mechanical works, Hydropower, Ferrule installation, Pelton runner, Welding distortion, Logistics, Mountain engineering

Track 03: Artificial Intelligence, Computing, and
Digital Transformation

The Screen-Time Trap: An Explainable Machine Learning Framework for Pediatric Screen-Time Overuse Prediction

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Excessive screen time is linked to health problems in children and adolescents, such as poor sleep, eye strain, anxiety, and obesity risk. The existing research tends to centre on smartphone addiction or descriptive associations rather than explainable predictive modelling of screen-time overuse in pediatric populations. In this study, we developed and evaluated an explainable machine learning framework to predict which children exceed the recommended daily screen time limit using a real-world dataset of 9,668 Indian children aged 8–18 years (4,928 male and 4,740 female). Screen-time overuse was observed in 86.7% of male respondents and 84.8% of female respondents. Our pipeline includes data preprocessing, duplicate removal, encoding, imputation, feature scaling, SMOTE-based class balancing, comparative evaluation of classifiers, hyperparameter optimisation, ensemble learning, and SHAP-based explainable AI. Among the evaluated models, XGBoost with hyperparameter tuning achieves the best results: 85% accuracy, 94% precision, 89% recall, 91% F1-score, and 91% ROC-AUC. Explainable AI showed that poor sleep and the educational-to-recreational screen-time ratio were the strongest predictors, while eye strain and anxiety also emerged as important factors. These findings show that explainable machine learning can support the early identification of children at risk of excessive screen time and inform targeted interventions.

Keywords: SMOTE, Hyperparameter, Ensemble learning, Explainable AI, Stacking classifier, Hard and Soft voting

Support Vector Machine Models with Smooth Generalized Pinball Loss

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Support vector machine models are commonly formulated as constrained convex minimization problems, to be solved using the method of Lagrange multipliers. Through introduction of a loss function, these models may also take the form of unconstrained optimization problems. Common loss functions include the hinge loss, the pinball loss and the generalized pinball loss. They are non-differentiable, so that efficient numerical methods such as gradient descent or Newton-type methods are not guaranteed to converge.

We present a one-parameter family of C^2 -smooth loss functions to overcome the challenge of non-differentiability. These functions render the objective function in the formulation of the standard support vector machine model (SVM) twice continuously differentiable and improve model performance by reducing sensitivity to noise as well as increasing stability in resampling. Similarly, a novel twin-bounded support vector machine (TBSVM) model with smooth loss function is obtained.

It is shown that the solutions of the proposed SVM and TBSVM models are unique, and that they converge to the solutions of the models with generalized pinball loss as the family parameter approaches zero. Furthermore, the performance of the support vector machine models involving our novel smooth loss functions is compared against other approaches by means of experiments with common UCI datasets. The experimental results show that for some of the datasets, the proposed model shows superior performance in the TBSVM model with RBF kernel.

Keywords: Support Vector Machine, Loss Function, Smooth Function

DrukSerenity: A Culturally-Aware Multi-Agent Chatbot Framework for Mental Health Support in Bhutan

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Mental health support in Bhutan faces persistent challenges including cultural stigma, emotional restraint, and a shortage of trained professionals. This paper presents DrukSerenity, a multi-agent conversational AI framework that coordinates six specialized agents through a hybrid adaptive pipeline with crisis branching, retrieval augmented generation grounded in over 900 Bhutanese proverbs and culturally relevant sources including Gross National Happiness (GNH) and mindfulness-based texts, bidirectional Dzongkha–English translation, two tier memory, privacy protection, and ethical guardrails. Evaluation on a synthetic benchmark of 542 messages across six categories shows strong safety critical performance: 100% crisis precision with 0% false positives, 92.2% crisis detection F1, and 97.1% Dzongkha response accuracy. Cultural grounding achieves 0.94 RAG fidelity, with the cultural RAG category scoring 4.38/5 on an ensemble judge. Overall functional accuracy is 83.8% and the mean ensemble judge score is 4.02/5. While fine grained emotion classification (52.2%) and processing latency (19.1s) require further improvement, DrukSerenity reliably handles crisis escalation, cultural appropriateness, and privacy preservation, offering a replicable template for culturally aware mental health AI in resource constrained settings.

Keywords: Multi-agent systems, mental health support, cultural adaptation, conversational AI, retrieval-augmented generation, crisis detection, Dzongkha translation, privacy architecture.

Knowledge-Action Gap and Optimism Bias in Digital Scam Prevention in the Royal University of Bhutan

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With the ongoing digital transformation in Bhutan, understanding the link between optimism bias and vulnerability to scams is key to creating effective cybersecurity strategies. Despite repeated awareness campaigns from the Bhutan Cyber Incident Response Team and the Royal Bhutan Police, digital scam victimization remains a persistent problem. The study investigates the knowledge-action gap by examining the prevalence and behavioral implications of optimism bias (OB) and its influence on susceptibility to scams within the Royal University of Bhutan. A cross-sectional survey (N = 330), combined with simulated scam scenarios, was used to compare generational differences and to examine the relationships among campaign recall, bias level, and protective behavioral responses.

The study revealed a pronounced and widespread optimism bias within the sample, with respondents consistently rating others' susceptibility higher than their own. A generational comparison using Welch's t-test indicated no significant evidence that youths exhibit higher bias than adults. While general campaign awareness showed no significant association with optimism bias, specific recall of campaign messages was linked to higher optimism, highlighting the importance of tailored education to enhance self-efficacy among digital users.

Contrary to common assumptions, behavioral tests using two simulated scams did not demonstrate that higher bias increases vulnerability. Instead, the findings suggest that optimism bias may reflect digital self-efficacy. This study can serve as a baseline for future nationwide research and may motivate agencies to support the development of effective cybersecurity strategies.

Keywords: Optimism bias, knowledge-action gap, cyber scams, digital self-efficacy, cybersecurity

Authority, Renewable Energy Policy, Net Billing

Parameter Recovery of Vasicek Model with Kolmogorov-Arnold Networks: A Synthetic Study with Zero-Coupon Pricing Implications

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When governments, corporations, municipalities, or other public institutions require medium- or long-term funding, they frequently issue bonds to investors. This paper studies parameter calibration for the Vasicek short-rate model and discusses the pricing implications of recovered parameters for zero-coupon bonds. The theory is stated under the risk-neutral measure, while the physical-to-risk-neutral mapping is summarized explicitly to avoid ambiguity in the pricing drift. A spline based Kolmogorov-Arnold Network (KAN) is compared with exact maximum likelihood estimation (EMLE), Euler-Maruyama maximum likelihood estimation (EMMLE), and a quadratic variation-initialized two-stage likelihood baseline on synthetically generated short-rate paths. The training corpus contains 1.2 million independent Vasicek paths and the out-of-sample evaluation uses an additional 10,000 paths drawn from the same simulation design. The results show that KAN recovers the mean level and mean-reversion speed more accurately than the benchmark procedures on this in-distribution synthetic design, whereas likelihood-based methods remain more accurate for volatility. The pricing figures are therefore interpreted as pricing implications of parameter recovery rather than as direct market pricing validation

Keywords: Vasicek model, affine term structures, Kolmogorov-Arnold Networks, synthetic calibration, pricing implications

Scaling Transformers for Low-Resource NLP: An Empirical Study on Dzongkha Next-Word Prediction

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The digital preservation and accessibility of the Dzongkha language face significant challenges due to limited annotated corpora and complex linguistic structures. While previous research has predominantly relied on Recurrent Neural Network (RNN) architectures, the recent shift toward Large Language Models (LLMs) offers a new paradigm for linguistic modeling. In this paper, we present an empirical study on the scaling properties of causal Transformer models for next-word prediction in Dzongkha. We depart from traditional syllable- and word-level modeling in favor of a sub-word tokenization strategy using a SentencePiece Unigram model, trained with a 32K vocabulary size on 903,392 Dzongkha sentences. This approach effectively resolves vocabulary sparsity. We evaluated GPT-2 architectures ranging from Tiny (~35M) to Extra Large (1.5B) parameters. Our results demonstrate a clear convergence in loss and perplexity as model capacity increases. Small Transformers perform similarly to Bi-LSTM baselines. However, the GPT-2 Large and Extra Large variants achieve significant improvements in accuracy. The Extra Large model reached a state-of-the-art perplexity of 9.98. This work provides the first comprehensive benchmark of Transformer Scaling Laws for Dzongkha, the national language of Bhutan. It offers a blueprint for high-performance predictive text in low-resource settings.

Keywords: Dzongkha NLP, Transformer Scaling Laws, GPT-2, Low-Resource Languages, Next-Word Prediction, Sub-word Tokenization.

**Track 04: Environmental Policy, Climate
Science, and Engineering Education**

Emerging Patterns of Precipitation Extremes in Bhutan: A Multi-Dataset Evaluation

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Precipitation in the eastern Himalayan region is strongly influenced by the Indian monsoon, which is increasingly affected by climate change. However, detailed assessment of high-resolution precipitation extremes in this region remains limited. This study investigates the precipitation regime in Bhutan using Expert Team on Climate Change Detection and Indices (ETCCDI) metrics at both national and latitudinal scales. In-situ observed data are compared with widely used global datasets, including Aphrodite, ERA5, WFDE5, HARv2, IMERG, and MSWEP, to evaluate their ability to capture extreme precipitation and intensity patterns. The results indicate a “fewer but fiercer” precipitation regime at the national scale. Total annual precipitation and the frequency of rainy days (R1mm) show a declining trend, while precipitation intensity (SDII) and extreme event magnitudes (Rx1day and Rx5day) are increasing. A clear spatial pattern is also observed along latitudinal gradients. Lower and middle latitudes emerge as hotspots of intense precipitation, with increasing contributions from very wet and extremely wet days (R95pTOT and R99pTOT). In contrast, higher latitudes show an increase in rainy day frequency (R10mm and R20mm) and extreme event magnitude, but no significant trend in extreme wet day contribution or intensity. The global gridded datasets do not consistently capture these observed patterns and, in some cases, show opposite trends compared to in-situ data. These findings highlight the need for high-resolution, observation-based datasets to support effective climate adaptation and infrastructure planning in the region, particularly in addressing emerging hydrological extremes

Keywords: Extreme precipitation; ETCCDI; Hydroclimatic Trends; Bhutan Himalayas, Gridded datasets comparison.

Algorithmic Modeling and Efficiency Prediction of Low-Cost Hydraulic Ram Pump

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This study presents the design, fabrication, and hydraulic performance analysis of hydraulic ram pump (hydam) as an energy independent water lifting system suitable for mountainous terrains. The hydraulic ram pump operates based on the water hammer phenomenon, where the sudden closure of a waste valve generates a high-pressure transient wave within the drive pipe. This pressure surge enables a friction of the input flow to be delivered to elevations of significantly higher than the supply source without external power input. Although hydam is widely used in some regions, it has not gained popularity in Bhutan despite the country's abundant water resources and high per capita water availability. Given Bhutan's significant river discharge and mountainous terrain, the hydraulic ram pump presents a promising sustainable solution for rural and agricultural water supply. The purpose of the research is to develop a working prototype of a hydraulic ram pump from the parts available in the market, study the conversion of kinetic energy of water from drive pipe to pressure surge in the system to lift water to a higher delivery head and provide a low cost, easy to assemble and a sustainable alternative water pump that does not require external source of energy for operation. The system performance was interpreted using fundamental hydraulic principles and the pump efficiency was determined as the ratio of output hydraulic power to input hydraulic power. Experimental investigations were conducted at delivery heads of 9m and 10m under different supply head conditions. Results indicate a direct proportional relationship between supply head and discharge rate, attributed to increase pressure surge intensity with higher inlet velocities. Hydraulic efficiency improved progressively with increasing supply head, though optimal performance was achieved when an appropriate supply heads and delivery head ratio is maintained to ensured stable valve oscillation and minimized head losses due to friction and turbulence. Overall, the findings confirm that the hydraulic ram pump is a technically viable, low-cost, and sustainable water-lifting technology suitable for energy-free applications in remote and mountainous regions.

Keywords: Hydraulic Ram Pump, Hydam, Pump, Supply head, Delivery head, Valve.

Human Wildlife Conflicts in Central Bhutan: Drivers, Mitigation Strategies, and Attitudes toward Technology Adoption

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This study looks at Human–Wildlife Conflict (HWC) in farming communities in Dangkhar Chiwog under Zhemgang District, Bhutan. It examines communities' experiences, conflict drivers, mitigation strategies, and attitudes toward technology adoption. Using a qualitative research method, the data collected from the focus group discussion (n=30) is analyzed using NVivo by means of thematic analysis, which provides significant findings on themes such as crop-damaging species, causes of wildlife intrusion, existing mitigation practices, and perceptions of emerging technologies. The findings show that HWC poses a major threat to livelihoods and food security, with studies in Bhutan reporting that up to 30-40% of the crop produce is lost annually to wildlife damage in highly affected areas. The problem has considerable socio-economic repercussions, which include reduced household income, increased labor burdens, and higher levels of food insecurity. From an environmental perspective, the conflict reflects broader ecological degradation such as habitat loss and fragmentation, driven by expanding human activities. The main drivers are habitat loss, increased human activity, and religious restrictions on controlling wildlife. Traditional methods like scarecrows, wooden fences, barbed wire fences, and night guarding are still in use. However, all participating farmers (n=30) expressed a growing interest in modern technologies such as solar fencing, electric fencing, IoT-based deterrent systems, and Digital Twin applications for real-time monitoring and predictive management. The research provides policy recommendations that combine the use of existing mitigation systems with suitable digital technology advancements, as well as the need for revising and updating the Bhutan National Human-Wildlife Conflict Management Strategy. This combination will be very crucial for fostering sustainable human-wildlife co-existence in Bhutan.

Keywords: Human–Wildlife Conflict; Digital Twin; Smart Deterrents; Fencing; Technology Adoption; Community Engagement; Rural Livelihoods.

Wind Simulation in a Lake Surrounded by Steep Mountains -Using Lake Suwa in Japan as an Example

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Understanding the characteristics of lake currents is extremely important for managing water quality in the lake. Wind has an important role in the behavior of lake currents, especially in shallow lakes. Toyota et.al. (2006) showed that spatially non-uniformity of wind distribution had a great influence on the current in Lake Suwa surrounded by steep mountains. It is very difficult to measure the wind field at many stations continuously both in terms of cost and effort. In Japan, some calculations of winds over the lake surface have been performed for lakes with large horizontal scales or lakes with flat topography. However, high-resolution wind analyses targeting small-scale lakes with steep topography are not available. In this study, we aim to reproduce wind distribution over a lake surface using a numerical fluid dynamics model. Calculations for steady-state solutions using the Finite Element Method and unsteady calculations using the Multi-Scale Simulator for the Geoenvironmental (MSSG) developed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) were performed. As a result, while Finite Element Method calculations could hardly reproduce wind non-uniformity, MSSG calculations were able to reproduce wind non-uniformity to a large extent.

Keywords: Wind over the Lake, numerical simulation, steep topography

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2	Integration of Remote Sensing and GIS for Urban stormwater runoff estimation	
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9	Interlocking Adobe Blocks for Low-Carbon Construction: A Nature-Based Sustainable Solution	
10	Drukpool	Gyalpozhing College of Information Technology
11	K Lhab	Gyalpozhing College of Information Technology
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13	Analyze the Voltage Profile and Power Quality of the solar PV Integrated to the JNEC Campus	Jigme Namgyel Engineering College
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