International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 10, pp 255-264, October-2025

https://doi.org/10.47001/IRJIET/2025.910032

A Geospatial AI and Digital Twin Framework for Financial Risk Management in Sustainable Infrastructure Corridors: A Comprehensive Review

[1]Nisha Kumari, [2]Arun Kumar, [3]Dr. Manoj Kumar, [4]Manpreet Singh, [5]Mohit

[1]Assistant Professor, Department of Commerce, Govt. College Dehra Kangra Himachal Pradesh, India, nishahpu@gmail.com
[2]Assistant Professor, Chandigarh School of Business, CGC University, Mohali, Punjab, India, aryaa7477@gmail.com
[3]Assistant Professor, Department of Management, Sant Baba Bhag Singh University Jalandhar, India manojchandel24@gmail.com
[4]Assistant Professor, Department of CSE, UIET, Sant Baba Bhag Singh University, Jalandhar, India
[5]Assistant Professor, Department of CE, Ludhiana College of Engineering & Technology, Katani Kallan, Ludhiana, India

Abstract - **The global push for sustainable development is driving unprecedented investment in large-scale infrastructure corridors, such as renewable energy grids, sustainable transport networks, and resilient water systems. While critical for a low-carbon future, these projects present a unique and complex set of financial risks that traditional risk management models, often siloed and reliant on historical data, are ill-equipped to handle. This paper proposes and elaborates on a novel, integrative framework that leverages the convergent power of Geospatial Artificial Intelligence (GeoAI) and Digital Twins to revolutionize financial risk management for sustainable infrastructure corridors. We review the limitations of current financial models in capturing the dynamic, multi-scale, and interconnected risks from climate physical risks and geopolitical tensions to supply chain disruptions and community opposition inherent in these long-lived, place-based assets. The core of the paper delineates the architecture of the proposed framework, detailing how GeoAI ingests and analyzes vast spatiotemporal data (e.g., satellite imagery, IoT sensor feeds, social media data) to create a living, data-rich representation of the corridor. This representation is then operationalized through a financial Digital Twin, a dynamic simulation model that mirrors the physical corridor's behavior and its financial performance in near real-time. We explore specific applications across the project lifecycle, including: enhanced due diligence and site selection, real-time monitoring of construction progress and budget adherence, dynamic forecasting of operational revenues under climate stress, and stress-testing financial resilience against cascading failure scenarios. The paper concludes by discussing the significant implementation challenges data governance, model interoperability, and skills gaps and outlines a future research agenda. This framework promises a paradigm shift from reactive, static financial assessment to a proactive, predictive, and spatially-aware approach, thereby de-risking capital, lowering the cost of financing, and accelerating the deployment of vital sustainable infrastructure.**

Keywords: Geospatial AI, Digital Twin, Financial Risk Management, Sustainable Infrastructure, Project Finance, Climate Risk, ESG, Real-Time Analytics, Predictive Modelling.

I. Introduction

The 21st century is defined by two interconnected imperatives: the urgent need for sustainable development and the digital transformation of every economic sector [1] [2] [3]. Nowhere is this convergence more critical than in the development of large-scale **sustainable infrastructure corridors** [4] [5] [6].

These are not single projects but extensive, interconnected systems think of transnational high-speed rail networks, continental-scale green hydrogen pipelines, or sprawling offshore wind farms connected to smart grids. They form the backbone of a resilient, net-zero economy [7] [8] [9] [10].

However, their scale, complexity, and long lifespan (often 50-100 years) expose investors, developers, and governments to a formidable array of financial risks [11] [12] [13]. Traditional financial risk management, rooted in spreadsheet-based models and historical actuarial data, struggles with the **dynamic, non-linear, and spatially explicit** nature of these risks [14] [15] [16]. A single extreme weather event can damage multiple assets along a corridor; a change in land-use policy can derail a project's viability; community opposition in one locality can create cascading delays and cost overruns [17] [18] [19] [20].

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

The core problem is a disconnect between the physical reality of the infrastructure and its financial representation. Financial models are often abstract, static, and blind to the geographic context that fundamentally drives risk. This gap leads to capital misallocation, unexpected losses, and ultimately, a higher cost of capital for projects that are essential for our collective future [54] [55] [56].

This paper posits that a solution lies in the synergistic application of two transformative technologies: **Geospatial Artificial Intelligence (GeoAI)** and **Digital Twins**. GeoAI provides the "eyes and brains" to understand the complex, changing environment in which the corridor exists. Digital Twins provide the "nervous system and crystal ball," creating a living, virtual replica that connects physical conditions directly to financial outcomes. Together, they enable a paradigm shift from reactive risk mitigation to proactive risk intelligence.

This review paper aims to:

1. Critically analyze the limitations of current financial risk management practices for sustainable infrastructure.
2. Introduce and describe a comprehensive framework integrating GeoAI and Digital Twins.
3. Detail the application of this framework across the infrastructure project lifecycle, with specific financial use cases.
4. Discuss the implementation challenges and propose a future research agenda for the finance and business management community.

II. The Inadequacy of Traditional Financial Risk Models for Sustainable Corridors

Sustainable infrastructure corridors are characterized by risks that are poorly served by traditional models [21] [22] [23] [54].

2.1 The Multi-Scale and Interconnected Nature of Risk

- **Climate Physical Risks:** The impact of a hurricane, wildfire, or flood is not a single probability event. It is a geospatial phenomenon. Traditional models might assign a blanket risk premium, but they cannot model how a 1-in-100-year flood would specifically inundate a substation, wash out a rail segment, and disrupt a just-in-time supply chain for maintenance, all simultaneously. The risk is correlated and cascading across geography [24] [25] [26].
- **Transition Risks:** The policy and technological landscape for sustainability is evolving rapidly. A new protected area designation or a shift in carbon pricing can alter the economics of a corridor. These are spatial policies with localized impacts that static models fail to incorporate dynamically [27] [28] [29] [30].
- **Geopolitical and Social Risks:** A corridor crossing multiple jurisdictions faces a mosaic of regulatory, political, and social acceptance challenges. Community opposition, often visible through localized social media sentiment or land-use disputes, can manifest as "social license to operate" risk, causing costly delays. This is inherently a geospatial and socio-economic data problem [30] [31] [32] [33] [34].

2.2 The Static vs. Dynamic Disconnect

Financial models are typically "point-in-time" assessments. Once built, the model is often shelved until the next reporting period. A sustainable infrastructure corridor, however, is a living entity [35] [36]. Soil erosion gradually undermines a foundation, changing weather patterns affect renewable energy output, and urban encroachment creates new maintenance challenges [51] [52] [53]. The financial model, disconnected from this physical reality, becomes increasingly inaccurate over time [55] [37].

2.3 The Data Silos

Engineering data (from CAD/BIM models), environmental data (from satellite imagery), operational data (from SCADA systems), and financial data (from ERP systems) reside in separate silos. This prevents a holistic view of how a physical event, like a turbine blade crack detected by a drone (geospatial engineering data), translates into repair costs, downtime, and lost revenue (financial data) [38] [39] [40].

III. The Convergent Technology Framework: GeoAI and Digital Twins

To overcome these limitations, we propose an integrated framework where GeoAI and Digital Twins function as two halves of a cohesive whole.

3.1 Geospatial AI (GeoAI): The Situational Intelligence Layer

GeoAI is the application of Artificial Intelligence particularly machine learning (ML) and deep learning to geospatial data. It moves beyond simple mapping to extracting

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

patterns, making predictions, and automating analysis from location-based information [41] [42] [43].

- **Data Ingestion and Fusion:** The framework ingests a constant stream of multi-source data:
  - **Remote Sensing:** Satellite imagery (optical, SAR, hyperspectral) for land cover change, vegetation encroachment, construction progress monitoring, and disaster impact assessment [44].
  - **IoT and Sensor Networks:** Data from sensors on assets (vibrations, strain, temperature) and environmental sensors (weather, air quality) [45].
  - **Unstructured Data:** News feeds, social media, and regulatory documents, which can be geotagged and analysed for sentiment and risk events.
  - **Traditional Data:** BIM/GIS models, financial transactions, and demographic databases.
- **AI-Driven Analytics:** GeoAI models process this data to generate actionable insights [49] [50]:
  - **Object Detection:** Automatically identifying and counting assets, tracking construction equipment, or detecting unauthorized structures in the right-of-way [46].
  - **Change Detection:** Monitoring land degradation, coastal erosion, or urban expansion over time.
  - **Predictive Modelling:** Forecasting solar irradiance or wind patterns for revenue projections, or predicting flood paths and their asset impact.
  - **Anomaly Detection:** Identifying unusual patterns in sensor data that indicate impending equipment failure.

3.2 The Financial Digital Twin: The Dynamic Simulation Layer

A Digital Twin is a virtual, dynamic, and data-driven replica of a physical asset, process, or system. A **Financial Digital Twin (FDT)** is a specialized incarnation that simulates the financial performance of the physical asset in response to its operating conditions [47] [48].

- **The Feedback Loop:** The FDT is not a static model. It is continuously updated with real-world data from the GeoAI layer. If GeoAI detects a construction delay via satellite, the FDT automatically updates the project's cash flow forecast and debt service coverage ratio. If sensors indicate higher-than-expected wear on a component, the FDT revises maintenance capital expenditure forecasts [54] [55] [56].
- **Core Capabilities:**
  1. **Real-Time Financial Dashboards:** Providing a live view of key financial metrics (NPV, IRR, DSCR) linked directly to physical performance.
  2. **Scenario Analysis and Stress-Testing:** Running "what-if" simulations in a risk-free virtual environment. "What is the financial impact if a drought reduces hydropower output by 20% for six months?" or "How does a 15% increase in steel tariffs affect our total project cost?"
  3. **Predictive Maintenance and CAPEX Forecasting:** Moving from scheduled to condition-based maintenance, optimizing spare parts inventory, and providing accurate long-term capital allocation forecasts.
  4. **Cascading Failure Analysis:** Modelling how a failure in one part of the corridor (e.g., a key transformer) impacts the financial performance of the entire system.

IV. Framework in Action: Applications Across the Project Lifecycle

The value of the GeoAI and Digital Twin framework is realized through its application across the entire infrastructure lifecycle.

4.1 Phase 1: Pre-Construction (Planning, Due Diligence, and Financing)

This is the phase of highest leverage, where key decisions lock in 80% of the project's risk profile.

- **Optimal Corridor Routing:** GeoAI can analyze terabytes of geospatial data to model the lowest-risk, lowest-cost route. ML models can weigh factors like

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

slope stability, flood plains, wildfire risk, habitat sensitivity, land value, and social acceptance (using socio-economic data). This moves routing from an art to a data-driven science.

- **Enhanced ESG Due Diligence:** Investors are increasingly mandated to assess ESG risks. GeoAI can automatically map a proposed route against protected areas, indigenous lands, and biodiversity hotspots, flagging potential conflicts years in advance. This mitigates reputational risk and the risk of legal challenges.

- **Accurate Cost and Schedule Estimation:** The FDT can be seeded with this geospatially-informed design. By simulating the construction process virtually, accounting for terrain, weather, and potential supply chain bottlenecks, it can generate a far more robust and probabilistic budget and schedule, reducing the risk of "optimism bias."

4.2 Phase 2: Construction (Execution and Monitoring)

This phase is notorious for cost overruns and delays. The framework provides real-time transparency.

- **Progress Verification and Draw Management:** Instead of relying on monthly manual reports, lenders and investors can use GeoAI on satellite or drone imagery to autonomously verify construction progress. This data feeds directly into the FDT, which can automatically validate payment (draw) requests against physically completed work, reducing fraud and dispute risk.

- **Proactive Risk Mitigation:** GeoAI can monitor for geohazards. For example, InSAR (Interferometric Synthetic Aperture Radar) can detect millimeter-scale ground subsidence that could threaten a tunnel or pipeline. An alert is triggered, and the FDT immediately models the financial impact of potential mitigation strategies, enabling proactive intervention before a major cost event occurs.

- **Supply Chain Logistics Optimization:** Tracking the movement of materials (e.g., wind turbine blades) using GPS and GeoAI can predict delays due to weather or traffic, allowing for dynamic rescheduling and cost avoidance.

4.3 Phase 3: Operation and Maintenance (Long-Term Value Preservation)

This is the longest phase, where steady cash flows and operational efficiency determine ultimate financial returns.

- **Dynamic Revenue Forecasting:** For a solar corridor, the FDT integrates GeoAI-powered weather forecasts with the physical model of the solar farm (including panel efficiency and degradation) to predict power output and revenue for the next 72 hours or next season. This is crucial for energy trading, hedging, and meeting lender covenants.

- **Resilience-Linked Finance:** The framework provides the technological backbone for innovative financial instruments. An insurer or bondholder can offer lower premiums or interest rates if the FDT can demonstrate, through continuous monitoring and simulation, that the asset is being maintained to a high resilience standard and that pre-defined risk mitigation protocols are being followed.

- **Climate Stress-Testing:** Regulators and investors are demanding climate stress tests. The FDT can run scenarios where IPCC climate models (e.g., RCP 8.5) are downscaled to the corridor's specific location. It can simulate the financial impact of decades of sea-level rise on a coastal asset or prolonged heatwaves on a transmission line's capacity, informing long-term adaptation investments.

V. Challenges and Implementation Pathway

The promise is profound, but the path to implementation is non-trivial.

- **Data Governance and Quality:** The framework's output is only as good as its input. Establishing data standards, ensuring sensor calibration, managing the sheer volume (the "data deluge"), and navigating data privacy (e.g., from drone footage) are critical challenges.

- **Interoperability and Integration:** Getting legacy financial systems, BIM models, GIS platforms, and IoT networks to communicate seamlessly requires significant investment in APIs and middleware. A common semantic framework is needed.

- **Model Risk and "Black Box" Concerns:** The complex ML models within GeoAI and the FDT can be perceived as "black boxes." For financial decision-

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

making, explainability (XAI) is crucial. Stakeholders need to understand *why* the model is predicting a certain outcome.

- **Skills Gap and Organizational Change:** Financial institutions lack geospatial experts, and engineering firms lack financial modellers. Bridging this gap requires cross-disciplinary teams and a cultural shift from siloed decision-making to integrated, data-driven collaboration.

- **High Initial Investment:** The cost of setting up the sensor network, computing infrastructure, and skilled team can be high. A clear business case focusing on risk reduction, lower financing costs, and operational efficiency is required to justify the investment.

A prudent implementation pathway starts with a **"Minimum Viable Twin"** a focused Digital Twin for the highest-risk segment of a corridor or for a single critical process, like predictive maintenance. Success in this limited scope can build the case for broader rollout.

VI. Conclusion and Future Research Agenda

The transition to a sustainable global economy is the largest investment opportunity of our time, but it is fraught with novel and complex risks. Traditional financial risk management, a relic of a less connected, less data-rich era, is no longer fit for purpose. The integrative framework of Geospatial AI and Financial Digital Twins presented in this review offers a transformative alternative.

By creating a living, breathing, and spatially-aware virtual representation of a sustainable infrastructure corridor, we can bridge the critical gap between physical reality and financial abstraction. This enables a shift from managing surprises to managing foreseen uncertainties. The benefits are systemic: it de-risks private capital, lowers the cost of finance for essential projects, enhances transparency for regulators and communities, and ultimately accelerates the deployment of the infrastructure we need for a resilient future.

This emerging field presents a rich agenda for future research in finance and business management:

1. **Quantifying the Financial ROI:** Empirical studies are needed to quantify the risk premium reduction and valuation uplift achievable through this framework.

2. **Standardization of ESG Metrics:** Research into how GeoAI can be used to create standardized, auditable, and spatially-explicit ESG performance indicators for infrastructure assets.

3. **Blockchain Integration:** Exploring the integration of blockchain with the FDT for automated, smart contract-based insurance payouts or bond coupon payments triggered by verifiable geospatial events (e.g., a hurricane of a certain intensity).

4. **Behavioral Finance Aspects:** Investigating how to present the complex outputs of the FDT to CFOs, board members, and investors to facilitate trust and decision-making.

5. **Policy and Regulation:** Developing proposals for how regulators could accept FDT-based stress tests as part of prudential requirements for infrastructure lenders and investors.

The journey towards this new paradigm has begun. For financial institutions, engineering firms, and policymakers, the question is no longer *if* this convergence will happen, but how quickly they can build the capabilities to lead and thrive in the new era of spatially intelligent finance.

REFERENCES

[1] Chagger, Jeevanjot & chedda, Er & Wuntah, Er. (2025). Review study: Waste glass powder (WGP) with replacement of cement. *International Journal of Structural Design and Engineering*. 6. 01-06. 10.22271/27078280.2025.v6.i2a.43. https://www.researchgate.net/publication/394245448_Review_study_Waste_glass_powder_WGP_with_replacement_of_cement

[2] Sharma, H., Singh, J., Kumar, A., Bala, M., & Kumar, S. (2025, June). Review on the utilization of the Geogrids in road construction. *In AIP Conference Proceedings* (Vol. 3261, No. 1, p. 120002). *AIP Publishing LLC.* https://www.researchgate.net/publication/392428380_Review_on_the_utilization_of_the_Geogrids_in_road_construction

[3] Singh, Mehir & Thakur, Dr. (2024). Optimizing Tourism and Traffic with ITS in Nepal and India. *International Journal of Applied Science and Engineering Review*. 5. 2582-6948. Vol. 5 Issue 7, July 2024, https://www.researchgate.net/publication/387540549_Optimizing_Tourism_and_Traffic_with_ITS_in_Nepal_and_India

[4] Ashraf, Aadil & Thakur, Dr. (2023). Use of Waste Polythene in Bituminous Concrete Mixes for Highways. *International Journal for Research in Applied Science and Engineering Technology*. 11. 1709-1712. 10.22214/ijraset.2023.56293. https://www.researchgate.net/publication/375113951_

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

Use_of_Waste_Polythene_in_Bituminous_Concrete_Mixes_for_Highways

[5] Chagger, Jeevanjot & Anil, Er. (2025). A REVIEW STUDY: ELECTRICAL WORK ON CONSTRUCTION SITE. *Industrial Engineering Journal, ISSN: 0970-2555*, Volume: 53, Issue 6, No.5, June: 2024. https://www.researchgate.net/publication/396053644_A_REVIEW_STUDY_ELECTRICAL_WORK_ON_CONSTRUCTION_SITE

[6] Chagger, Jeevanjot & chedda, Er & Wuntah, Er. (2025). Review study: Waste glass powder (WGP) with replacement of cement. *International Journal of Structural Design and Engineering.* 6. 01-06. 10.22271/27078280.2025.v6.i2a.43. https://www.researchgate.net/publication/394245448_Review_study_Waste_glass_powder_WGP_with_replacement_of_cement

[7] Sharma, H., Singh, J., Kumar, A., Bala, M., & Kumar, S. (2025, June). Review on the utilization of the Geogrids in road construction. *In AIP Conference Proceedings* (Vol. 3261, No. 1, p. 120002). *AIP Publishing LLC.* https://www.researchgate.net/publication/392428380_Review_on_the_utilization_of_the_Geogrids_in_road_construction

[8] Suri, Navleen & Chagger, Jeevanjot & Sharma, Er. Harish & Chandel, Dr. (2025). INVESTIGATION ON THE TENSILE STRENGTH WITH USE OF ScBA AND WPSA WITH PARTIAL REPLACEMENT OF CEMENT IN CONCRETE. *Industrial Engineering Journal.* 54. 678-704. https://www.researchgate.net/publication/391643779_INVESTIGATION_ON_THE_TENSILE_STRENGTH_WITH_USE_OF_ScBA_AND_WPSA_WITH_PARTIAL_REPLACEMENT_OF_CEMENT_IN_CONCRETE

[9] Jeevanjot Singh, Simran, Pema Chheda, Prince Wuni Wuntah. A review study on machine learning to investigate the issue of plastic pollution in oceans. *Int J Hydropower Civ Eng* 2025; 6(1):48-51. DOI: 10.22271/27078302.2025.v6.i1a.62. https://www.researchgate.net/publication/396213967_A_review_study_on_machine_learning_to_investigate_the_issue_of_plastic_pollution_in_oceans

[10] Chagger, Jeevanjot & Sharma, Er. Harish & Bala, Er. (2024). PARTIAL REPLACEMENT OF CEMENT WITH RICE HUSK ASH & SUGARCANE BAGASSE ASH: REVIEW PAPER. *Industrial Engineering Journal ISSN: 0970-2555* Volume: 53, Issue 6, June: 2024. https://www.researchgate.net/publication/387567151_PARTIAL_REPLACEMENT_OF_CEMENT_WITH_RICE_HUSK_ASH_SUGARCANE_BAGASSE_ASH_REVIEW_PAPER

[11] Suri, Navleen & Chagger, Jeevanjot & Sharma, Er. Harish & Chandel, Dr. (2025). INVESTIGATION ON THE COMPRESSIVE STRENGTH WITH USE OF ScBA AND WPSA WITH PARTIAL REPLACEMENT OF CEMENT IN CONCRETE. *Industrial Engineering Journal. Industrial Engineering Journal ISSN: 0970-2555* Volume: 54, Issue 4, April: 2025. https://www.researchgate.net/publication/391643772_INVESTIGATION_ON_THE_COMPRESSIVE_STRENGTH_WITH_USE_OF_ScBA_AND_WPSA_WITH_PARTIAL_REPLACEMENT_OF_CEMENT_IN_CONCRETE

[12] Chagger, Jeevanjot & Bala, Er & Sharma, Er. Harish. (2024). INVESTIGATE THE COMPRESSIVE STRENGTH OF CONCRETE USING FLY ASH ON M30 CONCRETE GRADE. *Industrial Engineering Journal ISSN: 0970-2555* Volume: 53, Issue 6, No.5, June: 2024 https://www.researchgate.net/publication/387566115_INVESTIGATE_THE_COMPRESSIVE_STRENGTH_OF_CONCRETE_USING_FLY_ASH_ON_M30_CONCRETE_GRADE

[13] Singh, Er & Chagger, Jeevanjot. (2024). Review Study: Robotics and Automation in Construction, *IRJIET*, Volume 8, Issue 11, November 2024 pp. 260-264. 10.47001/IRJIET/2024.811033. https://www.researchgate.net/publication/396051331_Review_Study_Robotics_and_Automation_in_Construction

[14] Chagger, Jeevanjot & Sharma, Er. Harish. (2024). Review Study on Partial Replacement of Cement with Sugarcane Bagasse Ash (SCBA), *National Conference on "Empowering Sustainability: Bridging Science, Technology and Climate Resilience" (ESBSTCR-2024)*, 17-19 Jan 2024; SBBS University, Jalandhar, Punjab. https://www.researchgate.net/publication/396270286_Review_Study_on_Partial_Replacement_of_Cement_with_Sugarcane_Bagasse_Ash_SCBA

[15] Chagger, Jeevanjot & Sharma, Er. Harish. (2024). A Review: ScBA& WPSA Used in Concrete as Partial Replacement of Cement, *National Conference on "Empowering Sustainability: Bridging Science, Technology and Climate Resilience" (ESBSTCR-2024)*, 17-19 Jan 2024; SBBS University, Jalandhar, Punjab. https://www.researchgate.net/publication/396270282_A_Review_ScBA_WPSA_Used_in_Concrete_as_Partial_Replacement_of_Cement

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

[16] Chagger, Jeevanjot & Sharma, Er. Harish. (2024). A Review on Improving Asphalt Mixtures Through the Use of Geosynthetics and Waste Fibers, *National Conference on "Empowering Sustainability: Bridging Science, Technology and Climate Resilience" (ESBSTCR-2024)*, 17-19 Jan 2024; SBBS University, Jalandhar, Punjab. https://www.researchgate.net/publication/387573908_A_Review_on_Improving_Asphalt_Mixtures_Through_the_Use_of_Geosynthetics_and_Waste_Fibers

[17] Mahi, Vishal & Chagger, Jeevanjot & Sharma, Er. Harish & Bala, Er. (2024). Performance Evaluation of Adhession in Recycled & Reused Construction Material in RCC, *International Research Journal of Innovations in Engineering and Technology (IRJIET)*, ISSN (online): 2581-3048, Volume 8, Issue 1, pp 19-37, January-2024. https://doi.org/10.47001/IRJIET/2024.801004,https://www.researchgate.net/publication/387570170_Performance_Evaluation_of_Adhession_in_Recycled_Reused_Construction_Material_in_RCC

[18] Anmol, & Sharma, Er. Harish & Bala, Er & Chagger, Jeevanjot. (2023). An Examination the Use of Waste Glass Powder as Cement Partial Replacement in Concrete. *International Research Journal of Innovations in Engineering and Technology (IRJIET)* ISSN (online): 2581-3048 Volume 7, Issue 11, pp 343-355, November-2023. https://doi.org/10.47001/IRJIET/2023.711047,https://www.researchgate.net/publication/375826197_An_Examination_the_Use_of_Waste_Glass_Powder_as_Cement_Partial_Replacement_in_Concrete

[19] Chagger, Jeevanjot & Singh, Gurpreet & Mohit, (2023). A Review Study on The Use of Geosynthetics in Road Constructions. *International Journal of Research Publication and Reviews*, Vol 4, no 7, pp 518-522 July 2023. https://ijrpr.com/uploads/V4ISSUE7/IJRPR15273.pdf,https://www.researchgate.net/publication/396052553_A_Review_Study_on_The_Use_of_Geosynthetics_in_Road_Constructions

[20] Chagger, Jeevanjot. (2023). ASSESSING THE EFFECTIVENESS OF BAMBOO IN ENHANCING THE STRENGTH OF CONCRETE STRUCTURES: A REVIEW STUDY, *International Journal of Engineering Technology Research & Management*, Vol-07 Issue 07, 68-76, July-2023. https://www.researchgate.net/publication/396052546_ASSESSING_THE_EFFECTIVENESS_OF_BAMBOO_IN_ENHANCING_THE_STRENGTH_OF_CONCRETE_STRUCTURES_A_REVIEW_STUDY

[21] Singh, J.; Chandel, S.K.; Mohit; Singh, G. The Article Explores Improving the Performance of Asphalt Mixtures through the Utilization of Added Fibers. *Int. Res. J. Innov. Eng. Technol.* 2023, 7, 59–65. https://www.researchgate.net/publication/389533862_The_Article_Explores_Improving_the_Performance_of_Asphalt_Mixtures_through_the_Utilization_of_Added_Fibers

[22] Singh J, Mohit, Gurpreet Singh. Case study on partial replacement of cement with RHA. Int J Res Anal Rev (IJRAR). 2023; 10(3):5-10. Available from: http://www.ijrar.org/IJRAR23C1002.pdf,https://www.researchgate.net/publication/389533760_Case_Study_on_Partial_Replacement_of_Cement_with_RHA

[23] J. Singh, D. S. Chandel, "An Examination and Investigation Compressive Strength the Use of Waste Paper Sludge Ash and Rice Husk Ash as Cement Substitutes in Concrete", *International Journal of Innovative Research in Engineering and Management (IJIREM)*, Vol-10, Issue-3, Page No-60-66, 2023. Available from: https://doi.org/10.55524/ijirem.2023.10.3.11,https://www.researchgate.net/publication/372098556_An_Examination_and_Investigation_Compressive_Strength_the_Use_of_Waste_Paper_Sludge_Ash_and_Rice_Husk_Ash_as_Cement_Substitutes_in_Concrete

[24] Jeevanjot Singh, Mohit, Gurpreet Singh (July2023), "THE EXAMINATION STUDY TO INVESTIGATE THE EFFECTS OF USING A REDUCED AMOUNT OF CEMENT WITH WPSA, '*International Research Journal of Modernization in Engineering Technology and Science*, Volume:05/Issue:07/July-2023 Impact Factor- 7.868 www.irjmets.com, e-ISSN: 2582-5208. https://www.researchgate.net/publication/396052546_ASSESSING_THE_EFFECTIVENESS_OF_BAMBOO_IN_ENHANCING_THE_STRENGTH_OF_CONCRETE_STRUCTURES_A_REVIEW_STUDY

[25] Jeevanjot Singh, Dr. Sandeep Kumar Chandel, Mohit, Gurpreet Singh (2023), "A Study: How Using Waste Paper Sludge Ash and Rice Husk Ash Instead of Cement in Concrete, '*Quest Journals Journal of Architecture and Civil Engineering*, Volume 8 ~ Issue 7, pp: 20-29, ISSN (Online): 2321-8193, www.questjournals.org, https://www.researchgate.net/publication/396052558_A_Study_How_Using_Waste_Paper_Sludge_Ash_and_Rice_Husk_Ash_Instead_of_Cement_in_Concrete

[26] Sah, Nandkishor& Thakur, Dr. (2025). Evaluation of Innovative Construction Techniques for Rapid MSE Wall Installation. 10.1007/978-981-96-7779-5_12. https://www.researchgate.net/publication/396546906_E

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

valuation_of_Innovative_Construction_Techniques_for_Rapid_MSE_Wall_Installation

[27] Singh, Mehir & Thakur, Dr. (2025). USING INTELLIGENT TRANSPORTATION SYSTEMS FOR TOURISM AND TRAFFIC CONTROL IN NEPAL AND INDIA. 2024. https://www.researchgate.net/publication/396143907_USING_INTELLIGENT_TRANSPORTATION_SYSTEMS_FOR_TOURISM_AND_TRAFFIC_CONTROL_IN_NEPAL_AND_INDIA

[28] Thakur, Dr. (2025). View of Thermal Properties of Concrete Prepared with Water Absorbing Beads, *International Conference on Multidisciplinary Approaches for Sustainable Development*, Volume: 32. https://www.researchgate.net/publication/394873033_View_of_Thermal_Properties_of_Concrete_Prepared_with_Water_Absorbing_Beads

[29] Sah, N., Thakur, A., Sah, S.K. (2025). Evaluation of Innovative Construction Techniques for Rapid MSE Wall Installation. In: Dixit, M.S., Jaiswal, S.S., Shermale, Y., Satyam, N., Singh, A.P. (eds) *Proceedings of the Indian Geotechnical Conference (IGC 2024)*, Volume 6. IGC 2024. *Lecture Notes in Civil Engineering, vol 702. Springer, Singapore*. https://doi.org/10.1007/978-981-96-7779-5_12

[30] Thakur, Dr. (2024). Comparative Simulation of Advanced Oxidation Process and Electrocoagulation for Wastewater Treatment: A Two-Dimensional Diffusion–Reaction Study, *Conference: International Conference on Multidisciplinary Approaches for Sustainable Development*, Volume: 31. https://www.researchgate.net/publication/394872905_Comparative_Simulation_of_Advanced_Oxidation_Process_and_Electrocoagulation_for_Wastewater_Treatment_A_Two-Dimensional_Diffusion-Reaction_Study

[31] Thakur, Dr. (2024). Development of Sustainable and Cost-Effective Framework for Rain Water Treatment, *Conference: International Conference on Multidisciplinary Approaches for Sustainable Development*, Volume: 32, https://www.researchgate.net/publication/394872689_Development_of_Sustainable_and_Cost-Effective_Framework_for_Rain_Water_Treatment

[32] Thakur, Dr. (2025). Development of Sustainable and Cost-Effective Framework for Rain Water Treatment. *International Conference on Multidisciplinary Approaches for Sustainable Development*, Volume: 32, https://www.researchgate.net/publication/394872496_Identification_of_Contaminants_Present_in_Rainwater_Collected_from_Ground_Pit_and_its_Removal

[33] N. Sah and A. Thakur, "Innovative Techniques for Rapid MSE Wall Installation", *J. Sci. Techn.*, vol. 4, no. 2, pp. 90–93, May 2025. https://www.researchgate.net/publication/396733403_Innovative_Techniques_for_Rapid_MSE_Wall_Installation

[34] Singh, Mehir & Thakur, Dr. (2024). Optimizing Tourism and Traffic with ITS in Nepal and India. *International Journal of Applied Science and Engineering Review*. 5. 2582-6948. Vol. 5 Issue 7, July 2024, https://www.researchgate.net/publication/387540549_Optimizing_Tourism_and_Traffic_with_ITS_in_Nepal_and_India

[35] Ashraf, Aadil & Thakur, Dr. (2023). Use of Waste Polythene in Bituminous Concrete Mixes for Highways. *International Journal for Research in Applied Science and Engineering Technology*. 11. 1709-1712. 10.22214/ijraset.2023.56293. https://www.researchgate.net/publication/375113951_Use_of_Waste_Polythene_in_Bituminous_Concrete_Mixes_for_Highways

[36] Themisana, Rajkumari & Thakur, Dr &Thaguna, Parwati& Thounaojam, Anuradha & Senagah, Amenjor. (2023). TO DETERMINE THE STRENGTH OF CONCRETE WITH PARTIAL REPLACEMENT OF SAND WITH MARBLE DUST POWDER. 10.17605/OSF.IO/QD68N. https://www.researchgate.net/publication/372724255_TO_DETERMINE_THE_STRENGTH_OF_CONCRETE_WITH_PARTIAL_REPLACEMENT_OF_SAND_WITH_MARBLE_DUST_POWDER

[37] Thagunna, Parwati& Thakur, Dr & Devi, Rajkumari & Thounaojam, Anuradha & Senagah, Amenjor. (2023). EXPERIMENTAL STUDY FOR STABILIZING PROPERTIES OF BLACK COTTON SOIL BY USE OF GEOGRID AND ADMIXTURE. *Journal of Biomechanical Science and Engineering*. APRIL 2023. 725-728. 10.17605/OSF.IO/A4E39. https://www.researchgate.net/publication/372724185_EXPERIMENTAL_STUDY_FOR_STABILIZING_PROPERTIES_OF_BLACK_COTTON_SOIL_BY_USE_OF_GEOGRID_AND_ADMIXTURE

[38] Thakur, Dr. (2023). ASSESSMENT OF INITIATION OF SOIL LIQUEFACTION INDUCED BY EARTHQUAKES: A RESEARCH. *European Chemical Bulletin*. (Special Issue 7). 2240-2259. https://www.researchgate.net/publication/372102614_ASSESSMENT_OF_INITIATION_OF_SOIL_LIQUEFACTION_INDUCED_BY_EARTHQUAKES_A_RESEARCH

[39] Yousuf, Saleem & Thakur, Dr. (2023). A Review Intelligent Transport System. *Zeitschrift fur celtische Philologie*. volume 10. 2017-2045.

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

https://www.researchgate.net/publication/371131269_A_Review_Intelligent_Transport_System

[40] Thakur, Dr. (2023). Enhancing the soils geotechnical properties by using plastic waste: A Review. Yingyong JichuyuGongcheng Kexue Xuebao/*Journal of Basic Science and Engineering*. 23. 168-186. 10.37896/JBSV23.5/2096. https://www.researchgate.net/publication/370528028_Enhancing_the_soils_geotechnical_properties_by_using_plastic_waste_A_Review

[41] Er. Abhilash Thakur, NaveenKumar, Sangharsh Kaith, Sanchit Rana, Pranshu Goyal, D. K. Tiwary, D. R. K. Thakur, "A Critical Review On Fiber Reinforced Polymer Composites In Strengthening Reinforced Concrete Structure", *International Journal of Innovative Research in Engineering and Management (IJIREM)*, Vol-9, Issue-2, Page No-562-567, 2022. Available from: https://doi.org/10.55524/ijirem.2022.9.2.88.

[42] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). A Multi-Method AI Framework for the Sustainable Optimization of Concrete Mix Designs Using Industrial and Agricultural Waste: A Comprehensive Review. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 82-87. Article DOI https://doi.org/10.47001/IRJIET/2025.909012

[43] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). A Geospatial and AI-Based Decision Support System for Planning Sustainable Infrastructure Corridors: Integrating Material Science and Modern Construction Techniques. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 88-94. Article DOI https://doi.org/10.47001/IRJIET/2025.909013

[44] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). Life-Cycle Assessment and Digital Twin Modeling for Resilient and Eco-Friendly Construction Practices: A Comprehensive Review. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 95-102. Article DOI https://doi.org/10.47001/IRJIET/2025.909014

[45] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). An Integrated Review: Harnessing Industry 4.0 Technologies for a Circular Economy in the Construction Sector. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 103-111. Article DOI https://doi.org/10.47001/IRJIET/2025.909015

[46] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). Predicting the Mechanical and Durability Properties of Hybrid Green Concrete using Artificial Neural Networks and Weight of Evidence: A Comprehensive Review. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 112-120. Article DOI https://doi.org/10.47001/IRJIET/2025.909016

[47] Er. Manpreet Singh, Dr. Jagdeep Kaur, & Er. Simran. (2025). Investigation into the Valorization of Agro-Industrial Waste for Sustainable Construction: From Material Characterization to Field Application. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 121-127. Article DOI https://doi.org/10.47001/IRJIET/2025.909017

[48] Er. Manpreet Singh, Dr. Jagdeep Kaur, Er. Simran. (2025). Resilient Infrastructure Development in Mountainous Regions: A Synergy of Natural waste Materials, Geosynthetics, and Intelligent Systems. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 128-134. Article DOI https://doi.org/10.47001/IRJIET/2025.909018

[49] Er. Manpreet Singh, Dr. Jagdeep Kaur, & Simran. (2025). Meta-Analysis and Knowledge Synthesis in Sustainable Construction Materials Using Machine Learning and Information Value Models. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 135-141. Article DOI https://doi.org/10.47001/IRJIET/2025.909019

[50] Er. Manpreet Singh, Dr. Jagdeep Kaur, & Er. Simran. (2025). Automation and Robotics for the Precision Manufacturing of Precast Elements using Sustainable Concrete Mixes. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 142-148. Article DOI https://doi.org/10.47001/IRJIET/2025.909020

[51] Er. Manpreet Singh, Dr. Jagdeep Kaur, & Er. Simran. (2025). A Unified Performance-Based Specification Framework for Green Concrete Incorporating Waste Materials and Advanced Monitoring. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 149-154. Article DOI https://doi.org/10.47001/IRJIET/2025.909021

[52] Chagger, Jeevanjot. (2025). GEOGRAPHIC INFORMATION SYSTEM FOR CIVIL ENGINEERS. 10.5281/zenodo.10636618. https://www.researchgate.net/publication/396525537_GEOGRAPHIC_INFORMATION_SYSTEM_FOR_CIVIL_ENGINEERS

[53] Vanadi, Vinay & Kumar, A & Chagger, Jeevanjot. (2025). NUMERICAL METHODS IN CIVIL ENGINEERING: PRACTICAL APPLICATIONS AND TECHNIQUES. 10.5281/zenodo.15227277.

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 255-264, October-2025
https://doi.org/10.47001/IRJIET/2025.910032

https://www.researchgate.net/publication/396525095_NUMERICAL_METHODS_IN_CIVIL_ENGINEERING_PRACTICAL_APPLICATIONS_AND_TECHNIQUES

[54] Singh, V., Taneja, S., Singh, V., Singh, A., & Paul, H. L. (2021). Online advertising strategies in Indian and Australian e-commerce companies: A comparative study. In Big data analytics for improved accuracy, efficiency, and decision making in digital marketing (pp. 124-138). *IGI Global.*

[55] Sardana, S., Singh, V., & Adhikari, D. (2025). Sustainable Product Design: Materials, Processes, and Longevity. *In Sustainability, Innovation, and Consumer Preference* (pp. 65-90). *IGI Global Scientific Publishing*.

[56] Lalit, N., & Singh, V. (2025). Neuro Green: Case Studies on the Power of Neuromarketing in Promoting Eco-Investments. *In Neuromarketing's Role in Sustainable Finance* (pp. 231-244). *IGI Global*.

Citation of this Article:

Nisha Kumari, Arun Kumar, Dr. Manoj Kumar, Manpreet Singh, & Mohit. (2025). A Geospatial AI and Digital Twin Framework for Financial Risk Management in Sustainable Infrastructure Corridors: A Comprehensive Review. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(10), 255-264. Article DOI https://doi.org/10.47001/IRJIET/2025.910032

****