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SIP2026 CANADA



SIP 2026

**Sustainable Innovations
and Partnerships**

16-17 APRIL
BC, Canada

Abstract Book

2026 International Conference on Sustainable Innovations and Partnerships

April 16 -17, 2026
University of British
Columbia (UBC)
Vancouver, Canada



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3rd International Conference on Sustainable Innovations and Partnerships (SIP2026)

16-17 April, 2026

University of British Columbia (UBC), C.K. Choi Building, 1855 West Mall
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Table of Contents

Acknowledgements	vi
Conference Organizing Chair Message	vii
Vision and Goals	viii
Conference Chairs	xi
Scientific Committee	xii
Conference Publications	xiv
SIP2026 Submitted Abstracts - Executive Summary	1

List of Abstracts

Data Balance and Fairness in Mobility: The Impact of Gender Representation on AI-Based Models for Sustainable Mobility	3
Katja Andrea Rösler University of Applied Sciences Ruhr West, Mülheim an der Ruhr, Germany	
An Integrated AI-Enhanced Post-Quantum Security Framework for 6G Edge IoT Ecosystems	4
Hani Al-Balasmeh University of Technology Bahrain, Bahrain	
Digital Transformation of Nepalese Cooperatives Through Akash DMS	5
Tanka Prasad Adhikari Akash Digital Pvt. Ltd., Nepal	
Enhancing Healthcare Interoperability Using AI and Blockchain Integration	6
Hani Al-Balasmeh University of Technology Bahrain, Bahrain	

Social Science and Humanities for Global Sustainability: Human Insight for a Sustainable Future	7
Rajveer Kaur Chandigarh University, India	
Agriculture, Food, and Environmental Sustainability: Building Climate-Smart Agriculture and Secure Food Chains	8
Parvinder Singh Amity University Noida, India	
Green-tech Complexity, Energy Consumption, and Environmental Quality: A Machine Learning Framework for Sustainable Solutions	9
Hashmat Ali ¹ , Imad Ali ¹ , Khan Baz ² Abbottabad University of Science and Technology ¹ , Zhejiang Agriculture and Forestry University ² ; Pakistan, China	
Fossil Fuel Subsidies and Green Technology Impact on Carbon Emissions: A Study on Achieving Net-Zero Policy	10
Khan Baz ¹ , Hashmat Ali ² , Imad Ali ² Zhejiang Agriculture and Forestry University ¹ ; Abbottabad University of Science and Technology ² ; China, Pakistan	
Industrial Wastewater Management and Cleaner Production Adoption in Stone-Cutting and Concrete Industries: A PLS-SEM Study from the Wadi Zomer Catchment, Palestine	11
Momen N. Alqub, Eldon R. Rene, Abdelhaleem I. Khader, Jaap Evers, Adel S. Yasin Palestinian Water Authority; Al-Najah National University; IHE Delft – Institute for Water Education, Palestine; The Netherlands	
Accelerating the 17 SDGs Actualization in Africa's Emerging Economies: The Role of Innovation, Collaboration, and Policy through ESG Leadership	12
Lukman Abayomi Jimoh Rahim; Saheed Adesunkanmi Oyede University of Jos, Nigeria	

Supply Chain Resilience in the Era of Disruption: An Empirical Review of Risk Management, Digital Transformation, and Sustainability (2019–2025) 13

Shafiqul Islam; Zaharuzaman Bin Jamaluddin
 Universiti Selangor (UNISEL), Malaysia

Tourism as a Living Intelligence System: An AI-Native Framework for Sustainable Innovation and Governance 14

Harilal Bhaskar
 iSTEM, India

Teacher AI Tool Adoption and Student 21st-Century Competencies in Rural Pakistan: A Descriptive-Correlational Study 15

Muhammad Kashif Majeed; Tunku Badariah Binti Ahmad
 International Islamic University, Malaysia

Digital Solution to Optimize a Unified Surface and Subsurface Simulation Framework for Geothermal Systems 16

Deepinder Jot Singh Aulakh¹; Muhammad Faisal Iqbal²; Arash Behrang¹
 SLB (Schlumberger), Canada¹; United Kingdom²

Decision Support Tool for Integrating Cargo Bicycles and Microhubs in Urban Logistics Systems 17

Vladyslav Shramenko; Natalya Shramenko
 Karlsruhe University of Applied Sciences; Baden-Württemberg Institute of Sustainable Mobility, Germany

Intelligent Thermal Runaway Detection and Prevention System for Electric Vehicle Batteries using Edge AI 18

Vishnu C; D. Beulah Princiba
 St. Joseph's College of Engineering, India

AI Power Sign Language Interpreter for Inclusive Communication 19

R. Jenitha; M. Anusuya; M. Muthupriya; K. Nivitha
 PSR Engineering College, India

Upcoming Conferences 20

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We also thank our publishing and indexing partners: *Springer & Springer Nature, Crossref, ISSN, and DOI*; and our collaboration platforms: *EasyChair, OSJ, and Zotero*. These partnerships ensure global visibility, standardized scholarly communication, and long-term accessibility of contributions.

Following successful registration, presentation, and peer review, accepted papers will be scheduled for publication and considered for reputable venues based on recommendations of the Scientific Committee. All submissions undergo rigorous evaluation by a distinguished editorial board, including *single-blind review*, and *DOI assignment*.

Publication opportunities for SIP2026 include the Springer Nature proceedings volume *Selected Contributions from SIP2026*, the *REPA Journals (JSO, JSER, JESR, JETR, JBM, JEPR)*, and the *REPA Proceedings Series (ISSN 2435-7308)*. No Article Processing Charges (APCs) are required for the REPA Journals and Springer proceedings. Final outlet assignment is determined by the research's thematic alignment, scientific quality, and editorial guidance, thereby ensuring the highest academic and ethical standards.

The Conference Organizing Committee
April 2026

Message

From the Conference Organizing Chair

Dr. Mir Sayed Shah Danish

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It is with great enthusiasm that I welcome you to the 3rd International Conference on Sustainable Innovations and Partnerships (SIP 2026), hosted at the University of British Columbia (UBC), Vancouver, Canada. In a time when the world faces unprecedented environmental, technological, and socio-economic challenges, SIP2026 stands as a vital platform for advancing innovation, collaboration, and practical solutions directly aligned with the United Nations Sustainable Development Goals (SDGs).

This year's program highlights a wide spectrum of research and practice across our core themes, reflecting the depth and diversity of global contributions. Together, we will explore key domains including Artificial Intelligence, Machine Learning & Data Science for Sustainability; Renewable Energy, Smart Grids & Clean Technology; Climate Change, Resilience & Environmental Sustainability; Smart Infrastructure, IoT & Sustainable Cities; Sustainable Agriculture, Food & Water Security; Robotics, Automation & Industry 4.0; Green Finance, Economics & Business Sustainability; Social, Behavioral & Policy Dimensions of Sustainability; Health, Well-being & Inclusive Development; and Future-Oriented Pathways such as Space, Aerospace & Next-Generation Transportation. Each theme represents a crucial dimension of the sustainability transition, showcasing both cutting-edge research and transformative real-world applications.

At SIP 2026, we emphasize the power of interdisciplinary collaboration and knowledge exchange to drive real-world impact. The program features plenary keynote lectures, expert panel discussions, thematic sessions, posters, and technology demonstrations, all designed to translate knowledge into tangible outcomes. By bringing together academics, researchers, industry leaders, entrepreneurs, investors, NGOs, and policymakers, SIP 2026 fosters opportunities for dialogue and partnerships that extend beyond the conference.

The conference is technically organized by the Research and Education Promotion Association (REPA) LLC, with the support of distinguished academic, industry, and institutional partners dedicated to advancing sustainability-oriented research and innovation. Publication opportunities include indexed conference proceedings (subject to rigorous peer review and editorial standards) and pathways to partner journals and proceedings series.

As a passionate advocate for sustainability-driven innovation, I am deeply inspired by the groundbreaking work presented at SIP 2026. Your participation is essential in shaping a future that is resilient, inclusive, and forward-looking. I encourage you to engage fully, explore new collaborations, and take bold steps toward advancing sustainability, climate action, and global partnerships.

Thank you for being part of SIP 2026. I look forward to the ideas, discussions, and partnerships that will emerge from this gathering, helping to chart a course toward a more sustainable world.

Dr. Mir Sayed Shah Danish
April 2026



Vision & Goals

3rd International Conference on Sustainable Innovations and Partnerships (SIP 2026)

<https://sip2026.org>

The 3rd International Conference on Sustainable Innovations and Partnerships (SIP2026) seeks to advance sustainability by fostering innovation, interdisciplinary collaboration, and impactful solutions to global challenges. Through the integration of cutting-edge research, inclusive dialogue, and strategic partnerships, SIP2026 promotes actionable pathways that enhance environmental, economic, and social resilience. The conference emphasizes the translation of knowledge into real-world applications, particularly in fields such as renewable energy, digital transformation, AI-driven decision support, and sustainable infrastructure development.

SIP2026 is firmly aligned with the United Nations Sustainable Development Goals (SDGs), addressing critical issues such as climate action, clean energy access, resilient cities, responsible consumption and production, inclusive growth, and evidence-based governance. By uniting academics, practitioners, policymakers, and industry leaders, SIP2026 provides a unique platform for exchanging knowledge and co-developing strategies that drive systemic change for a more sustainable and equitable future.

Key Thematic Areas:

- ✓ AI, Machine Learning & Data Science for Sustainability — climate modeling, predictive analytics, monitoring systems, and decision-making support.
- ✓ Robotics, Automation & Industry 4.0 — precision manufacturing, agriculture, inspection systems, and circular production processes.
- ✓ Quantum Computing, Cybersecurity & Digital Ethics — secure, responsible, and future-ready digital infrastructures.
- ✓ Renewable Energy & Clean Technology — solar, wind, storage, hydrogen, hybrid systems, and smart grid integration.
- ✓ Smart Cities, IoT & Infrastructure — sensor-based systems for sustainable mobility, energy, water, and disaster resilience.
- ✓ Climate Change & Environmental Sustainability — mitigation, adaptation, biodiversity protection, and nature-based solutions.
- ✓ Green Finance, Economics & Business Sustainability — ESG practices, carbon markets, transition finance, and circular-economy models.

- ✓ Sustainable Agriculture, Food Systems & Water Security — climate-adaptive methods, waste reduction, and efficient resource management.
- ✓ Social, Behavioral & Policy Dimensions — equitable development, governance frameworks, adoption strategies, and community engagement.
- ✓ Health, Well-being & Sustainable Lifestyles — sustainable living environments and practices that improve human outcomes.
- ✓ Space, Aerospace & Future Transportation — low-carbon mobility, satellite monitoring, and Earth observation for sustainability.
- ✓ Sustainable Technologies & Innovations — materials, processes, and systems designed to minimize environmental footprints.

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Conference Publication

Publication Opportunities

<https://sip2026.org/publication-indexing.php>

All submissions underwent a rigorous double-blind peer review process conducted by a distinguished Editorial Board, ensuring the highest academic standards in originality, impact, and relevance.

After the conference, accepted papers were carefully assigned for publication based on scientific quality, thematic relevance, and editorial recommendations.

1. Springer Nature – Scopus-Indexed

Selected papers will be featured in the Springer proceedings volume: Innovative Approaches for Global Sustainability – Selected Contributions from SIP2026

- Reviewed by at least two independent reviewers
- Checked for plagiarism using the required tools
- Assigned DOIs and indexed in major databases via SpringerLink
- No Article Processing Charge (APC) is required.
- Authors must complete SIP2026 registration and present their papers at the conference.



2. REPA Journals – Multidisciplinary Open-Access Publications

A significant number of conference papers have been published in REPA's partner journals, contributing to research in sustainability, engineering, business, and environmental sciences. These include:

- Journal of Sustainability Outreach (*ISSN 2435-7243*)
- Journal of Sustainable Energy Revolution (*ISSN 2435-7251*)
- Journal of Environmental Science Revolution (*ISSN 2435-726X*)
- Journal of Engineering and Technology Revolution (*ISSN 2435-7278*)
- Journal of Business and Management Revolution (*ISSN 2435-7286*)
- Journal of Ecoscience and Plant Revolution (*ISSN 2435-7294*)

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3. REPA Proceeding Series (ISSN 2435-7308)

All accepted abstracts and select full papers have been published in the REPA Proceeding Series, ensuring open-access visibility and indexing in major academic databases.

SIP 2026 Submitted Abstracts

Executive Summary

Editorial Note

The abstracts presented in this conference represent a diverse and interdisciplinary body of research addressing critical challenges at the intersection of sustainability, technological innovation, and socio-economic development. Collectively, the contributions highlight the growing role of advanced technologies, including artificial intelligence, digital systems, and data analytics in supporting sustainable transitions across multiple sectors.

A prominent theme within the collection is the integration of artificial intelligence and digital infrastructure into complex systems. Several studies examine how AI techniques can improve system intelligence, security, and decision-making capabilities. Research addressing post-quantum security for 6G edge IoT environments, AI-enabled healthcare interoperability, and AI-supported mobility planning demonstrates how emerging technologies are reshaping the design of resilient digital ecosystems. These works emphasize the need for scalable architectures that maintain security, fairness, and efficiency in increasingly connected environments.

Sustainability in energy systems and environmental management forms another important research direction. Contributions examining biomass-derived silicon-carbon materials for supercapacitor energy storage, green technology adoption and environmental quality, and the policy impacts of fossil-fuel subsidies highlight the importance of technological innovation combined with policy alignment in achieving global decarbonization goals. These studies provide empirical evidence supporting the transition toward renewable energy systems, sustainable materials, and climate-aligned economic policies.

Several papers also explore sustainable production systems and environmental governance. Research on cleaner production strategies in industrial wastewater management demonstrates how circular resource practices can reduce environmental impacts while improving operational efficiency. Similarly, studies examining agricultural sustainability and climate-smart farming practices illustrate how technological and management innovations can strengthen food security under increasing climate pressures.

Beyond technical systems, the conference also emphasizes the importance of human and institutional factors in sustainability transitions. Studies focusing on gender representation in mobility datasets, ESG leadership for sustainable development, and the role of social sciences in global sustainability highlight the need to integrate social equity, governance quality, and behavioral dynamics into sustainability frameworks.

In addition, research on digital transformation in cooperatives, supply chain resilience, and AI adoption in education systems illustrates how digital technologies are reshaping organizational capabilities and knowledge systems across diverse sectors.

Overall, the contributions demonstrate that sustainable development challenges require integrated solutions combining technological innovation, policy coordination, and social awareness. The research presented in this abstract collection provides valuable insights into how emerging technologies, interdisciplinary collaboration, and responsible governance can collectively support a more resilient, equitable, and sustainable global future.

Data Balance and Fairness in Mobility: The Impact of Gender Representation on AI-Based Models for Sustainable Mobility

Katja Andrea Rösler

University of Applied Sciences Ruhr West, Mülheim an der Ruhr, Germany

Abstract: This study examines how gender representation within mobility datasets affects the fairness, reliability, and decision-support outcomes of artificial intelligence models used in sustainable transport planning. As data-driven approaches become more common in mobility systems, imbalances in underlying datasets can influence accessibility assessments, safety outputs, and optimization processes, creating unintended disparities between user groups. The research aims to evaluate how different gender distributions shape model results and influence key mobility indicators related to efficiency, safety, and service quality. The problem addressed centers on the underrepresentation of women in mobility and safety datasets and how this imbalance may affect model performance. The study uses open mobility data, sectoral statistics, and AI-supported scenario modeling to compare balanced and empirically observed gender distributions. Analytical methods include statistical evaluation, fairness assessment, and scenario-based transport simulations. Findings indicate that balanced datasets produce more equitable and safety-oriented recommendations without reducing system performance. The study contributes a structured approach for integrating gender representation into AI mobility modeling and demonstrates how demographic balance influences algorithmic outcomes. Tools used include statistical modeling frameworks, fairness evaluation metrics, and AI-based mobility analysis environments. Overall, the work highlights the importance of equitable data representation for responsible AI development and for supporting sustainable, inclusive mobility planning.

Keywords: *AI Mobility Modeling, Gender Representation, Algorithmic Fairness, Sustainable Mobility, Data-Driven Analysis*

An Integrated AI-Enhanced Post-Quantum Security Framework for 6G Edge IoT Ecosystems

Hani Al-Balasmeh

University of Technology Bahrain, Bahrain

Abstract: This study proposes an integrated security architecture for sixth-generation (6G) edge-enabled Internet of Things (IoT) ecosystems to address emerging vulnerabilities associated with quantum computing and ultra-dense device environments. Conventional public-key cryptographic systems such as RSA and elliptic-curve cryptography are expected to become vulnerable in the presence of large-scale quantum computing capabilities. At the same time, future IoT systems require security mechanisms that maintain low latency, scalability, and energy efficiency. The proposed framework integrates lattice-based post-quantum cryptography, AI-based anomaly detection, and blockchain-supported federated learning to provide multi-layered security protection across distributed edge networks. Experimental evaluation using emulated IoT traffic with up to 100,000 connected devices demonstrates that lattice-based cryptographic schemes can reduce encryption latency by more than 50% compared with RSA and ECC while maintaining approximately 24,000 secure sessions per second. Additionally, a hybrid CNN–LSTM intrusion detection model achieved 96.7% classification accuracy with a 3.1% false-positive rate, outperforming traditional machine learning approaches. The federated learning layer supported by blockchain infrastructure enables decentralized and privacy-preserving model training while maintaining performance comparable to centralized learning. Overall, the proposed architecture provides a scalable and resilient framework for securing future 6G edge-IoT infrastructures against emerging post-quantum threats.

Keywords: *Post-Quantum Cryptography, 6G Networks, Edge IoT Security, AI-Based Intrusion Detection, Federated Learning*

Digital Transformation of Nepalese Cooperatives Through Akash DMS

Tanka Prasad Adhikari

Akash Digital Pvt. Ltd., Nepal

Abstract: This study evaluates the digital transformation of Nepalese cooperatives through the implementation of the Akash Digital Management System (Akash DMS). The research addresses long-standing operational challenges including document mismanagement, manual loan processing, compliance gaps, and inefficiencies caused by paper-based workflows. The study investigates whether cloud-based automation, digital documentation, and workflow optimization can enhance transparency, governance, and operational performance across the sector. Using a mixed-methods approach involving workflow analysis, interviews with cooperative staff, and extraction of quantitative performance metrics from more than 500 cooperatives, the study assesses improvements across key operational indicators. The findings show substantial gains: document retrieval time decreased from several hours to seconds, loan-processing duration was reduced by 50–60%, manual error rates dropped by over 80%, and compliance readiness increased significantly. The Akash DMS framework integrates features such as Digital KYM, automated loan workflows, task management, expiry alerts, and cloud-based archives. These capabilities collectively reduce workload by up to 70% and improve accuracy by more than 80%, demonstrating strong alignment with sustainability and digital-governance objectives. The novelty of the study lies in its sector-scale empirical evaluation using real operational data from a diverse cooperative network. The results indicate that Akash DMS represents a scalable digital-governance model for emerging economies, supporting efficiency, accountability, and long-term institutional sustainability. Future work includes integrating AI-driven risk assessment, OCR-based document extraction, and blockchain-enabled secure archiving.

Keywords: *Digital transformation, Cooperatives, Akash DMS, Automation, Document management, Nepal*

Enhancing Healthcare Interoperability Using AI and Blockchain Integration

Hani Al-Balasmeh

University of Technology Bahrain, Bahrain

Abstract: This study proposes a layered framework for secure and semantically reliable healthcare interoperability across heterogeneous clinical systems by integrating artificial intelligence (AI) and permissioned blockchain technologies. Existing interoperability solutions often face limitations related to semantic inconsistencies, fragmented governance structures, and excessive data exposure during cross-institutional information exchange. To address these challenges, the proposed architecture combines HL7 FHIR-based interoperability middleware for standardized data normalization, AI-driven semantic intelligence for clinical concept alignment across heterogeneous medical terminologies, and blockchain-based governance mechanisms for decentralized access control, consent management, and data provenance tracking. Experimental evaluation using simulated multi-institutional healthcare datasets demonstrates semantic alignment accuracy between 96% and 98%, outperforming traditional terminology mapping approaches. Privacy analysis indicates that the governance layer reduces unnecessary data exposure by more than 50%, while policy enforcement tests confirm the absence of unauthorized access events. Performance analysis shows that the system maintains end-to-end interoperability latency below 8 ms and transaction throughput exceeding 2000 transactions per second under increasing interoperability workloads. By integrating semantic confidence validation with decentralized governance, the proposed framework enables healthcare systems to exchange clinical data securely while preserving semantic integrity and patient privacy. The results suggest that AI-blockchain integration offers a scalable solution for next-generation healthcare data interoperability and trusted clinical data sharing.

Keywords: *Healthcare interoperability; Artificial intelligence in healthcare; Blockchain governance; HL7 FHIR; Semantic data integration*

Social Science and Humanities for Global Sustainability: Human Insight for a Sustainable Future

Rajveer Kaur

Chandigarh University, India

Abstract: This study explores how social science and humanities perspectives contribute to global sustainability by examining the human factors that shape fairness, resilience, trust, and inclusive development. While technology and economic tools are essential, the research argues that long-term sustainability also depends on understanding how people live, interact, govern, and make collective decisions. Persistent global inequalities, such as the 692 million individuals living with extremely limited resources, highlight the continued need for social insight alongside technical solutions. Drawing on international assessments covering 222 countries, the study examines how variations in social cohesion, governance quality, equity, and leadership affect progress toward global development goals. Recent global reports indicate that only about 35% of assessed targets are on track, while nearly 18% have regressed since 2015, suggesting that social systems influence the success of sustainable development initiatives. Through conceptual analysis supported by global indices, the study investigates why some societies advance while others lag despite similar economic or technological conditions. The findings suggest that strengthening trust, unity, fairness, and collective resilience can accelerate progress and reduce long-standing disparities. This work emphasizes that sustainable transformation requires integrating human behavior, cultural norms, ethical frameworks, and governance practices into planning processes. Sustainable change must therefore blend technological innovation with social understanding to ensure that growth remains equitable, inclusive, and resilient.

Keywords: *Social Sustainability, Governance and Development, Social Cohesion and Trust, Inclusive and Equitable Development, Global Sustainable Development Goals*

Agriculture, Food, and Environmental Sustainability: Building Climate-Smart Agriculture and Secure Food Chains

Parvinder Singh

Amity University Noida, India

Abstract: This study examines the interconnected challenges and opportunities within agriculture, food systems, and environmental sustainability, emphasizing how resource-efficient land-use practices and emerging agricultural innovations can enhance productivity while reducing ecological degradation. The work is motivated by rising global food demand, increasing climate variability, soil degradation, and water scarcity, all of which threaten long-term food security. The study focuses on three strategic pathways: precision agriculture, climate-smart practices, and circular food-system approaches, each evaluated for their potential to improve yields, reduce waste, and support resilient production systems. The research aims to (1) measure the environmental performance of selected sustainable farming practices, (2) evaluate their economic feasibility for both smallholders and commercial producers, and (3) analyze how these interventions contribute to climate adaptation and resource efficiency. The problem addressed is the lack of integrated assessments that quantify both environmental and economic impacts across multiple sustainable agricultural innovations. A mixed-methods design is applied, combining field observations, stakeholder interviews, and environmental impact assessments with quantitative modeling supported by GIS, LCA tools, and simulation platforms such as R, ArcGIS, and Python-based analytical models. Preliminary findings indicate that precision agriculture reduces water use by up to 25% and improves nutrient-use efficiency, while agroforestry and other climate-smart techniques significantly enhance carbon sequestration. Circular strategies, such as food-waste valorization—further reduce emissions within the supply chain. The novelty lies in the study’s holistic evaluation framework, which simultaneously examines productivity, environmental outcomes, economic viability, and social acceptability. This integrated perspective provides a more comprehensive understanding than earlier studies that typically consider these dimensions in isolation. The results suggest that scaling climate-smart and resource-efficient innovations, supported by enabling policies and farmer training, can strengthen food security while lowering environmental impacts.

Keywords: *Sustainable Agriculture, Land-Use Practices, Food Security, Agroforestry, Water Scarcity*

Green-tech Complexity, Energy Consumption, and Environmental Quality: A Machine Learning Framework for Sustainable Solutions

Hashmat Ali¹, Imad Ali¹, Khan Baz²

Abbottabad University of Science and Technology¹, Zhejiang Agriculture and Forestry University²; Pakistan, China

Abstract: This study examines the relationship between green technology complexity, energy consumption, and environmental quality using a combined econometric and machine-learning framework. Motivated by rising global energy demand and the urgency of decarbonization, the research evaluates how fossil fuel use, renewable energy adoption, and technological complexity jointly influence environmental outcomes. The analysis uses panel data from the top twenty-five carbon-emitting countries covering the period 1995-2023. First, a random-effects ordinary least squares model is applied to capture country-specific effects and identify baseline relationships among key variables. Second, a deep neural network model is employed to assess nonlinear interactions and predictive performance across the full variable set. The econometric results indicate that fossil fuel consumption and economic growth negatively affect environmental quality, while renewable energy use and green technology complexity contribute positively. The machine-learning model further confirms the importance of interaction effects, showing that the combined influence of green technology complexity and renewable energy consumption improves environmental quality more strongly than either factor alone. The study contributes by integrating traditional panel estimation with deep learning to capture both causal direction and complex nonlinear dynamics. The findings suggest that coordinated investment in renewable energy systems and green technological advancement can support emission reduction goals and enhance environmental quality in high-emission economies.

Keywords: *Green Technological Innovation, Complexity Index, Machine Learning, Energy Consumption, Environmental Quality*

Fossil Fuel Subsidies and Green Technology Impact on Carbon Emissions: A Study on Achieving Net-Zero Policy

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Abstract: This study analyzes the effects of fossil fuel subsidies, green technology adoption, renewable energy use, and forest carbon stocks on carbon dioxide emissions in high-emission economies. The research is motivated by the policy tension between subsidy-driven fossil fuel dependence and the transition toward low-carbon energy systems. Using panel data from the top twenty per capita carbon-emitting countries over the period 2010–2022, the study applies bootstrapped quantile regression to capture heterogeneous impacts across emission distributions. The results show that renewable energy consumption and forest carbon stocks reduce carbon emissions, while fossil fuel subsidies and green technology adoption are associated with higher emissions. Granger causality analysis identifies unidirectional causality from fossil fuel subsidies, green technology, and forest carbon stocks to carbon emissions, and bidirectional causality between renewable energy use and emissions. The findings suggest that subsidy structures can offset the benefits of technological progress when policy incentives remain misaligned. The study contributes by jointly examining fiscal policy, technological adoption, and natural carbon sinks within a distributional econometric framework. The results indicate that achieving net-zero targets requires phasing out fossil fuel subsidies, strengthening renewable energy deployment, and aligning green technology policies with emission-reduction objectives.

Keywords: *Fossil Fuel Subsidies, Energy Policy, Green Technology, Eco-Friendly Technology*

Industrial Wastewater Management and Cleaner Production Adoption in Stone-Cutting and Concrete Industries: A PLS-SEM Study from the Wadi Zomer Catchment, Palestine

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Abstract: This study investigates the adoption of cleaner production strategies (CPS) as an industrial wastewater management approach in stone-cutting, concrete, and brick industries located in the Wadi Zomer catchment, a transboundary and environmentally sensitive region in Palestine. Industrial effluents from stone-cutting activities in the area contain high suspended solids that cause sewer blockages, wastewater treatment plant malfunction, and widespread environmental degradation. The proposed CPS separates sludge and water streams, enabling sludge reuse in brick and concrete manufacturing and recycling treated water for industrial cooling processes. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), the study analyzes survey data collected from 45 stone-cutting and ready-mix concrete and brick factories. The results identify the availability of reuse options for effluents and sludge, along with factory owners' awareness, as the strongest drivers of willingness to adopt CPS, exceeding the influence of enforced regulation or general sustainability perceptions. Willingness to adopt CPS shows a strong positive effect ($\beta = 0.622$) on reducing perceived environmental and economic impacts of industrial wastewater. The findings demonstrate that CPS adoption can significantly reduce pollutant loads to sewer networks and wastewater treatment facilities, lower transboundary wastewater-related costs, and improve resource efficiency. The study contributes empirical evidence from a conflict-affected region, highlighting cleaner production as a practical pathway toward sustainable industrial wastewater management under institutional and geopolitical constraints.

Keywords: *Industrial Wastewater, Stone-Cutting Effluents, Cleaner Production Strategy, Resource Recovery, PLS-SEM, Transboundary Wastewater Management*

Accelerating the 17 SDGs Actualization in Africa's Emerging Economies: The Role of Innovation, Collaboration, and Policy through ESG Leadership

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Abstract: This study examines how environmental, social, and governance (ESG) leadership influences progress toward the Sustainable Development Goals (SDGs) in Africa's emerging economies, with specific attention to SDGs 9, 12, 13, 16, and 17. Despite increasing ESG adoption by governments and firms, sustainability performance in Sub-Saharan Africa remains limited, with recent assessments indicating that fewer than 15% of SDG targets are on track. The research addresses the gap between ESG policy adoption and measurable development outcomes by analyzing the mediating roles of innovation capability and cross-sector collaboration, and the moderating effect of policy coherence. A mixed-methods triangulation design is employed, combining Partial Least Squares Structural Equation Modeling (PLS-SEM) with semi-structured interviews. Quantitative analysis indicates that stronger ESG leadership is associated with improved SDG performance, while innovation and collaboration partially mediate this relationship. Policy coherence further strengthens outcomes, with integrated governance systems achieving 20–30% higher SDG indicator performance compared to fragmented policy approaches. The study contributes an Africa-specific ESG leadership framework that positions ESG practices not only as disclosure mechanisms but as operational drivers of sustainable development. The findings suggest that aligning ESG initiatives with innovation systems, collaborative partnerships, and coherent policy frameworks can accelerate SDG progress in emerging African economies.

Keywords: *ESG Leadership, Innovation, Collaboration, Policy Coherence, Sustainable Development Goals*

Supply Chain Resilience in the Era of Disruption: An Empirical Review of Risk Management, Digital Transformation, and Sustainability (2019–2025)

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Abstract: This study presents an empirical integrative review of supply chain resilience research published between 2019 and 2025, with specific focus on risk management, digital transformation, sustainability, and network design under conditions of heightened disruption. The review synthesizes evidence from 60 peer-reviewed empirical studies employing structural equation modeling, panel econometrics, simulation modeling, network analysis, and qualitative case studies. The analysis demonstrates that supply chain resilience is a dynamic, multi-dimensional capability system rather than a static operational attribute. Formalized supply chain risk management, digital visibility and analytics, operational flexibility, relational governance, organizational learning, and sustainability-oriented practices emerge as mutually reinforcing enablers of resilience. The findings further show that digital transformation and sustainability initiatives contribute to resilience only when embedded into organizational routines and aligned across supply chain networks. Recent empirical developments extend resilience thinking toward the concept of supply chain viability, emphasizing long-term survivability through coordinated robustness, adaptability, and recovery. Despite substantial progress, the literature remains dominated by cross-sectional and firm-centric designs, with limited attention to capability orchestration across supply chain tiers. The study identifies clear directions for future research, including longitudinal and multi-tier empirical designs, refined resilience measurement, and integrated assessment of financial, environmental, and social performance outcomes.

Keywords: *Supply Chain Resilience, Risk Management, Digital Transformation, Sustainability, Supply Chain Viability*

Tourism as a Living Intelligence System: An AI-Native Framework for Sustainable Innovation and Governance

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Abstract: This study proposes a conceptual reframing of tourism as a Living Intelligence System, defined as a continuously sensing, learning, and adaptive socio-technical system supported by artificial intelligence. Tourism governance is currently characterized by fragmented institutional arrangements, siloed data practices, and retrospective sustainability indicators, which limit the sector's ability to respond to climate risk, overtourism, and resource constraints. Using a design-science and systems-theory methodology, the study introduces the Tourism Intelligence Grid (TIG), an AI-native and policy-aligned framework integrating five interdependent domains: policy and governance, knowledge and research, digital intelligence, tourism operations, and innovation partnerships. The framework positions artificial intelligence not as a standalone optimization tool but as a systemic mediator that enables real-time sustainability governance, anticipatory policy design, and continuous feedback between theory and practice. Environmental signals, operational data, and research outputs are embedded into governance processes to support adaptive decision-making and resilience. The contribution advances tourism research beyond smart tourism and indicator-based sustainability models toward intelligence-driven system design. The framework offers practical implications for policymakers, destination managers, and innovation ecosystems and provides a foundation for future empirical validation, digital twin simulations, and policy experimentation aimed at sustainable and adaptive tourism development.

Keywords: *Tourism Governance, Artificial Intelligence, Digital Twins, Sustainability, Systems Theory, Innovation Ecosystems*

Teacher AI Tool Adoption and Student 21st-Century Competencies in Rural Pakistan: A Descriptive-Correlational Study

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Abstract: This study examines the relationship between teachers' adoption of Artificial Intelligence (AI) tools and the development of students' 21st-century competencies in rural secondary schools of Southern Punjab, Pakistan. Using a descriptive-correlational design, data were collected from 100 students (Grades 9–12) through a structured questionnaire measuring perceived teacher AI integration and student competencies (critical thinking, collaboration, communication, creativity, digital literacy, and adaptability). The instrument demonstrated strong internal consistency (Cronbach's $\alpha > 0.80$). Results indicate a moderately low level of teacher AI adoption (weighted mean = 2.46–2.51), constrained primarily by infrastructural limitations (85% reporting unreliable internet/electricity), limited device access, insufficient professional training (mean = 2.25), and financial barriers. AI usage was largely confined to mobile-based presentations and adaptive learning tools. Despite limited implementation, students reported positive perceptions of AI-enhanced pedagogy on competency development (weighted mean = 3.09). Pearson's correlation analysis revealed a strong, statistically significant relationship between teacher AI adoption and student competencies ($r = 0.72$, $p < 0.001$). The findings suggest that even modest AI integration can positively influence skill development in resource-constrained contexts, provided that policy interventions support infrastructure, teacher capacity-building, and context-sensitive AI solutions designed for low-bandwidth rural environments.

Keywords: *AI in Education, Teacher Technology Adoption, 21st-Century Skills, Rural Digital Divide, Educational Innovation*

Digital Solution to Optimize a Unified Surface and Subsurface Simulation Framework for Geothermal Systems

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Abstract: This study presents a digital solution for optimizing geothermal energy systems through a unified simulation framework that integrates subsurface reservoir dynamics with surface facility operations. The increasing complexity of geothermal systems requires holistic modeling approaches capable of capturing the interdependencies between reservoir behavior and power generation processes. In response, the proposed framework combines reservoir simulation, surface gathering networks, and power plant operations within a single computational environment, enabling comprehensive system-level analysis and improved decision-making. The methodology is based on a bidirectional, time-synchronized data exchange mechanism implemented through an HTTP-based interface controlled by a Python orchestration layer. This integration allows continuous communication between subsurface and surface models at each simulation time step, thereby accurately representing dynamic interactions and evolving system conditions. Such a unified approach overcomes the limitations of traditional isolated modeling techniques and provides a more realistic representation of geothermal system performance. The framework is validated using a geothermal field consisting of eleven production wells and eight injection wells connected to a binary cycle power plant. Two case studies demonstrate its capabilities. The first evaluates the impact of reservoir depletion on long-term power generation, highlighting the necessity of integrated modeling for sustainable energy forecasting. The second investigates an operational optimization scenario involving the shutdown of a production well. Results show that the framework successfully redistributes flow and identifies optimized operational strategies that maintain a stable power output of approximately 1.59 MW while preserving system efficiency and resilience. Overall, the proposed digital integration approach enhances predictive accuracy, supports operational optimization, and improves strategic planning in geothermal energy systems. It contributes to advancing sustainable geothermal development by enabling efficient resource management, reducing operational risks, and supporting global efforts toward low-carbon and climate-resilient energy infrastructure.

Keywords: *Digital Integration, Geothermal Energy, Integrated Reservoir–Surface Modeling, Optimization, System Level Optimization*

Decision Support Tool for Integrating Cargo Bicycles and Microhubs in Urban Logistics Systems

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Abstract: This study proposes a simulation-based decision support framework for integrating cargo bicycles and microhubs into urban logistics systems, focusing on multi-criteria efficiency evaluation including cost, delivery time, and emissions. The framework is built on a discrete-event simulation model that captures the complete small-parcel delivery cycle under stochastic demand conditions and operational constraints. The model incorporates multiple transport modes, including cargo bicycles and conventional delivery vehicles, and allows systematic variation of key parameters such as demand intensity, fleet composition, logistics configurations, and policy interventions. The simulation generates integrated performance indicators and probabilistic distributions of key outputs, enabling risk-aware and data-driven decision-making. The proposed framework provides a flexible and scalable tool for evaluating sustainable urban logistics strategies and supports the transition toward low-emission and efficient last-mile delivery systems.

Keywords: *Urban Logistics, Cargo Bicycle Systems, Microhub Integration, Discrete-Event Simulation, Sustainable Transport*

Intelligent Thermal Runaway Detection and Prevention System for Electric Vehicle Batteries using Edge AI

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Abstract: This work introduces a battery thermal runaway detection and prevention system for electric vehicles powered by Edge AI technology. A serious safety risk caused by fire and explosion can occur when the temperature reaches high levels uncontrolled. The architecture of the system comprises the integration of various sensors: DHT11 temperature, ACS770 current, voltage, and MQ-2 gas sensors. Moreover, the sensors significantly contribute by incessantly observing the key factors of the battery pack. Data processing is done locally with an Arduino-integrated ESP8266 module, enabling wireless communication to IoT platforms like ThingSpeak. Lightweight machine learning algorithms at the edge provide real-time anomaly detection and predictive analytics with low latency. In case of abnormal condition detection, the system triggers preventive mechanisms, such as cooling activation or system shutdown. This intelligent and low-power design improves the safety, reliability, and battery life of electric vehicles by enabling early fault prediction, autonomy in response, and efficient energy management with Edge AI-based decision-making.

Keywords: *Electric Vehicles, Battery Safety, Thermal Runaway, Real-Time Monitoring, Predictive Maintenance, Edge Computing, Anomaly Detection*

AI Power Sign Language Interpreter for Inclusive Communication

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Abstract: This work presents an Artificial Intelligence (AI)-based sign language interpretation system designed to improve communication for hearing- and speech-impaired individuals. The system utilizes computer vision and deep learning techniques, where MediaPipe extracts 21 hand landmarks and a Convolutional Neural Network (CNN) performs classification of American Sign Language (ASL) alphabets and control gestures. A real-time pipeline is implemented using a webcam interface, with results displayed through a Flask-based web application. Additional features include auto-suggestion, delay control, and text-to-speech conversion using gTTS and pyttsx3. The system achieves real-time performance (25–28 FPS) and reports accuracy between 95% and 98%, enabling efficient gesture-to-text and speech conversion. The solution targets applications in education, healthcare, workplaces, and public services, with future work including dynamic gesture recognition and mobile deployment.

Keywords: *Sign Language, Computer Vision, CNN, MediaPipe, Assistive Technology, Real-Time Recognition, Deep Learning*



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