IWDRi 2019

Agenda Notes

International Workshop on Disaster Resilient Infrastructure

19th – 20th March 2019

Taj Mahal Hotel, New Delhi
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Opening Session 1

Stage Setting

10:45 – 12:00

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
The Panel

Chair

- Dr K. VijayRaghavan, Principal Scientific Advisor, Government of India

Speakers

- Prof Jim Hall, Environmental Change Institute, University of Oxford

Moderator

- Kamal Kishore, National Disaster Management Authority, India

Discussants

- Ms Alice Hill, Hoover Institution, Stanford University
- Prof Anand Patwardhan, University of Maryland School of Public Policy
- Andrew Maskrey, Risk Nexus Initiative
- Rowan Douglas, Insurance Development Forum

Session Format

This session will begin with a keynote presentation by Prof Jim Hall, Environmental Change Institute, University of Oxford followed by a panel discussion.
The session will reflect on the big-picture scale of risks to infrastructure systems. The discussion will explore the ‘systems approach’ and policy responses required to enhance infrastructure resilience and address the need to bring resilience analysis ‘upstream’ in the infrastructure decision making process. This session will look at the adaptation of globally interconnected infrastructure systems in light of dynamic risks presented by climate change.

Keynote address:

The global challenge of adapting infrastructure systems to be resilient to climate disasters

Professor Jim Hall, Environmental Change Institute, University of Oxford

Infrastructure systems worldwide are threatened by extreme events and the chronic impacts of climate change. There must be increased attention to how these systems can be adapted. This talk will present an analysis of climate risks to infrastructure at country and global scales. It is proposed that infrastructure adaptation should be thought of at three different levels that incorporate (i) physical adaptations to climate-proof infrastructure assets; (ii) adaptations to the systems that operate on infrastructure networks, so that they are more resilient to disruption and; (iii) long term planning to ensure that infrastructure investments avoid hazardous locations and do not build up exposure for the future. Through the talk, there will also be a demonstration of methodologies based on big data analytics and systems modelling that can help to pinpoint vulnerabilities in infrastructure networks and prioritized adaptation interventions.
Thematic Session 1

Thematic Pillars
Driving Infrastructure
Resilience

12:00 – 13:30

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
Discussants

- Chairs and moderators of the breakout panels

Moderator

- Kamal Kishore, National Disaster Management Authority, India

Session Format

This session will commence with a joint introductory presentation and then break into 3 parallel sessions T1-A, T1-B, T1-C.

Each breakout session will have presentations by 3-4 speakers of 10 minutes each highlighting the key challenges and opportunities for the typology, followed by a moderated discussion.

Chairs and/or moderators from the three panels will then reconvene for a joint panel discussion.
This session will advance the discussion on the three thematic pillars driving the coalition for disaster resilient infrastructure (DRI).

1. T1-A: Risk assessment methodologies, risk metrics and indicators of sustainability for different infrastructure classes.
2. T1-B: Standards, design and regulation for infrastructure development, operations and maintenance.
3. T1-C: Reconstruction and recovery planning of key infrastructure sectors after disasters.

Gaps in both knowledge and practice in these thematic areas act as barriers to creation of resilient infrastructure. While these gaps are reflective of the global status, different countries have had varying amounts of success in addressing each theme. This session will bring together experts who are working at the forefront of the three pillars that are aiding better decision making for DRI.

Each thematic breakout session will address the following questions:

- What is the current state of play in this area?
- How should this pillar evolve as an area of specialization?
- In what ways can these be integrated in upstream planning stages?
- What are the knowledge and capacity gaps that the CDRI can address?
Thematic Session 1-A

Risk Assessment

12:05 – 13:10

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
Chair

- Chen Xi Mao, Professor of Institute of Engineering Mechanics, China Earthquake Administration, China

Moderator

- Andrew Maskrey, Risk Nexus Initiative

Speakers

- Prof Bilal Ayyub, Center for Technology, and Systems Management, University of Maryland [Video Keynote address]
- Dr Raghav Pant, ECI Oxford
- Prof Ravi Sinha, IIT Bombay

Discussants

- Neil Sandro Alata Olivares, PhD, CENEPRED, Peru
- Cristobal Mena Amigo, ONEMI, Chile

Session Format

This is a breakout session as part of Thematic Session 1.

It will have presentations by the speakers of 10 minutes each followed by a panel discussion.
A review of literature shows that there still are multiple gaps in the global practice of disaster risk assessments. While hazard and vulnerability data is being recorded in various forms around the world, there is a lack of standardisation in the data formats and collection methods. This, combined with the lack of accurate time-series data at the local level, and the lack of capacity to carry out complex risk analysis in various countries, leads to the end users being deprived of the information they require, to make risk-informed decisions about future development. This gap is further exacerbated by the effects of climate change that dynamically alter the patterns of hydro-meteorological hazards thereby limiting our ability to predict and mitigate their effects.

This session will address the following key questions:

- What are the major challenges in incorporating new disaster risk assessment practices as part of the country's infrastructure investment approval process?
- What new methods are being explored globally for quantifying uncertainty due to climate change?
- How can countries organise a system of continually updating risk assessments across different scales (country, province, city) that will inform future development?
- How can effective communication be facilitated between policy makers, infrastructure developers, regulators, and the general public regarding the findings of risk assessments?
Risk Assessment involves carrying out an analysis of historical data on hazards, and their interactions with exposed and vulnerable populations and assets. This helps to quantify and predict the probability and impact of a disaster in order to prepare for it accordingly. The gaps in the global practice of risk assessment have been identified as listed below:

1. Lack of mechanisms and systems to collect accurate data regularly
2. Lack of capacity to perform complex risk analysis
3. Data collected is not standardised and sometimes cannot be shared with the end user due to legal barriers
4. Lack of risk assessment models that take into account climate change
5. Inadequate dissemination / accessibility of risk data to end-users

Each of these gaps has been elaborated on below:

1. **Lack of mechanisms and systems to collect accurate data regularly**

Disaster risk assessment is a complex task and it requires very detailed, accurate, time-series data on hazards, exposure and vulnerability. Particularly in developing countries, the capacity, mechanisms, and systems to collect such detailed data do not exist. A related set of information which is required is data on damage and losses, after an event. Of these, data on hazards is reasonably easy to acquire and record. In the case of large hazards such as major cyclones, or earthquakes, global monitoring systems and satellite imagery can accurately measure them. In the case of small and medium scale hazards, and hazards like landslides, there still are major data gaps. Small and medium hazards may not cause catastrophic damage in one go, but rather cause cumulative damage over time which leads to degradation of the infrastructure. They are also more frequent than large, catastrophic hazards.

On the point of exposure, the data are reasonably easy to acquire and record, though not as easy as hazard data. Anecdotally, in developing countries large gaps do exist in asset inventories and values data.

The third point viz. vulnerability, and also data on losses after an event is where the gap is most significant. Reliable data on these two points is sparse, and is tricky to acquire. A lot of developing countries do not have the capacity or the systems to collect and record such data, since it involves extensive monitoring and assessment, and meticulous record-keeping.
A related concept which is often ignored or not well developed in developing countries is the risk from infrastructure i.e. impact assessment. Creation of new infrastructure can lead to the creation of new risks for the surrounding areas even if the infrastructure itself resilient. For example, building a large airport could disrupt watersheds, and increase the risk of flooding in the surrounding areas, as a result.

2. Lack of capacity to perform complex risk analysis
Risk analysis for disasters involves very complex analysis using statistical models which utilise hazard, exposure and vulnerability data. Another layer of complexity is added to this risk analysis when we consider cascading effects of non-resilient infrastructure. The failure of one piece of infrastructure can have a domino effect which causes the failure of several other pieces of infrastructure. A further layer of complexity arises out of climate change, and the need to incorporate climate models into risk analysis.

Performing these analyses requires personnel well trained in mathematical modelling and statistics. Further, these personnel need the right equipment, i.e. computers and other hardware and mathematical modelling software, and the know-how to use them. In a lot of developing countries, this kind of capacity does not exist within the government.

3. Data collected is not standardised and sometimes cannot be shared with the end user due to legal barriers
Countries themselves and other countries like them or in the same region can benefit greatly from exchanging data on disaster risk. However each country has different formats for collecting such data. The lack of standardised data poses a significant hurdle to compiling and sharing it, which in turn hampers research into infrastructure resilience. Lack of standardised data can also impede the development of smooth project pipelines which in turn discourages private and international investors from investing.¹

In some cases legal barriers might prevent a country from sharing data with other countries. This presents an additional challenge.

4. Lack of risk assessment models that take into account climate change
The lack of reliable time-series data, as pointed out earlier, is indispensable for conducting robust risk assessments. However, we also need to bear in mind that in the face of climate change, risk analyses based on past data on hazards — especially hydro-meteorological

¹ Preqin, 2016
hazards — need to be augmented with estimates of emerging risk scenarios. Developing these models require extensive research, and involve incorporating climate models into risk analysis. Another significant knowledge gap in this respect is in methodologies to statistically downscale global climate models to the sub-regional levels. The Intergovernmental Panel on Climate Change (IPCC) provides projections downscaled to 35 world regions, but not below that. While a few countries such as USA, Australia and France have developed downscaled national and sub-regional level climate models, the vast majority of the developing countries have not, and do not possess the capacity to do so either.

5. **Inadequate dissemination / accessibility of risk data to end-users**

Even after risk data are collected and recorded, the systems which make it available to users may not always exist. Taking the example of India for vector data on flood-lines of rivers, the data are regularly collected but usually stored in individual silos — typically the irrigation/water-resources department offices at the district level, and in some cases at the state level.

This observation holds good for all categories of infrastructure, especially for developing nations. Usually such data are not consolidated into one centralised database, or published on a platform which can be easily accessed by parties who might actually use such data. As with data standardisation, the lack of data accessibility also impedes the creation of project pipelines, which in turn can lead to the infrastructure projects being perceived as less bankable. This may discourage private and international investors.²

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² World Bank’s Global Infrastructure Facility, and G20’s Global Infrastructure Hub, having identified this symptomatic gap and are now providing support to countries to develop project pipelines to make infrastructure projects more attractive to investors.
Key insights from IWDRI 2018

1. **Understanding the fundamentals of resilience:**
   - Development of a framework for investing in DRI must be preceded by a clarification of the fundamentals of resilience. This includes ways of measuring resilience, performance metrics for different infrastructure classes and recovery profiles of infrastructure towards a range of disasters for a given context.
   - Resilience indicators must be able to measure performance, link it to achievement of SDGs, incorporate effects of climate change, Industry 4.0 and the cyber economy.

2. **Create better risk metrics:**
   - Infrastructure standards are not absolute, and must be seen as a function of resource availability, risk appetite and capacity to reduce risks. Therefore, using a notional definition of resilience can help in the development of metrics for measurement.
   - A comprehensive risk management strategy must move from creation of risk metrics to development of a national multi-hazard risk profile to a high-resolution infrastructure sector risk systems model. As systems level coordination may be time-consuming; a sector-wise approach may be recommended to begin comprehensive assessments. E.g. UK has: (1) A national risk assessment produced every two years; and (2) Sector security resilience plans.
   - Sharing of methodologies and information at a global-level will be valuable to create a workforce that is able to understand and use risk information to build resilience.

3. **Data standardization:**
   - While hazard and vulnerability data is being recorded in various forms, there is a lack of standardization in data formats and collection methods. Combined with the lack of accurate time series data at local-level and lack of capacity to carry out complex risk analysis; end users are being deprived of information required to make risk-informed decisions about development. This gap is further exacerbated by the effects of climate change that dynamically alter the patterns of hazards.

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3Workshop Summary, IWDRI 2018
4. **Use local knowledge:**
   - While the quality of risk assessments may be sufficient for investment decisions, they may not be nuanced enough for policy and political decisions. Risk assessments must be aligned with the needs of the end-user and the local planning process. E.g. Mozambique, Kenya, Afghanistan and Kyrgyz Republic.
   - Chile has developed a “Supplementary Methodology to Reduce Disaster Risk in Public Investment” by integrating disaster risk assessment in the public infrastructure investment process. The supporting online spread-sheet tool enables site-level risk calculations that can inform decisions about mitigation measures.

5. **Create access to open source data and tools:**
   - The next generation of decision makers (engineers, town planners and infrastructure financiers) must be provided access to open source risk models to aid risk-informed infrastructure development. There is a need for a tech
Thematic Session 1-B

Standards, design and regulation

12:05 – 13:10

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
IWDR 2019
The Panel

Chair
- Mathew Crossman, UK

Moderator
- Russell Muir, World Bank Group

Speakers
- Toshihiro Kamatani, MLIT Japan
- Dr Sudhir Jain, IIT Gandhinagar
- Mark Johnson, International Code Council

Discussants
- Jimmy Scott, Queensland Reconstruction Authority
- Phil Rizcallah, National Research Council, Canada
- Prof CVR Murty, IIT Chennai

Session Format

This is a breakout session as part of Thematic Session 1.

It will have presentations by speakers of 10 minutes each followed by a moderated discussion.
Standards play an important role in disaster risk reduction and creating resilience. In order to be effective, they need to be rational, need to be enforced, and need to be updated regularly to keep pace with the evolving understanding of natural hazards and advancements in engineering technology. International standard setting bodies such as the International Organisation for Standardisation (ISO), the International Electro-technical Commission (IEC) and the International Telecommunication Union (ITU), develop and provide such standards for countries to voluntarily adopt. Infrastructure standards under these bodies are regularly updated and are already incorporating resilience elements, towards achieving the targets of the Sendai Framework. For example, the United Nations Office for Disaster Risk Reduction (UNISDR) agreed in 2015 (within the context of the Sendai Framework) to work with ISO to develop new standards for disaster proofing cities. ISO is currently in the process of developing new Indicators for Resilient Cities under their Sustainable Development in Communities project.

National frameworks for design and construction standards need to be strengthened through better regulation, state-of-the-art technology, incentives (financial and non-financial) and innovation. These frameworks should incorporate the structural engineering aspects of physical infrastructure as well as for Operation and Maintenance (O&M) of this infrastructure. Lack of O&M standards can increase the impact of hazard events or even trigger new ones, for example urban floods due to inadequate maintenance of sewage systems.

This panel will discuss the following questions:

Are emerging risk factors such as climate change manifestations being considered adequately while developing standards? What are the regulatory gaps that must be plugged to address these risks better?
Are the standards for operation and maintenance adequate for existing levels of disaster risk, without even taking climate change into account? Are they being suitably updated?
How can enforcement of standards be improved? How can compliance be improved in cases where state capacity for enforcement is limited?
How can regulation of professions play a role in improving compliance with standards?
Standards are one of the most important mechanisms for incorporating resilience into infrastructure. On the design and engineering side, standards pertain to standards for materials and construction which may take the form of building codes or bye-laws, and land use planning and zoning regulations. On the management side, standards can take the form of regulations for Standard Operating Procedures (SOPs), inspection, monitoring and surveillance, operations & maintenance (O&M), and crisis/emergency management.

The gaps in global practice of creation and implementation of standards for design and implementation have been identified as:

- Lack of enforcement of standards
  - Lack of licenced disaster resilience professionals — civil engineers with expertise on building disaster resilient infrastructure
  - Lack of standards for operations & maintenance
  - Overlapping standards in some cases
  - Lack of systems to evolve standards as capacity, technology, and knowledge of risk management evolves
  - Standards for Contingency Planning

These gaps have been elaborated below:

1. **Lack of enforcement of standards**

Enforcement of standards in developing countries tends to be lax.\(^4\) This can be a result of any of a multitude of factors such as ineffective command and control, insufficient qualifications of officials in charge of enforcement, lack of focus on risk management, opaque bureaucratic procedures, and corruption.\(^5\) The outcome of these lapses is that infrastructure and communities in developing countries is more vulnerable to damage than in developed countries.

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\(^5\) GFDRR, 2014.
2. Lack of licenced disaster resilience professionals—civil engineers with expertise on building disaster resilient infrastructure

Often in developing countries, personnel with knowledge of building disaster resilient infrastructure are not easily available.\(^6\) This holds good for both developers of infrastructure, as well as inspectors / regulators. Anecdotally, it has been observed that in India, typical civil engineering courses did not include training on how to incorporate resilience to seismic shocks into buildings.\(^7\) Without having the capacity to build according to standards, having high building standards becomes a moot point.

3. Lack of standards for operations & maintenance

Typically, building standards may provide very detailed parameters for the engineering and design but standards for O&M are not given as much attention. Resilience of any infrastructure is inextricably linked with proper O&M, since without it the infrastructure will deteriorate over time. For example, anecdotally it is commonly observed that road quality in developing countries is bad: once a road gets built it is not properly maintained and repaired. The scores for Road Quality Index — from the Global Competitiveness Index — partially confirm this observation. Most developing countries score less than 5 (out of 7) on road quality.\(^8\)

4. Overlapping standards in some cases

While the lack of standards is a problem in some instances, in some cases there may be more than one standard for the same kind of infrastructure. This may arise out of the complexity of that particular infrastructure project (e.g.: a bridge meant to serve both railways and road vehicles), or they could arise out of overlapping jurisdictions.\(^9\)

Creating a uniform building code is necessary in such cases. The USA underwent such a process starting from 1966.\(^10\)

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\(^7\) Source: DRR Roundtable discussions.


\(^10\) Ibid.
5. Lack of systems to evolve standards as capacity, technology, and knowledge of risk management evolves

Most developing countries lack the systems and the capacity to develop their own standards. Further, as pointed out earlier in this report, creating new standards requires thorough risk assessments and cost-benefit analyses. The data gaps and capacity gaps for these two components have been described earlier. As a result, usually, standards are borrowed from other developed countries, and mandated top-down without consideration for local needs, resource availability and capacities.11

6. Standards for Contingency Planning

Sometimes, despite the greatest care in planning, construction and O&M, an extremely rare event can destroy infrastructure built to the best of standards. An example of such a situation is the earthquake and tsunami which led to the Fukushima-Dai’ichi nuclear disaster in Japan in 2011. The nuclear reactor was designed to withstand earthquakes of up to magnitude 7 on the Richter scale. Immediately after the earthquake hit, the active reactors automatically shut down their sustained fission reactions. However, the ensuing 13 m high tsunami overwhelmed the 10 m sea wall and disabled the emergency generators that would have provided power to control and operate the pumps necessary to cool the reactors. The insufficient cooling led to three nuclear meltdowns, hydrogen-air explosions, and the release of radioactive material in Units 1, 2 and 3 from 12 to 15 March. For large infrastructure whose failure can have far-reaching negative effects, standards are needed for contingency planning to handle infrastructure failure due to extreme rare hazard events. The infrastructure has to be “safe to fail”, i.e. systems need to be put in place in order to minimise the downstream impacts of the failure.

Key insights from IWDRI 2018

1. **Manual of Practice for end users:**
   - A bouquet of state-of-the-art standards must be made available for end users of information on resilient infrastructure. A Manual of Practice (MoP) for Climate Resilient Infrastructure that is being developed by the American Society of Civil Engineers (ASCE) is a good example.
   - A more comprehensive MoP maybe co-created by experienced practitioners, government representatives and researchers to collate systematic knowledge in the field that provides necessary guidance to practitioners. The Coalition provides an important platform to capture lessons learned and manage their dissemination towards creating a required pool of knowledge.

2. **Adopting a lifecycle approach for adaptive standards:**
   - Past statistical trends are no longer a good guide for future standards. Hence, “stationary, non-time variant” prescriptive standards must give way to “evolving adaptive” standards to continually tackle changes from climate risks and other externalities that impact the life span of infrastructure.
   - The adaptive design framework may lead to “real options” that are pre-decided responses to changes in the infrastructure project environment. E.g. The Los Angeles to San Diego (LOSSAN) rail corridor uses the “Observational Method” for constant monitoring to update risk models and take decisions about upgrading or discontinuing the use of the infrastructure.

3. **Standards for soft infrastructure:**
   - The “systems approach” must attribute due importance to soft infrastructure. This underpins the vital knowledge base, supporting institutions and capacity development needs for technical specialists.

4. **Interdisciplinary standard setting:**
   - Appropriate standards may provide the first line of defence against shocks and stresses. However, standards permeate through disjointed phases of procurement, design review and failure analysis. The “design phase” of any

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12Workshop Summary, IWDRI 2018
project is critical to enable comprehensive inclusion of good standards for resilience.

- A multidisciplinary design phase that includes land-use planning, climate science, disaster management in coherence with the engineering sector can make for better informed decisions underpinning investment in resilient infrastructure.
Thematic Session 1-C

Planning for recovery and reconstruction of infrastructure

12:05 – 13:10

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
IWDR 2019

The Panel

Chair

- Setsuko Saya, Cabinet Office, Japan

Moderator

- Prof. Mauro Dolce, Dipartimento della Protezione Civile, Italy

Speakers

- Dr Josef Leitmann, Recovery Advisor, World Bank Group
- Rita Missal, Recovery Specialist, UNDP

Discussants

- Diana Arlette Cordero Devesa, Seguridad, Mexico
- Saudi Arabia*
- Indonesia*

Session Format

This is a breakout session as part of Thematic Session 1.

It will have presentations by the speakers of 10 minutes each followed by a moderated discussion.
At present, most countries focus on systematic post-disaster recovery of infrastructure sectors only after major disasters. Small and medium scale events also cause incremental damage and degradation of infrastructure leading not only to direct loss of capital assets but also productivity losses. This calls for predictable mechanisms for systematically assessing damages and losses to financing infrastructure recovery after disasters of varying magnitudes. Reconstruction and recovery in infrastructure sectors must follow the “Build Back Better” principle for multiple hazards. The principle needs to be applied not only for the structural design of the infrastructure but also in management systems.

A disaster risk financing framework can involve:

a. **risk retention** that involves government budget reserves, calamity funds and contingent credit facilities;

b. **risk transfer** through government and private insurance and reinsurance markets, catastrophe bonds and other insurance-linked securities; and

c. **post-disaster budget allocations** that may divert funds from other programs.

This panel will discuss the following questions:

- How do we improve the reporting of medium scale and smaller disasters? How can loss assessments be improved to take into consideration gradual degradation due to such events?
- How do we identify critical infrastructure? How can we increase the likelihood that critical infrastructure services are recovered and resumed rapidly following a disaster?
- How do we resolve the tension between providing essential services quickly, and ‘building back better’? What are the measures to establish good contingency planning to ease this?
- How can countries make coherent disaster recovery financing strategies to ensure that liquid funds are reliably available at the appropriate levels of government recovery and reconstruction?
- How can decisions on retaining and transferring risk be rationalised?
- How can we institutionalize the learning process after each disaster?
Reconstruction and recovery after a disaster requires a systematic approach for assessing losses, estimating needs, and channelling adequate funds to the affected areas in a timely manner. The gaps leading to delays and inefficiencies in post disaster recovery and reconstruction have been identified as:

(a) Lack of reliable mechanisms for assessing damages and financing infrastructure recovery after moderate and small scale disasters
(b) Most countries do not always follow the build back better principle

These gaps have been elaborated on below.

1. **Lack of reliable mechanisms for assessing damages and financing infrastructure recovery after moderate and small scale disasters**

Currently most countries conduct systematic recovery and reconstruction only after major disaster events. However, small and medium scale disasters — which cause limited damage per event but cause cumulative damage over time — do not receive the same response. Part of this issue is due to gaps in data regarding the occurrence and impact of such small and medium scale disasters, as compared to data on large disasters. It is possible that they occur more frequently and, because they escape attention, cause more damage and economic losses overall.

2. **Most countries do not always follow the build back better principle**

“Build back better” is a core principle for post-disaster reconstruction. However, usually even when the principle is applied, its application is typically limited to structural design of the infrastructure. Redesigning management systems which contributed to the structure’s vulnerability in the first place get overlooked. Thus, the application of the “build back better” principle is often incomplete.
Key insights from IWDRI 2018

1. Small and medium scale disasters:
   - At present, most countries focus on systematic post-disaster recovery of infrastructure sectors only after major disasters. More predictable mechanisms are needed to account for damages, degradation and productivity losses due to small and medium-scale events.

2. Build Back Better:
   - Under the concept of “Build Back Better”, Japan highlighted the importance of having a combination of structural and non-structural (social and economic) measures for faster recovery. Japan has established a system of pre-disaster contracts that are made with private sector infrastructure developers such that they are prepared to facilitate efficient post-disaster reconstruction activities.
   - As infrastructures are interconnected, their reconstruction must be discussed at a regional/territorial level to account for downstream risk creation and capacities must be built at the local level to manage reconstruction activities.
   - The expenditure money for reconstruction after the 2011 Tohoku earthquake was derived from taxation, issuance of bonds, and even taking 10% off all government employees’ salaries for a period of three years.

3. Standardized reporting methods:
   - UNDP reflected on its experience in infrastructure recovery and reconstruction to emphasize the role of a standardized format for estimation of post-disaster damages, losses, and replacement costs. E.g. Post Disaster Need Assessment (PDNA) tool, Global Recovery Cost Estimation guideline.
   - PDNA plays a critical role in guiding future projects, especially in order to follow the “Build Back Better” principle based on existing building codes.
   - There is a need to move away from pure “restoration of services” to “resilience focused reconstruction”. Hence, alternative models of financing recovery such as private sector participation, selling of reconstruction bonds, and the setting up of intergovernmental risk pools must be explored.
   - Nepal’s experience in reconstruction and recovery after the 2015 Gorkha Earthquake started with the setting up of the National Reconstruction Authority (NRA).

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13Workshop Summary, IWDRI 2018
Environmental impact assessments encourage reduction in creation of new risks, adopting different approaches to rural and urban reconstruction projects and the incorporation of business continuity related indicators in the resilience building process.

4. **Owner-driven reconstruction:**
   - Post-disaster reconstruction is an opportunity for incorporating resilience.
   - An owner-driven reconstruction programme will provide greater impetus for mainstreaming risk awareness and resilient practices.
   - An inclusive approach for recovery and reconstruction is crucial for ensuring that the needs of the most vulnerable sections of the population, such as the poor, marginalized and persons with disabilities, are effectively incorporated.

5. **Psychology of decision making:**
   - Uncertainty, complexity and volatility are factors that challenge decision making in post-disaster contexts. Additional complexities are added due to time pressure, changing preferences/norms and the cascading effects of infrastructure damage.
   - Mapping and quantifying vulnerabilities of various sectors, industries and their failures aid in prioritization of decisions.
   - The Humanitarian Decision Maker’s Anatomy helps understand the psychology of decision-makers in post-disaster contexts that must be able to account for various interdependencies and fragmented/volatile coordination.

6. **Role of sub-national governments:**
   - Faster rebuilding processes require developing and maintaining capacities of sub-national governments
Thematic Session 2

Policy and Governance Landscape for DRI

14:30 – 16:15

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
IWDR 2019
The Panel

Speakers

- Amit Prothi, 100 Resilient Cities

Moderator

- Kamal Kishore, National Disaster Management Authority, India

Discussants

- Chairs and moderators of breakout sessions.

Session Format

This session will begin with two overview presentations and then breakout into 3 parallel sessions to discuss different contexts.

Each breakout session will have presentations by 3-4 speakers of 10 minutes each highlighting the key challenges and opportunities for the typology, followed by a moderated discussion.

The three panels will then re-convene for a joint panel discussion.
Infrastructure has the power to enable smooth functioning of economies. This session will present the big picture of the policy discourse and governance mechanisms that are aiding and ailing decision making for key infrastructure sectors, mainstreaming disaster risk management and harmonization of related policies. The session will advance thinking on these issues for a specific typologies of economies with particular geographical and socio-economic characteristics. The joint panel discussion will reflect on gaps and opportunities for knowledge exchange between the groups.

Questions to be addressed in each grouping and context

- What are good examples where leadership of the national or regional government is providing a coherent basis for decision-making to inform investment in risk-informed investments in developing and maintaining infrastructure?
- How is resilience to infrastructure approached in difference economic and geographical contexts? What are the critical issues in governance systems that drive this decision?
- What are the potential areas of partnerships between countries that may be forged under the CDRI to address these issues and improve practices?
Given the government’s central role in planning, funding and providing infrastructure, they must aim to have an accurate estimation of the risks faced by their infrastructure, implement clear standards and policies at the time of construction and have a plan for the recovery and reconstruction of critical infrastructure.

There is a growing realisation that infrastructure resilience needs to be looked at in a system of systems perspective. National governments will have to provide the institutional basis for the implementation of a systems approach. Governments will have to consider mechanisms for mainstreaming of disaster risk management considerations at all levels and a harmonisation of policies to build national resilience.

Three typologies of development contexts have been identified to help unpack the issues and challenges faced by countries that have different levels of infrastructure growth, economic development, and geographical characteristics. While these contexts present a large diversity of challenges, the typologies attempt to bring together countries with similar contexts so as to help identify the institutional arrangements required to build disaster resilient infrastructure in their context.

The three typologies that have been identified are:

1. **Large incoming investment in new infrastructure stock**
   This session addresses economies where a large amount of investment is expected in building new infrastructure. The focus in these contexts is on putting in place the regulatory and governance structures that would be required to ensure the construction and maintenance of resilient infrastructure.

2. **Focus on refurbishment and replacement of existing infrastructure stock**
   This session addresses economies where there is a heavy focus on refurbishment and replacement of existing infrastructure stock and relatively lower low levels of new investment. The focus in these contexts is on the challenge of reinforcing, protecting and upgrading existing infrastructure, and putting in place risk financing measures.

3. **Small Island Developing States (SIDS) and Landlocked Countries (LLC)**
   This session addresses economies that are isolated from the global supply chain by land, as is the case for Landlocked Developing Countries (LLDCs), or by sea, as is the case for small island developing states (SIDS). Countries that depend on single ports, airports, pipelines, or highways, are severely constrained in their economic and social development. The challenge for these nations is not only protection and reduction of
domestic vulnerability, but also diversification and creating redundancy in their infrastructure systems.

Challenges to building infrastructure resilience

The Institute for Government, UK published a report titled *How to design an infrastructure strategy for the UK* in 2017. It identified three main problems with the system of decision making about infrastructure in the country. The report also sets out recommendations to tackle these problems.

While the report addresses the entire infrastructure decision making process, building resilient infrastructure would also require similar arrangements. Thus, the problems and recommendations have been restated in generalised terms below, to serve as discussion points for this session.

Problem 1:

*Without a credible evidence base and long-term approach, infrastructure decision making is subject to continuous and disruptive policy change.*

Regular changes in political leadership lead to regular changes in national infrastructure policies and priorities, with a focus on short-term objectives. Building infrastructure resilience requires decisions to be evidence-based and focussed on the long term future. Infrastructure projects, particularly large ones, can take years to build and often have lifetimes of several decades or more. Constant policy change disrupts this process, resulting in delays, additional expense and poorly co-ordinated projects.

Recommendations for mitigation:

- Develop an independent national body that assesses long term infrastructure needs and makes recommendations to the government.
- Such a body should provide clear evidence for its recommendations and public statements.
- The general public must be made aware of the work done by this body. This would provide citizens and the private sector a rational basis for decision making. It will also help them to align their expectations regarding future developments.

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Problem 2:

*The lack of an overarching strategy to guide decision making leads to poor co-ordination between government departments and levels of government*

Government departments building various types of infrastructure usually work in silos. The lack of an overarching strategy for resilience building leads to a lack of coordination between the departments and across levels of government. The systems of systems approach points to the need for a national level strategy that understands the interactions between various infrastructure systems and harmonises policies and plans for national resilience building.

**Recommendations for mitigation:**

- Governments should develop a cross-governmental national strategy for infrastructure resilience based on a comprehensive assessment of risks to national infrastructure.
- Such a strategy will act as a decision making framework for delivery of projects in line with building national resilience.
- This strategy should be under the scrutiny of the political leadership of the country.

Problem 3:

*The lack of forums for productive and structured public debates on infrastructure policy options*

Infrastructure resilience is intrinsically linked to the resilience of local communities. These communities need to be engaged at all stages of infrastructure development to ensure the long-term climate and disaster resilience. Not only are local communities a rich source of data required for designing resilient infrastructure, they also form an integral component of the functional continuity of an infrastructure asset.

**Recommendations for mitigation:**

- Governments should establish mechanisms for public engagement and facilitate in-depth deliberations as part of infrastructure decision making.
- Governments should leverage local capacities to increase the resilience of infrastructure assets.
Thematic Session 2-A

Large Investments in New Infrastructure

14:50 – 15:55

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
IWDR 2019
The Panel

Chair
- NITI Aayog, India

Moderator
- Tshawekazi Tembani, Dept. of Cooperative Governance, South Africa

Speakers
- Prof Jagan Shah, National Institute for Urban Affairs, India
- Sebastián Alonso, Director of Public Works Planning, Ministry of the Interior, Public Works and Housing, Government of Argentina
- Nigeria*

Discussants
- Ming Zhu, Ministry of Emergency Management, China
- Ishita Jalan, Council on Energy, Environment and Water, India

Session Format
This is a breakout session as part of Thematic Session 2.
It will have presentations by speakers of 10 minutes each followed by a joint moderated discussion.
Infrastructure has the power to enable smooth functioning of economies. This session addresses economies where a large amount of investment is expected in building new infrastructure. The focus in these contexts is on putting in place the regulatory and governance structures that would be required to ensure the construction and maintenance of resilient infrastructure.

This session will present the big picture of the policy discourse and governance mechanisms that are aiding and ailing decision making for key infrastructure sectors, mainstreaming disaster risk management and harmonization of related policies. The session will advance thinking on these issues for a specific typologies of economies with particular geographical and socioeconomic characteristics. The joint panel discussion will reflect on gaps and opportunities for knowledge exchange between the groups.

The session will address the following questions:

- What are good examples where leadership of the national or regional government is providing a coherent basis for decision-making to inform investment in risk informed investments in developing and maintaining infrastructure?
- How is resilience to infrastructure approached in difference economic and geographical contexts? What are the critical issues in governance systems that drive this decision?
- What are the potential areas of partnerships between countries that may be forged under the CDRI to address these issues and improve practices?
Emerging economies and developing countries are poised to invest in a lot of new infrastructure. In countries like India – the growing middle class, steady economic growth and a favourable demographic dividend require the nation to build the foundational physical infrastructure that will serve as the basis of growth and development for decades to come. Some estimates about India say that the nation may need to build more infrastructure in the next 20 years than it has built in the last 200 years. This means that majority of the infrastructure required to meet the current and future demands is yet to be built. This is true for a majority of the emerging nations in Asia, Africa and the Americas.

This situation presents a unique opportunity to ‘get it right’. There is an urgent need to address the structural issues that underpin this development and put in place risk estimation, standards and governance arrangements, to ensure that all new infrastructure development is resilient to climate change and disasters impacts.

**Challenges and opportunities in addressing new infrastructure:**

1. **Climate change and changing risk profiles:**
   Changing climate patterns around the globe are increasing the intensity, frequency and uncertainty of extreme weather events. New infrastructure built in this context of high uncertainty requires a careful and integrated approach to ensure that these investments are safe in the longer term. The constantly changing nature of climate and disaster risks, the high volume of initial investment required, and the long life-cycles of infrastructure projects necessitate the continuous monitoring of risks and the development of adaptation strategies that are responsive to the changes in the risk profile.

2. **Rapid pace of urbanisation:**
   Today, more than half of the population live in urban areas and 1.5 million people are added to the global urban population every week.¹⁵ About 90% of this urban population growth will take place in emerging the economics of Africa and Asia with rapid urbanisation placing huge demands on infrastructure,

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services, climate and environment. Combatting these challenges of rapid growth, and achieving sustainable development requires fresh regulatory and planning approaches, technologies and capacity development.

3. **The lack of an integrated approach**

Ensuring adequate resilience in individual infrastructure assets may not always translate to systemic risk reduction, unless processes for regional planning are also developed and implemented. When building the same infrastructure (e.g. a bridge) in two geographically different locations, both the built and natural environment at each location plays an important role in terms of whether the chosen infrastructure standards are sufficient. An integrated approach is therefore needed, where both the type of infrastructure as well as the environment it is being built in, is considered. Here, developing the capacity and regulatory framework for integrated infrastructure development is a prerequisite. There may be a need to develop national level bodies and plans that consider all the interlinkages and interdependencies between sectors. Such a body could regulate regional infrastructure development and coordinate the actions of various ministries and departments that usually work in silos.

4. **Need for regulation of professionals and capacity building at all levels**

The construction and maintenance of resilient infrastructure will require capacity building of professionals and workers at all levels. At the grass-roots this may entail putting in place local vocational training programs to continuously develop and update the skills of construction workers. At the national levels, the development of statutory regulators for professions like engineering and planning would help reduce risk by setting educational requirements and developing systems for licensing professionals. Licensing would allow for vetting the skills of the professionals, and continuous updates of these skills. This would, in turn, increase accountability of safety outcomes.

5. **Technological evolution**

Many emerging nations lack the experience of constructing and sustaining large scale infrastructure systems. The research base on the interactions between the various interconnected infrastructure systems, and their effects on the population they serve, is still being built. Emerging technologies like sensors, big data, machine learning and robotics present an opportunity for these nations to accelerate their learning curve and put in place state of the art systems to ensure infrastructure resilience.
The rapid evolution of material sciences, building technologies, and energy sources also requires the planners of infrastructure to avoid getting locked into specific technologies or materials. There is a need to move from prescriptive standards that specify designs and material specifications to standards that define only the performance required from the infrastructure and allow for the designs and material selection to evolve and innovate. Further research is required on the use of new materials, building designs, energy sources and nature based solutions and their effect on the resilience of infrastructure systems.

6. The need for urgent action
The high volume and rapid pace of growth in emerging economies is happening within the context of insufficient research, low human resource capacity, and a lack of integrated regulatory mechanisms for infrastructure development. To ensure that this growth builds in ‘resilience’ instead of ‘risk’ requires urgent actions to develop the requisite capacities and systems. The current time presents an opportunity for emerging nations to learn from the past mistakes of advanced nations and in a way ‘skip to the end’ and adopt solutions that have proven results.
While global best practices serve as a good guide for building the required systems, each nation will have to understand its own context thoroughly before adapting and adopting approaches that have worked in advanced nations.
Thematic Session 2-B

Focus on refurbishment and replacement of existing Infrastructure

14:50 – 15:55

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
Chair


Moderator

- TBD*

Speakers

- Alice Hill, Hoover Institution, Stanford University
- Prof Mauro Dolce, Dipartimento della Protezione Civile, Italy
- Phil Rizcallah, National Research Council, Canada

Discussants

- Mathew Crossman, National Infrastructure Commission, UK
- Michael Mullan, Global Commission on Adaptation

Session Format

This is a breakout session as part of Thematic Session 2.

It will have presentation from the speakers of 10 minutes each followed by a joint moderated discussion.
Infrastructure has the power to enable smooth functioning of economies. This session addresses economies where there is a heavy focus on refurbishment and replacement of existing infrastructure stock and relatively lower low levels of new investment. The focus in these contexts is on the challenge of reinforcing, protecting and upgrading existing infrastructure, and putting in place risk financing measures.

This session will present the big picture of the policy discourse and governance mechanisms that are aiding and ailing decision making for key infrastructure sectors, mainstreaming disaster risk management and harmonization of related policies. The session will advance thinking on these issues for a specific typologies of economies with particular geographical and socioeconomic characteristics. The joint panel discussion will reflect on gaps and opportunities for knowledge exchange between the groups.

The session will address the following questions:

- What are good examples where leadership of the national or regional government is providing a coherent basis for decision-making to inform investment in risk informed investments in developing and maintaining infrastructure?
- How is resilience to infrastructure approached in difference economic and geographical contexts? What are the critical issues in governance systems that drive this decision?
- What are the potential areas of partnerships between countries that may be forged under the CDRI to address these issues and improve practices?
The need to address ageing and degraded infrastructure is emerging as a critical issue facing many advanced economies and developed nations. Large infrastructure is built on the basis of forecasts of carrying capacity, design loads, and design life. For infrastructure built in advanced economies, all these three factors are being pushed to their limits. These countries experienced an infrastructure construction boom after World War II and put in place most of their transport, energy and water infrastructure in this period. The design life of infrastructure built in the post WWII era, which is usually about 50 years, is ending.

This outdated infrastructure is costing both the government and private industry millions in repairs, business interruption and supply chain risks. The American Society of Civil Engineers estimates that by 2020, “aging and unreliable” infrastructure will cost American businesses USD 1.2 trillion annually. Infrastructure maintenance requires consistent, significant investment from the public and private sectors, but re-development or re-construction requires large upfront capital expenditure. Some challenges and opportunities in addressing these issues have been identified below.

**Challenges and opportunities in addressing ageing infrastructure:**

1. **Climate change and changing risk profiles:**
   Changing climate patterns around the globe are increasing the intensity, frequency and uncertainty of extreme weather events. Road, rail, energy and water systems built more than 50 years ago are not designed to handle the current hazard profiles. This means that outdated infrastructure built on the basis of past risk assessments will need a reassessment of risks and upgrades to match the current level of risk. The constantly changing nature of these risks, the high volume of initial investment required, and the long life-cycles of infrastructure projects necessitate the continuous monitoring of risks and the development of adaptation strategies that are responsive to the changes in the risk profile.

2. **Urbanisation and changes in settlement patterns**
   The densification of urban areas over the last 50 years is putting an increasing load on support infrastructure like transport, energy and water-supply.
Urbanisation has also led to changes in the vulnerability and exposure patterns. Studies will be required to understand the changed context so as to inform appropriate reconstruction and renewal plans.

3. **High cost of reconstruction**
   While the increasing costs of repair and maintenance of ageing infrastructure components is a constant drain on a country’s economy, the reconstruction of these systems is doubly expensive. Upgrading infrastructure attracts a two-fold cost, the direct cost of the demolition/deconstruction of existing infrastructure followed by its reconstruction to higher standards, and the indirect costs in terms of disruption of lifeline services and economic activities. Attempts should be made to absorb these costs and disruptions in a planned and phased manner rather than have them forced by the sudden and catastrophic failure of the ageing infrastructure.

4. **Technological evolution**
   The rapid evolution of material sciences, building technologies, and energy sources requires the planners of infrastructure to avoid getting locked into specific technologies or materials. There is a need to move from prescriptive standards that specify designs and material specifications to standards that define only the performance required from the infrastructure and allow for the designs and material selection to evolve and innovate. Technological solutions that integrate robotics and machine learning can also be leveraged to minimise the human resource requirements and costs of operating and maintaining large infrastructure. Further research is required on the use of emerging technologies, new materials, building designs, and energy sources and their effect on the resilience infrastructure systems.

5. **The public policy challenge**
   The complexity of the issues described above leads to a reluctance of political actors to address them head-on. Policy makers face the challenge of making a case for the above actions in the face competing issues that are relatively easier to define, and hence more immediately actionable. The issue of ageing infrastructure needs to be addressed in a timely and systematic manner so as to avoid the unnecessary costs and suffering imposed by the catastrophic failure of large infrastructure.
Thematic Session 2–C

Small Island Developing States [SIDS] and Land Locked Developing Countries [LLDC]

14:50 – 15:55

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
IW DRI 2019
The Panel

Chair

- Colonel Ch. Ariunaa, Head of foreign relations division of NEMA, Mongolia

Moderator

- Etienne Coyette, Head of Sector Climate Change and DRR, EU

Speakers

- Arghya Sinha Roy, Asian Development Bank (ADB)
- Capt. Neville Wint, Office of Disaster Preparedness and Management, Trinidad and Tobago
- D. Ellayah, NDRRMC, Mauritius
- Fathimath Shaushan Moosa, NDMA, Maldives

Discussants

- N. Boseiwaqa, MITDMMS, Fiji
- Jamaica*

Session Format

This breakout session will have presentations by the speakers followed by a moderated discussion.
Infrastructure has the power to enable smooth functioning of economies. This session addresses economies that are isolated from the global supply chain by land, as is the case for Landlocked Developing Countries (LLDCs), or by sea, as is the case for small island developing states (SIDS). Countries that depend on single ports, airports, pipelines, or highways, are severely constrained in their economic and social development. The challenge for these nations is not only protection and reduction of domestic vulnerability, but also diversification and creating redundancy in their infrastructure systems.

This session will present the big picture of the policy discourse and governance mechanisms that are aiding and ailing decision making for key infrastructure sectors, mainstreaming disaster risk management and harmonization of related policies. The session will advance thinking on these issues for a specific typologies of economies with particular geographical and socioeconomic characteristics. The joint panel discussion will reflect on gaps and opportunities for knowledge exchange between the groups.

The session will address the following questions:

- What are good examples where leadership of the national or regional government is providing a coherent basis for decision-making to inform investment in risk informed investments in developing and maintaining infrastructure?
- How is resilience to infrastructure approached in difference economic and geographical contexts? What are the critical issues in governance systems that drive this decision?
- What are the potential areas of partnerships between countries that may be forged under the CDRI to address these issues and improve practices?
Small Island Developing States (SIDS)

Small Island Developing States (SIDS) are on the frontlines in terms of experiencing the impacts of climate change. SIDS are a special case in terms of their environment and development. They are ecologically fragile and vulnerable. Their small size, limited resources, geographic dispersion and isolation from markets; place them at an economic disadvantage, including challenges to develop economies of scale. For SIDS the ocean and coastal environment is of strategic importance and constitutes a valuable development resource. Their geographic isolation has resulted in their habitation of a comparatively large number of unique species of flora and fauna, giving them a very high share of global biodiversity. They also have rich and diverse cultures with special adaptations to island ecosystems and knowledge of the sound management of island natural resources. SIDS face all the environmental problems and challenges of coastal zones, concentrated in a limited land area. They are located among the most vulnerable regions in the world in relation to the intensity and frequency of natural hazards.

These challenges are causing major set-backs to their socio-economic development. SIDS’ small and open economies leave them especially exposed and highly vulnerable to external shocks. The increased indebtedness and constrained fiscal space can have long-term developmental consequences. Many SIDS are dependent on their narrow resource bases with little space for diversification. SIDS lacks the capacity to address these challenges themselves and rely on the support of and partnership with the international community to realize their sustainable development objectives.16

Issues specific to SIDS

1. Rising sea levels and annual average losses: The 2012 World Bank Report Turn Down the Heat, warns that if current commitments and pledges are not fully realised, sea-level rise of 0.5 to 1 meter or more by 2100 will threaten the very existence of entire countries and many SIDS. About 70% of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change.17 With these projections it can be assumed that many SIDS, particularly low-lying atolls, will be severely affected. Given their small size, the

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16 TST Issues Brief: Needs of Countries in Special Situations, UNDESA and UNDP
17 Working Group I Contribution to the IPCC Fifth Assessment Report, Climate Change 2013: The Physical Science Basis, Summary for Policymakers, SPM-18
expected annual average losses from earthquakes and tropical cyclone wind damage in SIDS represent respectively only 2 per cent and 1.4 per cent of the global total. However, precisely because they are small, 8 of the 10 countries that would lose the largest proportion of the value of their produced capital stock in a one-in-250 year earthquake are SIDS. In the case of a 1-in-250 year cyclone, SIDS comprise of 6 of the 10 countries most at risk.\(^\text{18}\)

2. **Unique resilience strategies:** These risks will require SIDS to develop unique resilience strategies which may include investing in new infrastructure classes like large-scale Sea Walls or the development of nature based solutions for protection against rising sea levels. Designing these solutions in the context of high-uncertainty is a challenge. Adaptive strategies may need to be developed as investments to protect against a 40 cm rise in sea levels, is very different from that required for protection against a 50 cm rise in sea levels.

3. **Energy production:** Although each country has a unique set of economic and energy sector conditions, they all share several common characteristics. Most SIDS depend almost exclusively on imported petroleum for their electricity generation and transportation needs. As much as 15% of gross domestic product (GDP) can be expended on energy imports with electricity costing USD 2.50 per unit, among the highest costs per unit in the world. This dependence leaves these countries vulnerable to volatility in international oil prices and is a tremendous drain on capital for imports. The increasing cost of imported fossil fuels represent a major impediment to the achievement of sustainable development and poverty eradication in SIDS as scarce financial resources are diverted from efforts to promote social and economic development and ensure environmental sustainability.

**Water governance and resource management:** SIDS are particularly vulnerable to increased stresses on their water resources through the limitations of land, population, and water resources and the need for economic development and social well-being. For most SIDS governments, the problems now being encountered include quality of service, maintenance and operation of existing infrastructure, ageing infrastructure, high levels of water wastage, and quality of potable water. This suggests difficulties with the management of water services and with securing the necessary levels of investment to address the supply-demand gap. The

\(^\text{18}\) UNISDR (2013) From Shared Risk to Shared Value – The Business Case for Disaster Risk Reduction
projected increase in frequency and intensity of tropical cyclones will result in further damage to infrastructure (pipelines, pumping stations), silting of storage reservoirs and damage to wastewater treatment facilities. While SIDS already contend with these impacts following the passage of a tropical cyclone, any increase in frequency and intensity of these weather conditions will have deleterious effects.

The Landlocked Developing Countries (LLDCs)

The Landlocked Developing Countries (LLDCs) face special challenges that are linked to their geography, including remoteness from major international markets, inadequate transport infrastructure and high transport and transaction costs. As a consequence, many LLDCs find themselves marginalized from the world economy, cut-off from the global flows of knowledge, technology, capital and innovations, and unable to benefit substantially from external trade. This affects their development prospects, including sustained economic growth, poverty reduction and the achievement of the Sustainable Development Goals.
Issues specific to LLDCs

1. **Restricted access to the sea**: The primary challenge that LLDCs face is that they do not have access to the sea, and therefore cannot through their own efforts alone, improve infrastructure and access to global trade. With international trade largely dependent on other transit countries, they face not only longer land distances from global markets, but also the need to develop cordial relationships with their neighbours in order to reduce transaction costs in terms of money and time at borders, both for the import and export of raw materials and products. LLDCs are completely dependent on the physical and trade infrastructure of transit countries, and are thus in a difficult position.

2. **Geo-political vulnerabilities**: These arise from the four dimensions of dependence identified by literature: 1) dependence on neighbours’ infrastructure; 2) dependence on sound cross-border political relations; 3) dependence on neighbours’ peace and stability; and 4) dependence on neighbours’ administrative practices. These factors combine to yield different sets of challenges and priorities in each landlocked country.

3. **Water scarcity and desertification**: The structural vulnerabilities and limited productive capacities of LLDCs expose them disproportionately to the severe negative impacts of climate change, desertification and drought. Most LLDCs are dependent on a few primary agricultural and/or mineral commodities and almost two-thirds of the population is dependent on agriculture. While this is the case, many LLDCs are located in dryland regions where the impacts of climate change, desertification and land degradation are more pronounced. 54% of total land in LLDCs is classified as dryland, and about 60% of the population in LLDCs is located in dryland areas.

Issues common to both typologies

1. **High transportation costs**: Quality of infrastructure necessarily varies between LLDCs and SIDS. However, what is clear is that most lack the necessary transportation linkages to support the scale-up of their international trade. High
transportation costs typically place landlocked countries and small island states at a distinct disadvantage relative to other nations when competing in global markets.

2. Both SIDS and LLDCs have a **low per capita GDP** (less than USD 1000). LLDCs have historically been ranked amongst the nations with the lowest human development index. Both have always had a limited productive capacity arising from **limited human resources** and consequently, **limited capacities**. Building disaster resilient infrastructure is a major challenge in both these contexts. Leveraging of technologies like robotics and machine learning can help in overcoming human resource constraints.

3. **Energy and telecommunications**: Both SIDS and LLDCs also face challenges with regards to data and energy connectivity. Their lack of access to major internet backbone connections limits their sources for internet connectivity and limits their capacity to upgrade the capacity of those connections. Resilient telecommunications infrastructure is a key consideration for developing nations to leverage their intellectual capital and improve their international exposure and competitiveness. Information Technology is also an important component of infrastructure resilience.

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Thematic Session 3

Finance for Disaster Resilient Infrastructure

16:30 – 18:00

Tuesday, 19th March 2019

Taj Mahal Hotel, New Delhi
Chair

- Shaohua Wu, New Development Bank (NDB)

Moderator

- Dr Krishna Vatsa, UNDP

Speakers

- Aniket Shah, US SIF/ Oppenheimer Funds
- Rowan Douglas, Capital Science and Policy Practice, Insurance Development Forum
- Prof Ila Patnaik, National Institute of Public Finance and Policy

Discussants

- Mariela Flores, Ministry of Economy and Finance of Peru
- Dr Josef Leitmann, World Bank
- Dr George Thomas, Insurance Institute of India
- Michael Mullan, Global Commission on Adaptation
- Satish Raju, Swiss Re
- Sabin Basnyat, Green Climate Fund

Session Format

This session will have anchoring 3 presentations of 15 minutes each followed by a moderated panel discussion.
The session will focus on the fourth and most critical pillar of CDRI: Financing new infrastructure and mechanisms for covering risks to and from this infrastructure.

As countries step up their investment in infrastructure, they need to consider different mechanisms of ensuring their resilience. Governments need to improve standards and specifications for public financing based on risk assessment. The nature and frequency of hazards should guide the inclusion of hazard-resistant features in the design and implementation of infrastructure projects. Based on risk assessment, the governments can allocate resources for mitigating infrastructure risks. For example, investments in storm water drainage can improve the resilience of urban infrastructure. Introduction of risk pools and insurance can also improve the resilience of infrastructure. In this session, different financial mechanisms of infrastructure risk management will be discussed, achieving a good balance of public and private sector resources to address the funding gap in resilience of infrastructure systems and ways to mainstream this effectively.

Questions to be addressed in this session:

1. How are we addressing the funding gap in developing resilient infrastructure: in terms of quantum of funding and allocation for resilience?
2. What are the issues hampering long-term investments in resilient infrastructure in changing socio-economic environments? Why are traditional tools (such as deterministic cost benefit analysis) no longer suitable?
3. How can the role of financial institutions at various levels (national, sub-national, global) be harmonized for better factoring in of resilience in infrastructure investments?
4. What mechanisms can be adopted to enable creation of effective risk pools?
5. What mechanisms may be adopted to enable better understanding of the acceptable or optimal level of risk, and how much could be retained, before transferring their risk to markets through insurance.
6. What is the current imbalance in ownership of risk? How can the role of various stakeholders be re-evaluated to enable risk-sharing in a more efficient manner (private sectors, insurance, international financial organisations (IFIs) etc)?
Traditionally, the role of finance in disasters has focused on ensuring the availability of funds for relief, recovery and reconstruction. However, finance already plays an important role ex-ante. Infrastructure is largely publicly owned in many countries. Therefore, figuring out the extent of resilience a country can afford is a public finance problem; the goal is to maximise benefits (i.e. loss of assets, or economic losses down the line) while minimising costs (since resources are limited). If the design and materials take resilience components into account, it is estimated that upfront costs of construction rise by 5% to 15%, which may discourage their incorporation.

However, since the infrastructure is publicly owned, the cost-benefit analyses have to consider the cost over the full lifecycle of an infrastructure project. The design standards, then, have to be based on such a life-cycle oriented cost-benefit analysis. One challenge in this regard, especially in countries with low capacity for enforcement, is that compliance with standards is low. Another is that designing finance-based incentives requires a thorough understanding of risks. The session explores if and how finance can play a role in monitoring and incentivizing compliance with standards for location, design and materials for disaster resilient infrastructure. For e.g. If insurance premiums are risk reflective then premium reduction can incentivize resilience. Banks may charge lower interest rates for more resilient infrastructure (“DRR loans”) as the risk is lower. For large infrastructure projects where there is a small market, premiums may not be risk reflective. “DRR bonds” similar to green bonds that invest only in resilient infrastructure could have similar characteristics. But for this they need the capacity to measure, monitor and incentivize risks.

Financing mechanisms play a pivotal role in development of new infrastructure and risk management. New infrastructure can be financed through a variety of mechanisms such as direct government expenditure, private investment and PPPs. Each of these financing mechanisms requires a careful balancing of differing incentives of the various stakeholders involved. For example, attracting private investments and Public Private Partnerships (PPPs) requires cheaper, easier and more streamlined regulatory and approval processes. Financing resilience might require more innovative approaches which similarly leverage the incentives of key stakeholders. For example, infrastructure lenders can play a significant role in ensuring resilience components are incorporated by the developer in every infrastructure project.

Given the huge investments required in the infrastructure sector, private investment will play a pivotal role in infrastructure development in the near future. The funds for financing
infrastructure as well as the appetite among private players to invest in infrastructure already exist. To attract these investors, infrastructure projects need to be made more bankable. This requires the development of project pipelines, especially in developing countries.

Finally for risk management and financing, many developing countries have so far relied on donor-driven recovery and reconstruction. As a result, risk financing has languished.

“In many developing countries, governments, businesses and individuals have limited measures in place to secure financing for crisis response, recovery and reconstruction and often mobilise funds after a crisis event through budget reallocation, distress sales of assets, international aid and loans. Such ex-post funding is unpredictable and may not be timely or sufficient to meet relief, recovery and reconstruction needs. Failure to make adequate financial provisions against risk therefore may not only bear heavy costs for the individuals who may face impoverishment but also for governments, which may face acute fiscal crises, loss of public confidence and longer term economic consequences.” — OECD, 2014

However, robust risk management and financing systems are as integral to infrastructure resilience as engineering standards.

Common gaps in the financing of disaster resilient infrastructure have been identified as:

- Lack of coherent strategy across various levels of government for risk financing
- Lack of adequate, accurate data affecting risk financing decisions and hampering insurance markets
- Lack of research and data on incentives for each stakeholder to create resilient infrastructure
- Lack of robust cost-benefit analyses for resilience components

These gaps have been elaborated below:

1. **Lack of coherent strategy across various levels of government for risk financing**

   Risks to infrastructure can be covered using a variety of different mechanisms — catastrophe bonds, insurance, risk assumption etc. Each of them comes with its own advantages and disadvantages which need to be carefully considered.

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20 Preqin, 2016.
For each risk, a country has to decide whether to assume the risk, or to finance it. If it decides to finance the risk, then whether it wants to make budgetary allocations for it or transfer it. If it wishes to transfer the risk, then it has to determine what kind of instrument(s) is/are best suited for that particular case.

This requires having a coherent strategy, and decision-making systems for risk financing at every level of government, for every kind of risk. Typically developing countries lack the systems and the capacity to develop such strategies.

2. Lack of adequate, accurate data affects risk financing decisions

A comprehensive risk assessment (as stated earlier) is not possible without reliable and adequate data. Without a risk assessment a government cannot make informed decisions regarding risk financing. Further, lack of adequate, reliable risk data leads to improper pricing of risk, which can further lead to market failures. In the face of lack of easily accessible data, one of two things is likely to happen viz. (1) insurance companies may either be unwilling to offer insurance, (2) or they would charge very high premiums. The latter is either, because they have some data that the buyer does not (i.e. information asymmetry), or because nobody has good data and they are playing safe.

While this specific example in the box above is about consumer insurance, the principle is applicable to insurance markets and risk financing in general.

Typically, when data is sparse, people tend to underestimate the risk from low-probability, high-impact events.²¹ This can only be remedied with better risk data.

²¹ Tversky and Kahneman, 1973
3. Lack of research and data on incentives for each stake-holder to create resilient infrastructure

In order to make infrastructure resilient, the incentives of various stakeholders need to be carefully thought through. For example, an infrastructure developer may be discouraged from adding resilience components for fear of higher initial capital costs. In this respect, the role of infrastructure lenders can be pivotal in ensuring proper risk assessments and engineering standards are complied with. The long-term nature of infrastructure lending implies that lenders have an incentive to measure and monitor disaster risk. The incentives-structure for insurers, and infrastructure developers to incorporate resilience needs more thought. Some research and innovation is necessary in order to align the incentives of all stakeholders to incorporate resilience in to infrastructure projects.

4. Lack of robust Cost-Benefit Analysis (CBA) for resilience components

Cost-benefit analyses are critical for determining feasibility and design of any project. CBAs are also necessary for making decisions regarding adoption of standards for any country, such that they match its needs, resources and capacity.

However, robust cost-benefit analyses are extremely difficult to do and require a great amount of data. It follows that in developing countries — where data is sparse, data collection systems are weak and capacity to conduct such elaborate analyses is likely lacking — it is not possible to do cost-benefit analysis to support decisions regarding adoption and design of standards, and design of projects. In this scenario it also becomes difficult for a government to correctly gauge the importance and value of resilience components in infrastructure works.

This further affects risk analysis and financing.
1. **The role of finance in incentivizing resilience:**
   - Infrastructure is largely publicly owned. Therefore, determining the extent of resilience a country can afford is a public finance issue with the goal being to maximize benefits (i.e. loss of assets, or economic losses) while minimizing costs.
   - Financial instruments play a key role in incentivising uptake of good practices towards building DRI. However, effective financial planning requires a sound underpinning of data on hazards, risks and climate dynamics. E.g. Taking resilience into account while developing infrastructure may raise upfront construction costs by 5 to 15%. This can be justified only by a comprehensive cost benefit analysis over the lifecycle of a project.

2. **Understanding contingent liabilities:**
   - Governments are advised to set up institutional and operational frameworks to understand “contingent liabilities” to identify how and to what extent a budget is impacted after a disaster.

3. **Acceptable level of risk:**
   - Mitigation funding and residual risk financing is beneficial for recognition of risk at various levels. Governments need to better understand the acceptable or optimal level of risk, and how much could be retained, before transferring their risk to markets through insurance.
   - Mexico’s Fund for Natural Disasters (FONDEN) provides a series of different financial instruments to address risks at all levels. Colombia also uses public private partnerships (PPP) for disaster resilience, and strong disincentives are built into the policy for non-compliance.

4. **Looking beyond insurance:**
   - While insurance is able to create incentives for governments and private institutions by making premium risk reflective, it is unable to address the root cause of risk. Hence, using insurance in the absence of other systemic measures cannot be the answer to creating incentives for building resilient infrastructure.
   - Risk financing strategies for sovereign nations will depend on their varying capacities, risk appetite, resources and willingness to manage risk. Ownership of risk is a critical issue in this regard. No matter who owns the infrastructure, the government of any country still has to plan for the risk.
• A layered approach to risk management can be facilitated through a range of financial instruments that are now available to address financing development (or redevelopment) of resilient infrastructure. Disaster risk screening of infrastructure is one such method.

5. **Mainstreaming the role of the private sector:**

• Since the last decade, the Indian private sector is investing almost half as much as the Government in infrastructure. Banks are a key source of finance for infrastructure projects and have a role in improving compliance to standards for risk assessment and building. Institutional risks are critical, which is why a study of contingent liabilities becomes important.
Opening Session 2

Recap of Day 1 and Reflections

09:30 – 10:15

Wednesday, 20th March 2019

Taj Mahal Hotel, New Delhi
This session will comprise of a moderated panel discussion.

The session will bring together the Chairs and Moderators of sessions on Day 1 to reflect on the discussions and key insights from the previous day and to set the stage for the sessions on Day 2 building towards the outcomes of the workshop.
Working Session 1

Perspectives from Multilateral Agencies

10:15 – 11:30

Wednesday, 20th March 2019

Taj Mahal Hotel, New Delhi
This session will have presentations by the speakers of 10 minutes each followed by a moderated panel discussion.
Multilateral support to infrastructure development has acquired a renewed relevance against the backdrop of the 2030 Agenda (global commitments for the year 2030 envisioned in the Sustainable Development Goals, Sendai Framework for Disaster Risk Reduction, Paris Agreement and the New Urban Agenda).

50-70% of the Official Development Assistance (ODA) for infrastructure in low-income countries is attributable to multilateral agencies. Multilateral development banks (MDBs) make an estimated annual investment of US$ 45 billion on infrastructure through financial instruments like concessional and non-concessional loans, grants, equity investments, and guarantees. Investment focus across the infrastructure sectors varies geographically – as reflected in the mandates of the Regional MDBs – and has also evolved in line with the needs of the times. During 2004-2013, transportation and electricity generation sectors constituted over 70% of infrastructure lending for the eight largest MDBs.

MDB engagement in infrastructure development has evolved in the past seven decades, limited not only to the function of ensuring access to dependable and low-cost finance in developing countries but also providing technical resources for quality and planning. Over the years, MDBs have sought a shift from directly financing projects towards ‘crowding-in capital’ by using their reputational and financial strengths to de-risk projects and attract private investments.

Going forward, the challenge for infrastructure is not just one of scale. Although, that is a formidable challenge in itself – given that infrastructure added in the next 15 years will be more than the entire existing stock. The next 15 years also represent a time-scape fraught with climate and disaster risks, geopolitical uncertainty, large-scale population movements, and unprecedented urban and technological expansion. Another marked difference is the increased capacities of large middle-income countries to finance their infrastructure needs coupled with continued need for technical support towards design, innovations and quality. The launch of several large-scale, multi-year and sometimes, multi-country, infrastructure projects by these countries are indicative of these enhanced

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22 Centre for Global Disaster Protection (2018), Financial Instruments for Resilient Infrastructure Technical Report
23 Centre for Global Development (2017), Billions to Trillions? Issues on the Role of Development Banks in Mobilizing Private Finance
IWDRI 2019 capacities, while also highlighting the potential to lock-in large-scale risks or resilience for the future.

This new context has spurred calls for newer ways of working for the multilaterals. These have included recommendations to ‘shift from project-level to national or international-level reforms’, ‘enhancing MDB coherence and collaboration’, ‘mobilise private finance for sustainable infrastructure’, ‘understand changing client needs’ and ‘address systemic governance issues’.

Multilaterals have already begun steps in this direction, for example, several initiatives have been launched for multilateral cooperation in infrastructure development. Emerging from discussions at the Addis Ababa conference on financing for development in 2015, these initiatives seek to strengthen the enabling environment, institutional capacities and development of well-prepared investable projects. The global infrastructure facility, platforms like the PPP knowledge lab, the MDB Infrastructure Cooperation Platform and the annual global infrastructure forums are some examples.

2018 was an important year for further driving this shared narrative of infrastructure development towards disaster resilient infrastructure (DRI). The first IWDRI, held in January 2018, witnessed participation from the World Bank Group, Asian Development Bank, UNISDR, and UNOPS, with emergence of ideas for collaborative actions for DRI. These included the need for a global infrastructure inventory, a regional manual of practice, and harmonization of policy provisions amongst others. The World Bank Group and IMF Annual Meetings took place in Bali against the heels of the catastrophic natural disasters that struck in Indonesia, bringing the spotlight on fragility of infrastructure not built for resilience. At the Global Infrastructure Forum in 2018, also held in Bali, MDBs reaffirmed their commitment towards delivery of ‘resilient, inclusive and sustainable technology-driven infrastructure’.

Similarly, bilateral development financing is also increasingly echoing the need for ‘quality’, ‘sustainability’, and ‘climate resilience’ in infrastructure investments.

Whilst there has been substantive dialogue and interest evinced – both by multilaterals and national governments – a consensus is yet to emerge on a coherent narrative, consistent framework, clear role, concrete actions and investments at scale for disaster resilient infrastructure.

This session will bring together representatives from multilateral development banks, UN agencies and bilateral development agencies to explore the following questions:

1. What are the ongoing programs and initiatives by multilateral agencies towards disaster resilient infrastructure?

2. What are the experienced catalysts and barriers to creating an enabling policy environment for disaster resilient infrastructure?

3. How can multilaterals leverage systemic changes in policies and practice? Over the long run, what commitments are being made or may be expected to be made in order to bring about this systemic change?

4. How will these commitments be manifested within the Coalition for Disaster Resilient Infrastructure (CDRI), especially during the roll-out of CDRI in the first three years?
Featured event

Emerging Technologies and Innovation

11:30 – 12:45

Wednesday, 20th March 2019

Taj Mahal Hotel, New Delhi
IWDR 2019

The Panel

Speakers – Digital Technologies

- Seema Kumar, IBM
- Sella Nevo, Google
- Andre Cuomo, Sacertis
- Michael Anthony, Sarmap
- Daisuke Abe, Weathernews Inc.

Speakers – Engineering and Nature Based Solutions

- Prof Mauro Dolce, Dipartimento della Protezione Civile, Italy
- Cees van de Gucht, Netherlands
- Chen-Xi Mao, Haoyu Zhang, China Earthquake Administration
- Dr K. Satyagopal, Tamil Nadu
- Dr Sushil Gupta, Assistant Vice-President, Risk Modelling & Insurance, RMSI

Session Format

This session will comprise two parallel sessions. Each will have presentations by speakers of 7 minutes each followed by a joint moderated panel discussion.
Digital Technologies

Increasing digital coverage, dropping costs and rapid rate of innovation is enabling a transformation from analog to digital disaster risk management. In the last three decades, every year, bandwidth cost has reduced by 20%, computing cost by 33%, data storage cost by 37% and mobile services cost by 3%. Across the four stages of preparedness, response, recovery and mitigation, use of emerging technologies like Artificial intelligence (AI), Internet of Things (IoT), Blockchain are revolutionizing the way disaster managers and decision makers acquire, analyse and act on the data. Use of emerging technologies is critical to an efficient, scalable and cost-effective resilience building of current and future infrastructure assets.

1. Remote sensing + Machine Learning + Cloud Computing

Hazard and extreme event warnings and advisories play a critical role in determining the extent of preparedness and impact of extreme events on populations, infrastructure, livelihoods and economies. Remote sensing technologies can collect panel data at low marginal cost, repeatedly, and at large scale on proxies for a wide range of hard-to-measure characteristics. As improved satellite imagery becomes available, new remote-sensing methods and machine-learning approaches have been developed to convert terrestrial earth-observation data into meaningful information about the vulnerability of infrastructure, affected population and other assets. Artificial intelligence (AI) and data science technologies, specifically machine learning and data mining, bridge the gap between numerical model prediction and real-time guidance by improving accuracy. They can be used to enhance the accuracy of parametric weather information, timeliness and location-specific early warnings and make simulations more useful for decision makers. Combination of satellite imagery, machine learning and surface modelling is also being used for structural vulnerability and impact assessments and monitor progress of reconstruction. For example, combining high definition satellite imagery with 3D surface models allows immediate recognition of structural deficiencies, oblique-level of damage assessment, and ability to run automated change detection to identify increase in infrastructure density, abnormality in structures, etc. Until recently, expensive satellite imagery and limited computational power only allowed analysis of small geographical areas. Cloud-based computational platforms are becoming increasingly accessible and allow one to scale analysis across space and time. Publicly available satellite data (e.g.
2. Internet of Things (IoT)

Over the last two decades, infrastructure assets have increased at an exponential pace, and so have the number of potential assets at risk. The development of sensor-based technologies has greatly improved information collection, data transmission and processing, which can serve as the foundation of the modernization of resilient infrastructure construction management. The IoT leverages heterogeneity, interoperability, distributed processing, and real-time analytics in parallel. Structural health monitoring (SHM) is critical to identify the vulnerability and risks early on and monitoring the key parameters such as temperature, deformation, stress and displacement acceleration, displacement and strains on the structure is a key part of it. IoT or sensors and wireless sensor networks (WSN) play an important role in structural health monitoring. For example, temperature sensors embedded in concrete can record the concrete hardening process in an early phase, which has been used to evaluate the quality, compressive strength and flatness of concrete; optical-fibre sensors embedded in concrete have been applied to monitor the strain and cracks of structures. In recent years, WSN has been widely utilized in structural health monitoring of bridges, dams and other critical infrastructure.

WSNs are also widely deployed in other areas of disaster management. For example, IoT is being used for landslide monitoring in Uttarakhand and Kerala in India, where deployment of tilt sensor, pressure sensor, moisture sensor, geophone, and strain gauge sensors were deployed to monitor rain fall induced landslides. IoT-enabled beacons are designed to notify its user about possible earthquake or tsunami in personal-aware mode, makes alarming sound and sending push notifications to user smart phones instantly. For floods, open crowd-sensing IoT-enabled infrastructure is connected to flood sensing nodes around the globe is usually deployed under the river bridge, measures the water level and transmits on map networks. If water-level exceeds the predetermined safety level, the map changes colours. To enable rapid disaster response, pre-deployed sensors can easily broadcast signals and communicate critical data such as temperature, water quality, or smoke to help government can make more informed decision on how to deploy resources during a disaster situation.

3. Drones

Plummeting acquisition and operational costs, lower operational risks, higher quality data and increasing ease in regulations have made drones a popular tool for extensive data collection, detailed mapping, as well as regular inspections of infrastructure projects,
especially in remote and disaster vulnerable areas. In resilient housing for example, identifying which homes face the greatest hazard risk and their exact location is critical information for government officials deciding which household should receive a subsidy or upgrade/package. This technology can now be leveraged to inform infrastructure policy design and implementation in a timely manner. High-resolution drone imagery, combined with street imagery and machine learning, along with disaster vulnerability maps, helps build an infrastructure profile that can identify which assets are safe, which can be made safer at reasonable costs, and which need to be relocated or dismantled. In post-disaster scenarios, drone overflights can employ both optical and LiDAR sensors to provide aerial imagery at 8-12 cm resolution as well as 3D imagery. Deep machine learning models can be used to process to compare the drone imagery taken pre and post events to identify the infrastructures which are damaged due to extreme events and geo-tag them automatically to communicate the damaged infrastructure location to the concerned officials.

4. Blockchain

Blockchain is a type of distributed ledger technology (DLT) that creates a transparent, secure, immutable, and verifiable database which does not need a central administrator to update and maintain it. Application of Blockchain technology can bring transparency, verifiability, security and immutability to disaster risk management.

Blockchain-enabled technology is for example, being used to reimagine how electricity is distributed. If and when power lines go down during a disaster, the electricity connection is broken, resulting in region-wide blackouts. Blockchains can help create and manage a grid so that electricity could be bought, sold, and traded locally (i.e. directly between nearby batteries and consumers), thereby spreading out the risk and drastically increase community resilience. Blockchain platforms can be embedded with peer-to-peer smart contracts, allowing anyone with a solar panel, generator, battery, and the ability to put electricity back on the grid—to sell electricity directly to nearby consumers without going through a distribution centre. Hence, when a disaster knocks off the power line, a decentralized grid could completely disconnect from the central system and operate in ‘island-mode’ for days, weeks—or potentially indefinitely.

Blockchain technology can seamlessly secure the vast amounts of information created by the IoT sensors. Because the information sent is unable to be changed or redirected, potential threats to the infrastructure are decreased drastically. Blockchain use-cases are also emerging in reconstruction of resilient infrastructure and housing where it is being used for aspects like land and asset titling verification, keeping track of permits, materials and contracts, reconstruction grant payments, etc.
Nature-based solutions are inspired and supported by nature and simultaneously provide environmental, social, cultural and economic benefits. Nature-based solutions, such as well-connected green and blue infrastructure, green and unsealed surfaces in cities, green roofs, natural water retention measures, and salt marshes and dunes for coastal protection, use the properties and functions of ecosystems to provide water regulation, flood risk protection, climate change adaptation, etc. They are designed to bring more nature and natural features and processes into cities, landscapes and seascapes, through locally adapted and systemic interventions. They are locally attuned, resource efficient, multi-purpose, multi-functional and multi-beneficial. Robust evidence of the cost-effectiveness and longer-term social, economic, cultural and ecological benefits of these solutions is currently lacking and this has prevented their wider deployment.

Nature-based solutions that strategically conserve or restore nature to support conventionally built infrastructure systems can reduce disaster risk and produce more resilient and lower-cost services in developing countries. In the disaster risk management and water security sectors, NBS can be applied as green infrastructure strategies that work in harmony with grey infrastructure systems. NBS can also support community well-being, generate benefits for the environment, and make progress on the Sustainable Development Goals (SDGs) in ways that grey infrastructure systems alone cannot. Though NBS approaches have yet to be fully integrated into decision-making or to compel widespread investment in developing countries, this is on the brink of change.

Developing countries and their partners (including multilateral development banks and bilateral agencies) are increasingly utilizing NBS in disaster risk management, as well as in water security, urban sustainability, and other development projects. The growing number of projects offers lessons and insights to help mainstream NBS into development decision making. As more disaster risk managers understand and integrate well-designed NBS into infrastructure projects, more finance can be routed towards making infrastructure cost effective and disaster and climate resilient.
Both panels will address the following issues:

1. **On cost:** Monitoring the vulnerability or structural health of critical infrastructure such as roads, bridges, etc. is an expensive affair, especially with the sensor and monitoring ecosystem to be put in place. This can even make it prohibitive. What are the factors that can bring the costs down; is it scale, cheaper sensors, or are there newer, more affordable technologies in the making? (Examples from some key infrastructure sectors: e.g. water, irrigation, power)

2. **On technology:** What are some emerging technologies that can ensure that disruptions in services provided by critical infrastructure can be minimized? What are some of the enabling conditions for ensuring the most optimal utilization of such technologies for investing in disaster resilient infrastructure?

3. **On policy:** Are there any policy roadblocks that are preventing the full harnessing of the myriad technologies out there? What may be the enabling policies that need to put in place to attract more innovation, low-cost interventions in the space of DRM and enable translation of new technologies into practical frameworks?

4. **On scaling up:** How can technology be used to in better informing decision makers and communities to prepare for disasters. What can be done to scale up the use of tech across the country, especially in disaster vulnerable states?

5. **On Data:** What are the technical gaps (for e.g. gaps in data architecture, data formats) that are hampering development and adoption of emerging technologies?

6. **On improving capacities:** What technological innovations are being made in the area of improving “capacity development” along the four thematic pillars of CDRI?
Working Session 2

Resilience of Key Infrastructure Sectors

13:45 – 15:15

Wednesday, 20th March 2019

Taj Mahal Hotel, New Delhi
Introduction to the session by Kamal Kishore, National Disaster Management Authority, India

Session Format

This session will have three parallel breakout sessions, each covering different infrastructure sectors. (Group 1: WS2-B; Group 2: WS2-A and WS2-C; and Group 3: WS2-D)

Each session will have presentations by 5 - 6 speakers of 7 minutes each followed by a moderated panel discussion.
Building resilience has a broader implication, beyond just risk assessment and disaster management. Management of infrastructure systems is already complex encompassing overlapping and interconnected systems and multiple stakeholders, financial and political considerations; all of which must come together in consensus for integrated development.

The session will discuss the challenges and opportunities of incorporating disaster resilience in rapidly expanding, and interconnected infrastructure systems/nodes that must balance these aspects while also playing a key role in the socio-economic prosperity of the region. For each sector, the speakers will assess strategies of physical and economic resilience of the infrastructure system including: possible impacts of a disaster, significance of vulnerabilities, prioritizing investments, adaptation measures and engagement with stakeholders. It will conclude with an actionable agenda for knowledge building for each of the sectors pertaining to an issue or a type of economy.

The following issues need to be addressed for every sector:

- How have risk management systems in older infrastructure systems (power plants, ports, railway lines, etc) been updated in line with the evolving understanding of natural hazards?
- What is the state of art practices being adopted to incorporate resilience in newly developed infrastructure systems? What are the systems for using risk metrics and standards?
- How are the projected impacts of climate change taken into account for long-term decision making?
The Need for Infrastructure

Increasing physical infrastructure, both in quality and quantity, is a pre-requisite for supporting economic growth.\textsuperscript{26} Infrastructure spending is the most direct way of creating and sustaining employment.\textsuperscript{27} This is particularly significant for short-term growth restoration after a shock, as seen in response to the 2008 financial crisis.\textsuperscript{28} In the long term, the indirect spill-overs of increased infrastructure create a base upon which future growth and long-term development objectives can be achieved, and are therefore particularly significant to developing countries. Some infrastructure investments can yield cost benefit ratios of up to 1:20 if they are planned and executed well.\textsuperscript{29}

Current Status of Infrastructure

Currently annual global infrastructure investment stands at about USD 2 trillion.\textsuperscript{30} The investment in infrastructure has grown at an average 2.9\% from 2007 to 2015.\textsuperscript{31} While there is steady growth in the year-on-year investment, several estimates indicate that in the mid-term in the business as usual scenarios, investments are going to fall short of what is required for healthy economic growth. Global Infrastructure Hub pegs the global annual infrastructure investment needs at USD 3.7 trillion per year, going from 2016 to 2040.\textsuperscript{32} They estimate the annual shortfall to be in the range of USD 650 billion. Furthermore, if we consider the targets set under the UN Sustainable Development Goals, these investment-needs increase to USD 4–4.4 trillion per year.\textsuperscript{33} That represents a gap of USD 1 to 1.5 trillion per year. This is likely an underestimate, since most estimates only take into account provision of household electricity and water supply — some account for household sanitation.

\textsuperscript{26} Estache and Garsous, 2012; Spence et al., 2008; Straub, 2008
\textsuperscript{27} International Labour Organization, 2009
\textsuperscript{28} Estache and Garsous, 2012
\textsuperscript{29} McKinsey Global Institute, 2016
\textsuperscript{30} McKinsey Global Institute, 2016; Global Infrastructure Hub, 2017
\textsuperscript{31} Global Infrastructure Hub, 2017
\textsuperscript{32} Based on the assumption that World GDP will grow at an average 3.6\% over the period of 2016-2040
\textsuperscript{33} McKinsey Global Institute, 2016; Global Infrastructure Hub, 2017; United Nations Conference on Trade and Development, 2014
Emerging economies account for 54–60% of the total global investment needs in infrastructure. Nearly 60% of the world’s total investment needs from 2016–30 will be in Asia.34 Just China, USA, Japan and India account for more than 50% of the global investment needs.35 In Europe, Americas and Oceania—which predominantly consist of developed countries—the investment needs are typically for replacement of aging infrastructure and/or incremental changes to improve infrastructure which has already been built. In contrast the investment needs in Asia and Africa are for mainly for construction of brand new infrastructure. As with the nature of investment needs, across the globe there is also great variation in the sectors which require the greatest investment.36 In Asia the energy and road transport sectors require the highest amount of investment, and also face the largest gaps, closely followed by telecom. In Africa large investments are necessary in all four infrastructure sectors. In the Americas the investment needs and gap are maximum in roads. Europe needs investment in roads, energy, rail, and telecom, however, in a business as usual scenario there is no gap between potential investment and what is required. In Oceania investment is required in energy, ports, and rail, but similar to Europe, these countries are expected to have their investment needs met in the business as usual scenario.

It is in this context of limited funding, that the disaster and climate resilience of the infrastructure that will be built in the coming years becomes a non-negotiable consideration.

34 McKinsey Global Institute, 2016
35 Global Infrastructure Hub, 2017
36 McKinsey Global Institute, 2016; Global Infrastructure Hub, 2017
Disasters cause massive human and economic loss across the world. Between 2005 and 2015 the UNISDR estimates that disasters have killed 0.7 billion, and affected another 1.7 billion. According to Internal Displacement Monitoring Centre more than 26 million people have been displaced by disasters every year from 2008.\(^\text{37}\) The UNISDR estimates that between 1995 and 2015, disasters caused between USD 2 to 2.5 trillion in economic losses. Figure 1 shows the distribution of losses caused by disasters across the globe by type of hazard and region. More than 70% of the losses are due to hydro-meteorological or climatological disasters. These types of hazards are likely to cause even more damage in the future due the unpredictability in their frequency, intensity and location, as a result of climate change.

The impact of disasters on infrastructure manifests itself in two forms. One is the outright destruction of an infrastructure asset due to a high intensity disaster event. The other is the gradual degradation of assets over successive medium or low intensity events. The frequency of medium and low intensity events is much higher, and the attention they receive is lower than high intensity events. Therefore, it is likely that such degradation overall contributes to higher damage and economic losses than events which lead to the

\(^{37}\) Internal Displacement Monitoring Centre, Norwegian Refugee Council, 2015
physical destruction of infrastructure. Figure 2 summarises the infrastructure losses due to recent disasters.

<table>
<thead>
<tr>
<th>Country / Year</th>
<th>Event</th>
<th>Total damages and losses (D&amp;L) (USD mn)</th>
<th>Infrastructure D&amp;L as % of TOTAL losses</th>
<th>Infrastructure D&amp;L as % of PUBLIC losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>India/ 2001</td>
<td>Earthquake</td>
<td>2.131</td>
<td>16%</td>
<td>n/a</td>
</tr>
<tr>
<td>Indonesia/ 2004</td>
<td>Tsunami</td>
<td>4.452</td>
<td>20%</td>
<td>56%</td>
</tr>
<tr>
<td>Sri Lanka/ 2004</td>
<td>Tsunami</td>
<td>970</td>
<td>13%</td>
<td>n/a</td>
</tr>
<tr>
<td>Pakistan/ 2005</td>
<td>Earthquake</td>
<td>2.852</td>
<td>17%</td>
<td>n/a</td>
</tr>
<tr>
<td>Indonesia/ 2006</td>
<td>Earthquake</td>
<td>3.134</td>
<td>2%</td>
<td>17%</td>
</tr>
<tr>
<td>Pakistan/ 2010</td>
<td>Floods</td>
<td>10.056</td>
<td>20%</td>
<td>n/a</td>
</tr>
<tr>
<td>Samoa/ 2012</td>
<td>Cyclone</td>
<td>204</td>
<td>37%</td>
<td>66%</td>
</tr>
<tr>
<td>Cape Verde/ 2014</td>
<td>Volcano</td>
<td>28</td>
<td>8%</td>
<td>30%</td>
</tr>
<tr>
<td>Nepal/ 2015</td>
<td>Earthquake</td>
<td>7.065</td>
<td>9%</td>
<td>30%</td>
</tr>
<tr>
<td>Fiji/ 2016</td>
<td>Cyclone</td>
<td>1.327</td>
<td>9%</td>
<td>47%</td>
</tr>
</tbody>
</table>

The table shows that the loss of infrastructure is a significant part of disaster loss, especially public loss. This could be attributed to the fact that usually major infrastructure assets are publicly owned. Furthermore, the aggregate impacts of disasters on infrastructure are often greater than their impacts on individual assets.

**Infrastructure as a system of systems**

Modern infrastructure is an interconnected system of systems. Damage to one asset can lead to cascades which result in the reduction in service levels of many different individual infrastructure assets. Beyond the damage to assets themselves, these cascades can result in major disruption of supply chains, which can severely hamper relief and recovery operations, and also lead to major economic losses. An example of such a cascade was seen in the aftermath of Hurricane Katrina which struck New Orleans, USA in 2005. The cyclone damaged power grids, which led to power outages. This led to failure of telecommunications networks, and also led to the shut-down of railways in the region. Three critical transportation conduits were shut down for 48 hours, which later functioned on reduced power for two weeks. This led to massive disruption in transportation and distribution of relief supplies, food and fuel. Relief and rescue efforts were severely hampered by the power outages and disruption of telecommunication. Similar cascades were also observed in the aftermath of the earthquake and tsunami in Tohoku, Japan in

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38 Wilbanks et al., 2012
2011 and more recently in Houston, Texas in 2017 due to Hurricane Harvey. Further downstream, this kind of systemic disruption can have profound impacts on mid-term economic productivity of the region, and on the lives and livelihoods of residents, especially the poor.

**Emerging issues in infrastructure resilience**

1. **Infrastructure growth and replenishment**
   As shown earlier, investments in infrastructure are on the rise. While ports and airports in small island nations represent critical economic lifeline services, emerging nations in Africa and Asia are looking at rapidly expanding their infrastructure base to provide their citizens with a foundation for economic activity. The current focus on resilience represents an opportunity to get it right. It has been shown that about 80% of the investment in a new infrastructure project is locked in at the design phase. Thus, it is at this phase that we should aim to lock in the resilience paradigm at the core of an infrastructure system.

2. **Climate change and changing risk profiles:**
   Changing climate patterns around the globe are increasing the intensity, frequency and uncertainty of extreme weather events. This means that infrastructure built on the basis of past risk assessments will need a reassessment of its risks and upgrades to match the current level of risk. The constantly changing nature of these risks, the high volume of initial investment required, and the long life-cycles of infrastructure projects necessitate the continuous monitoring of risks and the development of adaptation strategies that are responsive to the changes in the risk profile.

3. **Technological evolution**
   The rapid evolution of material sciences, building technologies, and energy sources requires the planners of infrastructure to avoid getting locked into specific technologies or materials. There is a need to move from prescriptive standards that specify designs and material specifications to standards that define only the performance required from the infrastructure and allow for the designs and material selection to evolve and innovate. Further research is required on the use of emerging technologies, new materials, building designs, and energy sources and their effect on the resilience of infrastructure systems.
4. **Building infrastructure affects future development**

Investment in physical infrastructure is a key driver of growth and urbanisation and affects human settlement patterns. This alters the exposure characteristics of the area in which the infrastructure is built and changes the risk profile of these regions. Thus infrastructure is not only affected by the regional characteristics, but also affects them in return. As an example, the international airport at Chennai was constructed in low lying areas outside the main city. While by itself the airport is resilient to flooding at the time of heavy rainfall, the surrounding residential settlements that have emerged after the construction of the airport are even more susceptible to flooding than before.

Infrastructure like ports and airports require large land areas and such lands are often found in hazard prone or reclaimed or low lying land (for airports). The existence of the port or airport attracts populations to live in areas surrounding these for employment or providing support services. This increases the population in living in hazardous areas thereby increasing risk. It is important to consider such fallouts at the time of site selection and planning.

**Potential actions**

A review of literature suggests the following actions that need to be carried out at various levels to build the resilience of key infrastructure sectors.

**At national and sub-national level:**

1. Defining a national climate adaptation strategy
2. Defining a national strategy / framework / master plan on infrastructure development that incorporate disaster and climate resilience
3. For new infrastructure: Laws requiring plans of new infrastructure to incorporate disaster and climate resilience considerations in every phase.
4. For existing infrastructure: Laws requiring assets to assess their disaster and climate risks and to create adaptation plans and monitor progress
5. Updating national standards on infrastructure construction including disaster and climate resilience
6. Vulnerability assessments of various infrastructure sectors
7. Developing design guidelines for infrastructure sectors incorporating resilience
8. Urban and spatial planning considerations
9. Improving coordination between stakeholders
At infrastructure asset level:

1. Conducting disaster and climate risk and vulnerability assessments
2. Defining an adaptation strategy
3. Incorporating the adaptation strategy into the master plan
4. Developing resilience planning, design, and construction guidelines
5. Upgrading of infrastructure in line with adaptation strategy
6. Business and operational continuity planning in light of risks
7. Regular monitoring and review
8. Involvement of local communities
Working Session 2–A

Resilience of Airport Infrastructure

13:50 – 14:55

Wednesday, 20th March 2019

Taj Mahal Hotel, New Delhi
IWDR 2019
The Panel

Speakers

- Dr Shefali Juneja. Ministry of Civil Aviation, India
- Airport Authority of India

Session Format

This breakout session will have presentations by speakers for each sector of 7 minutes each followed by a moderated panel discussion.
Airport infrastructure is defined here as all airport infrastructure, including terminals, runways, aprons and hangers, and dedicated parking.\textsuperscript{39} The Global Infrastructure Outlook forecasts a global investment of USD 2.1 trillion in air transport from 2016 to 2040 in a business as usual scenario [Figure 1]. The aviation sector will require an additional investment of USD 530 billion over the same period to maintain the current growth rates and mitigate the effects of climate change and disasters.\textsuperscript{40}

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\textsuperscript{39} Global Airport Database (GADB) (http://www.partow.net/miscellaneous/airportdatabase/)

\textsuperscript{40} Global Infrastructure Outlook, GIH (https://outlook.github.org/)
Reports from 2017 indicate that the northern hemisphere has nearly twice the number of airports (3317 airports) as that in the southern hemisphere (1798 airports). In the same year the top 5 countries with the most number of airports were USA (with 552 airports), Germany (529), France (472), South Africa (262), and Canada (259). Thus, currently the bulk of global airport infrastructure is situated in North America and Europe. This also accounts for the fact that Europe and North America account for 7 out of 10 of the world’s most connected airports. This presence of airports does not equate to volumes though, as Asia accounts for 8 out of 10 of the busiest airports by international flight volumes.  

A country-wise analysis by the International Air Transport Association (IATA) forecasts the top 5 fastest growing aviation markets from 2016 to 2036 will be China, US, India, Indonesia and Turkey. Over the same period, at a regional level, they estimate that the aviation market in African nations will lead the growth with a CAGR of 5.9 % with the Middle East and Asia following closely at 5.0 % and 4.6% respectively. On the whole the IATA predicts a near doubling of global passenger volumes from 2016 to 2036.

Criticality of Airport Resilience

Airports are an essential part of the air transport system. They support regional and national growth by connecting various nodes of the economic system. Although airports play an important role in domestic and regional economic activities, they have been vital in recent disaster response and recovery operations. The role that played by airports like San Juan Airport (2017), Kathmandu Airport (2015), Yamagata Airport (2011), and Port-au-Prince Airport (2010) in the post-disaster phase has demonstrated that airports are a critical element of disaster recovery operations. Accessibility, open space, large buildings, redundant communication systems, logistics handling systems and security make airports magnets for many stakeholders in post disaster situations.  

Airports become hubs for the inflow of relief supplies and the evacuation of survivors. Thus the survival and continued functioning of airport infrastructure is vital to recovery from disaster situations.  

Apart from their role as disaster response hubs, the disruption of airport services due to hazards like earthquakes, floods or volcanic eruptions can lead to significant economic losses due to the disruption of the global supply chain. The highly interconnected nature of air transport systems means that these economic losses can spread to all the regions dependent on the continued functioning of the airport infrastructure.

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41 https://www.oag.com/analytics
The damage to airport infrastructure due to the impacts of natural hazards, like the Bam earthquake in Iran (2003) and Cyclone Evan in Fiji (2012) and the resulting economic disruption and losses, highlights the importance of building airports that can withstand, survive, and continue to operate under the impacts of such extreme events. Most international literature on disaster management at airports assumes the survival of the airport terminal building and the continued functioning of its support services. The resilience paradigm on the other hand examines the process of airport construction right from its conception to the end of its life cycle, while treating disruptions by natural hazards as threats to its survival and functioning. The disaster and climate resilience of airports depends on the decisions made at each stage of the planning and design process. A few considerations for building resilient airports have been identified below:

1. **Climate change and changing risk profiles:**
   Changing climate patterns around the globe are increasing the intensity, frequency and uncertainty of extreme weather events. This means that airports built on the basis of past risk assessments will need to reassess their risks and upgrade their infrastructure to match the current level of risk. The constantly changing nature of these risks, the high volume of initial investment required, and the long life-cycles of infrastructure projects necessitate the continuous monitoring of risks and the development of adaptation strategies that are responsive to the changes in the risk profile.

2. **Technological evolution**
   The rapid evolution of material sciences, building technologies, and energy sources requires the planners of airport infrastructure to avoid getting locked into specific technologies or materials. There is a need to move from prescriptive standards that specify designs and material specifications to standards that define only the performance required from the infrastructure and allow for the designs and material selection to evolve and innovate. Further research is required on the use of new materials, building designs, and energy sources and their effect on the resilience of airport systems.

3. **Dependence on other infrastructure sectors**
   Airport resilience is also a function of the resilience of other infrastructure sectors. The disruption of support infrastructure like power supply, telecommunications and even water supply directly affect the continuity of airport operations. The resilience paradigm necessitates the view of infrastructure as a system of smaller systems.
and the need to plan for the resilience of sub parts as well as the whole system. The disruption of Kochi Airport (Kerala, India) in 2018 highlights the lack of an integrated approach to resilience planning. The same solar panels, that allowed the airport to boast of its use of renewable energy and climate sensitivity in 2017, led to the disruption of power supply when the panels were submerged under flood waters the next year.

4. **Growing importance of air transport**
   As shown earlier, aircrafts are increasingly becoming the preferred mode of transportation for people, goods and services around the globe. While airports in small island nations represent critical economic lifeline services, emerging nations in Africa and Asia are looking at rapidly expanding their airport infrastructure to cater to the growing demand. The current focus on resilience represents an opportunity to get it right. It has been shown that about 80% of the investment in a new infrastructure project is locked in at the design phase. Thus, it is at this phase that we should aim to lock in the resilience paradigm at the core of an infrastructure system.

5. **Airports affect future development**
   Just as traditionally towns developed around rail and freight corridors, airports are now becoming key drivers of growth and urbanisation and affecting human settlement patterns around them. This alters the exposure characteristics of the area and changes the risk profile of these regions. Thus airports are not only affected by the regional characteristics but also affect them in return. As an example, the international airport at Chennai was constructed in low lying areas outside the main city. While by itself the airport is resilient to flooding at the time of heavy rainfall, the surrounding residential settlements that have emerged after the construction of the airport are even more susceptible to flooding than before. Airports require an extremely large land area and such lands are often found in hazard prone or reclaimed or low lying land. The existence of the airport attracts populations to live in areas surrounding the airport to in for employment or providing support services. This increases the population in living in hazardous areas thereby increasing risk. It is important to consider such fallouts at the time of site selection and planning.
Working Session 2-B

Resilience of Ports, Railways and Freight corridors

13:50 – 14:55

Wednesday, 20th March 2019

Taj Mahal Hotel, New Delhi
The Panel

Moderator

- Anurag Sachan, Dedicated Freight Corridor Corporation of India

Speakers

- Florian Hofstetter, SBB AG, Switzerland
- Dr Shoichi Hashimoto, Former Director, NRRI, Japan
- Dr Raghav Pant, ECI Oxford
- Shu Moriyama, Michiya Kitayama, JICA

Session Format

This breakout session will have presentations by speakers for each sector of 10 minutes each followed by a moderated discussion.
Ports

Port infrastructure is defined here as all infrastructure in a port, including container, bulk, break-bulk, non-bulk and commodity ports. The Global Infrastructure Outlook forecasts a global investment of USD 1.7 trillion in port infrastructure from 2016 to 2040 in a business as usual scenario [Figure 1]. Ports will require an additional investment of USD 555 billion over the same period to maintain the current growth rates and mitigate the effects of climate change and disasters.44

![Infrastructure investment at current trends and need](image)

**Figure 5: Investment requirement in Ports**
 Global Infrastructure Outlook, GiH

Roadways and freight corridors

Road infrastructure is defined here as all paved roads, including highways and motorways. The Global Infrastructure Outlook forecasts a global investment of USD 26 trillion in roads from 2016 to 2040 in a business as usual scenario [Figure 2]. Road infrastructure will require an additional investment of USD 8 trillion over the same period to maintain the current growth rates and mitigate the effects of climate change and disasters. 45

44 Global Infrastructure Outlook, GiH (https://outlook.gihub.org/)
45 Global Infrastructure Outlook, GiH (https://outlook.gihub.org/)
Railways

Rail infrastructure is defined here as all below-rail heavy-rail infrastructure. The Global Infrastructure Outlook forecasts a global investment of USD 10 trillion in air transport from 2016 to 2040 in a business as usual scenario [Figure 1]. The railways sector will require an additional investment of USD 1.1 trillion over the same period to maintain the current growth rates and mitigate the effects of climate change and disasters.\(^6\)

\(^6\) Global Infrastructure Outlook, GIH (https://outlook.gihub.org/)
Sustainable transport is a key enabler for all dimensions of sustainable development. It is a pre-requisite for the movement of goods, expansion of markets and growth of trade required for spurring economic and social development. The transport sector makes significant contributions to national GDPs as transport related businesses directly or indirectly employ a large portion of the workforce. Transport businesses also generate significant contributions to tax revenues. Transport systems are considered sustainable if they are able to provide services in a manner that is safe, affordable, accessible, efficient and resilient to extreme events, while minimizing carbon and other emissions and environmental impacts.

Ports, railways and road freight corridors are the economic backbones of countries, as they are used extensively to provide goods and services for everyday sustenance. Much of this provision is done ‘just-in-time’, which creates a supply-chain critically dependent on uninterrupted freight logistics. In understanding freight corridor resilience the key issue is to understand supply chain risks induced by localised failures along important freight corridors. The consequences of climate induced ‘single points of failures’ on important freight corridors could potentially create widespread socio-economic impacts on countries. Such single points of failures could be a major transport hub (e.g. a port or railway station/yard) or a key linkage (e.g. a road, maritime or railway line) towards a major production or demand centre. Identifying the climate exposures and the potential impacts of such single points of failures goes a long way towards prioritising the climate resilience of locations of key economic importance.

Ports and major freight corridors are severely at risk due to rising sea-levels and increased storm surges magnified by climate change. Due to rising sea temperatures resulting in warm ocean waters, there have been catastrophic hurricanes in the United States and the Caribbean that have had major impacts on ports and freight corridors. In 2012 Hurricane Sandy — fuelled by unusually warm ocean waters — produced storm surges almost 6 meters high, resulting in massive flooding that shut down the Port of New York and New Jersey for 5 days.  

Many of the solutions towards improving the climate resilience of the infrastructures identified in the freight supply chain lie in enhancing the design standards underlying systems. Port docks and shipping areas need to be built to account for rising seas levels and increase storm surges, often by designing higher sea walls and improving the dredging of the channels. Railways and roads design standards need to be upgraded to become capable of withstanding more extreme flooding and wind events. Many of such upgrades will require significant investments, which could be prioritised by performing a detailed cost-benefit assessment of climate adaptation that takes into account the wider economic benefits of avoided losses of failures of key freight linkages.

A key option towards improving the climate resilience of freight system is to strengthen the multi-modal linkages across of freight corridors. In most countries major roads are heavily used for freight transport due to lack of reliable railway options, even though railways might be a cheaper transport option. This creates highly congested road networks where freight transport competes with passenger transport, also adding to the global emissions that exacerbate climate change. Improving the road-railway-port (maritime and inland) physical and logistic connectivity across several sections of freight corridors could potentially benefit during adverse climate impacts, where the impacts of failures in one mode could be reduced by substituting with the other modes.

The benefits of improving climate resilience of freight corridors goes beyond national and sub-national interests, as their significance to an increasing connected global supply chain is immense.
Working Session 2–C

Resilience of Energy and Telecom Infrastructure

13:50 – 14:55

Wednesday, 20th March 2019

Taj Mahal Hotel, New Delhi
IWDRI 2019

The Panel

Speakers

- Luke Brown, Assistant Secretary, Emergency Management Australia
- Manoj Kumar Singh, Indus Towers
- Stephen Gitonga, Regional Energy Specialist, UNDP
- Ritesh Khattar, Ministry of Power, India

Session Format

This breakout session will have presentations by speakers for each sector of 10 minutes each followed by a moderated panel discussion.
The energy sector represents sub-systems ranging from power generation to transmission to distribution. It is estimated that globally USD 26 trillion will have to be invested in this sector from 2016 to 2030 to sustain the current growth rate. An additional investment of USD 2.9 trillion will be required to meet the SDG targets for the energy sector.

![Figure 6: Investment requirement in Power 2016-2040](Global Infrastructure Outlook, GiH)

The various subsystems of energy infrastructure are exposed to disaster risks which can be managed by adopting appropriate standards. While risk assessment and evaluation is hard-wired in the design of assets built since the 1980s, many assets (for e.g. hydroelectric dams) currently under operation were commissioned or built prior to this.

**Telecommunications Infrastructure**

The Global Infrastructure Outlook estimates global investments for 2016 to 2040 in telecommunications to be USD 7.8 trillion in a business as usual scenario. It estimates that an additional investment of USD 1 trillion would be required for a total investment of USD 8.8 trillion to maintain the current growth rate and combat the effects of climate-change and disasters.
Electricity and telecom systems face risks due to extreme flooding, storm winds that knock debris on equipment. In addition, droughts can potentially result in threats to hydropower generation, transmission and distributions. These outages have global implications due to the dependence of every other system on electricity and telecoms. Though not climate related, the biggest electricity blackout in history happened when India’s super grid failed in 2012 over two days, which affected 600 million people.48 Similarly telecoms failures grounds worldwide operations of the British Airways flights stranding 400 flights and 75,000 passengers in one day.49 The take-away from such disruptions is the instantaneous and widespread cascading impacts they induced on dependent systems.

Though global electricity transmission grids are built to high standards and there are enough network redundancies to safeguard against more than one generation and transmission failure, the distribution levels networks generally depend on individual pinch-points whose failures results in widespread impacts. For example, in 2015 an electricity substation flooding in England impacted 61,000 homes and businesses.

There is a huge incentive in investing in safeguarding energy and telecoms infrastructures against climate impacts. The Recent report by the Environment Agency in England estimate that 41% of transport and utilities infrastructure assets are in areas at risk of flooding, comprising, 36% at direct risk of flooding and 5% at risk due to dependencies on

48 Romero, J. J. (2012). Blackouts illuminate India’s power problems. IEEE spectrum, 49(10)
49 https://www.networkworld.com/article/3200105/british-airways-outage-like-most-data-center-outages-was-caused-by-humans.html
electricity. The overall benefit to cost ratio of investing in climate resilience of these assets is estimated at 9 to 1.50

As energy systems are increasing shifting towards renewable generation technologies, the key nature of cascading failures can alter from centralised large-scale grid collapses to decentralised localised grid outages. While the former might have large impacts the recovery of the system can be quick if only few failure points need to be repaired, whereas for the latter several failures might have significant and longer impacts if sufficient resources cannot be allocated at several failure points.

Hence a key consideration in planning energy systems is to understand how the failures cascade and where the resources can be allocated optimally to improve systemic resilience.

The overwhelming dependence of global supply chains and services on a reliable computational hardware and software systems makes telecoms risks a global challenge. The 2011 flooding in Thailand resulted in a doubling of global hard drive prices, as 45% of the global supply chain of hard drives came from Thailand at that time.51

The key steps towards improving climate resilience of energy and telecoms systems include among others:

1. Increasing the redundancy of the networks to create backup supply in case of failures.
2. Improving the design standards of equipment to be more resistance to extreme heat, snow, floods and winds.
3. Providing portable solutions to easily store, transport and deploy energy and telecom systems when there are climate disasters.
4. Identify the critical supply chains which are most impacted by energy and telecom failures, by mapping the geospatial nature of failure cascades and locations that are most a risks. This would lead towards prioritising adaptation planning

Working Session 2-D

Resilience of Water Infrastructure

13:50 – 14:55

Wednesday, 20th March 2019

Taj Mahal Hotel, New Delhi
IWDR 2019

The Panel

Speakers

- Katrin Bruebach, 100 Resilient Cities
- Cees van de Guchte, Netherlands
- Prof Kapil Gupta, IIT Bombay
- Central Water Commission, India
- Junichi Katayama, Ishigaki, Japan

Discussants

- Phil Rizcallah, National Research Council, Canada

Session Format

This breakout session will have presentations by speakers for each sector of 10 minutes each followed by a moderated discussion.
The purpose and nature of the water infrastructure investments needs have significantly expanded with the ambition of SDG 6 — to Water Supply and Sanitation, flood protection, drought management, and water quality management — and are interlinked with investment needs for food security, health, sustainable consumption and production, sustainable urban development and terrestrial ecosystems. The Global Infrastructure HUB (GIH) estimated that globally USD 5.7 trillion will have to be invested in this sector from 2016 to 2040 to sustain the current growth rate. An additional investment of USD 1.5 trillion will be required to meet the SDG targets for the water sector.  

The human right to water and sanitation has yet to become a reality for one-third of the global population. 2.1 billion people still do not have access to safe drinking water and 4.5 billion people still lack access to sanitation compatible with the SDG6 objectives. Poor sanitation, water, and hygiene lead to about 675,000 premature deaths annually. The scale of global economic losses related to water insecurity and poor sanitation indicates USD 470 billion per year. USD 260 billion per year from inadequate water supply and sanitation, USD 120 billion per year from urban property flood damages, and USD 94 billion per year of water insecurity to existing irrigators. Further, water-related losses in

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52 Global Infrastructure Outlook, GIH, https://outlook.gihub.org/
agriculture, health, income, and property could result in a decline by as much as 6% of GDP by 2050 in some regions of the world and spur sustained negative growth. Investment needs substantially exceed current financing flows. Projections of water security investment needs diverge, but they all indicate that the scale of investment ought to increase significantly. Global estimates range from USD 6.7 trillion by 2030 to USD 22.6 trillion by 2050. To achieve the water-sanitation-hygiene component of SDG6 by 2030, it is estimated that capital investment needs to triple (to reach USD 1.7 trillion), and operating and maintenance costs will be commensurately higher. The FAO has projected that an estimated USD 960 billion of capital investment is needed to expand and improve irrigation between 2005/07 and 2050 in 93 developing countries.

Investments are needed not only in new infrastructure but also in the maintenance and operations of the existing stock in order to improve their efficiency and reduce water losses. So far, a strong economic case for water-related investment has failed to translate into a compelling financial case for investment. Investment in water security faces a number of barriers, including:

- Water is generally an under-valued and under-priced resource, resulting in a poor record of cost recovery for water investments.
- Water infrastructure is typically capital intensive, long-lived with high sunk costs. It calls for a high initial investment followed by a very long pay-back period.
- Improvements in water generate a mix of public and private benefits in terms of valued goods and services, as well as reduced water-related risks. Many of these benefits cannot be easily monetised, or their positive impacts appear outside of the water investment project.
- Lack of appropriate analytical tools and data to assess complex water-related investments, and track record of such investments can deter financiers.
- Water projects sometimes are too small and too specific. This raises transaction costs and makes emerging innovative financing models difficult to scale up.

The infrastructure investment gap, as well as market-, policy- and governance failures occur all over the world; this means the task of readjusting has a global dimension. While

54 World Bank (2016), High and Dry: Climate Change, Water and the Economy, World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO
56 Hutton G., Varughese M.C. (2016), The costs of meeting the 2030 sustainable development goal targets on drinking water, sanitation, and hygiene, The World Bank.
57 Koohafkan, P. et al. (2011), Investments in land and water, SOLAW Background Thematic Report – TR17, FAO
58 Based on structured discussion at the OECD – WWC – Netherlands Roundtable on financing water. For more information, please visit http://www.oecd.org/environment/resources/roundtableonfinancingwater.htm
water-specific investments will be critical, investments in other sectors (land use, urban development, energy and agriculture) can also be beneficial.

Some specific principles for building the resilience of Water related infrastructure:

1. **Maximise the value of existing assets for water-related investments by improving their disaster resilience.**
   Service providers can also reduce overall investment needs and improve resilience through improving the operational efficiency and effectiveness of existing infrastructure. Engagement with stakeholders is required to set acceptable levels of service and risk.

2. **Design investment pathways that maximise water-related benefits over the long term.**
   The social, environmental, and economic benefits that water-related investments generate depend on how investments are designed and sequenced along strategic and adaptable pathways. This goes beyond cost-benefit analysis of stand-alone projects and requires strategic planning of portfolios of projects, considering how pursuing a specific project may foreclose or enable future investment options. Pathways may include modular, scalable investments, which minimise the cost of adjusting to changing conditions and support robust solutions.

3. **Attract more financing by improving the risk-return profile of water investments.**
   A proper allocation of financial risks and returns from water-related investments enable public and private actors (including water users) to earn returns commensurate to the risks they take. The “3Ts” (tariffs for water services, taxes, and transfers from the international community) as well as raising investments from local financial markets remain the ultimate sources of funding to close the financing gap.

4. **Identify permanent revenue sources for operations and maintenance**, preferably from drinking water user charges, wastewater, and irrigation water, when assessing investment projects.

5. Also estimate the social and economic costs of not investing in the disaster and climate resilience of urgently needed water infrastructure.

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59 Adapted from: OECD (2016), Policy Perspectives. Water, Growth and Finance, Paris
60 [https://sustainabledevelopment.un.org/content/documents/hlpwater/08-WaterInfrastrInvest.pdf](https://sustainabledevelopment.un.org/content/documents/hlpwater/08-WaterInfrastrInvest.pdf)