ICSI Convening:
Accelerating Implementation of Disaster Risk Reduction and Resilience in Infrastructure

UNDRR Risk Reduction Hub side event
High-level meeting on the Midterm Review of the Sendai Framework for Disaster Risk Reduction
17 May 2023, UN Headquarters NYC
ABOUT ICSI

The International Coalition for Sustainable Infrastructure (ICSI) was founded in 2019 by Resilience Rising, the American Society of Civil Engineers (ASCE) and its ASCE Foundation, the Institution of Civil Engineers (ICE), the Global Covenant of Mayors for Climate & Energy (GCoM), WSP and LA Metro, among others. We bring together a global coalition of change agents from across the engineering, investment, city, and philanthropic communities committed to bold action to solve the systemic problems that exist at the intersection of climate change, ecosystem degradation, ageing infrastructure, and underinvestment. ICSI is the global movement for engineering action on infrastructure sustainability, resilience, and climate change. We place engineers at the forefront of climate action, harnessing their ability to provide solutions and matching it with urgent demand. The solutions we develop and promote will deliver impact on the ground, where it is needed most. ICSI was created to bring the practical, science-based, and solution-oriented perspective for which engineers are known to solve the systems-level problems surrounding infrastructure underinvestment, climate change, and resilience. From its origin, ICSI has been committed to driving action towards instilling sustainability and resilience as the cornerstone of every decision in the infrastructure lifecycle. Built upon a commitment to tangible and collaborative action, ICSI continues to broaden participation across other stakeholder communities to accelerate the innovation, adoption and scaling of people-centred, sustainable, and resilient infrastructure solutions that support sustainable development for all.

ACKNOWLEDGEMENTS

Thank you to those who contributed to the ICSI side event at the UNDRR Risk Reduction Hub on 17 May 2023, on which this report is based. A full list of speakers and contributors can be found in Annex 1. Special thanks to ICE, Resilience Rising, and the World Federation of Engineering Organizations (WFEO) for their support in delivering the event.

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Infrastructure is the backbone of a safe, functioning, and prosperous society. It underpins sustainable development and plays a vital role in the implementation of Disaster Risk Reduction (DRR) and resilience.

The importance of building resilient infrastructure systems has been highlighted as a key area of focus in the Midterm Review of the Sendai Framework (MTR SF), as seen in Priority 4, Recommendation 4.2: Invest in resilient infrastructure and systems. However, there are many challenges to building resilient infrastructure. This report outlines key opportunities and solutions to these challenges, complemented by real-world case studies from across the globe. Some key takeaways from the report are:

- **Good governance** is critical to enhancing resilience, particularly in the context of disaster risk reduction (DRR). There is an urgent need for the policy and regulatory environment to better consider the risks of today and those of the future.

- **Scaling up resilience solutions** requires sustained financing, and access to resources, training, and capacity building opportunities. It requires the establishment and maintenance of stakeholder partnerships and strong governance structures that foster accountability, trust, and the empowerment of local communities. Justice, transparency, and inclusivity need to be at the core of any solution, with frontline communities centred and reflected in resilience interventions.

- **Globally, there is a lack of capacity to imagine infrastructure in a systemic way.** This means that we need to bring in a multi-sectoral approach that considers the interconnectedness of different systems. We need to think in terms of systems, not silos, in order to scale infrastructure resilience and bring experts together to promote an integrated approach.

- The engineering community can offer a significant contribution to accelerate the implementation of DRR and resilience in infrastructure systems. For example, they can capitalise on technological advancements to enhance traditional risk assessments to include resilience thinking. This would help with better understanding uncertainty, systemic complexity, and long-term approaches that incorporate climate change impacts.

The breadth of case studies and examples presented in this publication is a striking testament to the need for everyone involved in the development of infrastructure to come to the table to truly accelerate the implementation of DRR and resilience.

Engineers are rising to the challenge and are adopting a bolder, more proactive approach to lead convenings around these important topics. The ICSI-led Risk Reduction Hub side event is part of a larger effort to break down silos between sectors, professions, and regions, and to encourage a more holistic, inclusive conversation on what is needed to advance sustainable, resilient, and just infrastructure. It was a powerful and effective way to form partnerships and alliances among key stakeholders in DRR who do not usually convene in the same room and between whom dialogue does not usually occur. ICSI advocates for similar implementation-focussed multi-lateral dialogues to serve as a blueprint for stakeholders to convene and catalyse action.
INTRODUCTION

The resilience of infrastructure systems has been recognised as a key area of action in the Midterm Review of the Sendai Framework (MTR SF), a formal review to take stock of implementation and impact since the launch of the UNDRR’s Sendai Framework for Disaster Risk Reduction in 2015. The review set out to understand what context shifts have occurred and to identify how to accelerate uptake to 2030 and beyond. The MTR SF was discussed at the UN General Assembly High-Level Meeting in May 2023 and Resolution 77/289 Political declaration of the high-level meeting on the midterm review of the Sendai Framework for Disaster Risk Reduction 2015–2030 was adopted by the General Assembly on 18 May 2023. The General Assembly reaffirmed its commitment to the full implementation of the Sendai Framework, including its guiding principles and four priorities for action (see Box 1).

The United Nations Office for Disaster Risk Reduction (UNDRR) coordinated a Risk Reduction Hub on the margins of the official sessions of the High-Level Meeting to include an array of side events and thematic engagements to discuss advancing risk reduction efforts across sectors, regions, and contexts. These events were for governments, experts, and stakeholders, including traditional DRR actors, to discuss how the calls-to-action from the political declaration (Resolution 77/89) can be taken forward to offer concrete solutions that can be the genesis of initiatives or coalitions emanating from the MTR SF.

The International Coalition for Sustainable Infrastructure (ICSI), with support from the Institution of Civil Engineers (ICE), led the development of an Input Paper to formally contribute to the MTR SF (see Box 2), the first and only voluntary contribution from the global engineering community outlining key positions on the implementation of the Sendai Framework to date and looking ahead. Following this contribution, ICSI was invited to contribute to the UNDRR’s Risk Reduction Hub and convene stakeholders from the infrastructure sector to discuss how the calls-to-action and recommendations of the MTR SF can be progressed in the context of infrastructure, focussing on concrete solutions and pathways to risk-informed infrastructure systems that support sustainable development for all. The ICSI-led side event, which took place on 17 May 2023, brought together actors from across the lifecycle of infrastructure, including policymakers across multiple levels (national, state, regional, municipal), owner-operators, investors, private sector, professional and industry associations, academia, and civil society.

The event was an opportunity to form partnerships and alliances among key stakeholders in DRR who do not usually convene in the same room and between whom dialogue does not usually occur. It is part of a larger effort to break down silos between sectors, professions, and regions, and to encourage a more holistic, inclusive conversation on what is needed to advance sustainable, resilient, and just infrastructure.

This publication captures perspectives and key messages from these stakeholders and highlights case studies that were shared at the side event. They are organised around themes of governance, scalable solutions and multi-stakeholder action. ICSI advocates for similar implementation-focussed multi-lateral dialogues to serve as a blueprint for stakeholders to convene and catalyse action.

**PRIORITY 1: UNDERSTANDING DISASTER RISK**
- 1.1 Develop a shared understanding of risk
- 1.2 Enhance knowledge and understanding of the systemic nature of risk
- 1.3 Build national and local data capacities
- 1.4 Improve collaboration between DRR and statistical communities
- 1.5 Enhance granularity in risk data and risk information
- 1.6 Improve data standards, enhance data governance, and invest in data technology
- 1.7 Enable all-of-society engagement and participation
- 1.8 Strengthen risk awareness and communication

**PRIORITY 2: STRENGTHENING DISASTER RISK GOVERNANCE TO MANAGE DISASTER RISK**
- 2.1 There is a need for more coherent and integrated management of risks
- 2.2 An all-of-society approach to risk management
- 2.3 Multi-scale risk management
- 2.4 Building capacity for integrated risk-informed decision-making

**PRIORITY 3: INVESTING IN DRR FOR RESILIENCE**
- 3.1 Increased public investment in DRR
- 3.2 Better internalise negative externalities of the private sector
- 3.3 Incentivising private sector investment in DRR

**PRIORITY 4: ENHANCING DISASTER PREPAREDNESS FOR EFFECTIVE RESPONSE AND TO “BUILD BACK BETTER” IN RECOVERY, REHABILITATION AND RECONSTRUCTION**
- 4.1 Increase the coverage of early warning systems
- 4.2 Invest in resilient infrastructure and systems
- 4.3 Enable more inclusive recovery
ICSI, with support from ICE, undertook a consultation in Summer 2022 with the global engineering community and submitted a report entitled *The Sendai Framework for Disaster Risk Reduction 2015-2030: Reflections and insights from the Global Engineering Community* as a voluntary contribution to the MTR SF. Although the Sendai Framework is aimed at national governments, its implementation is a multi-stakeholder effort, and engineers have a key role to play.

The following recommendations and key positions are highlighted as areas where the engineering community can offer a significant contribution to accelerate implementation.

1. **THE ROLE OF DRR AND RESILIENCE NEEDS TO BE HIGHLIGHTED IN RELATION TO GLOBAL AGENDAS**

There is a need to elevate DRR and resilience in relation to the Sustainable Development Goals (SDGs) and other global agendas, and to better connect them to other systemic drivers and priorities.

2. **DEVELOP AND IMPLEMENT SYSTEMIC RISK AND RESILIENCE FRAMEWORKS AND ESTABLISH RESILIENCE FOCUSED AGENCIES AND GOVERNING BODIES**

There is an urgency to develop policies, regulations, codes, plans or other mechanisms that encourage or enforce the uptake of DRR and resilience measures, and to establish agencies or bodies that oversee their implementation. Multi-national agencies can play a key role assisting during the pre-development phase and enhancing local capacities during implementation.

3. **ACCELERATE IMPROVEMENT OF DATA COLLECTION, ANALYSIS AND METHODOLOGY THROUGH TECHNOLOGICAL ADVANCES AND SUSTAINED INVESTMENT**

Improved understanding of technological abilities and increased investment are needed to accelerate the development and uptake of new technology beyond its current trajectory. Technological advancements can push the envelope of traditional risk assessments that include resilience thinking to deal with uncertainty, systemic complexity, and long-term approaches that incorporate climate change impacts.

4. **ENCOURAGE MULTI-DISCIPLINARY CROSS-SECTOR COLLABORATION AMONG EXPERTS TO TACKLE COMPLEX CHALLENGES**

Extensive collaboration among expert groups from different backgrounds (engineers, planners, social scientists, climate scientists, data scientists, finance experts etc.) is needed to develop better assessments and build local capacity during project implementation. There is also a need for the engineering community to engage more proactively and provide input into policy development and early-stage project development.

5. **EDUCATE POLICYMAKERS, PRACTITIONERS, AND THE PUBLIC ON DRR AND RESILIENCE CONCEPTS**

Education could enhance understanding of the importance of DRR and resilience. Educating and building capacity of policymakers is a priority, since they are responsible for developing regulations and incentives to increase the uptake of DRR and resilience. Enhancing capacity of practitioners at local level is urgently needed, and educational settings and civil society have a key role to play here.
Perspectives from National Disaster/Emergency Management Authorities

- Globally, there is a lack of capacity to imagine infrastructure in a systemic way. This means that we need to bring in a multi-sectoral approach that considers the interconnectedness of different systems. **We need to think in terms of systems, not silos, in order to scale infrastructure resilience** and bring experts together to promote an integrated approach.

- The MTR SF calls for more biodiversity and ecosystem approaches to infrastructure. However, there are challenges in advancing these approaches which often take years to accrue benefits. Whilst crucial for long-term development gains, we cannot rely on these approaches alone at risk of overlooking urgent short-term DRR and disaster risk management (DRM) needs. **We need to take an approach that promotes grey and green solutions together to improve community resilience now, and for years to come.** Engineers will be key to the success of these approaches and should be consulted throughout the infrastructure lifecycle – particularly in the early planning phases - to ensure that we are advancing the right solutions.

- On a broader level, **engineers have the technical expertise needed to inform and influence policy** and should be welcome stakeholders at the policymaking table. Policy can and should be used as a key tool to advance the development of sustainable and resilient infrastructure that can better serve and protect communities in times of disaster. Policy reform can also benefit the underserved, for example by removing barriers to entry such as rigorous cost-benefit analyses that can impinge access to financing and investment in infrastructure projects and DRR.

- Investment is also critical to instilling equity in emergency management and helping underserved communities build resilience. The recent floods in Pakistan have highlighted the importance of investing in pre-disaster adaptation and mitigation measures, and of taking a proactive approach to ensure that communities are better prepared through effective communication and other DRR strategies.

- Managing parallel disasters requires input from multiple stakeholders. **Engineers, policymakers, and other key actors need to transcend the boundaries of their own professions to problem-solve and work towards solutions together.** Academia also has much to contribute to DRR, for example through research on early warning systems that can inform communities of a potential disaster months in advance, saving lives and livelihoods. There is also a role for academia in establishing national think tanks on disaster management; university departments should be encouraged to develop projects relevant to their local context and to use local knowledge to inform solutions.

Based on remarks from Lieutenant General Inam Haider Malik, Chairman, National Disaster Management Authority of Pakistan; Victoria Salinas, FEMA Acting Deputy Administrator for Resilience; and Kamal Kishore, member of India’s NDMA and Indian Co-Chair of CDRI’s Executive Committee, at the ICSI-led side event on 17 May 2023.
KEY THEME 1 - GOVERNANCE FOR RESILIENCE

Good governance is critical to enhancing resilience, particularly in the context of DRR. There is an urgent need for the policy and regulatory environment to better consider the risks of today and those of the future. Effective governance can ensure that policies, plans, and mechanisms are in place to mitigate, respond to, and recover from disasters. It allows resilience measures to be considered in development plans and infrastructure projects from the outset, ensuring that DRR is prioritised and accounted for. Strong governance also fosters transparency, accountability, and participation, enabling communities to actively engage in decision-making processes and contribute their local knowledge and expertise. This results in localised resilience interventions that have community buy-in and are more likely to see long-term success.

Ultimately, effective governance plays a key role in building community resilience, reducing vulnerability, and helping to reduce the impact of disasters and climate events.

At the ICSI-led side event, representatives from New York City (NYC) government agencies highlighted that they need to work together to prioritise areas of action. The following case studies are examples of initiatives and projects that will enhance the resilience of the millions of people living in NYC.

“All kinds of solutions are needed, including green infrastructure and grey infrastructure, so we’ve got to work with all agencies to share solutions and be transparent. Funding is an issue for everybody, so we need to work together to prioritise areas of action.”

Tom Abdallah, Vice President, Design Services, MTA

“We must look at the interdependence of sustainability and resilience and [ensure] that these are both integrated into each project.”

Jennifer Cass, Senior Vice President, Capital Program, NY EDC

Photo by Li-An Lim on Unsplash
Rebuilding Together NYC is a nonprofit organisation dedicated to empowering low-income residents of NYC through the preservation of affordable housing and the development of life-sustaining careers in construction trades. Its core belief is that through collaboration, communities can grow stronger and better prepared to stand up to whatever challenges tomorrow brings.

In the wake of Hurricane Sandy, Rebuilding Together NYC launched the Rebuild by Design (RBD) competition to encourage affected communities to rebuild differently in order to improve their physical, economic, social, and environmental resilience. The RBD scheme has implemented two large scale regional design competitions to address resilience challenges, resulting in more than $3.6 billion of investments. The competitions and projects are an example of a successful initiative that promotes innovation by developing local resilience solutions that are regionally scalable.

Creating a competition model approach for DRR and resiliency solutions within the Sendai Framework, complimented by establishing dedicated funding with expenditure deadlines, could accelerate implementation of DRR and resilience measures. The competition can promote innovation by developing local resilience solutions that are regionally scalable. Individuals and organisations can be evaluated for the best expertise and understanding of the affected community’s challenges to make regions stronger and more resilient places to live. In addition, primary objectives can be integrated into the competition selection criteria to enable greater focus in low- and moderate-income (LMI) communities. Employing dedicated funding sources can speed up implementation, as well as create a more efficient process. Meanwhile, an expenditure date can be incorporated to incentive spending and avoid delays.
The NYC Department of Design and Construction (NYCDDC) is urging the importance of resilience components in architecture and civil project designs. A climate risk assessment should be performed for proposed projects to assess the benefits of including sustainability early on in planning phases and to request the inclusion of specific goals for sustainability and resilience in final project initiation. Appropriate scope of work and funding for resilience and sustainability components should also be included and then implemented in selected infrastructure upgrade and/or renewal.

The New York City Panel on Climate Change (NPCC) is also using data from storm surges at high tide to simulate future sea level rise due to global warming. This data-driven work can provide a model for dealing with weather prediction and sea level rise for coastal cities.

The threat and reality of increased extreme weather events is the current risk that we face today in regard to climate change. In NYC, the centuries-old sewer system was designed to handle a maximum of 1 to 2 inches of rain per hour. Some recent rain events have seen up to 3 inches per hour, causing flooding and damage to property. In addition, flooding is problematic for NYC subway infrastructure. The Metropolitan Transportation Authority (MTA) and the New York City Department of Environmental Protection (NYC DEP) are working together to solve this challenge.

The MTA has been preparing for storms with ventilation grids and mechanical closure devices, but there needs to be a clear investment strategy to handle future rain events in the city. This includes capital investment in infrastructure, more maintenance, and a clear understanding of how NYC, with over 500 miles of coastline, will handle future storm events.
Raise Shorelines Citywide is a unique project that has involved planning, design and construction to address flooding and erosion associated with climate-change caused sea level rise. This project is being implemented by the New York City Economic Development Corporation in coordination with NYC’s Mayor’s Office of Climate and Environmental Justice. During the study phase, the project evaluated all 600+ miles of NYC coastline for tidal inundation risk from sea level rise in 2050 and identified at-risk locations. The project was intended to isolate a portfolio of locations that could benefit from shorter-term interventions, i.e., 20- to 30-year horizon vs 80- to 100-year horizon, for a relatively low cost.

Projects looking to address larger flood risks such as storm surge and higher frequency storm events often have price tags within the hundreds of millions of dollar range. The Raise Shorelines project identified multiple projects that could be implemented within the $109M project budget through a three-phase prioritisation process. The at-risk locations were screened and indexed for parameters such as flooding depth, impact to critical facilities and roadways, environmental impacts, property ownership (private vs public), estimated project cost and benefit cost ratios.

Through this planning process, ten projects were identified, which were further refined down to four projects during the design phase. Several standard shoreline protection measures were identified including bulkhead, i-wall or crown walls, revetment, berm, and riprap slope protection. The project with the highest ranking was identified as Old Howard Beach Street Ends. Two locations were identified within the Old Howard Beach peninsula in Queens, NY: 165th Avenue and 95th Street. Both locations experience periodic flooding today and by 2050, are expected to be a pathway for daily tidal flooding into the community from a 32-inch rise in sea level.

In coordination with various city, state and federal agencies, the project was designed to address this flooding with crown walls, drainage improvement such as tide gates and new outfalls, and riprap slope protection. It is currently under construction but faced numerous delays due to permitting, scope expansion to address existing degraded infrastructure in and around the project site, and extensive community and adjacent property owner coordination.

The projects currently in the design and construction phase have shown proof of concept of the full city screening methodology. They have also revealed the complicated nature of constructing along the waterfront to protect communities from flooding, from a design, regulatory, and constructability perspective.
Scaling up resilience solutions requires sustained financing, and access to resources, training, and capacity building opportunities. It requires the establishment and maintenance of stakeholder partnerships and strong governance structures that foster accountability, trust, and the empowerment of local communities. Justice, transparency, and inclusivity need to be at the core of any solution, with frontline communities centred and reflected in resilience interventions.

A wide breadth of solutions was showcased at the ICSI-led side event, including the Handbook for Implementing the Principles for Resilient Infrastructure, developed by UNDRR (see Box 3) and the empowerment of women through data and technology. Crucially, representatives spoke on the need for all stakeholders (academia, private sector, civil society, etc.) to come together to work towards solutions that can be delivered at pace and at scale. The following case studies are examples of solutions that can be replicated and scaled up to advance the adoption of DRR and resilience in infrastructure across different contexts.

“Women have to be seen not just as users, but as builders, designers, monitors and managers of infrastructure”
Suranjana Gupta, Senior Advisor, The Huairou Commission

“The Principles for Resilient Infrastructure, the accompanying Handbook, and their integration into the Sendai Framework as part of the midterm review, represent significant steps toward more resilient, DRR-consistent, future societies... A Net Resilience Gain culture, supported by greater systemic understanding, is urgently needed.”
Tom Dolan, Senior Research Fellow, UCL
Member States and stakeholders are encouraged to place the *Principles for Resilient Infrastructure* at the heart of critical infrastructure planning and financing, both in regards to developing new and upgrading existing systems. The *Principles for Resilient Infrastructure*, which have been developed in consultation with over 110 governments and industry stakeholders, provide a policy framework by which countries can pursue infrastructure resilience.

Following the release of the Principles, a practical *Handbook for implementation* has been developed. It expands on the *Principles for Resilient Infrastructure* with actionable interventions for each stakeholder group (e.g., policymakers, infrastructure regulators, investors, designers, contractors, civil society, etc.), providing practical examples and indicators to assess progress. In addition, it offers a governance framework for effective implementation considering the country’s priorities, context, and available funding.

The Handbook was developed through consultations with stakeholders in sectors such as infrastructure and finance, investigating how to transform the Principles into actions, interrogating the role of stakeholders on the ground and how to measure success. The Handbook can be used at country level to make a self-assessment and understand where each country stands, utilising a scorecard to help do so. The scorecard can help identify vulnerabilities and where the countries can focus action. All countries are welcome to share feedback with UNDRR for continual process improvement.
Arup is working with The World Bank Group to 1) estimate adaptation investment needs for Colombia’s national primary road network in accordance with viable resilience policies, and 2) provide recommendations on mainstreaming disaster risk analysis and resilient design into Private-Public Partnership (PPP) road infrastructure projects.

The project first undertook a landslide and flood risk quantification, and a policy and regulations analysis, and then provided high-level recommendations addressing technical, policy, and institutional spheres. The risk assessment leveraged the country’s existing probabilistic risk assessment for road infrastructure of the 2050 Long-Term Strategy, and project-specific data for fourth- and fifth-generation PPP projects to estimate direct, indirect, and larger socioeconomic consequences. The project then referenced indicative costs and benefits of proposed national adaptation measures to estimate the adaptation gap and propose policy and technical recommendations.

The second phase answered the question of how the Colombian road infrastructure sector could finance the estimated adaptation gap. This included a deep investigation into applicability of risk transfer and financial instruments, specifically looking at institutional structures, and aiming to foster private investment. The project then evaluated financial instruments targeted at managing disaster risks and organised them according to financing needs and by the applicable DRM stage. This resulted in a taxonomy outlining the suitability of private financing for different project typologies, and a risk financing roadmap that translates project parameters into a combination of recommended financial instruments. This study, which will be published as part of the World Bank’s Country Climate and Development Reports, can serve as an example of how accelerating strengthening of governance and investment in risk reduction can be achieved by understanding and leveraging the contributions from technical, private, and public actors.

How this case study supports implementation of the Sendai Framework’s priorities for action

One of the key recommendations in the MTR SF focuses on the commitment to governing and managing risk in “all-of-society” engagements in alignment with Priorities 2 (strengthening disaster risk governance) and 3 (investing in risk reduction). Regarding Priority 2, governance was at the core of the project, finding a balance of risk distribution between the public and private sectors, beginning with regulatory/policy documents and contracts for PPPs, then capturing larger national thematic strategies and commitments, and concluding with portfolio management and risk transfer mechanisms. Regarding priority 3, the project identified and evaluated instruments ranging from project-specific funds or budgetary items to reserve funds, contingent credit facilities, insurance/reinsurance, and bonds and capital markets. The project aims to leverage existing mechanisms and provide simple inputs and decision parameters to facilitate that choice and foster implementation.
Current predictions show that the NYC Metropolitan Area (Metro NY) will see increased storm surges, downpours, and sea level rise, but protecting this area from flooding is complex and multifaceted. Current efforts to manage the enormous and complex problem of coastal flooding in Metro NY include the New York-New Jersey Harbor and Tributaries Study (NYNJHATS), now proceeding under the auspices of the US Army Corps of Engineers (Army Corps), with the participation of the states of New York and New Jersey and the City of New York. There are over forty different possible approaches to flood risk reduction identified in the latest NYNJHATS report, the Tentatively Selected Plan (TSP), released on September 26, 2022.

The key to the success of this monumental undertaking will be picking the right combination from over forty available interventions for each community along the 900 miles of coastline covered by the NYNJHATS (and in dozens of inland neighbourhoods which also face severe flooding). The only way in which the Army Corps and its state and city partners will be able to do so is by co-creating local flood protection plans in partnership with the communities they cover. It will be no small task to effectively incorporate community-based knowledge into the NYNJHATS in a meaningful and accountable way.

To address the growing risks from climate-related disruption and repair the damage caused in frontline communities by systemic underrepresentation and disadvantage, coastal resilience planning must evolve to uplift community knowledge, comprehensively address the multiple flood-related threats facing these communities, prioritise natural and nature-based features and address other community goals for their coastlines. With proper resources and sufficient time, the NYNJHATS study could become an enduring example of the benefits to be gained by empowering communities, governments and academics to co-develop urban-scale resilience projects — while also helping to transform our at-risk coastal communities into safer, more vibrant and biodiverse spaces.
BOX 4 – A Perspective on Disaster Risk Reduction with Knowledge-Integrated Data Sciences

Contribution from Prof. Auroop Ganguly, Northeastern University

The impacts of climate change and variability on critical infrastructures, such as transportation lifelines or hydraulic infrastructures, and natural resources such as water or ecological systems, are critical to understand at urban and regional scales.

However, we currently have an inability to develop predictive understanding of relevant variables at stakeholder-relevant scales in a way that neither minimises the uncertainty and variability, nor gets overwhelmed by them.

The underlying coupled natural, human-engineered, and social systems are complex. Thus, climate systems exhibit chaos and non-linear dynamics which lead to intrinsic variability. Infrastructure systems tend to have cascading failures owing to growing interdependence, and social systems may fall victim to the tragedy of the commons when resources are shared. While each system is complex, their coupling in the context of disaster resilience may produce significant additional complexity. This is called the convergence of complexities in climate resilience.

These challenges lie at the interface of the science, engineering, and policy dimensions of earth systems, civil infrastructures, hydrological resources, and ecosystem services, and need to be informed by a myriad of state-of-the-art and innovative data, computational science and engineering solutions. One major gap in data sciences is the big data and small data challenge. While the data sizes are often massive and may come in at high velocities (such as from remote sensors and archived earth system model simulations), data for extremes and failures are rare, and data from in-situ sensors for certain urban or infrastructural systems are relatively small, especially at historical time scales. Thus, the science of big data (including managing and learning from massive and heterogeneous data), as well as the science of small data, (such as analysis of extremes or failures, along with extracting novel science insights and causal structures ), may need to be blended intelligently.

The second major gap is the lack of systematic approaches to blend process understanding, whether from physics and biogeochemistry, or from engineering and socio-economic principles, or based on policy principles, with data-driven insights. This is especially so for real or non-idealised systems.

Our accumulated knowledge and models (or parameterisations) have often been developed when data sets were much less available. The availability of new and often massive data offers a way to improve our collective understanding, yet the insights are often more meaningful, explainable, and interpretable when methods such as Artificial Intelligence (AI) are blended with existing process knowledge, thus suggesting hybrid physics-AI approaches.
The urban and coastal areas of Bangladesh and Indonesia face challenges from several natural disasters such as floods, sea level rise, and extreme hydro-meteorological events; this case study focuses on these two regions. Over 1.5 billion people have been affected by floods in Bangladesh, and thousands of lives were lost in the period from 2005 to 2015, whilst Indonesia is witnessing millions of people being displaced from their capital city, Jakarta, due to sea level rise and high flood risks. Climate change, rising inequality, ageing infrastructure, and excessive groundwater abstraction are some of the factors that contribute to the challenges faced by Bangladesh and Indonesia. To improve flood emergency management and build preparedness, investment in resilient infrastructure and an early warning system should be made, which will ensure a more inclusive recovery. However, conventional weather forecasting methods still cannot predict floods precisely, which results in insurmountable losses of lives and livelihoods.

In a NASA-funded project, Northeastern University is developing short-term precipitation forecasting for the Appalachian Valley in the United States using NASA satellite imagery and radar measurements to aid river management, emergency preparedness, and power production. This advancement of knowledge and forecasting methods can be customised for flood-prone zones in Bangladesh and Indonesia to mitigate extreme precipitation events and improve water resource management. The availability of global satellite imagery will enable us to resolve the data shortage problems in Bangladesh and Indonesia. The initial study focused on short-term weather forecasting, while the second study addresses water issues on a climatological scale. The project is also exploring how climate change and land use impact extreme weather events at regional scales in the United States and is examining the variability of these events in urban versus non-urban regions. These studies can be customised and extended to different climatological regions in Indonesia and Bangladesh, aiming to enhance the resilience of communities worldwide and providing critical information for policymakers as they design and implement effective water management strategies.

How this case study supports implementation of the Sendai Framework’s priorities for action

Priority 1 of the Sendai Framework is to develop a shared understanding of risk. This case study focuses on the development of a short-term weather forecasting system to create very high-resolution precipitation forecasts with remote sensing, machine learning, and AI. This system can help develop a shared understanding of risk and enhance knowledge and understanding of the systemic nature of risk by providing accurate and timely information on weather patterns. The system can also improve collaboration between DRR and statistical communities and enhance granularity in risk data and information. The system enables all of society’s engagement and participation and strengthens risk awareness and communication. Overall, the system can help build national and local data capacity, which is an essential aspect of Priority 1.
Access to education is a basic human right. Quality of education is the SDG 4, strongly determining poverty reduction. Providing facilities to educate children requires rapid expansion of school infrastructure. However, when expanding education facilities, what attention is being given to the sustainability and resilience of school infrastructure? Schools not only provide education but also act as community hubs and post-disaster shelters. Understanding their multi-hazard vulnerability is essential to assess and enhance disaster preparedness and recovery, thus minimising disruption of delivering education. The operational capacity of the transportation network and ensuring connectivity both influence the accessibility and speed of a community’s recovery after an event. Additionally, the social vulnerability of the community also plays a critical role in the recovery process. The engineering community has achieved substantial progress towards understanding building performance against natural hazards and devising scalable risk-reduction solutions. However, this knowledge has not reached decision-makers, nor is it used to drive school infrastructure investments. Without this knowledge, the opportunity to maximise benefits from intervention and optimise investments in school safety can be lost.

The UNESCO Chair in Disaster Risk Reduction and Resilience Engineering (DRR_RE), within the World Bank GPSS programme, has co-developed the Global Library of School Infrastructure (GLOSI) to be the instrument of this knowledge transfer. GLOSI is a live repository of evidence-based knowledge and data on school infrastructure performance in natural events. GLOSI provides governments and development partners with the tools to assess disaster risk in the education sector and effectively devise school infrastructure investment plans. To operationalise this resource, the UNESCO Chair DRR_RE is developing a probabilistic framework, adaptable to multi-hazard assessment of system resilience, integrating a decision-support mechanism for optimal recovery, incorporating qualitative and quantitative information. A Bayesian network estimates the probability of the schools and the road network operational capacity when exposed to earthquakes and floods of any given intensity. An Agent-Based framework is then used to simulate decision-making for the recovery process, allowing to infer the relative benefits of intervention strategies and preparedness plans to reduce or prevent the loss of education. This methodology is illustrated on the school-road network in two case studies in the Philippines and the Dominican Republic. The decision-making horizons are scoped and agreed with community leaders such as school principals, road network managers and ministry officials. The modular approach adopted in the model enables scaling for capturing larger systems and adaptation for multi-hazard resilience-recovery assessment of critical infrastructure.
The Lloyd's Register Foundation World Risk Poll provides a valuable new data tool to support the implementation of the Sendai Framework for Disaster Risk Reduction, primarily in relation to Priority 1 (understanding disaster risk).

As part of the 2021 World Risk Poll (published in 2022), 125,000 respondents in 121 countries were asked about their perceptions and experiences of a broad range of factors that contribute towards disaster resilience, across four domains including individual, household, community and societal. Assessing strengths and weaknesses across these domains enabled the creation of a holistic Resilience Index, comparing the resilience not just of countries but also of particular social demographics within them.

When combined with data on experience of disasters related to natural hazards within the same World Risk Poll resilience report – A Resilient World? Understanding vulnerability in a changing climate – this data constitutes a unique resource for governments and other DRR stakeholders to understand areas of vulnerability in order to better assess risk and target interventions, particularly in LIM countries where little comparable data exists.

Specifically in relation to infrastructure, the poll data includes questions that cover resilience factors including internet access, satisfaction with local healthcare, education and transport infrastructure, and how long people have gone without access to basic services such as electricity, drinking water, food and medical supplies, and telecommunications.

The ability to disaggregate this data across different social demographics contributes to improving the granularity of risk data, and the engagement and preparation of an inclusive, all-society approach to DRM and recovery.

In addition, the generic nature of the majority of the resilience indicators measured by the poll speaks to the systemic nature of risk and supports the prioritisation of interventions that will improve resilience in relation to a broad range of disaster risk sources.

Looking forwards, the next edition of the World Risk Poll Resilience Index – due for publication in 2024 following data collection in 2023 – will enable an assessment of how specific aspects of resilience are either improving or deteriorating in different parts of the world, and those investing in DRR and resilience should be responsive to the problem areas identified. Lloyd's Register Foundation is itself funding a number of exemplar intervention programmes to put the World Risk Poll resilience findings into action and calls on potential partners in the resilience space to increase the scale and impact of such targeted interventions.
This case study presents the outcomes of a pre-feasibility study on the use of a range of Nature-based Solutions (NbS) for flood-risk reduction, water quality and quantity improvements, and other co-benefits in the western part of the Thessaly region in Greece.

Extreme flood events represent one of the most destructive natural hazards in the Thessaly region, with potentially significant negative impacts on communities and the economy. The latest major flood event (known as the “Iannos Medicane” in September 2020), is considered one of the most disruptive events ever to have hit the region, causing estimated economic losses totalling between EUR 0.5 – 1 billion. Large parts of the Pineios river basin are characterised as areas of potentially significant flood risk. The plain of Thessaly constitutes the most productive Greek agricultural territory. Flood-risk reduction interventions that have been implemented in the past seem to have contributed only a limited extent to protecting valuable assets and communities. Conventional “grey” infrastructure alone is not able to cope with recurring river floods in the region, due to their severity.

There is very strong political will (at all levels) to reduce flood risk, as evidenced by the series of interviews with local municipalities and the capacity-building workshop conducted in Trikala in November 2021. However, the current plans focus heavily on grey solutions (including the potential creation of several new dams and other grey constructions in the target water catchment). The study has identified the portfolio of NbS interventions tackling water security challenges likely to deliver the needed services in the context of the local challenges in the Thessaly region.

In addition, the study has also identified potentially suitable locations in the Thessaly River basin where these interventions could maximise their services, if implemented. The outcomes of the study will need to be verified in other technical studies (e.g., feasibility study). In summary, the study supports the claim that the unwanted impacts of riverine flooding in the region of Thessaly in Greece can be effectively addressed with NbS, provided there is a strong political will to shift national and regional investments from grey infrastructure to NbS. Allowing NbS to complement, augment or replace conventional grey structures, where possible, would increase regional resilience and create additional benefits for the local communities.
Urban resilience to climate change is of ever-increasing importance as we move through the 21st century. Many aspects of understanding and managing climate risks in cities remain open problems; this is at least partially attributable to the multi-disciplinary nature of any lasting solutions, or the lack thereof. As climate change exacerbates hydrometeorological extremes, the capability to anticipate changes in how weather extremes are distributed through space and time becomes crucial for municipal preparedness, emergency response, and renewable energy production. Without this knowledge, it remains difficult to incorporate proactive resilience into lifeline infrastructures. The ability to translate scientific insights on extreme events into recommendations for policymakers, and of stakeholders to make informed planning decisions under uncertainty, allows for the minimisation of inevitable functionality loss due to extreme weather and the prevention of cascading failures across interdependent critical infrastructure systems. Initiatives led by Northeastern University’s Sustainability and Data Sciences Laboratory (SDS Lab) continue to build solutions to these complex problems and advance the state of knowledge in areas including weather prediction, infrastructure resilience, and climate finance, generating patents and successful startups.

Two US patents have been generated by the SDS Lab which focus on climate risk and infrastructure resilience. One of these patents is a predictive climate change model driven by climate model simulations, in-situ observations, and remote sensing data, quantifying the uncertainty within and between these datasets. The second patent centres on the generation of optimal recovery sequences for networked infrastructures and ecological webs following disruptions such as storm damage and local extinction, respectively, intercomparing the efficacy of recovery strategies to inform stakeholder decisions.

The startup risQ, funded by NSF SBIR, developed risk models to quantify the economic value of urban assets jeopardised by climate change and produced climate vulnerability measures with an emphasis on underserved communities. RisQ’s success in modelling climate-based risks in the municipal debt market led to the company’s acquisition by Intercontinental Exchange, a Fortune 500 company. Zeus AI, funded by NASA SBIR, is currently developing state-of-the-art data products for weather forecasting using AI and near real-time satellite observations. Emphasis is being placed on rainfall and windspeed prediction for flood management and renewable energy production, respectively.

Recent efforts include the exploration of hybrid physics-AI models and network science method development informed by techno-social principles, inspiring patents and startups in emerging economies. Domains of interest include India, Indonesia, Nepal, Tanzania, Brazil, and Peru, visited through study abroad programmes.
Huairou Commission is a global movement and network focused on empowering grassroots women to build resilient, sustainable, gender-just communities. The movement's experience supporting women's collective leadership in response, recovery, reconstruction, and DRR demonstrates that grassroots women are not simply users but also designers, planners, managers and monitors of housing and infrastructures. Huairou's Community Resilience Fund, designed to enable women's groups to drive resilience agendas from the ground up, has surfaced practical insights on grassroots women's approach to resilient infrastructure.

Women living in poor and marginalised communities articulate their need for resilient infrastructure differently from development professionals. Women's articulation of the need for resilient infrastructure is often embedded in their demands for any kind of infrastructure – such as footbridges, paved roads, retaining walls - where none exists. For the resource-poor, investments in building resilient infrastructure must be staged to allow for incremental investments that gradually upgrade infrastructure as aspirations and financial capacities evolve.

Flexible funds in the hands of local women's groups are essential, even where there are strong policy frameworks and inclusive, decentralised planning and budget processes. Such funds allow grassroots women's groups to test solutions while demonstrating effective financial management capacities, building confidence, and gaining credibility in the eyes of decision-makers, thereby attracting partnerships and financial resources.

It is also critical to acknowledge that the resilience of brick-and-mortar structures address only one of many risks faced by women from poor and marginalised communities. Grassroots women's organisations operate in multi-risk contexts and must continually deal with risks emanating from different sources. For instance, women clearly express their reluctance to move to evacuation centres. The unhygienic, crowded conditions increase risks of infectious diseases, sexual harassment and abuse, and increase women's caregiving burdens. Given their tenuous housing conditions, women are also unsure as to whether their houses will still be there to return to. It is this interplay of risks that grassroots women must continually consider when they assess available options to keep them, their families, and communities safe in the face of multiple crises.

Despite these challenges, grassroots women's organisations have been actively engaged in building a demand for resilient infrastructure and demonstrating in partnership with local governments how resilient infrastructure responsive to the needs of grassroots women can be designed and delivered. Their experiences and insights call upon policymakers to collaborate with grassroots women's organisations and their networks to redefine ‘resilient’ infrastructure in ways that capture the multi-dimensional nature of the risks faced by women living in impoverished urban and rural communities. We need partnerships between policymakers and grassroots organisations to revisit policy incentive structures and financial flows to enable grassroots women's groups to learn, test, innovate and collaborate with government, private sector and technical specialists.
KEY THEME 3 - MULTI-STAKEHOLDER ACTION

International coalitions, the private sector, and Professional Engineering Institutions (PEIs) play a role in enhancing resilience and driving DRR and resilience in infrastructure through their project work, and through partnerships and initiatives.

For example, PEIs can work to adapt codes and standards, be open collaborators and adopt systems thinking. They must also help engineers grow the skills to facilitate multi-stakeholder participation in new blue-green-grey infrastructure solutions. Coherent guidance by these key players is needed to drive infrastructure resilience through policy and frameworks. There has been good progress, such as the UNDRR Principles and Handbook, but more consistent requirements are needed. Government project investment appraisals methods must also put more value on DRR, resilience, and social inclusion in investment decisions.

At the ICSI-led side event, there was a call for stakeholders to make a concerted effort to collaborate and form cross-sector, multi-disciplinary partnerships to accelerate the DRR and resilience work that is being done. Emphasis was placed on the role of youth and young professionals in driving change and leading the sustainable development solutions of the future, as well as the role of the private sector and PEIs in supporting, financing and prioritising meaningful climate action. The following case studies highlight examples of initiatives that rely on the input and uptake of multiple stakeholders for collective action.

“The involvement of youth and young professionals is crucial in supporting governments to integrate resilience as a core value in infrastructure planning and implementation”

Pulkit Kanotra, Civil Engineer, Arcadis; Member, WFEO Committee on Young Engineers/Future Leaders Working Group for Climate Action (SDG 13)

“We must recognise communities that have embraced resilience and adaptation – communities and the public are key to successful DRR and resilience”

David Smith, Chair of the Sustainable, Resilient Infrastructure Advisory Board, Institution of Civil Engineers
Successes happen when the private sector focuses on resilience that drives prosperity and growth in the communities they operate.

The Engineering Leadership Group (ELG), a Resilience Rising Lab initiative originating from a partnership between Resilience First and ICSI, is the first of its kind, peer-to-peer engagement platform bringing together the world’s leading engineering firms to advance infrastructure sustainability, resilience, equity, and action. It is a groundbreaking effort to harness the collective voice of engineering companies, which recognise the need for the engineering community to provide research- and evidence-based support to global policymaking about infrastructure resilience and sustainability. The need for DRR and resilience to be embedded in all phases of infrastructure decision-making is a core tenet of the ELG. To support implementation of the Sendai Framework going forward, the ELG pledges to take action and leverage the collective expertise of its members to support DRR and resilience throughout the infrastructure lifecycle and advocate strongly to policymakers that it becomes business-as-usual on all infrastructure projects.

The ELG will work on the development of risk assessment methodologies that address systemic impacts and incorporate climate change projections. The group will also advance DRR solutions that integrate hazard mitigation in the planning and implementation of disaster recovery, and endeavour to build the infrastructure disaster response and recovery toolbox of the future.

The World Federation of Engineering Organisations (WFEO) Disaster Risk Management Committee has released a booklet on Engineering Resilience in Disaster Risk Management for Sustainable Development, which highlights topics such as the importance of engineering input early in the land-use planning process and the critical importance of community engagement. The booklet is organised into five chapters: Land Use Planning; Resilient Infrastructure Systems; Data and Information Management; Capacity Building; and Institutional Framework and Public Policies, with case histories provided throughout.

A key point from the Institutional Framework and Public Policies chapter, is that communication that engenders public trust is an essential component of effective DRM.

The WFEO-CDRM has and will continue to contribute to advancing engineering practice for DRM in the context of achieving the UN SDGs and seeks to continue collaborating with all its partners (SDG 17).

1. Engineering Resilience in Disaster Risk Management for Sustainable Development

2. WFEO Model Code of Practice on Principles of Climate Change Adaptation for Engineers
In response to the devastating impacts of climate change affecting vulnerable people all over the world, the COP27 Presidency launched the Sharm-El-Sheikh Adaptation Agenda (SAA) in partnership with the High-Level Climate Champions and the Marrakech Partnership in November 2022. The SAA outlines 30 Adaptation Outcomes that are urgently needed to increase the resilience of 4 billion people and to accelerate transformations across five impact systems: Food and agriculture, Water and nature, Coastal and oceans, Human settlements, and Infrastructure.

The SAA underpins and provides the actionable breakthroughs required for the Race to Resilience campaign – the sibling campaign to Race to Zero – to catalyse a step-change in global ambition, to accelerate the investment and implementation of adaptation solutions, and to put people and nature first in pursuit of a resilient world where we do not just survive climate shocks and stresses but thrive in spite of them.

One outcome of the SAA is to improve the resilience of 2.2 billion people through the expansion of affordable public and private transport and to ensure that transport infrastructure is resilient to climate hazards through the adoption of new technologies, design, and materials. With 80% of energy systems currently at risk from climate hazards and nearly 75% of roads and 65% of rail predicted to be at risk by 2030, reliable and resilient infrastructure will be critical to proactively provide the services needed to create resiliency for people.

Collectively, these outcomes represent the first comprehensive global plan to rally both the public and private sectors behind a shared set of adaptation actions that are required by the end of this decade, recognising that progress towards adapting to climate consequences and enhancing resilience is crucially needed. Ultimately, the SAA can drive DRR infrastructure investment and a shared understanding of risk for impact.
The involvement of youth and young professionals is crucial in supporting governments to integrate resilience as a core value in infrastructure planning and implementation. Young professionals offer a unique & diverse perspective and innovative ideas that can contribute to the development of sustainable infrastructure that is resilient to future challenges. By engaging youth in decision-making processes, through increased employment of young professionals in government agencies/committees and by increasing youth engagement through knowledge sharing activities, governments can ensure that the infrastructure planning and implementation are responsive to the needs of current and future generations. Furthermore, empowering youth and young professionals to actively engage and participate in the planning and implementation of infrastructure projects builds capacity in sustainable development.

There are several other tangible actions that can be taken to boost investment in DRR and resilience in infrastructure:

- Firstly, governments can establish policies and regulations that require infrastructure projects to incorporate resilience and DRR measures. This can include mandating the use of resilient materials and designs; partnering with Indigenous groups to research, co-design and integrate nature-based solutions; conducting climate change risk assessments; and incorporating climate change projections into project planning.

- Secondly, governments can increase funding for infrastructure projects that prioritise resilience and DRR. This can include allocating a greater proportion of public funds to resilient infrastructure projects, as well as providing financial incentives for private sector investments in resilient infrastructure.

- Thirdly, governments can work with multi-sectoral international organisations and other countries to share best practices and innovative approaches to building resilient infrastructure. This can include participating in international forums, sharing technical and policy expertise, and collaborating on research and development projects.

Overall, boosting investment in DRR and resilience in infrastructure requires a multi-faceted approach that involves robust policymaking, funding, international and multi-sectoral cooperation, and community engagement. The youth and young professionals are a powerful and often overlooked subset within the climate policy community who are driving conversations around sustainable development and recognise climate change as an existential crisis. It is time that young professionals and policymakers are given their rightful voice to create meaningful change in the climate policy space.

**EMPOWERING YOUNG PROFESSIONALS TO BUILD CAPACITY IN SUSTAINABLE DEVELOPMENT**

Contribution from the WFEO Committee on Young Engineers/Future Leaders Working Group for Climate Action (SDG 13)
Annex 1 - Speakers and Contributors

Attendees at the ICSI convening
‘Accelerating implementation of DRR and resilience in infrastructure’ on 17 May 2023.

Meeting Chair
Savina Carlucchio, Executive Director, International Coalition for Sustainable Infrastructure (ICSI)

Keynote Speaker
Abhilash Panda, Head, Financing Resilience, De-risking investment & Infrastructure Resilience, United Nations Office for Disaster Risk Reduction (UNDRR)

Lead Discussants
Lieutenant General Inam Haider Malik, Chairman, National Disaster Management Authority of Pakistan
Kamal Kishore, Member of India’s National Disaster Management Authority (NDMA); Indian Co-Chair of the Coalition for Disaster Resilient Infrastructure’s (CDRI) Executive Committee
Victoria Salinas, Senior Official Performing the Duties of Deputy Administrator, Resilience, Federal Emergency Management Agency (FEMA)

Spotlight session speakers
Mathieu Verougstraete, Head of Infrastructure and Finance for Resilience Unit, UNDRR
Nicole Boothman-Shepard, Vice President, Resilience and Recovery, AECOM
Tom Dolan, Senior Research Fellow, University College London (UCL)

Moderators
Seth Schultz, CEO, Resilience Rising
Tom Lewis, LE4 Advisors
David Smith, Chair of the Sustainable, Resilient Infrastructure Advisory Board, Institution of Civil Engineers; Senior Vice President, Stantec

Roundtable participants
Thematic Session 1: Governance for Resilience
Thomas Abdallah, Vice President, Design Services, The Metropolitan Transportation Authority (MTA)
Eric Macfarlane, First Deputy Commissioner, NYC Department of Design and Construction

Jennifer Cass, Senior Vice President, Capital Program, New York City Economic Development Corporation (NY EDC)

Thematic session 2: Scalable Solutions for Resilience
Fiona Cousins, Principal, Americas Chair, Arup

Aurop Ganguly, Distinguished Professor, College of Engineering, Northeastern University
Puja Das, PhD Candidate, Northeastern University
Suranjana Gupta, Senior Advisor, The Huairou Commission
Paul Gallay, Lecturer, Undergraduate Program in Sustainable Development, Columbia University

Thematic session 3: Taking Action
Bill Kelly, Senior Advisor to the American Society of Civil Engineers (ASCE) and the World Federation of Engineering Organizations (WFEO)
Pulkit Kanotra, Civil Engineer, Arcadis; Member of WFEO Committee on Young Engineers/Future Leaders Working Group for Climate Action (SDG 13)
George Karagiannis, Director of the Engineering Leadership Group (ELG); Former Deputy Secretary General, Civil Protection in Greece

Additional Remarks
Peter Hall, Vice President & Global Director - Climate Resilience & ESG, WSP
Nat Keohane, President, C2ES

Additional case study contributors
Christopher Corliss, WSP
Prof. Dina D’Ayala, University College London; UNESCO Chair for DRR and Resilience Engineering
Juraj Jurik, Global Infrastructure Basel
Rachindra Mawalagedara, Northeastern University
Ed Morrow, Lloyd’s Register Foundation
