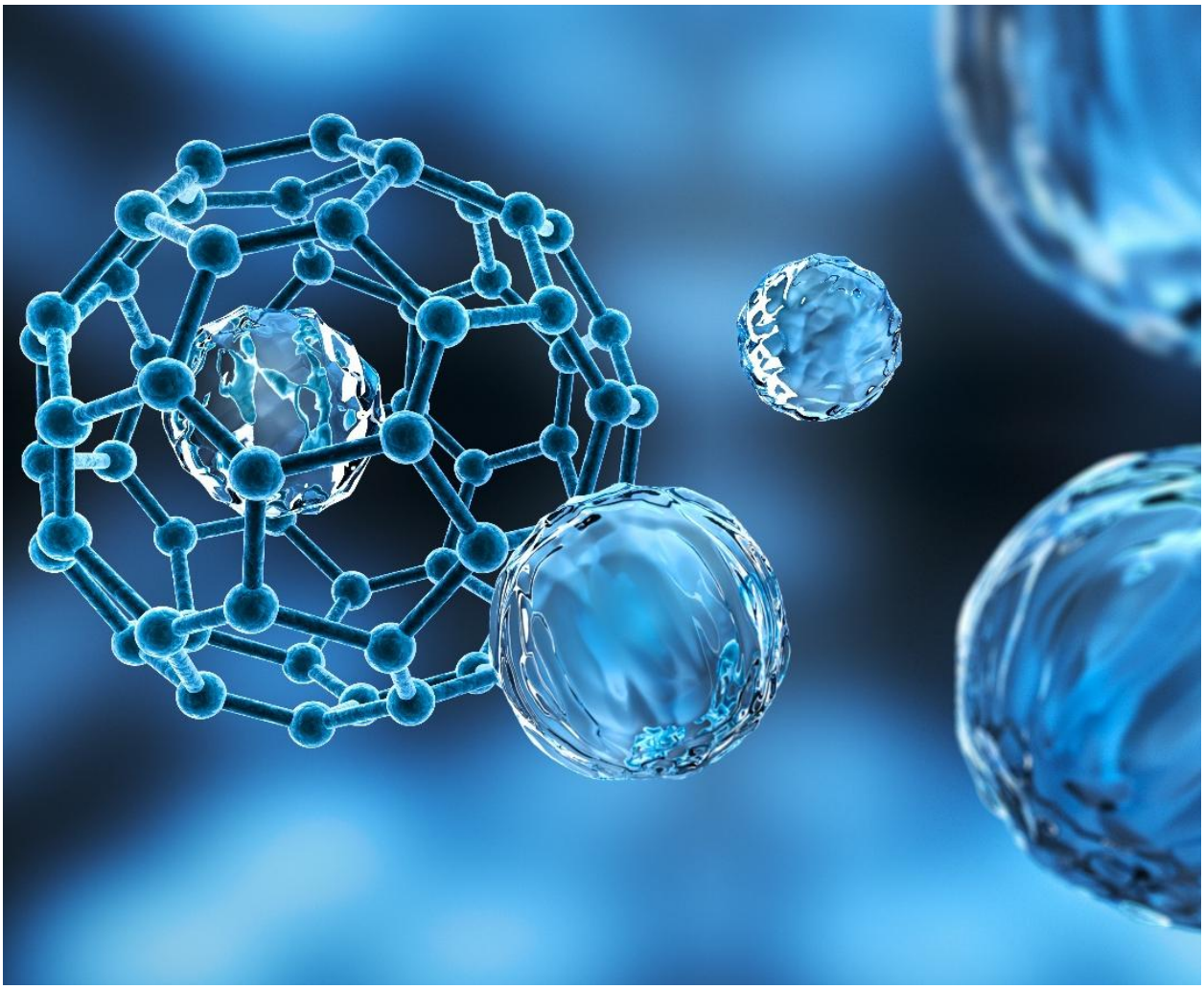
THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Indian Institute of Technology Delhi

UQ IITD Research Academy

UQ–IITD Research Academy **Collaborative Research Grant Scheme**

2024 Report



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Introduction to the Collaborative Research Grant Scheme

Introduced in 2024, the Collaborative Research Grant Scheme was designed to broaden research and engagement between UQ and IITD. It provides seed funding for collaborative projects expected to create enduring partnerships, publications, external-funding pathways and research impact. The scheme supports initiatives that combine complementary expertise, address high-impact questions, test novel concepts, strengthen educational provision, foster interdisciplinary research and demonstrate the added value of the UQ-IITD Research Academy.

UQ and IITD jointly fund selected projects through the scheme. Under the agreed funding arrangements, UQ provided funding for all projects selected in the 2024 round, while IITD funded all projects selected in the 2025 round. From the 2026 round onwards, the two institutions will contribute equal funding towards all selected projects.

2024 scheme at a glance

Funding available	**Up to AUD10,000 (INR550,000) per initiative**
Number of awards	Up to six collaborative research awards
Eligibility	Open to the UQ and IITD academic communities
Project period	Expected completion within 12 months of the award date

Research themes

- Advanced Materials and Manufacturing
- Clean Energy and Sustainability
- Digital Futures and Artificial Intelligence
- Healthcare and Biotechnology
- Quantum Technologies
- Societal Transformations and Livelihoods

Projects awarded in 2024

Project title	Project leads	Research theme	Status
Exploring chemical kinetics in superconducting splice interfaces: Capacity Building at IITD-UQ	Dr Md Shahriar Hossain, UQ and A/Professor Sangeeta Santra, IITD	Advanced materials and healthcare technology	Completed
Transforming agricultural waste into value-added nanocatalysts for green hydrogen production	Dr Yusuf Valentino Kaneti, UQ and Professor Nirat Ray, IITD	Clean Energy and Sustainability	Completed
Multidimensional disaster resilience of water infrastructure	Dr Jurij Karlovsek, UQ and Professor Dipti Ranjan Sahoo	Digital engineering and resilient infrastructure	Completed
Certified responsible AI	A/Professor Dan Kim, UQ and Professor Subodh Sharma, IITD	Digital Futures and AI	In progress
Understanding Autism Spectrum Disorder through micro-exon splicing	Professor Ernst Wolvetang, UQ and Dr Ishan Gupta, IITD	Healthcare and Biotechnology	Completed
Bridging the urban-rural gap: telehealth and NGO/social enterprise models	A/Professor Jay Weerawardena, UQ and Professor Sajay Dhir, IITD	Societal Transformation and Livelihoods	Completed

1. Exploring chemical kinetics in superconducting splice interfaces: Capacity building at UQ-IITD

- UQ Project Lead: A/Professor Md Shahriar Hossain; Professor Yusuke Yamauchi, AIBN
- IITD Project Lead: A/Professor Sangeeta Santra

Project Summary

Funded Activity Overview

The UQ-IITD project activity focused on advancing reliable superconducting magnesium diboride (MgB_2) joint technologies to enable green, cryogen-free MRI magnets and reduce dependence on liquid helium, a major cost driver for current MRI systems in Australia and India. The project addressed the complexity and unreliability of existing joint manufacturing processes and limited understanding of interfacial chemical reactions that constrain industrial deployment.

The activity was implemented through a joint Australia–India collaboration, primarily at UQ and IITD. Superconducting joints were fabricated using hot uniaxial pressing (HUP) and spark plasma sintering (SPS), with SPS demonstrating particularly promising performance. Joint interface engineering was investigated using advanced microstructural characterisation techniques, including SEM, TEM and FIB-SEM. Research findings were disseminated through presentations at the UQ–IITD Symposium, including an invited talk by Dr Sangeeta (IITD) in the international conference in diffusion in solids and liquids help in Naples/Italy. highlighting solid-state diffusion mechanisms and microstructure–kinetics correlations in cryogenic materials. Dr Hao from Dr Hossain's group also presented the project outcome results in top European superconductor conference EUCAS'25 in Porto/Portugal as invited speaker and poster.

Key Stakeholders and Beneficiaries

Key stakeholders included UQ, IITD, UniQuest (for IP assessment and protection of SPS-based joint technology), and the broader superconducting and MRI research communities. Beneficiaries include healthcare providers in Australia and India through potential reductions in MRI operational costs, industrial magnet developers, and the global MRI sector via improved cryogen-free superconducting technologies. Project outcomes include two draft high-impact journal manuscripts, IP review of SPS-manufactured joints, and preparation of an ARC Discovery Project proposal to translate these results into larger-scale research and innovation.

Project Outcomes and Benefits

This funded initiative addressed key scientific and technological challenges limiting the industrial deployment of superconducting magnesium diboride (MgB_2) joints, with the broader objective of enabling reliable, cryogen-free MRI magnets. Current MRI systems rely heavily on liquid helium, leading to high operational and maintenance costs that significantly impact healthcare systems in Australia and India. The project focused on advancing joint manufacturing processes and deepening understanding of interfacial reactions that underpin superconducting performance.

The expected outcomes were successfully achieved. Superconducting joints were fabricated using hot uniaxial pressing (HUP) and spark plasma sintering (SPS). While both techniques yielded functional joints, SPS demonstrated superior interfacial integrity and performance, marking a significant advance toward industrially viable joint technology. Detailed joint interface engineering studies were conducted using advanced SEM, TEM and FIB-SEM characterisation, addressing a major knowledge gap around microstructure–property relationships and solid-state diffusion mechanisms in cryogenic materials.

The project produced strong academic and translational outputs. Two manuscript drafts have been prepared for submission to high-impact journals, and promising SPS-based joint technology is currently under review by UniQuest for intellectual property protection. Selected results were

presented at the UQ–IITD Symposium by project lead Dr Hossain. An invited talk by Dr Sangeeta (IITD) to an international conference on Diffusion in Solids and Liquids, who showcased findings on microstructure–kinetics correlations derived directly from this project. One UQ-based PhD student played a central role in the research, with experimental fabrication and microstructural analysis forming a substantial component of his doctoral thesis, delivering high-quality HDR training and skills development. Postdoctoral Fellow Dr Hao, supervised by A/Prof Hossain, delivered an invited presentation at a leading European superconductivity conference, showcasing the project's successful joint manufacturing methodology, their reaction kinetics and high-performance results.

A key outcome of the initiative was the visit by Dr MD Shahriar Hossain to IITD, where he delivered an invited lecture to an audience of academics, early career researchers, and PhD students. This visit strengthened bilateral engagement, facilitated in-depth technical discussions, and enabled the identification of future joint research directions. Importantly, Dr Hossain's visit also supported early engagement with potential industry stakeholders and helped shape collaborative priorities aligned with large-scale funding opportunities.

The initiative delivered significant benefits to UQ stakeholders, including enhanced international research visibility, HDR training outcomes, and emerging IP with translational potential. IITD benefited through knowledge exchange, co-authorship, staff engagement, and strengthened links to Australian funding schemes. Broader beneficiaries include the superconducting materials community and, in the longer term, healthcare providers through the potential development of lower-cost, cryogen-free MRI systems.

Subsequent activities include the preparation of a new UQ-IITD PhD project and ARC Discovery Project proposal, leveraging the results, partnerships, and momentum generated by this initiative, with anticipated future opportunities in industry-aligned superconducting magnet development.

Additional Joint Research

The funding directly enabled new and deeper joint research activities between UQ and IITD. Financial support facilitated the fabrication and comparative evaluation of superconducting MgB_2 joints using hot uniaxial pressing (HUP) and spark plasma sintering (SPS), work that would not have been feasible within existing baseline resources. Access to advanced characterisation facilities (SEM, TEM and FIB-SEM) supported systematic joint interface engineering studies, significantly advancing understanding of microstructure–property relationships and solid-state diffusion mechanisms relevant to cryogenic applications.

The funding also enabled researcher mobility, including Dr Hossain's visit to IITD, which played a critical role in aligning experimental strategies, identifying complementary expertise, and defining future joint research directions. These interactions catalysed further collaborative work focused on scalable superconducting joint technologies and industry-relevant performance metrics.

Co-publications

The funded activities have resulted in strong co-publication outcomes. Data generated from the SPS-based joint development and advanced microstructural analysis underpin two jointly authored manuscript drafts, currently prepared for submission to high-impact international journals. The funding supported the acquisition of high-quality, publication-ready datasets and enabled iterative discussions between UQ and IITD researchers to jointly interpret results.

In addition, partial results were disseminated through co-presentations at the UQ–IITD Symposium, including an invited talk by Dr Sangeeta (IITD) that explicitly acknowledged and showcased findings from the funded project. These activities have strengthened publication pipelines and increased the visibility of the collaboration within the international superconductivity and MRI research communities.

Grant Applications or Access to External Funding

The funding has acted as a critical enabler for follow-on external funding. Outcomes generated through the project- particularly the promising SPS-based joint performance and improved scientific understanding - are now forming the technical foundation of a new ARC Discovery Project proposal jointly developed by UQ and IITD investigators.

Furthermore, the review of SPS-manufactured joint technology by UniQuest for intellectual property protection has positioned the research for future industry-aligned funding opportunities. Dr Hossain's visit to IITD also facilitated early discussions around industry engagement and translational pathways, expanding the project's funding horizon beyond competitive research grants.

Overall, the funding successfully delivered leverage, converting a focused seed initiative into sustained joint research activity, co-authored publications, and credible access pathways to larger national and international funding schemes.

2. Transforming agricultural waste into value-added nanocatalysts for green hydrogen production

- UQ Project Lead: Dr Yusuf Valentino Kaneti, AIBN
- IITD Project Lead: Associate Professor Nirat Ray

Project Summary

Funded Activity Overview

This project aims to employ agricultural waste to create highly active, stable non-precious metal nanocatalysts for enhancing the hydrogen production in water electrolysis. The project is expected to generate new liquid-phase methods for extracting and purifying phytochemicals (biocompounds) from agricultural waste, new bottom-up methods for converting agricultural waste into value-added catalysts, and new high-performance nanocatalysts for green hydrogen production.

The project involves two major tasks: (1) The biocompound extraction from agricultural waste and the subsequent characterisation were performed at IITD Delhi and (ii) the nanocatalyst fabrication and catalytic performance evaluation were conducted at AIBN, UQ.

Key Stakeholders and Beneficiaries

Key stakeholders included the UQ and IITD research teams, institutional research support units, and the broader clean energy research community. The primary beneficiaries are researchers and students trained through the collaboration, as well as long-term beneficiaries in the hydrogen and advanced manufacturing sectors who may adopt scalable, low-cost catalyst solutions. The project also contributes to environmental and societal benefits by enabling new potential pathways for agricultural waste recycling and supporting a sustainable circular economy, while strengthening the UQ-IITD strategic partnership in clean energy and sustainability.

Project Outcomes and Benefits

The project outcomes were successfully achieved. Through this project, the team developed new general liquid-phase methanol extraction methods to recover valuable phytochemicals, particularly anthocyanin, from agricultural waste including waste black rice, waste fruits (berries), and vegetables (cabbage and carrot). They then used the extracted anthocyanin-rich compounds as green structure-directing agents to replace conventional chemicals, and synthesise novel hierarchical metal phosphide nanocatalysts. These nanocatalysts demonstrated high catalytic activity and strong long-term stability for both the oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) in water electrolysis. Overall, this waste-to-nanocatalyst strategy provides an alternative pathway to recycle agricultural waste and convert it into value-added materials for green hydrogen production.

Benefits to UQ stakeholders and IITD: UQ gained new knowledge and capability in sustainable catalyst synthesis, reinforcing strategic research priorities in clean energy, advanced materials, and circular economy research. The initiative enhanced cross-institutional research visibility and positioned UQ for stronger competitiveness in future external funding aligned with hydrogen and sustainability agendas. IITD benefited through deepened collaboration with UQ in biomass valorisation and renewable energy conversion, access to complementary expertise, methodologies, and facilities available at UQ. This funding also enabled further extension of the joint research between the CIs at UQ and A/Prof. Nirat Ray from IITD, thus strengthening the mutual collaboration.

Benefits to students and broader community: This project has enabled a short-term (one-month) research visit at UQ for Mr Manjeet Godara (UQ-IITD student) and CI Hossain to visit A/Prof. Nirat's lab for a few days at IITD, thus strengthening UQ-IITD engagement. The project also provided training opportunities for UQ-IITD student (Mr. Manjeet Godara) and UQ ECR (Dr Silvia

Chowdhury) in biomass extraction, catalyst fabrication, and electrochemical evaluation, strengthening technical skills at the interface of materials chemistry and electrochemistry. The project also created capacity-building benefits beyond the immediate project team by establishing liquid-phase extraction protocols for extracting valuable biocompounds from agricultural waste and waste-to-nanocatalyst conversion technology that can be adopted by other UQ and IITD researchers as well as other researchers working in related areas.

This initiative has formed a robust platform for follow-on joint publications and future competitive funding applications (e.g., bilateral schemes, national grants, and industry-aligned funding programs), as well as future exchanges of students and researchers between UQ and IITD.

Additional Joint Research

This funding has enabled us to conduct additional joint research with Prof. Nirat Ray (IITD) and Dr Ni Luh Wulan Septiani (National Innovation and Research Agency, Indonesia) on the engineering of conductive nanoporous metal-organic frameworks (MOFs) for electrocatalytic oxygen evolution reaction, which led to one joint paper (currently under review by Langmuir). This collaboration expanded the international research network of A/Prof. Nirat Ray (IITD).

Additionally, through this funding, the UQ and IITD investigators were able to form new collaboration with Dr Nam Ho Ngoc, a computational scientist from Nagoya University (Japan) to study the mechanisms behind the enhanced catalytic performance of multimetal-doped hierarchical porous carbon for electrocatalytic oxygen reduction reaction and one draft is currently being prepared based on this new collaboration (see co-publication list).

Co-publications

This project has led to several co-publications (including pending papers) between the UQ's CIs and IITD CI:

1. M. Godara, S. Chowdhury, P. Cheng, R. Xin, B. Yuliarto, Y. Yamauchi, Y. V. Kaneti, N. Ray, Unraveling the Electrical, Dielectric, and Electrocatalytic Properties of Bimetallic Cobalt-Based Metal-Organic Frameworks, Advanced Energy and Sustainability Research, 6, 2300301, 2025
2. M. Godara, N. L. W. Septiani, O. Floweri, S. Chowdhury, A. Alowasheeir, Y. Yamauchi, Y. V. Kaneti, and N. Ray, Mixed-Metal NiCu-HHTP Frameworks with Boosted Conductivity and Oxygen Evolution Activity (under review by Langmuir as of 09/12/2025).
3. Y. V. Kaneti, S. Chowdhury, N. Ray, Y. Yamauchi, Agricultural Waste-Derived Multilayered Metal Phosphide Nanocatalysts for Highly Active and Stable Electrocatalytic Water Splitting (Experiments completed; Draft is being prepared, 80% complete).
4. M. Godara, S. Chowdhury, N. H. Ngoc, Md. S. Hossain, Y. Yamauchi, N. Ray, Y. V. Kaneti, Soft-Templated Preparation of Hierarchical Porous Fe, Co, and N-Doped Carbon for High Performance Oxygen Reduction Reaction (Experiments completed; Draft is being prepared, 60% complete).

Grant Applications or Access to External Funding

CI Kaneti is applying for ARC Discovery Project EOI (DP27 EOI) and ARC Future Fellowship using some preliminary results obtained through this project. In 2026, the UQ's CIs aim to apply for bilateral Australia-India Strategic Research Fund or Fellowship with A/Prof. Nirat Ray from IITD.

3. Multidimensional disaster resilience of water infrastructure

- UQ Project Lead: Professor Jurij Karlovsek (JK), Senior Lecturer, Director of UQ Sustainable Infrastructure Research Hub, School of Civil Engineering
- IITD Project Lead: Professor Dipti Ranjan Sahoo (DRS), Associate Dean (Infrastructure) and Professor in Department of Civil and Environmental Engineering

Project Summary

Funded Activity Overview

The funded activity focused on strengthening India–Australia collaboration in the area of resilience of underground and water infrastructure under multi-hazard conditions, with emphasis on digital engineering, modelling, and decision-support frameworks.

The Work Objectives (WO) were:

- [WO-1] Development of quantification framework for post-disaster impact of water infrastructure disruption on community resilience.
- [WO-2] Digital-twin-based framework for integrated assessment, monitoring, and management of urban water and underground infrastructure
- [WO-3] Predictive and data-driven models to support maintenance planning, risk assessment, and enhancement of structural resilience of urban water infrastructure.

The project delivered two major outcomes:

1. [WO-1] A quantitative framework was developed to assess post-disaster impacts of water infrastructure disruption on community resilience, integrating social, economic, and technological dimensions within a unified socio-economic-technological systems approach. This enabled policy-relevant quantification of community-level impacts under uncertainty.
2. [WO-2,3] A multihazard resilience modelling framework was established for underground tunnel infrastructure subjected to sequential earthquake–flood scenarios, combining nonlinear numerical simulations with data-driven predictive models. The work demonstrated that earthquake-induced damage can significantly amplify vulnerability to subsequent flooding and showed the effectiveness of hybrid physics-based and AI-based approaches for predicting deformation under complex hazard interactions.

The project was implemented jointly by researchers at UQ and IITD through coordinated modelling, data analysis, workshops, lectures, and international dissemination. Activities included development of analytical and computational frameworks, numerical simulations using advanced tools, organisation of joint workshops and symposia, and engagement with national and international infrastructure stakeholders.

Key Stakeholders and Beneficiaries

Key stakeholders and beneficiaries include UQ and IITD researchers and students, infrastructure agencies and professional bodies in India, and the broader research community working on disaster resilience, underground infrastructure, and digital engineering. The project directly supported capacity building, international research visibility, and translation of academic outcomes into deployable resilience assessment methods.

Project Outcomes and Benefits

Overall Outcomes

The expected outcomes of the project were fully achieved. The CRG funding enabled integration of conceptual resilience frameworks, advanced numerical modelling, and digital-engineering approaches into a coherent research programme addressing real-world infrastructure challenges. The initiative resulted in peer-reviewed publications, international conference proceedings, workshops, invited lectures, and follow-on external funding.

Benefits to UQ Stakeholders

- Strengthened UQ's research leadership in digital futures, disaster resilience, and underground infrastructure.
- Co-authored journal and conference publications with IITD, enhancing international visibility.
- Expanded global research networks through ITA-AITES, WTC, and international workshops.
- Contribution to UQ's strategic themes on Digital Futures and AI for Community Resilience.
- Benefits to partner institution (IITD).
- Access to advanced modelling frameworks and digital-twin concepts developed jointly with UQ.
- Capacity building through joint workshops, symposia, and expert lectures.
- Strengthened international engagement and follow-on funding opportunities.
- Enhanced alignment with national priorities on infrastructure resilience and digitalisation.

Benefits to Collaborating Institute (CSIR–National Institute of Oceanography, Goa, India)

- Academic research visit to UQ for strengthening the collaboration with UQ-IITD Research Academy, School of Civil Engineering and Sustainable Infrastructure Research Hub, UQ.
- Strengthened international engagement and follow-on funding opportunities.
- Collaboration for coastal multihazard resilience of underground Infrastructures.

Benefits To Wider Beneficiaries

- Infrastructure agencies and professional bodies (Tunnel Association of India (TAI), Central Board of Irrigation and Power (CBIP), and International Commission of Large Dams, India (INCOLD)) benefited from knowledge transfer on multihazard risk, digital twins, and resilience-driven decision-making by inviting Mr. Abhinav for keynote and expert lectures.
- Early-career researchers and students gained exposure to international research practices and interdisciplinary methods during the joint workshops and international events.
- The broader community benefits indirectly through improved understanding of infrastructure resilience and disaster-risk reduction.

Key Knowledge Dissemination Events

- Joint Collaboration Workshop 2025 – Multidimensional Disaster Resilience of Tunnels (UQ-IITD-CSIR_NIO). Organised by: Department of Civil and Environmental Engineering, Indian Institute of Technology (IIT) Delhi, New Delhi, India. Date: 27th March 2025. Invited guests: Prof. Jurij Karlovšek (UQ), Prof. Deepanshu Shirole (IITD), Prof. Jay K. Seelam (CSIR-NIO) and Mr. Abhinav Dewangan (UQ-IITD). Hosted by Prof. Dipti Ranjan Sahoo.
- World Tunnel Congress 2025: Dewangan, A., Zhang, Y., Sahoo, D. R., & Karlovsek, J. (2025). Multihazard resilience of tunnels in cohesive soil: Modeling and prediction

approach. In Tunnelling into a Sustainable Future–Methods and Technologies (pp. 1336-1343). CRC Press.

- UQ-IITD Symposium 2025 (Digital Futures and AI)- Topic: Disaster Resilience Framework for Utility Tunnels in Water Systems. Presented by Prof. Jurij Karlovsek and Co-led by Prof. Dipti Ranjan Sahoo and Mr. Abhinav Dewangan
- Invited Keynote (Mr. Abhinav Dewangan) – "Sustainable Tunnelling for Better Life", International Workshop. Organised by: Tunnel Association of India and MIT World Peace University, Pune. Topic: "Multihazard Resilience Simulation of Tunnels in Cohesive Soil". Date: 23-24 June 2025.
- Invited expert lecture (Mr. Abhinav Dewangan): Conference on Transforming Power & Water Sector Infrastructure. Organised by: Central Board of Irrigation and Power (CBIP) and International Commission of Large Dams, India (INCOLD). Topic: Digital Twin-Based Assessment of Cascading Loads on Utility Tunnels in Cohesive Soils. Date: 17-18 July 2025.

Subsequent Activities and Opportunities

The CRG outcomes directly enabled:

- Submission of multiple joint journal and conference publications.
- Organisation of national and international dissemination events.
- Successful award of a Coalition for Disaster Resilient Infrastructure (CDRI)-funding of USD15,000 for follow-on project focused on real-world validation of digital-twin-based multihazard resilience methods.
- Establishment of a pipeline for future collaborative research and funding proposals.

Additional Joint Research

The funding supported new joint research on quantitative community-resilience assessment, multihazard modelling of underground infrastructure, and digital-twin-based resilience evaluation, leading to co-authored publications and externally funded follow-on projects.

Co-publications

- Dewangan, A., P.A. Valenzuela, C. Meath, D.R. Sahoo, J.K. Seelam and J. Karlovšek. "Quantification framework for post-disaster impact of water infrastructure disruption on community resilience". *Sustainable Cities and Society*. [IF:12] [Under preparation].
- Dewangan, A., Zhang, Y., Sahoo, D. R., & Karlovsek, J. (2025). Multihazard resilience of tunnels in cohesive soil: Modeling and prediction approach. *Tunnelling into a Sustainable Future–Methods and Technologies* (pp. 1,336-1,343). CRC Press. [Book Chapter].
- Dewangan, A., Zhang, Y., Sahoo, D. R., & Karlovsek, J. (2025). Multihazard resilience of tunnels in cohesive soil: Modeling and prediction approach. *World Tunnel Congress 2025: Tunnelling into a Sustainable Future–Methods and Technologies*. [Conference].

Grant Applications or Access to External Funding

The Coalition for Disaster Resilient Infrastructure (CDRI)–funded project titled "Digital Twin Integrated with Multihazard Coastal Resilience of Underground Infrastructures", USD15,000 awarded. The project focuses on onsite testing and real-world validation of deployable digital-twin methods for assessing multihazard impacts on underground infrastructure in coastal conditions, supporting long-term resilience planning and decision-making. The project is led by Abhinav Dewangan along with Prof. Dipti Ranjan Sahoo (IITD), Prof. Jurij Karlovsek (UQ), Prof. Jaya K Seelam (CSIR-NIO), Prof. David Lange (UQ). The project is hosted by Prof. Dipti Ranjan Sahoo and endorsed for implementation by Department of Civil and Environmental Engineering, Indian Institute of Technology Delhi under the mentorship of Prof. Vasant Matsagar.

4. Certified responsible Artificial Intelligence

(Project in progress)

- UQ Project Lead: Professor Dan Kim*
- IITD: Professor Subodh Sharma

*This project was originally awarded to Professor Guangdong Bai (UQ), however, Professor Bai has concluded his employment at UQ. The project lead will be changed to Professor Dan Kim. Due to this change, there was some delay in project implementation, and this project is still in progress.

Project Summary

Funded Activity Overview

This project aims to enhance and broaden the existing collaboration between the research teams led by A/Prof Bai (UQ) and A/Prof Sharma (IITD). This project pioneers innovative research in the formal verification of AI models, to set a foundation for a responsible AI-based future digital world.

Objectives

- Objective 1: Formalisation of AI Models (Jul-Nov 2024). This project component focuses on constructing a formal abstraction that formalises AI models and their training and inference stages. This step mainly addresses the layered structure and non-linear activation functions (e.g., ReLU, Tanh, and ELU), ensuring a comprehensive understanding and structured representation of AI processes. The key challenge is to develop effective methods for calculating the bounds of these complex operations. This component builds on the WraLU verifier [POPL'24] of A/Prof Bai's team.
- During this period, a visit is planned for A/Prof Bai to work directly A/Prof Sharma at IITD. This visit will facilitate their close work on the project and allow them to advance their joint efforts efficiently. Besides, it provides an opportunity to present their collaborative research to the UQ-IITD Research Academy and other colleagues from the CSE Department, fostering more in-depth collaboration.
- Objective 2: Formalisation and verification of key properties of AI Models (Dec 2024 to Apr 2025). This component focuses on formalising and verifying key properties of AI models, based on the AI model abstraction built in obj1. We start with two key properties in this period, i.e., the robustness against adversarial perturbation and privacy. The key challenge is to measure the memorization of AI models during the training, and to tighten the bound of the models' transformation of input data. This component builds on the AIGENT tool [PRDC'23] of A/Prof Sharma's team.

During this period, a visit is planned for A/Prof Sharma visit UQ. This visit will allow them to showcase the progress and potential impact of their work and seek new opportunities for joint grant applications.

Significance

This project represents a crucial step towards certifiable responsible AI. By combining the strengths of UQ and IITD, the initiative is set to make significant contributions to the field of AI, fostering a digital world where AI systems can be trusted and relied upon. The project's success will serve as a testament to the power of international academic partnerships between UQ and IITD in driving forward the frontiers of science and technology.

Expected Outputs

A tool chain developed. A formal verifier will be built in an efficient way by integrating the research and tools of both UQ and IITD, particularly WraLU (UQ) and AIGENT (IITD). It can efficiently verify

the robustness and privacy preservation of neural networks of small to intermediate scale. It will also demonstrate its performance on 1-2 networks that have real-world deployment in various environments, e.g., ResNet.

One-two high-quality articles submitted to top-tier venues, e.g., ICSE, FSE, IEEE S&P, USENIX Security, NOSS, CCS, IEEE TDSC and TSE.

One-two demonstration sessions or workshops with UQ EECS and IITD CSE, and other industrial contacts and potential collaborators. These sessions will occur during the two visits These outreaches will demonstrate the capability of the joint team and enhance its identity in safeguarding AI-based digital world.

Progress Report

The project has now progressed to a stage where we have established a functional end-to-end, AI-assisted framework for synthesising formal specifications directly from natural-language descriptions of computational systems. This represents an important milestone, as translating informal and often ambiguous textual requirements into mathematically precise specifications is a key barrier to the wider adoption of formal methods in system design and verification.

The framework leverages AI to assist in interpreting textual requirements, identifying relevant system behaviours and constraints, and generating corresponding formal representations. The current approach achieves state-of-the-art performance under closed-setups, demonstrating the potential of AI-assisted methods to significantly reduce the manual effort and specialist expertise traditionally required for formal specification development. Current efforts are focused on further improving the precision, consistency, and robustness of the framework, particularly in cases where requirements contain complex dependencies, or domain-specific terminology. We are also investigating mechanisms for validating AI-generated specifications so that the resulting formal models faithfully preserve the intent and semantics of the original requirements while minimising incorrectly inferred or unsupported constraints.

In parallel, the second major component of the project is now underway. This phase focuses on extending the AI-assisted framework beyond specification synthesis and using the generated formal representations as an intermediate reasoning layer for a range of upstream and downstream analysis tasks. One important direction is to use these specifications to identify vulnerabilities, implementation defects, by comparing the formally expected behaviour of a system against its actual implementation. A complementary direction is to analyse the original requirements for inconsistencies, contradictions, omissions, ambiguities, or underspecified behaviours that may otherwise be difficult to detect through conventional manual review.

The use of AI in this stage is intended to support scalable reasoning across requirements, specifications, and implementations, while formal methods provide the rigour needed to validate and verify the resulting conclusions. By connecting natural-language requirements, AI-assisted formal specification synthesis, and implementation-level analysis within a unified workflow, the project ultimately aims to provide a more automated, scalable, and accessible approach to requirements validation, formal verification, and vulnerability discovery.

5. Understanding Autism Spectrum Disorder by deconstructing micro-exon splicing in the brain at single cell resolution

- UQ Project Lead: Professor Ernst Wolvetang, AIBN
- IITD Project Lead: Dr Ishaan Gupta

Project Summary

Funded Activity Overview

Autism Spectrum Disorder (ASD) is a childhood brain disorder characterised by repetitive behaviours and impaired communication skills. The molecular basis of ASD remains incompletely understood, in part due to the lack of a suitable model system. Research has shown that alternative splicing of RNA, which leads to an increase in the diversity of molecules in the guptaeukaryotic system, is a key aberration in the ASD brain.

Within the RNA diversity, particularly the mis-regulation of microexons (very small exons up to 27 nucleotides in length) is a unique finding. Building on this knowledge, the project sought to investigate whether microexon mis-splicing is unique to ASD or also observed in other neurodevelopmental disorders, such as Down Syndrome and Ataxia Telangiectasia, and to determine the role of splicing regulators SRRM3 and SRRM4 in this process.

Through the UQ–IITD Joint PhD Program, project student Ms Pallavi Gupta designed CRISPR guide RNAs to generate single and double knockout embryonic stem cell lines lacking SRRM3 and/or SRRM4. These experiments were conducted at the Australian Institute for Bioengineering and Nanotechnology (AIBN), UQ. Multiple clones from each knockout line were validated by sequencing to confirm frameshift mutations. To test their functional consequences, over 400 cortical brain organoids (up to 7 months old) were generated from the wild-type and knockout lines. Bulk RNA sequencing and single-cell RNA sequencing were performed at 140 days of development, a critical time point identified in prior work. Bulk RNA-seq was performed by Novogene, while single-cell RNA-seq libraries were prepared in-house and sequenced by MGI. Downstream bioinformatic analyses were conducted on high-performance computing platforms at UQ (Bunya HPC) and IITD (FunGeL HPC), using custom and public pipelines in bash and R.

Key Stakeholders and Beneficiaries

This project brought together expertise from UQ and IITD, combining stem cell biology, organoid technology, and computational genomics. The key beneficiaries include the scientific community, which gains the first systematic comparison of microexon regulation across neurodevelopmental disorders, and ultimately, families and individuals affected by ASD and related conditions, through improved molecular understanding that may guide future therapeutic strategies.

Project Outcomes and Benefits

The project successfully met its primary objectives of establishing knockout models for the splicing regulators SRRM3 and SRRM4, generating long-term cortical brain organoids, and conducting bulk and single-cell RNA sequencing to assess molecular and cellular consequences. Library preparations were carried out over multiple days with stringent quality checks, ensuring high-quality data for downstream analyses.

One of the central aims was to evaluate the extent of aberrant microexon inclusion in knockout lines compared to wild-type organoids. Analyses revealed that single knockouts of SRRM3 or SRRM4 resulted in relatively few changes (10–30 affected microexons), while the double knockout led to widespread disruption, with approximately 200 microexons showing reduced inclusion. This provides strong evidence of functional redundancy and cooperation between these splicing factors. Complementary immunolabelling experiments further demonstrated phenotypic consequences – neurons in double knockout organoids exhibited reduced neurite length, potentially limiting their

capacity for connectivity. Single-cell RNA sequencing provided an additional layer of insight by capturing cellular diversity within the cortical organoids, including mature and immature neurons, glial cells, and astrocytes. While preliminary analyses have been completed, ongoing work is expected to refine understanding of cell-type–specific splicing defects and developmental trajectories.

For UQ, the project created direct proof that a poorly understood process such as micro-exon splicing can be readily modelled in human pluripotent stem cells derived brain organoids. This has now opened the way for assessing the functional impacts of impaired or enhanced micro-exon splicing in brain development and disease. This new knowledge will underpin new grant applications from UQ going forward. The project team will publish the results in a high impact journal to the benefit of both partner institutions. Ms Gupta presented the work to Queensland Premier David Crisafulli when he visited IITD.

For IITD, the transfer of skills such as brain organoid generation will be important for fuelling new research and collaborations at IITD and with external partners. Simultaneously the datasets provided by the study will enable the development of better analysis methods and provides insight into the role of microexon splicing defects in diseases such as autism that are relatively prevalent in India. Ms Gupta was invited to present the work at the EMBO Organoids meeting in Heidelberg in October 2025.

A major beneficiary was the joint PhD student, who gained unique cross-disciplinary training spanning stem cell biology, molecular genetics, and computational analysis, thereby building valuable capacity for both institutions.

Subsequent Activities and Opportunities

This initiative has laid the foundation for multiple follow-up directions including joint papers and grant applications. It will be valuable to explore the possibility of leveraging the large patient cohorts in India with DNA mutations that lead to neurological diseases and then use brain organoids derived from such cohorts to develop bespoke therapeutic approaches and to examine the role of micro-exon) splicing in these conditions.

Additional Joint Research

The team has started to explore splicing and micro-exon splicing changes in other neurological diseases such as Ataxia Telangiectasia, Down Syndrome and hereditary spastic paraplegia type 56, revealing unexpected changes in ME splicing patterns in each genetic neurological condition. They have further discovered that ME splicing is altered in brain organoids infected with SARS-Cov2, suggesting viruses may impact this process in ways that are still to be uncovered. A paper outlining these data is also under development.

Co-publications

- “Advances in single-cell long-read sequencing technologies”. P Gupta, H O’Neill, EJ Wolvetang, A Chatterjee, I Gupta, 2024 NAR genomics and bioinformatics 6 (2), lqae047. 19 citations.
- “Protocol for generating embedding-free brain organoids enriched with oligodendrocytes”. B Al-Mhanawi, MB Marti, SD Morrison, P Gupta, M Alani, PG Noakes, 2023 STAR protocols 4 (4), 102725. 11 citations.

Grant Applications or Access to External Funding

Several grants that leverage the novel insights gained in this collaborative project have been used in grant submissions to the ARC, NHMRC and MRFF in Australia.

6. Bridging the urban-rural gap: Effectiveness of tele-health (telemedicine) combined with NGO/social enterprise model in the deeper penetration of healthcare services in rural communities in India

(Project in progress)

- UQ Project Lead: Professor Jay Weerawardena, School of Business
- IITD Project Lead: Professor Sanjay Dhir, Department of Management Studies

Project Summary

Funded Activity Overview

This research project was funded to investigate and model the integration of telehealth with Non-Governmental Organization (NGO) and Social Enterprise (SE) delivery systems to bridge the urban-rural healthcare gap in India.

The primary objectives were to:

1. Identify the key facilitators, barriers, and critical success factors for integrating telehealth within NGO/SE community-based models in rural and underserved regions.
2. Develop a strategic, evidence-based framework to understand the interrelationships among these factors and guide the scalable and sustainable implementation of such integrated models.

The activity was implemented as a multi-method research study in the Indian context. It involved:

- Qualitative Data Collection: Conducting in-depth, semi-structured interviews with 15 experts and practitioners from telehealth initiatives, NGOs, and social enterprises operating across rural India.
- Analytical Modeling: Employing Total Interpretive Structural Modelling (TISM) to analyze the complex interactions between ten identified critical factors (e.g., policy, infrastructure, trust, financial sustainability) influencing telehealth effectiveness.

Key Stakeholders

- Research Participants: Experts from implementing NGOs, social enterprises, and public health professionals.
- Research Beneficiaries: Rural communities in India facing healthcare access barriers, along with policymakers, healthcare administrators, and NGO/SE leaders seeking evidence-based strategies for sustainable digital health deployment.

Key Outputs

The project produced two core outputs: a qualitative analysis framed around the 5P domains (Policy, Place, Public, Provider, Product) and a hierarchical TISM model. Together, they provide a comprehensive roadmap indicating that sustainable telehealth integration requires synergistic action across government policy, digital infrastructure, community trust (built through local health workers), provider capacity/funding, and context-appropriate technology design.

The findings aim to inform multi-sector collaboration towards achieving equitable Universal Health Coverage (UHC) and related Sustainable Development Goals (SDGs).

Project Outcomes and Benefits

This project delivered significant academic, practical, and societal outcomes, advancing knowledge and providing actionable tools for improving rural healthcare access in India. The primary tangible outputs are two complementary manuscripts (under review) and a presentation at the UQ-IITD Symposium 2025 in Brisbane, which served as key dissemination milestones.

The primary knowledge outcome is a robust, two-part conceptual framework for understanding and implementing integrated telehealth. First, the empirically derived 5P Framework (Policy, Place, Public, Provider, Product) codifies the essential, interdependent domains for success. Second, the TISM-based hierarchical model reveals the causal pathways and strategic priorities among ten critical factors, demonstrating how foundational enablers like government policy and infrastructure drive operational and human resource factors, which ultimately build trust and drive effective adoption. This dual output moves beyond listing barriers to providing a validated, structural understanding of systemic integration.

The practical benefits are substantial for key stakeholders. For policymakers and government agencies, the project offers a clear roadmap for creating supportive regulatory environments, harmonizing interstate guidelines, and designing blended financing models. For NGO and Social Enterprise implementers, it provides a strategic checklist for program design, emphasizing the critical role of community health workers (like ASHAs) as trust intermediaries and the need for user-centric, offline-capable technology. Healthcare administrators gain insights into sustainable operational models, training protocols, and infrastructure investment priorities. The ultimate societal benefit is the project's contribution to more equitable and resilient health systems.

The ultimate societal benefit is the project's contribution to more equitable and resilient health systems. By providing a scalable model for telehealth integration, the research directly supports the expansion of quality healthcare access to remote and marginalized populations, reducing urban-rural disparities.

This aligns with and actively promotes national and global goals, including India’s Universal Health Coverage (UHC) agenda and the Sustainable Development Goals (SDGs) 3 (Good Health), 9 (Industry, Innovation, and Infrastructure), and 10 (Reduced Inequalities). The emphasis on community trust, local-language design, and financial sustainability ensures that the pathway to scale is both inclusive and durable, aiming for long-term transformative impact on public health delivery.

Additional Joint Research

Following the research seminar and industry dissemination of findings, the research team is seeking collaborative industry and institutional funding for further research.

Co-publications

Two manuscripts are fully developed and are being under review (with due acknowledgement of the funding from UQ and IITD):

- “Sustainable Telehealth in Rural India: An m-TISM Approach to NGO/SEs Integration.
- “Bridging the urban-rural gap: Effectiveness of Telehealth (Telemedicine) combined with NGO/social enterprise”.

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