CDRI
Coalition for Disaster Resilient Infrastructure

DRI Technical Conference 2022

Adaptive Pathways for Resilient Infrastructure

WORK BOOK

12-13 October 2022

India

The Coalition for Disaster Resilient Infrastructure (CDRI) is a partnership of national governments, UN agencies and programmes, multilateral development banks and financing mechanisms, the private sector, and knowledge institutions that aims to promote the resilience of new and existing infrastructure systems to climate and disaster risks in support of sustainable development.

CDRI promotes rapid development of resilient infrastructure to respond to the Sustainable Development Goals' imperatives of expanding universal access to basic services, enabling prosperity and decent work.

For details : www.cdri.world

For queries : publications@cdri.world

Citation: Coalition for Disaster Resilient Infrastructure (2022), DRI Technical Conference - Workbook.

CDRI
Coalition for Disaster Resilient Infrastructure

DRI Technical Conference 2022

Adaptive Pathways for Resilient Infrastructure

WORK BOOK

12-13 October 2022
India

CONTENTS

CDRI
Coalition for Disaster Resilient Infrastructure

CONTENTS

CONTENTS

CDRI
Coalition for Disaster Resilient Infrastructure

CONTENTS

ABOUT THE CONFERENCE

The Coalition for Disaster Resilient Infrastructure (CDRI) aims to bolster global thinking and action on Climate and Disaster Resilient Infrastructure (DRI) through knowledge creation, curation, and dissemination. Based on this mandate, and with a view to bolster research, CDRI is organizing a DRI Technical Conference 2022 in New Delhi. The conference is complemented with a special issue of the Sustainable and Resilient Infrastructure Journal, on the theme Adaptive Pathways for Resilient Infrastructure. The twin initiatives aim to map and collate cutting edge knowledge and research on DRI with added emphasis on practice-oriented research.

The DRI Technical Conference 2022 brings together researchers, practitioners, and policy makers working on DRI to exchange, review, critically assess, and evaluate pertinent issues. The conference also commemorates the International Day for Disaster Reduction. The conference is expected to facilitate a defining narrative on Adaptive Pathways for Resilient Infrastructure and identify avenues for future research and adaptive policy planning for DRI. It features presentations by leading researchers, thought provoking discussions, and debates on developmental and policy matters that the world must focus on.

Building climate and disaster resilience in infrastructure systems is essential for long-term sustainable development and safety of investments. However, such efforts require dealing with uncertainties, and understanding causes and impacts of disasters through holistic, systemic, and multi-disciplinary analysis. They will also require making risk informed decisions and shifting planning processes from static to dynamic, for reliability of critical services under acute shocks and stresses triggered by climate change and disasters.

Adaptive and integrated disaster resilience is defined as the ability of nations and communities to build resilience in an integrated manner and strengthen mechanisms to build system adaptiveness. It provides the ability to deal with complexities and uncertainties by designing institutional processes that function across scales, sectors, to engage with multiple stakeholders and to promote social learning. In addition, adaptive pathways for resilient infrastructure aim to integrate flexibility into infrastructure planning and are more relevant for large-scale, long-term infrastructure projects. Depending on future states and dynamics, adaptive pathways highlight a series of actions which can be implemented progressively for inclusive and resilient infrastructure.

While there are several success stories of adaptive pathways in real-world settings, there is a gap in the adoption of this approach in dealing with uncertainty in different scales, contexts, governance, resource and cultural settings. Past experiences also demonstrate that the optimum solutions of today may present critical challenges for tomorrow due to increasing complexities, interdependencies, and transitions in infrastructure.

For the DRI Technical Conference 2022, abstracts were invited highlighting solutions related to the uptake and implementation of adaptive pathways and fostering resilience of infrastructure systems. A total of 134 abstracts were received from 23 countries. Subsequently, 75 abstracts were shortlisted against which 45 manuscripts were received. Finally, 28 manuscripts were accepted for presentation at the conference. These manuscripts cover a range of themes on Adaptive Pathways and provide a rich collation of knowledge on DRI. Contributions include evidence-based case studies, literature review, original research, scientific articles, and policy analyses. A set of 12 accepted research papers are the outcome of the first cohort CDRI Fellowship Programme (2021-22).

CDRI heartily welcomes all the delegates to its first DRI Technical Conference. We look forward to an engaging, enlightening, and a productive conference leading to knowledge outcomes that would define future paradigm on DRI, and especially, on Adaptive Pathways.

SPEAKERS & PAPER ABSTRACTS

Aishwarya Narendr
Research Scholar
Indian Institute of Technology Kharagpur

Ms. Narendr is currently working as a doctoral student for MHRD-funded research at Ranbir and Chitra Gupta School of Infrastructure Design and Management, IIT Kharagpur. She has substantial experience with handling spatial data, including remote sensing, spatial libraries and machine learning. In her doctoral thesis, she developed a dynamic method for evaluating the flood loss of built infrastructure by integrating open source GIS with structural analysis. Her research interest includes disaster-resilient planning, geospatial data analysis, remote sensing, building damage assessment, nature-based solutions, climate change and sustainability.

Cost-Benefit Analysis of Flood Resilient Scenario Modelling (FReSMo) Based on a Dynamic Assessment of Coastal Flood Impact on Built Infrastructure

Aishwarya Narendr, Sutapa Das, Bharath Haridas Aitha

Abstract

Coastal flood impact assessment of built infrastructure is critical for coastal resilience and sustainability. The damage estimation process is rather complex for developing countries with limited access to information regarding future flood extent, changing land use character and damage behaviour of elements at risk (residential buildings). This is extremely relevant in the case of mud-housing in India, comprising 34% of the total housing stock. Hence, the rising impact of coastal floods on built infrastructure requires an impracticable and economical and lucrative intervention without the estimation of potential damage cost.

Hence, the current research proposes a systematic and novel approach for integrating a flexible multivariate damage model that can be easily reused over several spatial (local to regional) and temporal (flood character and intensity) dimensions in data scarce developing regions with climate and land use dynamics to estimate the cost-benefit and practicability of FreSMo in Sagar Island, West Bengal. The future built-up is predicted using a patch-growing algorithm – the FUTURES model. The model generates realistic outcomes based on landscape metrics, temporal landuse growth and demographic and socio-economic character of the region. The return period of high water flooding is calculated using Peak Over Threshold (PoT) analysis of long-term tidal data. The flood extent is mapped using a connected bathtub model derived from the Cartosat DEM. The residential building damage against 100 yr flood event is classified on the basis of potential damage cost and cost-benefit analysis of FReSMO is presented to showcase the efficacy of nature-based solutions in reducing coastal flood impact.

Amir Bazaz

Lead - Practice
Indian Institute for Human Settlements (IIHS)

Amir Bazaz holds a PhD in Management from the Indian Institute of Management Ahmedabad, with a specialisation in Public Systems. He works on issues at the intersection of economics, climate change mitigation, and adaptation and sustainable development. He has substantial experience in working with various integrated assessment frameworks and modelling arrangements. His current research interests are low carbon societies/ infrastructure, climate change adaptation and mitigation (across scales), with specific focus on urban-climate change linkages and climate, energy and environment policy.

He has previously been the National Expert Consultant to the Ministry of Environment, Forests and Climate Change, Government of India, for the Second National Communication to the UNFCCC and taught courses in Development & Environmental Economics during his academic engagements at Symbiosis International University, Pune. He has been a regular team member for many 'Disaster and Climate Resilience' projects at IIHS and teaches regularly in the Urban Fellows and the Urban Practitioners Program.

Reimagining Curriculum, Content, and Delivery for Adaptive Pathways: Higher Education and Disaster Resilient Infrastructure in the Indian Urban Context

Cassidy Johnson, Amir Bazaz, Vineetha Nalla, Mona C. Anand, Neha Bhatia

Abstract

In the context of urbanisation in the Global South and projections of an increase in the frequency and severity of climate-induced disaster events, fostering resilience in infrastructure systems becomes critical to deliver on goals of economic development, poverty reduction, and climate action. Adaptive pathways, given its inherent consideration of uncertainty and an embedded feedback mechanism, becomes a necessary conceptual underpinning to deliver on the complex and interconnected resilient infrastructure challenge. We argue that knowledge and iterative learning, is a key component that enables flexibility of adaptive pathways. Here, higher education (HE) plays a critical role in influencing knowledge that is adaptive and dynamic to respond to the resilient infrastructure challenge. The study adopts a qualitative approach with a case study design to identify the gaps in the current way urban resilient infrastructure is conceptualised and taught in HE Institutions in India. We find that the HE system in India, in its current configuration is bound to fall short on delivering on the promise of resilient infrastructure. To this end we deliberate, based on our research certain principles that would be best placed to create necessary and required capacities to address the resilient infrastructure challenge.

Atul Kumar
Ph.D. Research Scholar
Indian Institute of Technology Roorkee

Mr. Atul Kumar is currently a Ph.D. research scholar in the Department of Architecture and Planning, Indian Institute of Technology Roorkee, India concurrent Junior Research Fellow position in the DST, Govt. of India project of “Translating Urban Spaces as Strategic Energy and Water Security Measure”. Under the supervision of Prof. Mahua Mukherjee, Kumar received his M. Tech. Degree from IIT Roorkee India in Disaster Mitigation and Management and graduated in Architecture from Malaviya National Instituteof Technology Jaipur. He has research paper publications and several conference proceedings, his research expertise and interest in Urban Micro-Climate includes various risks analysis.

BGI Network Efficiency to Restore Urban Water System: Case Study Wazirabad Gurugram India

Atul Kumar, Archita Saha, Katha Mehta, Mahua Mukherjee

Abstract

Nature-based solutions are an efficient strategy to deal with the increased frequency and intensity of natural disasters such as urban floods, droughts, and heat waves caused by rising global temperatures, rendering densely populated areas, their population, and critical infrastructure more vulnerable. Blue-green Infrastructure (BGI) as component of NbS encompasses the strategic linking and networking of water and landscape elements to take advantage of ecosystem services and improve the resilience of communities to external forces. It has been well tested and adopted globally to mitigate the risk of urban floods. This study aims to check the efficacy of BGI network planning and designing at the catchment scale of Wazirabad lake site to restore the urban water system. Wazirabad is a lake site in the Gurugram district of Haryana, India, with three major natural streams flowing from the uphill of Aravalli to the urbanized region. During rainy seasons, the streams overflow and cause water filling and logging in the nearby region, driving urban flood conditions at major road of Golf course road (Highway) and locality. The study used the SWMM model-based approach to check the magnitude and extent of urban flood risk and the efficacy of nature-based solutions elements such as vegetative swales. It has been found that about 30 per cent decline in runoff volume from exiting case scenario to BGI case scenario considering the standard design parameters for vegetative swale, finally suggesting BGI network planning for restoring water system. BGI implementation can help to improve the existing natural ecosystem and balance the built and natural environments, making the city greener and more resilient.

David Espinoza

Ph.D., P.E.

David Espinoza is a Senior Principal Geo-environmental Engineer based in Maryland focusing on foundation design over soft soils, design of containment facilities (e.g., municipal solid waste, mining tailings, coal-combustion residuals), closure of containment facilities (e.g., tailing storage facilities) and more recently, financial evaluation of infrastructure investments taking into consideration physical risks such as climate change.

Changing the Valuation Paradigm to Promote Adaptive and Resilient Infrastructure Investment: Connecting Insurance Concepts and Valuation

David Espinoza

Abstract

Despite irrefutable evidence of a looming climate crisis that could lead to significant environmental disasters (i) climate-change risks are not sufficiently captured in the value of vital assets (e.g., power plants, roads, dams) and (ii) investors have not modified their approach to planning, valuing, and financing such assets to account for the considerable physical risks posed by climate change. Thus, the benefits of incorporating features to make assets resilient to climate change are not fully captured in financial analyses. Why? The mechanics of standard valuation approaches such as discounted cash flows (DCFs) exacerbate our innate human predisposition to short-term thinking by emphasizing short-term revenues and expenditures and neglecting long-term ones. Furthermore, these outdated techniques are incapable of properly valuing the flexibility provided by adaptive infrastructures to respond to the changing climate, thus neglecting (and undervaluing) management's ability to make changes as uncertainty gets resolved. Given the uncertainty of future climate impacts, a timely implementation of flexible and adaptive infrastructure will be paramount for optimizing the allocation of limited financial resources. Despite the benefits of investing in resilience and adaptation, DCF's inability to account for climate change risks in a financial analysis makes it hard to justify investing in such features. The urgency of pivoting to a robust model like the decoupled net present value (DNPV) is growing. Like insurance products, DNPV defines all risks (including climate change) as loss potentials and quantifies them in monetary terms (the cost of risk). Risk has a cost whether we pay for it or not.

Deepa Srinivasan

President
Vision Planning and Consulting

Ms. Srinivasan brings over 25 years of experience in policy consultation, project development/ implementation, hazard mitigation planning, stakeholder engagement, and public outreach arenas. Ms. Srinivasan has served as Program Manager for over 100 projects in all four phases of emergency management (mitigation, preparedness, response, recovery) for states and local governments and for a variety federal government agencies in the United States. Her expertise is in inter-governmental coordination between Federal, state, and local governments as well as academic institutions. Ms. Srinivasan directs all planning, disaster management, grants management, outreach, and technology projects for VPC and lead business development for the firm.

An Integrated and Dynamic Approach to Assessing Risks Through Capabilities

Andrew Estrain, Deepa Srinivasan

Abstract

Each year, jurisdictions with varying capabilities and vulnerabilities face risk of impacts from hazards. Local and state governments are tasked with a variety of hazard planning, analysis, and outreach activities and responsibilities to continuously build on, and support emergency preparedness and mitigation efforts to reduce vulnerability to hazard events. The Risk Assessment has traditionally been a major component of the Hazard Mitigation Plan development process, and includes a thorough examination of risks and potential impacts to the hard infrastructure of a community. This paper goes beyond the Risk Assessment and argues that the development of a Capability Assessment, to supplement the Risk Assessment, should be used to inform a Mitigation Strategy that addresses the risk of both, hard and soft infrastructure. This paper proposes a larger and clearer conceptualisation of the adaptive pathways perception that allows planners, policy makers, and decision makers to identify the necessity for, and the implications of, change within a community. Our approach provides a beneficial adaptive pathway by assessing the soft infrastructure, which enables systems to function to support and design the hard infrastructure, to reduce risk, and improve resilience. This approach involves gathering departmental and jurisdictional information related to human, physical, technical, informational, and financial resources through a series of surveys and information gathering processes. We provide a methodology for: gathering the information on various types of resources, and completing an equitable and all-inclusive Capability Assessment, to enhance overall disaster resilience through an understanding and strengthening of soft infrastructure. The importance of performing equitable outreach in the Capability Assessment process is also addressed, to ensure that traditionally underserved communities and the most vulnerable populations, are considered in decisions regarding the deployment of resources, to offset deficiencies in capabilities; and to ensure full awareness of the current resources, capabilities, and capacities of the community.

Dheeraj Joshi
Researcher
The University of Tokyo

Dheeraj Joshi has experience of over 13 years in Public Services with key competencies in the Power sector and Transportation sector in the fields of project, financial & human resource management and government administration. He gained further knowledge in the domains of disaster management & business continuity planning by actively carrying out my research from The University of Tokyo. His main area of interest is planning with focus on spatial planning for transit-oriented development, risk assessment of infrastructures utilising geo-spatial technologies, sustainable development & disaster resiliency of infrastructures.

Multi-hazard Risk Assessment of Rail Infrastructure in India under Local Vulnerabilities towards Adaptive Disaster Resilient Infrastructure Planning

Dheeraj Joshi, Ram Avtar and Wataru Takeuchi

Abstract

"Lifeline of the nation" is the motto of Indian Railways and it connects through a common thread, billion plus population in one way or the other and the National Rail Plan for India – 2030 is focusing on creating 'future ready' Railway system by 2030 by suitably integrating new railway systems like high-speed rails. But rail infrastructure being spatially distributed is exposed to multi-hazards and at times disasters result in disruptions to safe rail operations and in a developing country, infrastructure disruption is a cause of concern as it is a drag on the people and the economy. The current scenario as per various performance reports highlight a framework of managing disasters rather than managing risks. This makes it difficult for rail infrastructure managers and policy makers to take risk informed decisions and plan for policy resolutions towards business continuity planning and providing adaptive pathways for resilient infrastructure. This research thereby undertakes a novel study in this regard for a countrywide rail infrastructure risk assessment utilizing UNDRR framework and synthesized application of geo-spatial technologies with focus on disentanglement of local vulnerabilities of the rail infrastructure assets utilising factors of health of bridges, visibility obstruction to level crossings, labour wages & their regions and gross state domestic product (GSDP) under multi-hazard scenarios. Integrated approach of the study is useful in identification of critical routes towards risk informed adaptive disaster resilient infrastructure planning for providing safety and reliability of critical rail services through involvement of multiple stakeholders including urban and transport planners.

Indrajit Pal

Associate Professor
Asian Institute of Technology, Thailand

Indrajit Pal is an Associate Professor and the chair of the Disaster Preparedness, Mitigation and Management and Deputy Director of the Research Center “South- and South East Asia Multi-disciplinary Applied Research Network on Transforming Societies of Global South (SMARTS)” at, Asian Institute of Technology, Thailand. Dr. Pal is Advisor to DRR and Governance in Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES). Dr. Pal has published 12 books and over 100 academic papers and book chapters. His research area includes disaster risk governance, vulnerability, risk and resilience assessment, climate risk, critical infrastructure resilience and DRR innovation.

Multi-hazard Risk Assessment of Coastal Critical Infrastructure in Eastern Economic Corridor of Thailand

Indrajit Pal, Anil Kumar, Joyashree Roy, Nonthakarn Benjachat, Kittinut Pimpakhun

Abstract

Asian countries have been encountering multiple hazards with higher frequency and intensity. The disasters have been causing damage to infrastructures and disruption of services. Understanding the current situation of hazards and their probable impacts on these critical infrastructures becomes important to safeguard the normal functioning of society. The Eastern Economic Corridor (EEC) is a special investment zone in the coastal area of Chonburi, Rayong, and Chachoengsao provinces of Thailand. This research focuses on the risk assessment of critical infrastructures emphasising on transport, health, and education sectors from flood, cyclone, and coastal erosion in the EEC. Identification of the key indicators for hazard, exposure, sensitivity, and capacity for composite risk assessment of critical infrastructure was the primary consideration for multi-hazard context. The result shows districts with a very high-risk level are Si Racha (Chonburi) and Ban Chang (Rayong) and associated critical infrastructures. A moderate level of risk is found in Klaeng (Rayong), while Ko Sichang (Chonburi) and Sattahip (Chonburi) are considered low risk. With this knowledge, Laem Chabang Port and U-Tapao Airport are in very high-risk zones. Whereas, Map Taphut Port situated in Muang Rayong, has a high level of risk. Further, available risk information provides an opportunity for efficient allocation and prioritisation of resources for risk mitigation measures.

Jafarali Parol
Scientist
Kuwait Institute for Scientific Research

Dr. Jafarali Parol is currently working as a Scientist at Kuwait Institute for Scientific Research, Kuwait. He also worked as a Scientist at the Aeronautical Development Agency (ADA), Ministry of Defense, Government of India. At ADA he has significantly contributed to the development of the fighter aircraft TEJAS. He has lead research projects funded by industries and research counsel worth over $5m. His research interests are Computational Mechanics, Structural Health Monitoring, Physics Informed Machine Learning in SHM. He has publications in over 50 peer reviewed international journals and conference papers.

Enhancing Infrastructure Resilience Through Structural Health Monitoring

Jafarali Parol, Shaikha Al-Sanad

Abstract

Buildings and other infrastructures represent a significant investment by the government and private sectors and the public in any country. Safety, functionality, and sustainability of essential buildings such as tall buildings and residential and business facilities, schools, hospitals, power lines, power plants, transmission towers, and offshore structures are one of the key challenges. Structural Health Monitoring (SHM) is a very useful technology to identify the structural deterioration of these infrastructures. Damages that occurred during and after an earthquake, due to any other natural hazards, due to aging or due to harsh environmental conditions can be accurately quantified using the technique The main advantage of SHM is that monitoring can be carried in real-time continuously and therefore, is it possible to assess the damage during or immediately after any catastrophic events. This ability of immediate assessment would help the concerned authorities (especially civil defence authorities of a country) to determine which structures are safe for operation during emergency situations. Therefore, it is possible to automate the response activities and point shot disaster coordination during or immediately after an earthquake. In Kuwait, recently, there has been a significant increase in construction of tall buildings, new residential cities, bridges etc. In this paper we shall share real-time SHM system that is helping to assess the structural condition of the these assets in real-time. By carefully using the latest SHM technologies the structural resilience of infrastructures of city can be significantly enhanced.

Prof. Kapil Gupta

Professor
Indian Institute of Technology Bombay

Prof. Gupta has worked on several international research projects addressing flood risk reduction, resilience and mitigation in urban areas in Europe, Asia and Australia. His work has emphasized transferring academic research into the field and incorporating state-of-the-art international practices into national manuals and guidelines of India. His most recent projects have focused on maintaining the functionality of critical infrastructure like airports and railways in Mumbai during intense rainfall under climate change. He is presently carrying out a British Council project with University College, London on developing course material for disaster resilience engineering education.

Flood Disaster Risk Assessment for Critical Transportation Infrastructure Under Climate Change

Kapil Gupta, Vinay Nikam

Abstract

Major cities of the world such as Sydney, New York, London, Durban, Mumbai, Chennai and Bengaluru have been disrupted by severe rainfall events during 2021-22. This has overwhelmed the capacity of the existing drainage systems resulting in severe flooding and disruption to the critical transport infrastructure (road, rail and air) in many cities of the world. Climate change is now a harsh reality with increased rainfall occurring in shorter intervals of time. A flood vulnerability and mitigation assessment for flood prone areas was carried out for the Mumbai International Airport as well as the Mumbai suburban system of the Indian Railways for extreme rainfall scenarios including a 20 per cent increase of the design rainfall taking into consideration the scenario of climate change. This paper presents an overview of the problem, the flood risk assessment methodology adopted and the recommended adaptation and mitigation measures to reduce the flooding on the airport runway and the railway premises to levels well within the safe operating conditions. The methodology has been successfully implemented for the Mumbai International Airport while the model simulations indicated that the recommended adaptation and mitigation measures will enable the Indian Railways to continue train operations even under extremely severe rainfall in the future.

Kavya Kamepalli
Student
Technical University of Munich (TUM)

Kavya Kamepalli is currently pursuing her Master's in Aerospace Engineering at the Technical University of Munich, Germany, and ISAE-SUPAERO, France (a double-degree program). Her interests lie in spacecraft propulsion, space environment, and orbital mechanics. Previously, she has participated in conferences organized and funded by the United Nations Office for Outer Space Affairs (UNOOSA) where her ideas emphasized using Space-based technologies to overcome existing bottlenecks in Sustainable Development Goals #2 and #4. She is currently working on 'Hypervelocity simulations on Granular Media' where the behavior of ejecta (similar to that on the surface of asteroids) during crater formation is studied.

Solar Disruptions in Space Infrastructure

Kavya Kamepalli

Abstract

Space infrastructure, comprising of huge diversity of satellites and supporting telecommunication infrastructure play a very significant and crucial role in everyday activities. In Indian context, it is INSAT group of satellites that provide the primary means of connectivity to not only to the remote and far-flung regions of the country, but also to other South-Asian countries. Similarly, the role of space-based technologies, for instance, Navigation with Indian Constellation (NAVIC), Global Navigation Satellite System (GNSS), in day-to-day affairs and also in disaster management, is very significant. Accordingly, there has been a spurt in the launch of earth observing satellites and also small and nano satellites for other purposes in the Low Earth Orbit (LEO). On the other hand, entire space infrastructure is continuously exposed to different vulnerabilities ranging from space debris (anthropogenic) to cosmic reasons (Galactic Cosmic Rays, Solar Flares). India in particular and South Asia in general are prone to the natural disasters. The role of space based technologies is significant both in pre-disaster for early warnings and in post-disaster phase for optimising the rescue and relief efforts. Any disturbances, either shock (for instance, solar flares), or stress (space debris) events may have adverse impacts on pace infrastructure with negative implications on the realisation of Sustainable Development Goals (SDGs). An attempt in this article to articulate the impacts of shock events on space infrastructure and stress on the measures for resilience of space-based infrastructure is made based on our experiments on the influence of solar flares on quality of data. Further, in a paradigm shift, the Indian government has enabled the participation of private sector in space operations, an increase in the launch of small and nano satellites is expected and there is a need to develop a safety protocol and strict adherence should be adopted.

Kshitij Dahal
Researcher
Himalayan Risk Research Institute

Mr. Kshitij Dahal is a CDRI fellow (2021-2022) from the Himalayan Risk Research Institute, Nepal. He studied natural hazards, with a particular emphasis on landslides. Mr. Dahal is fascinated by remote sensing applications and developing machine learning based methods for landslide prediction and risk assessment. Kshitij will present about landslides and critical infrastructure in Nepal.

Mapping Landslide Susceptibility and Critical Infrastructures for Spatial Decision-making

Kshitij Dahal, Kaushal Gnyawali

Abstract

Landslides pose risk to the people, the environment, and the slope infrastructures. Several methodologies have emerged to determine the susceptibility of landslides that predict the next landslide locations. However, susceptibility alone does not provide information on how it will affect infrastructures, making it difficult to fortify vulnerable slopes and develop mitigation plans. We propose mapping landslide susceptibility alongside critical infrastructures, then overlaying and analyzing the results to determine where investments should be made for risk mitigation and resilience. We map multi-temporal landslide susceptibility in Nepal and create an integrated index, then we correlate the index with critical infrastructures. This identifies landslide-prone infrastructures that require investments. A web application is developed for easy spatial information dissemination. We evaluated the framework in Nepal and found that some provinces have more landslide-prone infrastructures than other provinces and require mitigation plans and investments. The developed approach is scalable to any other region and may be utilized for policy-making and investment planning to reduce landslide risk.

Liesl Keam

Climate Change Lead
Partnerships for Infrastructure

An industry innovator who operates at the forefront of the fast moving global climate change and sustainability space, Liesl is passionate about working alongside decision makers and governments for climate solutions. She has developed and implemented climate change and risk management tools and systems across investment portfolios linking project work to strategic priorities. With experience leading the incorporation of climate change risks and mainstreaming into projects and investment portfolios in Environment, Water and Wastewater, Agriculture, Transport, Renewable Energy, and livelihood sectors, Liesl has unique expertise targeting the Climate and Gender nexus and the application of systems thinking to climate solutions.

Improving Resilience Outcomes for Infrastructure: How to Maximise the Benefits from Disaster and Climate Risk Assessment

Liesl Keam, Becky-Jay Harrington

Abstract

Recent developments in the safeguarding systems, sustainable and green taxonomies, and IPCC Climate Resilience Framework (amongst others) have created new processes and criteria for delivering better climate and disaster resilience for Infrastructure projects and assets. There is not yet a standard risk classification methodology for climate change risk assessment or the inclusion of disaster risk within it, or within other international standards such as TCFD, ISO 14091, 92. Applying more dynamic selection of risk receptors, risk and hazard component variables, system/ asset boundaries, timeframes and socio-economic surroundings along with the exclusion of compound risk factors can improve the extent to which a disaster and climate risk assessment can deliver stronger system wide resilience and shape adaptation pathways. This paper and presentation will outline a number of key risk assessment elements and considerations that can improve their application, using practical examples from infrastructure projects and providing specific references to assist in replication. Key elements are; i) the inclusion of social and environmental risk receptors alongside asset/ infrastructure, ii) bringing risk classification in line with IPCC risk definitions and associated vulnerability definitions, iii) risk analysis that informs the creation of corresponding climate and disaster management plans, systems and processes and iv) moving beyond a compliance mindset to use a more dynamic risk assessment to deliver positive resilience outcomes in our assets and infrastructure.

Mauricio Sánchez-Silva
Professor
Universidad De Los Andes
Bogotá, Colombia

Professor Sánchez-Silva is PhD and Full professor at Universidad de Los Andes (Bogotá, Colombia). His area of expertise is risk analysis to support decision-making in engineering under uncertain conditions. He has experience estimating risk in complex problems where information is partial, incomplete, and difficult to quantify, and therefore, traditional risk modeling and engineering methods can only be applied partially. Some of his current areas of research include flexibility, adaptability, resilience, and sustainability of infrastructure systems. He has published over 100 refereed journal papers and two books, and he belongs to several journal editorial boards and international associations.

Flexible and Adaptable Strategies for Developing Sustainable and Resilient Infrastructure

Mauricio Sánchez-Silva, Nayled Acuña-Coll

Abstract

Disasters cost the global economy billion of US dollars annually affecting mostly the livelihood of the most vulnerable. Governments and worldwide institutions linked with this problem need to explore new approaches, in particular, in relationship with infrastructure, which is key to socioeconomic development. In this paper, we propose to rethink the problem based on a combination of two fundamental lines of thought: systems thinking and flexibility. Systems can be understood as a hierarchical arrangement of processes and system thinking helps understand how these processes interact at different levels. The idea of process is linked with the concept of life cycle since it describes all activities or changes in the system during a given time window. Flexibility is the ability of a system to respond or change some of its design or operational parameters easily to keep or add value to the system when subjected to either internal or external demands. Incorporating flexibility in the development of infrastructure contributes to better managing risks, and the varying demands (including those imposed by climate change), coping with planned/unplanned events, taking advantage of investment/business opportunities, reducing possible cost overruns, and handling the perceptions and interests of stakeholders. The paper discusses several approaches to flexibility and argues that the ideas behind “adaptation paths” cover only some aspects of the problem and do not provide a comprehensive picture of the system dynamics. Overall, the paper presents strategies to build dynamic flexible management policies that facilitate systems to respond and change over time; thus, fostering resilience to disasters and climate change.

Muhammad Abdur Rahaman

Director
Center for People & Environ (CPE)

Muhammad Abdur Rahaman is serving the Center for People & Environ (CPE) as Director. Mr Rahaman is a dedicated young climate scientist who has worked in the field of climate science and policy for more than 18 years. In this journey, Mr Rahaman has served national and international organizations as a researcher, practitioner, and development actor in climate change, disaster risk reduction, climate-smart agricultural innovations, climate change and health nexus. Mr Rahaman serves the Global Taskforce of Climate Change, Water & Energy as Chair to lead the scientific research. He is also doing UNESCO Groundwater Network as Scientific Panel Member.

Capturing Sustainable Disaster Resilient Infrastructure in Bangladesh: An Explanatory Analysis from Haor and Char Region

Muhammad Abdur Rahaman, A.N.M. Abuzar Giffary, Zereen Saba, Mithun Dutta

Abstract

Flood is the most common hazard in Bangladesh because of its location in the world's largest delta, formed by the Ganges, Brahmaputra, and Meghna (GBM) rivers and their tributaries. In Bangladesh, three types of flooding occur riverine floods, flash floods (in the northeastern region), and floods caused by storm surges in coastal areas. River floods regularly affect approximately 20% of the country, increasing to 68% in extreme cases. Haors are enormous bowl-shaped floodplain valleys in Bangladesh's northeastern region, directly below the hilly portions of India's states of Assam, Meghalaya, and Tripura. They are wetlands with distinct hydro ecological characteristics. The haor areas experience high rainfall as a result of their geographic location, and as a result, they are prone to floods. Like Haor, the char lands of northern Bangladesh are also susceptible to flood. Almost every year, the char lands are flooded during the monsoon. Food security, social protection, and health ensure that the poorest and most vulnerable members of flood-prone areas, including women and children, must be protected. To deal with increasingly frequent and severe floods, several infrastructural interventions were adopted by the development partners, government, and the initiative of flood-prone people.

The study aims to explore the sustainable disaster resilient infrastructural measures to reduce loss and damage, live savings and disaster risk recovery. The study was conducted in eight sub-districts (the Fulchari Upazila under Gaibandha, Bakshiganj under Jamalpur, Belkuchi under Shirajganj, Fulbari under Kurigram, Khaliajuri and Madan under Netrokona, Baniachong under Habiganj, Taherpur under Sunamganj under district) of Haor and Char by incorporating primary and secondary information. Secondary information was gathered by reviewing national databases, related scientific articles and disaster management plans available in the public domain. Primary information was extracted using both quantitative and qualitative data collection tools performing Household Survey (HHS), Key Informant Interview (KII), and Focus Group Discussion (FGD) at the local and national levels. The study also incorporated remote sensing and GIS to develop disaster vulnerability and resilience metrics. The study explored different infrastructural measures from the haor and char regions regarding protection, loss and damage reduction, and live savings infrastructures that are the most effective and sustainable flood management. The effectiveness was measured at the community level to reduce loss and damage, life savings (human and livestock), and improve the household well-being of flood-affected communities in the study area.

Nivya PC
Research Assistant
Coalition for Disaster Resilient Infrastructure

Nivya PC is an Urban Planner with a Civil Engineering background. Currently, she is a Research Assistant at Coalition for Disaster Resilient Infrastructure (CDRI) and supports the Urban and Transport Resilience programs of CDRI. She is passionate about sustainable development and believes that every development project should be people-centric and sustainable to balance present and future generations' environmental, economic, and social needs. Nivya holds a master's degree in planning with a specialization in Urban Planning from the National Institute of Technology, Calicut, India and a bachelor's degree in Civil Engineering from SCMS School of Engineering and Technology, Ernakulam, India.

Exploring the Potential of Urban Open Spaces as a City's Flood Mitigation Infrastructure

Nivya PC, Shreya Karmakar, Sharon Maria Sajan

Abstract

Public spaces are city users' open-air living rooms and define cities' cultural, social, economic, and political functions. They include three types: streets and pedestrian access; open and green spaces, such as parks, plazas, water bodies, and waterfronts; and public facilities, such as libraries, community centers, and municipal markets. The relevance of these spaces is being recognized globally and emphasized in international agendas. With the accelerating rise in the urban population, the city's land and other vital natural resources are put under constant strain, resulting in pollution, congestion, a lack of essential services, housing scarcity, slum settlements, encroachment on open spaces and water bodies, and increased vulnerability to disaster risks. This has also resulted in urban flooding incidences in many cities as with the increased demand for space, a significant reduction in areas for infiltration and detention facilities can be seen for the management of stormwater runoff during rains. Climate change and the increased frequency of extreme events further exacerbate the risk of flooding in urban areas.
Due to the increase in built-up areas in cities and high land values, building stormwater detention infrastructures to control urban floods becomes capital intensive whereas the return on such investments will be very less. In addition to using open spaces for recreational purposes, some developed countries have explored the opportunity of using open spaces for urban flood mitigation. Blue-Green surface solutions with reduced piping infrastructure are proven to be more investment-friendly than piped solutions. 2 Many cities like Rotterdam, Tokyo, Copenhagen, and other cities use their urban open spaces for flood mitigation. Urban open spaces can be used as an opportunity to build flood resilience in cities. This paper explores a solution to making cities resilient to hazards like flooding, storm surges, cloudbursts, etc through studying global best practices.

Nuwong Chollacoopand
Kampanart Silva
Researcher
National Energy Technology Center (ENTEC)

Kampanart Silva received his doctoral degree in nuclear engineering and management from the University of Tokyo. He is now a researcher at National Energy Technology Center (ENTEC) under National Science and Development Agency (NSTDA), working on enhancing resilience of energy and transportation infrastructure, and equipping them with climate adaptation capacity. He published articles in several well-known scientific journals, such as Reliability Engineering and System Safety, and Nuclear Engineering and Design. He is one of the founding members of the ASEAN Network on Nuclear Power Safety Research, and an alternative representative from Thailand to ASEAN Sub-Committee on Sustainable Energy Research.

Economic Analysis Framework for Climate Adaptation Investment in Land Transportation Sector with a Thailand Case Study

Khemrath Vithean, Pidpong Janta, Kampanat Thapmanee, Nuwong Chollacoopand Kampanart Silva

Abstract

Apart from concluding the global goal to achieve carbon neutrality by 2050, the world leaders also agreed upon making critical infrastructure resilient to enhance our communities' adaptability at COP26 (UK COP26, 2021). This aligns well with several priorities of the Sendai Framework (Kelman, 2015) that promote resilience in critical infrastructure to reduce disaster risks. Large scale investment is inevitable for infrastructure resilience enhancement. Climate adaptation investment is particularly large for projects in transportation sector, which necessitates the confirmation of the projects' economic feasibility. Cost benefit analysis (CBA) (UNDP, 2018) is generally used for this purpose. However, since it is performed on a case-by-case basis, it cannot cover the big picture of the whole sector. It cannot also visualize the cash outlays. Investment and Financial Flow (I&FF) assessment (UNDP, 2020b) perfectly fill these gaps. Yet, one would realize that there is a missing link between the two assessments when one tries to extend from CBA to I&FF. Therefore, this study aims to create a method that bridges CBA to I&FF assessment in transportation sector, and to verify the proposed method with a Thailand case study.

Olasunkanmi Habeeb Okunola
United Nations University (UNU)
Institute for Environment and Human Security

Dr Olasunkanmi Habeeb Okunola is a Visiting Scientist at the United Nations University, Institute for Environment and Human Security, Germany. His research interest focuses on issues related to climate change adaptation, disaster risk reduction, community-based natural resource management, coastal and marine resource management. He has worked across an array of development interventions in Sub-Saharan Africa and Europe for a decade. He served as the project manager, lead researcher, principal investigator on major research programmes and projects that have attracted funding from DAAD, IDRC and FORD Foundation. He has won various prestigious scholarships such as DAAD and Alexandra Von Humboldt Fellowships.

Adaptation Pathways to Flood Resilient Infrastructure in African Coastal Cities: Lessons and Experiences from Lagos, Nigeria and eThekwini, South Africa

Olasunkanmi Habeeb Okunol, Simatele Danny Mulal

Abstract

The recent increase in the frequency of flood episodes in some cities of the Global South, particularly those in sub-Saharan Africa (SSA), reveals the extent to which these cities are ill-equipped and prepared to deal with impacts arising from extreme weather induced hazards. Like many other cities in the world, Sub-Saharan African cities face the challenge of rapid urbanization in the context of poor governance, weak public institutions, and deficit infrastructure development. Thus, this paper aims to address this gap by analysing the extent to which the current infrastructure governance are aligned to dealing with current and projected cascading, complex and systemic nature of risks from climatic condition in Lagos, Nigeria and eThekwini, South Africa. Using a case study approach, concurrent triangulation mixed methods such as in-depth interviews, survey questionnaires, focus group discussions and seminars were adopted to obtain information from representatives of government agencies, civil society organizations, community members and academia. Similarly, the policy documents and frameworks selected for this study were assessed using text mining. Results show that despite cultural and geographical differences in these cities, the factors influencing resilient infrastructure governance were similar. Furthermore, findings established that weak bridging and linking relationships exist among stakeholders in implementing flood resilient infrastructure in Lagos and eThekwini due to lack of communication, funding, flexibility and inclusiveness. We argue that multistakeholder collaborations and political will play an essential role in building the adaptive capacity and resilient infrastructure for poor and vulnerable communities to extreme weather events. These themes have been explored within the broader framework of the 2030 sustainable development goals.

Parisa Kloss

Executive Director
Resilient Urban Planning and Development (RUPD) GbR

Parisa Kloss is a trained architect and urban planner and designer with 18 years of experience in the Middle East, Asia and Europe. She is the Founder and Executive Director of Resilient Urban Planning and Development (RUPD) GbR in 2013 in Germany. She is an expert in urban climate change planning, urban heat island effects, climate adaptive/intelligent cities, mitigation and adaptation strategies, and sustainable and resilient cities.

Empowering Decision Makers to take Resilient Action towards Urban Heat Island Mitigation by Developing Multi-Dimensional Climate Model

Parisa Kloss and Mojtaba Samimi

Abstract

One of the barriers on taking resilient action towards climate issues such as urban heat island (UHI) effect is the lack of an appropriate technological tool to visualize the existing hotspots and bring them into the decision makers eyes. There are many common methodologies applied by scientists to measure UHI effect like remote sensing, mobile traverses, using historical weather data etc. But the results and analyses coming out of those methods are not visually simple to understand for decision makers, planners, architects and other stakeholders. Although it can be proven scientifically that an urban area based on those measurements has higher temperature, accurately recognizing the responsible elements in that target area remains undisclosed. Today the state-of-the-art technology can provide a platform to develop models that can fulfil the previous methodologies, investigate the issue from various dimensions and empower the decision makers to not only take resilient action that can't be eroded overtime, but also save time and budget. To overcome the existing barriers, a model called "Multi-Dimensional Climate Model", which performs through a computational platform called "Solarchvision", has been developed to optimize climatic performance of cities from various dimensions by applying a spatial analysis which helps identify the hotspots, study and develop potential corrections and then evaluate the most suitable ones. The model can also serve as a base for granting construction permit. In fact, the model as a key enabler enables cities to take accelerated and more ambitious climate action as well as facilitating the implementation of climate action plans and related SDGs on the ground. The model has been tested in a pilot area in Montreal City, Canada.

Prasanna Bhangdia
India Smart Cities Fellow
Ministry of Housing and Urban Affairs, National Institute of Urban Affairs

Prasanna Bhangdia is an India Smart Cities Fellow under the Ministry of Housing and Urban Affairs, Government of India. He holds a degree in Masters of Urban Planning from NIT Jaipur. He is currently working on the development of a data-driven tool for Indian cities to adapt and mitigate the effects of climate change. The outcome of this work is in the form of a dashboard for decision makers and a gamification tool for citizens. He has published five research papers in prestigious national and international journals. In his free time, Prasanna enjoys reading and volunteering with social organizations.

Inclusion of People with Disabilities in Disaster and Climate Risk Reduction Planning: A Case of Bhubaneswar, Odisha

Prasanna Bhangdia and Akruti Murhekar

Abstract

India has a vast and changing topography and climatic conditions, which makes it prone to a myriad of disasters. Planning ahead for a vulnerable area can help to prevent catastrophic losses that occur. But the way society responds to such a situation varies from person to person. People with disabilities are the one who are exposed to the highest risk and need special attention while planning the disaster response policy. Research says that the mortality rate amongst people with disabilities tends to be two to four times higher than the rest of the population making them highly vulnerable. Hence this research advances with the aim to address this global issue by developing an inclusive, context-specific digital tool at the city level to integrate all strata of differently abled and elderly populations for effective disaster and climate risk reduction infrastructure planning. The city of Bhubaneswar, capital of Odisha state, has been selected for the purpose. This research details the major findings of the hazard risk and vulnerability assessment of cyclone hazard, based on which a digital tool has been proposed; a dashboard for decision makers and a mobile application for citizens. Mobile application will help to identify location and type of disability, it will show the efficient way to exit and reach nearby shelter and will have feedback mechanism which will be used as an input for policy making by decision makers. It has been found that such interventions can improve the quality, efficiency, and sustainability of disability-inclusive disaster risk reduction strategies at the city level. The outcome of the research will help to not only plan disaster-specific guidelines but also to build a disaster-resilient inclusive society.

Raghav Pant
Senior Research Associate
Oxford University

Dr. Raghav Pant is a Senior Research Associate at the Environmental Change Institute, Oxford University, United Kingdom (UK). He has over 16 years of relevant academic and professional experience creating novel methods and tools on infrastructure systems risk and resilience modelling. He has worked with several high-level stakeholders including the UK National Infrastructure Commission, UK FCDO and World Bank to create novel methodologies and studies on climate risk and adaptation assessments in UK, East Africa, Vietnam, Argentina, and Jamaica. Dr. Pant holds an undergraduate degree from IIT Kanpur, MSc from Princeton University and PhD from University of Oklahoma.

Systemic Assessment of Climate Risks and Adaptation Options for Transport Networks in East Africa

Raghav Pant, Diana Jaramillo, and Jim W. Hall

Abstract

Transportation networks are lifeline systems fundamental to economic and social prosperity. Disruptions to these networks can be detrimental to long-term growth plans. This is particularly important in the context of growing climate hazards such as flooding where long-term sustainable development, social wellbeing and economic stability is at risk from widespread failures of transport networks.

In view of these threats, there is a need to create evidence of the impacts of current and future climatic risks to transport networks. To address this problem, we have developed and implemented a multi-regional transport infrastructure climate risk and adaptation assessment framework. This framework seeks to understand the extent and location of extreme hazard exposures, direct damages and economic flow losses, risks and adaption investment needs for strategic transport networks. It aims to inform decision-makers: (1) improve network resilience by identifying and strengthening the locations of highest vulnerabilities; and (2) understand the benefits of investing in climate resilience in terms of avoided losses from climate risks.

We apply our climate risk and adaptation assessment tool for the case study region covering Kenya, Tanzania, Uganda, and Zambia, where we investigate the risks due to river and coastal flooding over current and future climate change driven scenarios. Our analysis shows that there are large benefits of investing in climate adaptation of major roads and rail network links in these countries that are exposed to flooding in the present and future. For example, we estimate that investing in climate adaptation from the present (2019) till 2080 to strengthen resilience of the 20 most flood risk incurring roads and railways lines in the region would amount to about US$ 9 million and US$ 92 million in adaption costs but would avoid risks as high as US$ 875 million and US$ 234 million across future climate scenarios.

Ram Wanare
Ph.D. Research Scholar
Institute of Infrastructure, Technology, Research And Management, Ahmedabad, India

Ram Wanare has completed his graduation in Civil Engineering (2012) and post-graduation in Civil Engineering with a specialization in Geotechnical Engineering (2014). He has 4.5 years of teaching experience. Currently, he is working as a research scholar under the guidance of Dr. Kannan Iyer at Institute of Infrastructure, Technology, Research and Management, Ahmedabad. His research is focused on understanding the cracking/shrinkage, suction and tensile strength characteristics during drying for both unstabilized and stabilized marine soils. During his research, he has published 5 journal publications and 4 book chapters. He has been granted an Indian patent related to his research work in 2022.

Water Stability Test: An Adaptive Tool to Evaluate the Resilience of Geotechnical Infrastructure to Flooding and Water Inundation

Parishi H. Dalal, Ram Wanare, Mahi Patil, A. Sandeep Reddy, Trudeep

Abstract

Safety and stability of geotechnical infrastructure are crucial for ensuring well-performing and resilient infrastructure. Heavy rainfall-induced flooding/water inundation can cause significant damage/failure of geotechnical infrastructure such as earthen dams, road and railway embankments, canals, temporary bunds, soil slopes, earth retaining structures, building/bridge foundations and underground structures. Water inundation/overtopping of geotechnical infrastructure can cause distresses such as internal/external erosion in soil, collapse of submerged soil, reduction in strength/stiffness and increase in settlement/differential settlement of soil; heaving of soil, foundations and underground utilities, etc.

Stabilization of soil is important for improving its properties, and to ensure good performance/stability of geotechnical infrastructure built within/on/with soil. Evaluation of the resilience of stabilized soil against temporal deterioration under water inundation conditions is important. Water stability tests/studies such as crumb tests, soil sensitivity tests, erodibility/scour studies have been utilized for dispersive soils, marine soils, soil slopes, river beds, etc. However, water stability test, as an adaptive tool for assessment of the stability of improved ground, has not gained much attention. In the above context, this study presents a methodology to evaluate performance of unstabilized and stabilized soils/alternate soils, to simulate inundation due to fresh water, saline water and acidic water. The performance of unstabilized and stabilized marine soil and landfill mined waste, as well as controlled low strength material have been evaluated through monitored crumb tests, and microstructural imaging before and after crumb tests. It has been noticed based on the study that biostabilized landfill mined waste exhibits high resilience to different water inundation conditions, and provides a sustainable method for improving resilience of geotechnical infrastructure. Further, it is opined that methodology presented in the paper may be useful to evaluate the effectiveness and resilience of soil stabilization methods, with an aim to develop robust, low-maintenance, and sustainable infrastructure for the future.

Prof. Ravi Sinha

Professor
Department of Civil Engineering, Indian Institute of Technology Bombay, India

Prof. Ravi Sinha is former Dean of Alumni & Corporate Relations at IIT Bombay. His research activities are mainly in earthquake engineering, structural engineering and disaster risk management. Prof. Sinha is closely associated with policy-making related to disaster risk management in India. Prof. Sinha has chaired/served in several government panels. Prof. Sinha is also a member of Maharashtra State Disaster Management Authority. He is the Co-Chairman of National Panel of Experts of Ministry of Road Transport and Highways, Government of India. Prof. Ravi Sinha is a member of Executive Committee of Bureau of Indian Standards.

Adaptive Pathways for Disaster-resilient Infrastructure – Resilience Assessment as a Fundamental Requirement

Prof. Ravi Sinha, Mohammad Rafiq Joo

Abstract

Built infrastructure must be resilient to prevail in the face of disasters. Adopting strategic options and policies for disaster risk mitigation and community resilience enhancement are conditioned on accurate, comprehensive, and systematic disaster risk assessment of infrastructure. The pathways promote incremental adaptation, and consider post-disaster requirements through a proper resilience assessment. Such an approach is a prerequisite for implementing pathways for disaster-resilient infrastructure but is currently not prevalent. The present study carries out resilience assessment from seismic risk reduction consideration, incorporating functionality loss and subsequent recovery for a representative archetypical commercial building. Various scenarios of pre- and post-disaster preparedness, planning, and mitigation options are considered to provide deeper understanding of their pathways. Assessments are conducted in accordance with the state-of-the-art performance-based earthquake engineering (PBEE) framework. The results are compared using a range of resilience metrics. The impact of an engineering intervention, viz. improvement to non-structural performance, a management intervention, viz. mitigation of post-disaster repair impedances, and their combination are demonstrated and quantified. The study shows how various pre-disaster planning, preparedness strategies, and post-disaster management options influence resilience and that they can be combined to enhance infrastructure resilience. Multiple options are presented for efficient decision-making by stakeholders to deal with uncertainties during disasters. The study advocates embracing the resiliency mindset and involving multiple stakeholders in risk-informed decision-making.

Richard Boothroyd
Postdoctoral Research Associate
University of Glasgow

Richard Boothroyd is a river scientist interested in capturing the dynamics of global rivers. He led the “InfraRivChange” project during the CDRI Fellowship (2021-22 cohort). His recent postdoctoral research has focused on: (i) quantifying geomorphic hazards in the Philippines (University of Glasgow); and, (ii) monitoring global river flooding (University of Birmingham). He uses satellite imagery and big geospatial data sets to understand the risks that river-related hazards pose to people and infrastructure.

"InfraRivChange" – A Web-based Application to Monitor River Migration at Sites of Critical Bridge Infrastructure in the Philippines

Richard J Boothroyd, Richard D Williams and Trevor B Hoey

Abstract

Shifting rivers represent a geomorphic hazard at sites of critical bridge infrastructure, particularly in rivers where migration rates are high. Conventional attempts to map and measure shifts in the position of river channels usually requires the manual digitization of satellite imagery using Geographic Information Systems (GIS); this type of analysis is time-consuming so can only be applied at a handful of bridge sites, using a small number of satellite images. As part of the CDRI Fellowship, we leveraged the cloud computing platform Google Earth Engine (GEE) to substantially upscale analyses using large collections of Earth observation (EO) data. Focusing on the Philippines, we designed a user-friendly web-application that enables technical and non-technical users to monitor the relative risk of river migration at sites of critical bridge infrastructure by analysing thousands of satellite images. The "InfraRivChange" web-application uses freely available satellite imagery from Landsat (30 m spatial resolution) and Sentinel (10 m spatial resolution) to quantify river channel changes at bridge sites. Here, we demonstrate the web-application at selected sites in the Philippines and suggest use-cases relevant to disaster resilient infrastructure. Outputs from the web-application provide stakeholders and decision-makers with new information that improves understanding of river behaviour, useful for mitigating risks to transport infrastructure. We recommend the "InfraRivChange" web-application as a low-cost approach for monitoring shifting large rivers in the vicinity of infrastructure. The web-application could be formally incorporated into bridge monitoring investigations (e.g., as a component of bridge stability assessments) and used to inform the strategic design and placement of future infrastructure. We envision that "InfraRivChange" can be applied to additional forms transport infrastructure adjacent to rivers (e.g. road and rail) and extended elsewhere to other dynamic riverine settings.

Santosh Subhash Palmate
Postdoctoral Researcher
Texas A&M University, USA

Dr. Santosh obtained a Ph.D. from the Indian Institute of Technology (IIT) Roorkee. After his Ph.D., he worked at 'Wetlands International South Asia,' New Delhi, for a year and is currently a postdoctoral researcher at the AgriLife Research Center of Texas A&M University, USA. Dr. Santosh works on developing strategies for potential climate change impacts on natural resources and providing alternative practices for achieving Sustainable Development Goals (SDGs). He has experience in hydrological modeling, land-use and climate change impact assessment, best management practices evaluation, and wetland conservation planning. He also develops research articles and grant proposals and supervises other personnel.

Potential of Himalayan Wetlands in Mountain Disaster Risk Reduction under Climate Change

Santosh Subhash Palmate, Saurav Kumar

Abstract

Mountain glaciers are retreating almost everywhere in the world due to melting under temperature rise and climate change. Also, mountain disasters like floods and landslides become uncertain and severe in the Himalayas, which could cause property damage, socio-economic loss, life devastation, and biodiversity disturbances. In addition, Himalayan wetlands that support ecosystem services and disaster risk reduction are more vulnerable to climate change. There are high chances of new natural wetland development in the future that can lower the risk of mountain disasters and act as natural resilient infrastructure. Therefore, this study aimed to invent and predict the probability of new wetlands in the Himalayas and their potential role in mountain disaster risk reduction. In this study, a maximum entropy algorithm was used to model the climate change impact on Himalayan glacier melting, new wetland development, and the potential of probable wetlands in reducing disaster risks. Spatial data of topographic characteristics, land properties, and bioclimate variables were used as inputs to the model. Existing wetland locations in the territory of India were considered for the training and testing of the model. The model performance was evaluated using the area under the curve (AUC; 0.950 for training and 0.943 for testing), which showed good simulation. Results showed that the Himalayan wetland vulnerability would continue as the temperature rise and extreme precipitation events are likely to happen. Spatial analysis showed the risk of 2 climate change to Himalayan wetlands is higher in the eastern and western parts. The melting of the high-altitude glacier can probably develop new wetlands in the depressed mountain areas. It will increase the water holding capacity and soil deposition potential of the Himalayan wetlands to an amount that could lower disaster severity. This study provides valuable insight into the role of the Himalayan wetlands in strengthening resiliency to mountain disaster risks.

Srishti Singh
Economics Consultant
Central Pollution Control Board

Srishti is an Economics Consultant at the Central Pollution Control Board under Ministry of Environment, Forests and Climate Change of India, where she works in the Research and Development Division. She is also a Coalition of Disaster Resilient Infrastructure Fellow for the year 2021-22, studying participatory monitoring and evaluation methods for drought resilience. She has a Masters in Economics from the Delhi School of Economics, University of Delhi, India where she studied Environment and Climate Change Economics.

Participatory Monitoring and Evaluation for Water Security: Case Studies from India

Srishti Singh, Ananya Goyal, Meghna Yadav

Abstract

Collaborative decision making, especially in the context of water security, in an uncertain world involves navigating multi-stakeholder partnerships for adaptive governance. In a world of uncertainty, adaptation and long-term resilience are interlinked. Resilience means building capacity for uncertainty in decision making due to unpredictable events which is necessary for adaptive governance. A key step in this process is participatory Monitoring and Evaluation (M&E) to address uncertainty and engender empowerment. To understand this, we explore participatory M&E through case studies in the state of Rajasthan, a semi-arid state in India. We study two participatory M&E models as part of multi-stakeholder partnerships which build and evaluate drought resilience and water conservation infrastructure, which are Social Audits under the National Rural Employment Guarantee Act (NREGA) and Seva Mandir Village Committee Monitoring Method. By comparing two different models, one institutionalised and facilitated by the Government and the other by a civil society organisation, we explore which of their components operationalise, or hamper, participation in participatory decision-making. We explore how the models operate in the context of building water infrastructure for drought resilience? How participatory M&E processes of the Government and Civil Society (CSO) complement each other to build successful partnerships for water security? Finally, what are the avenues, through the lens of M&E, to engender adaptive learning outside the silos of independent functioning of Government and CSOs? Our comparative analysis includes the methodology of systematic literature review, process net-mapping of two mature community-led M&E models and stakeholder interviews. Finally, we identify the key principles of effective participatory M&E models for water security interventions. The principles include empowering the community to monitor water security infrastructure; iterative, regular, and flexible evaluation; institutionalising feedback loops for learnings; and capacity building. The key takeaway is that participatory approaches, combined with multi-dimensional indicator tracking, can help build a loop of learning which can identify vulnerabilities in time. It is this alignment of incentives with resilience which could be harnessed by well-designed participatory M&Es for adaptive decision making for water security.

Vasant A. Matsagar

PhD, FINAE, FIEI, FISET, FCDRI
Professor, IIT Delhi

Professor-Dr Vasant Matsagar is currently serving as Professor and Dogra Chair in Structural Engineering in the Department of Civil Engineering, Indian Institute of Technology (IIT) Delhi. He obtained his doctorate (PhD) degree from IIT Bombay in 2005 in the area of earthquake engineering for his PhD Thesis titled “Earthquake Behavior and Impact Response Control of Base-Isolated Buildings” for which he has been honored with the “IIT Bombay Research Paper Award”. He performed post-doctoral research in the area of application of carbon fiber-reinforced polymer (CFRP) composites in prestressed concrete bridge structures at the Lawrence Technological University (LTU), Michigan in the USA.

Earthquake Response Control of Hospital Building using Unbonded Fiber-Reinforced Elastomeric Isolators

Sarranya Banerjee and Vasant A. Matsagar

Abstract

Lifeline structures such as hospital buildings need to be specifically designed such that they experience low level of vibration when subjected to earthquake excitations. This is necessary since it will not be easily possible to evacuate hospital buildings under the event of any earthquake. Therefore, the objective of the present study is to utilize flexible unbonded fiber-reinforced elastomeric isolators (UFREIs) for seismic isolation of an existing eight-story hospital building in New Delhi, India, to achieve minimal dynamic response of the structure under seismic excitations. Recently, the authors have proposed a novel trilinear hysteretic model (THM) to represent the force-deformation behavior of UFREIs, which could effectively predict the highly nonlinear behavior of the UFREI using only four design parameters. Although the THM has shown considerable promise in modeling the dynamic behavior of the UFREI, it is yet to be implemented in the response evaluation of actual UFREI-isolated structures. Thus herein, the detailed properties of the UFREIs installed in the considered hospital building are obtained utilizing the proposed THM, according to the site-specific design scenario. Further, a comprehensive numerical analysis of the UFREI-isolated hospital building is carried out. The UFREI-isolated hospital building is subjected to an ensemble of site-specific earthquake excitations and the response of the structure is obtained based on the novel THM of the UFREI. The various response parameters of the UFREI-isolated hospital building such as the top floor structural acceleration, the inter-story drifts of the structure, and the force-deformation behavior of the UFREIs are evaluated to demonstrate the performance of the UFREI-isolated hospital building under the selected ground motions. Consequently, the effectiveness of the UFREIs in the seismic isolation of the considered hospital building is established from this extensive numerical study.

Vipul Nakum
Project Manager
Resilience Innovation Knowledge Academy India

Vipul Nakum is a Disaster Risk Management professional and holds a Master's in Disaster Management degree from Tata Institute of Social Sciences, Mumbai. For the last ten years, he has worked closely with the state governments, civil society, UN organizations, and academic institutes, leading field projects and research studies on disaster risk management, climate change adaptation, urban resilience, community development and comprehensive school safety across Indian states. He has contributed significantly to implementing the SFDRR 2015-2030 at the local level. He received CDRI Fellowship 2021-2022 for conducting innovative research on Risk-Informed School Evaluation (RISE) Tool.

Comprehending School Disaster Resilience: Deriving Indicators for Risk-Informed School Evaluation

Vipul Nakum, Muhammed Sulfikkar Ahamed, Ranit Chatterjee, Rajib Shaw, Saki Isetani, Hanae Soma

Abstract

Disaster and climate change risks challenge the continuity and sustainability of almost all critical infrastructures worldwide, including schools. Disasters or extreme events in schools and their peripheries damage the school's infrastructure or results in injuries to students and staff, or create temporary closure, disrupting the continuity of education. Considering the increased risk of disasters and climate change concerning schools and unforeseen incidents with children, each parent and guardian must know the risk in their neighbourhood and the disaster resilience of the schools their children attend. These risks remain uncounted and neglected while selecting the school for enrolling the children. Conventional school selection in Asian countries such as India is driven by the factors such as academic achievements, curriculum, and quality of teachers in the school with less or no thrust on school disaster resilience aspects.

This paper attempts to explain the process followed to derive the indicators that can help evaluate the school based on two important factors – parental school selection criteria and school disaster resilience. The process followed the three-round Delphi survey method. The parents and expert group participated in the process by having a mutual interest in the subject and allied backgrounds such as education, disaster risk management, academia and policy. As an output, the paper summarises the final indicators that the authors used for developing the Risk Informed School Evaluation (RISE) Tool as a part of their study under the CDRI Fellowship Programme 2021–2022 of the Coalition for Disaster Resilient Infrastructure (CDRI).

ZIV Nicolas

PhD
Chief Operating Officer (COO), Resallience

ZIV Nicolas is an Engineer and an Urban Planner, he has a PhD from Université Paris-Est and Ecole Spéciale des Travaux Publics. He has more than 6 years of experience in the transport infrastructure domain and academic research. His Phd concerns the adaptation of methods from other industries, like Systems Engineering, to the construction sector to better manage complexity of large infrastructure projects.

Since 2021, Nicolas is Chief of Operation at Resallience, he is in charge of developing the activity in new markets. Curious and passionate, the long term goal of Nicolas, is to develop new infrastructure concepts with more value for people and their environment.

Resilience Performance Assessment (RPA): A Framework and Decision-making Tool to Evaluate and Follow the Resilience of Infrastructures and Territories

ZIV Nicolas, Didier Soto, Abla-Midi Edjossan Sossou, Sohouenou

Abstract

The Resilience Performance Assessment (RPA) is an innovative solution allowing efficiency and balance between climate change adaptation about the full infrastructure's life cycle, buildings and territories. It provides a holistic approach combining visualization of both current and future climate change impacts. It also brings vulnerability scoring of future and existing assets. This decision-making tool also allows the formulation of detailed physical and financial recommendations and a costs-benefits assessment to estimate the resilience performance of each project or policy aiming at improving resilience and a better share of risks between stakeholders.

Concept
Kamal Kishore, Executive Committee Co-Chair, CDRI

Guidance
Amit Prothi, Director General, CDRI

Organizers
Mona Chhabra Anand, Director – Research & Knowledge Management
Anand Kumar, Deputy Director – Admin & HR
Aishwarya Pillai, Lead Specialist – Publications
Alpana Saha, Lead Specialist – Partnerships & External Relations
Amarnath Shukla, Senior Specialist – IT
Aparajita Suman, Expert – Knowledge Management
Avinash Venkata, Analyst – Knowledge Management
Deepak Rawat, Manager – Procurement
Jessica Mossahari, Senior Specialist – Advocacy
Mallika Srinivasan, Lead – Communications
Neha Bhatia, Senior Specialist – Knowledge Management
Payal Bhatnagar, Analyst – Communication
Ratnesh Kumar, Senior Specialist – Research
Ravi Krishnani, Specialist – Communication
Renu Bhardwaj, Executive Assistant – Administration
Sumit Raghav, Executive Assistant – Procurement

Publishing Partner
Taylor & Francis

CDRI

Coalition for Disaster Resilient Infrastructure

COALITION FOR DISASTER RESILIENT INFRASTRUCTURE

4th & 5th Floor, Bharatiya Kala Kendra, 1, Copernicus Marg,
New Delhi 110001, India

www.cdri.world
info@cdri.world
+91 11 4044 5999
@cdri_world
@coalition-for-disaster-resilient-infrastructure
@cdri.world

CDRI PUBLICATIONS