DRAFT WORKING PAPER FOR SEADRIF WEBINAR

SEADRIF Knowledge Series: Financial Protection of Public Assets

Fact Sheet 8: Emerging Technologies for Public Asset Financial Protection

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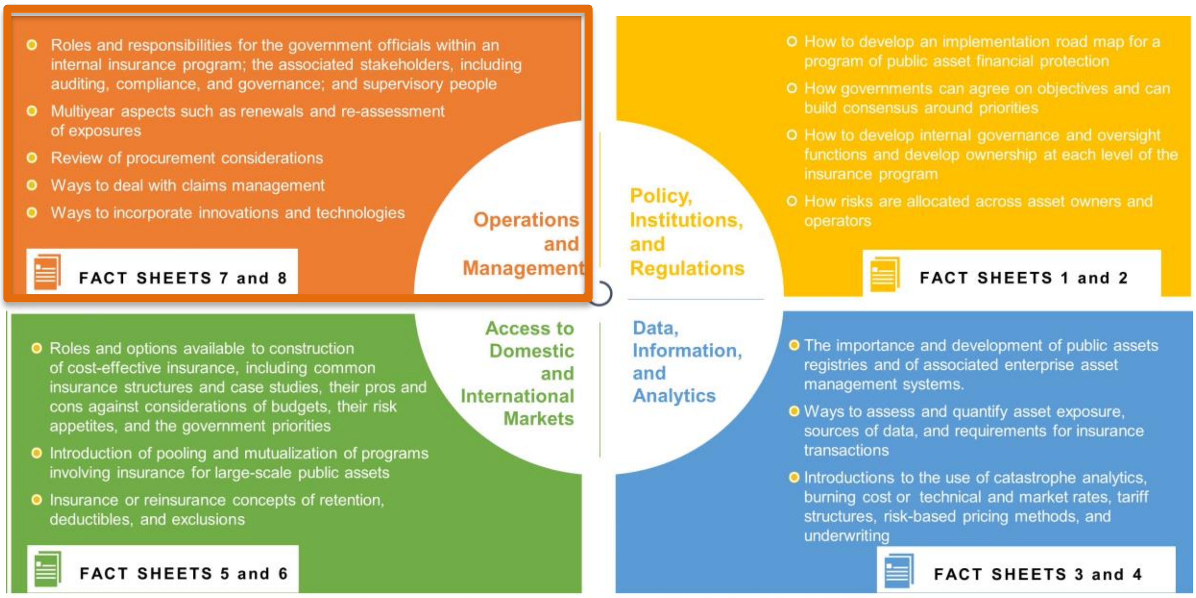
The SEADRIF Knowledge Series: Financial Protection of Public Assets

This eighth fact sheet[1] is the final part of a Knowledge Series that supports government officials as they develop their understanding of the steps needed to design, develop, deliver, and operate effective financial protection of public assets, particularly through risk transfer and insurance. The Knowledge Series encompasses an end-to-end development of public asset financial protection and insurance, as shown in figure 1. See previous fact sheets in this series for a more detailed introduction.

Each fact sheet will cover a major element of the process and will highlight considerations to assist government officials and other stakeholders who are tasked with developing solutions. New terminologies are defined in the glossary.

Figure 1. Overview of the Knowledge Series



[1] Compiled and edited by Lit Ping Low, with article contributions from Sally Sfeir-Tait (RegulAItion), Matt Foote, David Simmons (Willis Tower Watson), Julie Dela Cruz (Arcadis), Anirudh Rao (Global Earthquake Model Foundation), Antoine Bavandi, Giuseppe Molinario, Nicola Ranger, and Benedikt Signer (World Bank). The draft will be refined and finalized after completion of the series of SEADRIF webinars about public asset financial protection, and it will build on feedback from the SEADRIF members and other webinar participants. The findings, interpretations, and conclusions expressed in this fact sheet do not necessarily reflect the views of the World Bank, its board of executive directors, or the governments they represent. The World Bank does not guarantee the accuracy of data included in this work.

Introduction

Even before the COVID-19 pandemic, we lived in a transformative age with rapid technological innovations globally. The acceleration of digital transformation across many industries is coupled with continued market pressures on the insurance industry to streamline processes, cut costs, and refresh the types of services they can offer, and as well as the increased awareness, pressure, and regulations that manage climate- and disaster-related risks and their impacts on people and livelihoods. The nature of risks faced by governments and organizations are changing, both in terms of the types of risks and the nature of existing risks.

Many insurers and other capital providers have been embracing Insurtech and have adapted their business models in response to emerging technologies and shifting consumer preferences. Moreover, across many governments, financial managers are looking at ways to enhance transparency and improve financial management of their assets. Many countries, for example, are increasingly adopting public-private partnerships in the management and operations of their assets, as well as undergoing digital transformation.

The current COVID-19 pandemic reinforces all the trends just mentioned—trends that can support (or hinder) the development of public asset management and insurance programs. This fact sheet considers recent trends and innovations in public asset insurance programs, and it highlights some opportunities for governments to embrace new innovations or to react to existing trends.

This fact sheet is structured as a series of articles covering a range of innovations in technology, data, and analytics, and it responds to regulatory changes and dynamics. The articles have benefited from the contributions of authors and experts in the respective areas (See table 1, which lists articles and authors). Box 1 outlines key takeaways.

Table 1. Article Titles and Authors

Article	Contributors
1. Emerging Technologies to Support Risk Management and Disaster Prevention: Internet of Things, Big Data Analytics, and Building Information Modeling	Lit Ping Low, World Bank, with Contributions from Julie Dela Cruz, Arcadis
2. Damage and Loss Evaluation Using Remote-Sensing Data	Anirudh Rao, Global Earthquake Model Foundation
3. New Generation Catastrophe Modeling and Implications on Insurance Products	Matt Foote and David Simmons, Willis Tower Watson
4. Systems Mapping and Criticality Analysis of Infrastructure Systems	Nicola Ranger and Lit Ping Low, World Bank

5. Privacy Preserving Analytics of Aggregated Data to Support Risk Management and Disaster Prevention	Sally Sfeir-Tait, RegulAItion
6. Future Outlook—Rising Risks from Climate Change and Increased Focus from Regulators on Reporting Climate, Environmental Risk, and Disaster Risk	Lit Ping Low, World Bank, with Contributions from Matt Scott, former Head of Green Finance, UK Department of Business, Energy and Industrial Strategy

Box 1. Key Takeaways

The articles reveal a range of emerging technologies and regulatory shifts that affect the future of public asset insurance and financial protection. Looking forward, financial managers of public assets can expect the following:

- Insurers and asset managers will use technology and data to enhance their operations and business functions, to improve efficiency, and to automate processes. Those who are not embracing this approach will be penalized through higher operational and financing costs, including for insurance. (See article 1.)
- Insurers and risk modelers will leverage new and existing data to generate deeper risk insights, as well as to gather more insightful and higher-quality outputs. Better data and processing of those data will mean that insurers are starting to shift from "risk transfer" models to more sophisticated "risk prevention" models. (See articles 1, 2, and 3.)
- This development means more tailored solutions are likely to emerge, leading to a potentially more diverse range of solutions. This approach could include solutions to new coverage or risks. (See article 3 and 4 and Fact Sheet 5 for a range of emerging alternative risk-transfer solutions.)
- More data may bring challenges (for example, concerns about cyber security and data privacy). Many technological solutions are emerging to respond to such concerns. (See article 5.)
- In addition to the use of data to inform risks, asset owners and regulators are under increasing pressure to disclose and publicly report those risks. This disclosure will mean increased scrutiny about prudent and effective public asset management. (See article 6.)

1. Emerging Technologies to Support Risk Management and Disaster Prevention: Internet of Things, Big Data Analytics, and Building Information Modeling

Author: Lit Ping Low, World Bank, with Contributions from Julie Dela Cruz, Arcadis

Overview

Increasingly across the world, governments and industries are developing smart cities and infrastructures, and they are drawing on applications of the “Internet of Things” (IoT) and big data analytics. Those developments are further used through Building Information Modeling (BIM) and other processes that offer significant opportunities to manage public assets in a smarter way. They are also used in real time across a wide range of applications, including asset usage, performance service-level management, maintenance and repair schedule management, and potentially for tracking damages or service interruptions during disaster events.

- IoT is the concept that objects (in this case, public assets) may be embedded with smart devices and data connectivity to allow them to be monitored or controlled remotely—typically through the internet.
- The term “big data” refers to the process of gathering, storing, organizing, and analyzing very large data sets, such as those collated from smart and other IoT devices.
- BIM is a revolutionary set of processes involved to create digital representations of physical and functional characteristics of any smart building. The models form a collaborative way of using and sharing outputs in the architectural, engineering, and construction industries, and they provide documented, accessible, and usable information during each step in a building’s life cycle—from design to demolition.

Although the integration of BIM with real-time data from the IoT devices is still in nascent stages, this approach presents significant opportunities to improve construction and operational efficiencies, as well as to include effective and timely risk management. In the context of public asset insurance programs, benefits of incorporating smart asset management include these:

- Provide up-to-date and accurate information to inform insurance pricing.
- Demonstrate robust risk management procedures through optimization of safety checks, maintenance and repair operations, and preventive routine checkups, which can lead to savings in insurance premiums.
- Conduct simulations using BIM on buildings’ structural performance and resilience and use those simulations to estimate damages to the building, assess the damage cost and environmental impacts on a damaged building as a result of events such as earthquakes. The simulations can lead to better customization of insurance programs.
- Minimize losses and claims by incorporating early warning signals and sensors that will enable preventive actions during disaster events or that will both shut down certain critical assets and minimize damages.

Case Studies

Motor Insurance Application

One of the first applications of the IoT within the insurance sector is in motor insurance[2]. Car insurance premiums are typically set according to the type of vehicle and the demographics of the driver, rather than based on the driver's ability. By using low-cost in-car sensors, massive amounts of information about vehicles and about how their drivers drive will provide insurers and underwriters with a greater ability to judge risk on a much more individual basis than ever before.

In some countries, insurers offer drivers the option of installing a small telematics device into a car's diagnostics port. The telematics device records data such as the vehicle's speed, distance traveled, time of day, and rate of acceleration and braking. By analyzing those data, the insurer can determine the driver's style and can adjust the premium as necessary. Other similar devices can help to locate the car in the event of theft, thereby increasing the likelihood of recovering the car. In many cases, such a device may prevent theft in the first place. In a US survey of 1,135 drivers in 2015, the results revealed that 56 percent of the participating drivers reported that they had changed their driving style after installing a telematics device on their vehicle; and 82 percent of respondents received information about their driving behavior from their insurance company. The vast majority (88 percent) of this latter group found the information helpful.

5D BIM

A common BIM terminology is "dimension," which refers to how different kinds of data are linked to an information model. By adding dimensions of data, you can start to get a fuller understanding of the construction or building. Furthermore, 3D BIM refers to graphical and nongraphical information, 4D adds the time dimension, and 5D adds the cost dimension. This information might include capital costs (the costs of purchasing and installing a component), its associated running costs, and the cost of renewal or replacement down the line.

Traditionally, the design consultant hands over fragmented data consisting of 2D and 3D models, as well as schedules and specifications documents to the cost consultant once the design is complete. In the 5D BIM approach, the design team and the cost and programming consultants coordinate before the design stage, and the objects in the building model are developed according to the cost information requirements document, which assigns cost codes to the modeled objects, thus allowing automated takeoff and pricing.

In general, the use of 5D BIM during the design and costing phase can result in a savings of 30 percent to 40 percent in terms of efficiency in time. 5D BIM can also generate other benefits

[2] IoT for all websites is https://www.iotforall.com/use-case/usage-based-vehicle-insurance and was accessed October 2020; see also Insurance Research Council, "Auto Insurance Telematics: Consumer Attitudes and Opinions," 2015.

along the project lifecycle. For example, the data used could be recycled further down the project life cycle. Having all data inside a common data environment enables teams to collaborate on a single-source document.

Japan

In Japan[3], the federal government launched an emergency warning system in February 2007. Japan's disaster resilience solution was developed with support from a technology vendor, and it includes observation systems, information gathering capabilities, data analysis and decision-making aids, and an intelligent warning system—all of which are linked in an interoperable manner. During the Great East Japan Earthquake in 2011, which was followed by a 9-meter-high tsunami, the warning system prevented the tsunami from having an even greater impact.

The system uses seismometers to detect the first shockwave (primary waves, or P-Waves) caused by an earthquake. In 2011, computers analyzed the wave and estimated how powerful the second one (secondary waves, or S-Waves) would be. The waves were estimated to be above a certain threshold level so a warning alert was transmitted, and a series of preventive actions came into action. The Shinkansen bullet trains automatically stopped when the first tremors from the earthquake were felt. No trains derailed and no elevated bridges collapsed. Tokyo's subways were evacuated, surgical operations ceased, gas was disconnected, and nuclear reactors received an order to enter the shutdown process. Japan was also able to rapidly deploy its recovery support, and it dispatched nearly 28,000 members of the National Police Force and of the Fire and Disaster Management Agency in the tsumani's immediate aftermath; recovery personnel were supported by the telecommunications networks.

Implications

Asset and infrastructure development are increasingly incorporating smart features, many of which are becoming more affordable. Those features can support better risk management and prevention of disaster impacts for the assets, as well as provide real-time feedback. They can greatly improve initial response and recovery efforts. Governments can also explore partnerships and business models with the insurance providers to embed IoT and big data within the insured assets, which should improve insurance pricing and risk management.

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[3] GSMA and Japan Meteorological Agency, 2013, "Smart City Resilience: Learning from Emergency Response and Coordination in Japan," https://www.gsma.com/iot/wp-content/uploads/2013/02/cl_SmartCities_emer_01_131.pdf.

2. Damage and Loss Evaluation Using Remote-Sensing Data

Authors: Anirudh Rao, Global Earthquake Modelling Foundation, with Contributions from Giuseppe Molinario, World Bank Group

Overview

The availability of affordable and rapid risk financing in some nations is still a challenge and limits the ability to rapidly deploy funds toward the reconstruction and recovery process. One reason for this lack of financial coverage is that traditional insurance policies or national mechanisms for financial compensation often require local inspections of damaged properties, which can be quite resource-intensive and time-consuming. Alternative financial instruments such as parametric products have gained traction because of their relative simplicity, transparency, and promptness. However, imperfect correlations between the triggering criteria and the actual damage have demonstrated limitations in past events. Improvements in the assessment of damages and losses of a disaster event are critical to address this challenge.

The increasing number of satellite remote sensing (RS) missions and the tremendous improvements in RS data processing and interpretation techniques have made it possible to acquire and process earth observation (EO) data for natural disaster events within a few hours of their occurrence. Across EO data, three types of sensors are especially amenable to damage detection: optical sensors, LiDAR sensors, and radio detection and ranging (radar) sensors—particularly synthetic-aperture radar (SAR).

a) Optical Sensors

Optical sensors are a type of passive sensor, meaning that the sensor records the signal that is either emitted or reflected by objects on the ground on earth. Optical EO data are currently available at submeter spatial resolution from several satellites, making it particularly appealing for building-level damage detection methods. Optical imagery is also conducive for applications involving visual interpretation, such as crowd-sourced damage labeling.

Presently, a few rapid damage mapping services are in operation; they use primarily optical EO data as the basis for damage assessment such as the Operational Satellite Applications Programme of the United Nations Institute for Training and Research (UNITAR) and the Copernicus rapid damage-mapping service supported by the European Commission. However, the damage assessments from UNITAR and Copernicus need significant manual effort to scan the raw optical imagery that covers the affected area for collapsed buildings, signs of debris or other visible damage, and cracks in bridges and other infrastructure elements. Larger events may involve manual inspection of several thousand houses or buildings for signs of damage, and the process might take many days—and often weeks—to complete.

Automated detection of building damage by machine-learning algorithms that compare optical imagery of the affected area before and after the event has improved in recent years, but some other drawbacks arise with such methodologies. Because the pre- and post-event optical images might have been captured (a) in differing light conditions and cloud cover, (b) on different days, or (c) even by different sensors, comparing corresponding pixels in the two sets of images is beset with many issues regarding alignment of the images. In the case of floods, pervasive cloud cover usually limits or precludes altogether the use of optical imagery.

b) LiDAR Sensors

LiDAR is an active sensor that illuminates the target with laser light and measures the reflection with a sensor. Differences in laser return times and wavelengths can then be used to make digital 3D representations of the target. LiDAR-based approaches are less developed compared to SAR and optical imagery-based approaches, but they are promising in detecting damage types that may be missed by the SAR-based and optical imagery–based approaches, such as pancake collapses of buildings. However, pre-event LiDAR data are unavailable for the vast majority of events, thus limiting the application of change detection methods. Post-event LiDAR data also need to be acquired on an ad hoc basis and through the use of airborne sensors, thereby making this approach less suitable at present for use in a semi-automated framework for damage detection.

c) Radio Detection and Ranging (RADAR) Sensor—Particularly Synthetic-Aperture Radar Sensors

Synthetic-aperture radar (SAR) is a form of active sensor used to create two-dimensional images or three-dimensional reconstructions of objects, such as landscapes. Successive pulses of radio waves are transmitted to illuminate a target scene, and the echo of each pulse is received and recorded, which can then be processed to create a SAR image.

A significant advantage offered by SAR over optical EO and LiDAR is that SAR data can be obtained even in poor-light conditions or at night and can be nearly independent of cloud cover. However, most of the SAR-based methods do not yet provide very high resolution. Recently, meter-level spatial resolution is being offered by several SAR satellites, including ALOS-2, COSMO-Skymed, TerraSAR-X, and TanDEM-X. The enhanced resolution makes building-level damage detection promising, especially when ancillary datasets such as digitized building footprint layers are available for use in conjunction with high-resolution SAR data.

Finer differentiation of damage grades involving detection of cracks in walls or residual drifts might still be challenging with the 1-meter to 3-meter spatial resolution offered by the current generation of SAR sensors. The Advanced Rapid Imaging and Analysis team, which is a joint effort of NASA Jet Propulsion Laboratory and California Institute of Technology, has developed urgent response products that will detect areas of damage caused by earthquakes, landslides, liquefaction, wildfires, floods, volcanoes, and tsunamis within 24 hours of the event.

Case Study

Semi-automated Damage and Loss Assessment

The World Bank has initiated and funded a pilot project that involves a collaborative research team combining experts from NASA's JPL ARIA, the GEM Foundation, JBA Risk, and HOT develop a framework for semi-automated assessment of damage and loss caused by earthquake and floods. The framework will use Earth Observation (EO) data and other supplementary datasets, while leveraging recent advances in machine-learning algorithms.

The project conducts a comparison of the outputs from Damage Proxy Maps (DPMs) developed based on the methodology described by Yun et al. (2015) [4] - which are Interferometric SAR (InSAR) coherence maps before and subsequent to a damaging event - against a few earthquake events including the 2015 Gorkha earthquake (Nepal), the 2016 Norcia earthquake (Italy), and the 2020 Zagreb earthquake (Croatia).

The comparison revealed good spatial correlation between the DPM and preliminary damage assessment surveys for those events. The project team also generated Flood Proxy Maps for major flood events on the basis of available SAR imagery. These maps can potentially provide guidance about areas that are likely to be flooded as a result of heavy rains or tropical storms. SAR imagery can identify the spatial extent of flooding, and further post-processing can produce maps about flood depth. However, further improvements, which are supported through machine learning, are still required to incorporate other important factors of damages such as flow velocity or flood duration.

Implications

The accuracy and pace of damage detection can be improved by using several EO data together, by applying deep machine learning, and by incorporating supplementary information such as local site conditions and building inventory data. Such rich data fusion approaches to damage assessment are currently rare but are in development. The development of new risk-financing solutions will inevitably have to rely on innovative technologies, models, and datasets that leverage all the appropriate data in a semi-automatic approach. Some risk-financing solutions will become more relevant and attractive as this technology matures (for example, modeled loss-trigger parametric solutions will become more viable because of the improved ability to align modeled losses with the actual impact of the loss event).

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[4] Yun, S.-H., E. Fielding, F. Webb, and M. Simons, 2015, *Damage Proxy Map from Interferometric Synthetic Aperture Radar Coherence* (Patent No. US 9,207,318 B2), US Patent and Trademark Office,

3. New Generation Catastrophe Modeling and Implications on Insurance Products

Authors: Matt Foote and David Simmons, Willis Tower Watson

Context

Public assets and infrastructure include a wide range of high-value facilities and other physical assets that have complex structural, operational, and interdependent characteristics.[5] These characteristics create a significant challenge when developing risk-transfer strategies that effectively mitigate the risk to those assets from natural hazards, particularly for assets with a multidecadal lifespan. New mechanisms to support financial risk transfer of high value-at-risk, of aggregated asset exposures, and of at national or regional scales—such as multiyear insurance, parametric, and other alternative risk transfer mechanisms—also require an increased acceptance and use of data and modeling tools.

The Coalition for Climate Resilient Investment (CCRI),[6] which represents national and institutional public- and private-sector investment finance entities with more than US$5 trillion of real assets under management or investment, has also identified the critical need for data and analytics to quantify effectively the risk to infrastructure from current and expected future climate shocks. The potential longer-term impacts to infrastructure from chronic climate risks (such as sea-level rise, water stress, and heat stress) adds further complexity to the financial protection of assets and the need to develop long-term risk assessments that reflect the expected changes to hazard and vulnerability over decades.

Catastrophe models are a key source of asset risk assessment for risk transfer. Although the international (re)insurance industry has been at the forefront of their application for more than 30 years (see fact sheet 3), cat models still have limitations in representing infrastructure and complex assets. Until very recently, model coverage, particularly in South East Asia, has been at best partial—both geographically and in terms of the range of natural hazards included. There are significant gaps in every component of the catastrophe modeling framework: (a) exposure data are not adequately consistent or granular to represent asset structures and values, (b) vulnerability functions are poorly developed for complex and nonbuilding risks, and (c) data about the correlation or compound effects of different natural hazards are highly variable and lack the resolution for modeling asset risk. In recent years, several technological, data, and product developments have improved the potential to assess current and future risks to large-scale public asset and infrastructure and to support financial risk transfer, as shown in box 2.

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[5]Insurance Development Forum, 2019, "IDF Practical Guide to Insuring Public Assets," https://www.insdevforum.org/sites/default/files/2019_09_IDF%20Practical%20Guide%20to%20Insuring%20Public%20Assets%20-LR.pdf.

[6]Coalition for Climate Resilient Investment, "California Joins CCRI to Advance the Inclusion of Climate Risk Standards into Investment Decisions," www.resilientinvestment.org.

Box 2. Emerging Developments Supporting Risk Assessments

A. Developing new approaches to model asset vulnerabilities and resilience, approaches that better reflect the interdependent and localized nature of assets and infrastructure to climate hazards

1. Systems and network analytics to determine asset criticality and service disruption risk

The integration of systems and network analytics within asset-level catastrophe modeling is becoming possible if one uses appropriate data to represent the interdependencies and connectivity between assets (both physical, such as power transmission and distribution networks, and intangible, such as supply chain). This approach is being pioneered at national scales through international initiatives such as CCRI and for country-specific asset modeling, thus enabling networked assets for critical services such as power generation to be modeled against multiple hazards (see article 4).

2. Use of risk-engineering approaches to measure, monitor, and encourage resilience

The role of risk engineering[7] is becoming increasingly important within national public assets and infrastructure disaster risk-financing strategies. Risk-engineering teams within specialist insurers and intermediaries—who work in partnership with the asset owners—can assess, record, and prioritize factors that influence the level of vulnerability of those assets and their operation across a wide range of physical, maintenance, managerial, and safety issues. This approach enables the development of comprehensive risk-reduction strategies for critical assets to improve resilience. The level of physical (e.g., retrofitting or other physical resilience measures) and operations and maintenance resilience that protect those assets against failure or shock damage can then be represented within the insurance pricing mechanism. The specialist insight provided by expert risk engineers, either within insurers or specialist intermediaries, can be captured within catastrophe models by altering the vulnerability functions applied in appropriate ways, either through use of model vulnerability modifiers (see fact sheet 3) or use of bespoke damage functions in models that enable this approach. Resulting loss estimates can therefore reflect aspects of improved resilience.

B. Creating better data to represent the nature of assets and their resilience to disaster risks

1. Adoption of consistent open exposure data standards to improve asset data suitability

A key innovation within the catastrophe modeling field has been in the development of open data standards for exposure representation. The availability of accurate data that reflect the physical and operational characteristics of assets can influence the price and availability of insurance or other financial risk transfer products. The open exposure data standard

[7] Risk Engineering Society in Australia, https://www.engineersaustralia.org.au/Communities-And-Groups/Technical-Societies/Risk-Engineering-Society.

(developed through the Insurance Development Forum, OASIS LMF, and Nasdaq[8]) provides a clear and open access data format that can be used to structure key attribute data capture in a consistent and model-ready format. This format will be particularly important for modeling and risk management of assets at a regional, multinational scale.

By combining exposure data standards, risk-engineering approaches, and consistent climate-conditioned catastrophe modeling, a framework for analyzing the complexities of public assets risk assessment and insurance pricing can now be properly addressed and used to develop strategies at the national and regional scales for insurance and disaster risk financing options. However, the creation of consistently accurate exposure and vulnerability data is the most important development. Capturing risk-descriptive data within centrally managed public assets databases that can be applied to insurance modeling provides the most valuable component of regional public assets risk transfer. For example, in Indonesia, the SIMAN database provides a key data source for the ABMN public assets insurance program (see SEADRIF 6th webinar[9]). It also provides the base for a future fully integrated risk management and insurance system, thereby enabling both risk pricing and claims management.

2. The exploitation of geospatially referenced and valuation data (see also article 2)

The growth in new sources of earth observation (EO) and other geospatial data provides new sources of natural and built environment datasets to support improved model development. EO is also used for near-real-time event monitoring. This source of hazard and risk information is increasingly relevant to insurance product design and structuring (for example, in the derivation of improved catastrophe triggers for parametric risk-transfer products). Improved calibration and validation of models using EO and other sources will further increase model confidence and suitability, particularly to improve capture of local or regional hazard and exposure characteristics.

C. Developing the next generation of physical climate and disaster risk models to provide forward-looking estimation of both sudden catastrophe and slow onset climate hazards within the context of infrastructure lifecycles

1. Improved representation of current and future physical hazards (both shock and slow onset) using globally consistent hazard models

A new phase in catastrophe modeling and associated analytics is harnessing (a) new data and modeling approaches, (b) improved computational power, and (c) local data to produce

[8] Open Exposure Data, https://www.nasdaq.com/solutions/open-exposure-data-oed#:~:text=Open%20Exposure%20Data%20(OEDTM,of%20the%20Oasis%20financial%20module.

[9] Southeast Asia Disaster Risk Insurance Facility, https://cdn.financialprotectionforum.org/sites/default/files/SEADRIF%20Webinar%206%20-%20Country%20experience%20final.pdf

models that can better represent the risk to assets both under present climatic conditions and under possible future states. The recent development of the first globally consistent hazard models can account for possible future climate conditions by incorporating parameters that can represent scientific consensus on global and regional climate trajectories (such as the various Representative Concentration Pathway (RCP) scenarios that are produced under the Coupled Model Intercomparison Project CMIP6).

The ability to represent expected changes in hazard frequency and severity under various climate scenarios is now being provided for flood and other hydro-meteorological hazards. For example, the global flood model produced by JBA Consulting enables various hazard and vulnerability parameters to be modified to represent changing climate conditions. Other modeling suppliers are developing national-scale hazard models, including for perils such as wildfires, and will include potential increases in geographic distribution, frequency, and severity of wildfire under climate change.

Open source and open access data and models, such as the STORM stochastic tropical cyclone dataset, and the OASIS Loss Modeling Framework are providing increased access and capacity to create globally and regionally consistent hazard models, particularly with the input of local scientific and research institutions that can improve model representativeness and can provide better calibration against regional hazard characteristics.

2. The application of scenario modeling to support strategic decisions against potential future states

As well as fully developed catastrophe models, the use of integrated climate-risk scenarios enable risk-transfer strategies to be developed that will take account of a wide range of potential futures across socioeconomic, geopolitical, policy. and natural systems. Those scenarios reflect different possibilities of climate change impacts, which will affect every aspect of public asset and infrastructure insurance on both risk and investment sides of the insurance balance sheet.

The scenarios can be used by decision-makers to undertake "what-if" risk assessments, using different external and internal assumptions and parameters of the future, as well as to assess potential implications for long-term infrastructure investment and construction strategies.

"Heatmap" and risk indices of acute and chronic climate hazard risks can be generated for the different scenarios (for example, at 5- or 10-year intervals up to year 2100). The scenarios can be applied to understand how changes in hazard and vulnerability over asset lifecycles may impact the price of risk and may inform long-term strategies for investment and design of infrastructure to include resilience measures.

Trends in the Insurance and Risk-Transfer Mechanisms

The scale and complexity of the risks faced by national and regional public assets require structured (re)insurance products that can deliver rapidly the required financial compensation against potentially catastrophic losses to a wide range of assets. In addition, new products are needed that can provide compensation for critical service disruption impacts, for example a power outage. Faster and more effective claims payments after an event are also important—especially after a large-scale event that affects large numbers of assets and potentially produces multiple claims over a wide geographic area.

Many of the components of the insurance toolkit are well known and well proven, but innovation in technology, data, and modeling has led to more sophisticated products that are targeted at the needs for affordable and stable pricing and certain and rapid claims payments. Examples include (a) using parametric products where speed of settlement is important, (b) having multiyear coverages that provide certainty of cost and coverage, (c) creating pooling or collaborative purchase arrangements to lower costs and reduce exposure to market price shocks. Hybrid approaches are increasingly explored, for example designing a product with indemnity and parametric elements or using remote-sensed loss adjustment with an indemnity product to speed and simplify claims settlement.

Budget certainty is a concern of governments, and one mechanism to manage budget certainty is to create a special-purpose insurance company, which is often partly capitalized with donor finance (see fact sheets 5 and 6). Examples of such schemes at a regional level include the Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company (CCRIF SPC, see fact sheet 6), the African Risk Capacity (ARC), the Pacific Catastrophe Risk Insurance Company (PCRIF) and the South East Asia Disaster Risk Insurance Facility (SEADRIF). Other schemes are mooted in Central Asia, and pilots are underway to expand the concept to other regions and within countries (i.e., state, province, or city pools).

Another way to hold pricing levels and to ensure the continued availability of insurance—after a large loss event or market shock—is to buy multiyear coverage. Such covers are uncommon, but not unknown, in non–life insurance. Multiyear insurance is routinely offered by the capital markets through instruments called catastrophe bonds (see fact sheet 5). There is a growing interaction of the (re)insurance and capital markets. Many large (re)insurers have capital market arms, many capital market catastrophe funds have insurance operations, and several large reinsurance brokers can access both markets.

The main advantage of multiyear protection is the certainty of coverage for a set price over a normally three- to five-year term. However, that advantage comes with a higher premium. As insurers are unable to adjust their underwriting after a loss event in a multiyear cover, they will typically charge higher premiums to compensate for that increased risk. Capital market products also come with high transactional costs and typically with a higher risk premium than traditional insurance. They do offer price and coverage certainty after a market price shock, such as COVID-19, or an asset price crunch that impacts insurance availability and cost, but they do not protect against post-loss price and coverage volatility. Unlike traditional insurance, which typically can be reinstated for an agreed fixed price within the policy period, catastrophe bonds tend to be "single shot"; when coverage is exhausted, a new bond needs to be issued, which leads to possible gaps in coverage and to exposure to pricing risk when underlying risks are re-evaluated after a loss event.

The advantages can be largely gained and the disadvantages defrayed by using both markets in the placement, targeting capital markets where investor appetite offers the best return, and using reinsurance markets to put down lower price markers to guide capital market pricing. The use of a market neutral structuring and placement advisor is crucial. Innovative structuring can also be used. An example is the reinsurance arrangements for the New Zealand Earthquake Commission where overlapping multiyear insurance coverage smoothed post-loss price increases after the Canterbury earthquakes of 2010–2011.

Case Study

New Zealand Earthquake Commission (EQC)

More than 20 years ago, the reinsurance broker-advisor of the Earthquake Commission (EQC) recommended an overlapping multiyear insurance coverage. The general intent was to manage pricing volatility where only a set proportion of the program expired each year. This approach means that in sudden hard-market cycles, the EQC would not be exposed to the entire program being subject to those hardened market terms. In any one year, the following would happen:

- As per most catastrophe insurance, 25 percent of required coverage was purchased on a single-year basis.
- Next, 25 percent of coverage was placed on a three-year term, with pricing fixed and coverage reinstated; one guaranteed reinstatement would occur within each policy year with coverage fully reinstated at the start of each new policy year in the three-year term.
- Then, 25 percent of the coverage would roll over from three-year coverage placed the year before.
- Finally, 25 percent of coverage would roll over from the three-year coverage placed two years before.

The structure meant that every year 50 percent of the program was requoted. This change defrayed reinsurers' concerns that they were locked into coverage over a three-year term, but it also helped EQC because reinsurers were allowed to participate in the annual reinsurance only if they also wrote the multiyear at the same terms. This approach meant that the overall pricing was comparable with a traditional single-year cover.

Over much of the period, the reinsurance market was "soft," (i.e., prices were reducing), however its value became clear after the losses in Canterbury in the 2010 to 2011 policy year. In the following year, 50 percent of coverage was guaranteed at a fixed price and was unaffected by the loss. Although price levels for the expiring percentage of the cover increased significantly post loss as reinsurers re-evaluated the risk, overall pricing increases were halved for 2011 to 2012. In subsequent years, the active and expiring multiyear covers put down a price benchmark that helped prices moderate quickly.

4. Systems Mapping and Criticality Analysis of Infrastructure Systems

Authors: Nicola Ranger and Lit Ping Low, World Bank

Context

Historically, the focus of financial protection of public assets has been on protecting individual infrastructure and buildings (e.g., roads, hospitals, power plants, or government buildings). Recently, there has been increased recognition of the importance of considering the resilience of infrastructure systems as a whole, as well as the critical services that they provide (e.g., transportation, health care, energy, and administration). This focus has implications for the way we think about financial protection—shifting from protecting individual assets to ensuring that finance is available to guarantee the continuity of critical services.

Many public assets are also critical infrastructures (i.e., assets, systems, and networks that provide essential services for the security of a nation, its economic prosperity, and the health and safety of its citizens). Those services, such as energy, transport, and water, constitute the backbone of modern interconnected societies. To deliver those and other public services requires a well-functioning critical infrastructure system: (a) multiple physical assets connected in a network (e.g., roads, hospitals, power plants), (b) people, and (c) inputs (e.g., raw materials, fuel, electricity). Disruption to critical infrastructure can cause major adverse economic effects and significant harm to the well-being of citizens, especially the poor and vulnerable.

Better information and analytics can inform decisions at each step from planning to triggering action to implementing plans. *Systems mapping* provides the user with an ability to map and explore complex systems; to communicate understanding; and to allow for identifying knowledge gaps, intervention points, and insights. *Criticality analysis* is an approach increasingly being used in many countries to strengthen operational preparedness and resilience through identifying (a) the infrastructure that is most critical to the continuity of a service and (b) the critical points of failure in a system. Criticality assessment considers, for example, the *dependency* of the service on particular assets, inputs, or networks in terms of the amount of population served and the economic value of disruption to infrastructure, as well as the interconnectedness, resilience, and vulnerability to shocks. Different parts of the system will be exposed to different disaster or weather impacts. *Vulnerability assessments* and *stress-testing* can identify weak points where potential failures are likely to happen and to define the potential financial impacts under different scenarios.

Case Studies

Vietnam

The World Bank worked with the government of Vietnam in 2016 to conduct critical analyses that would help inform strategies to strengthen the resilience transport networks. The livelihoods for a growing and rapidly urbanizing population in Vietnam depend on reliable transport, energy, and water systems for their continued economic prosperity. A tool was developed to analyze and prioritize transport resilience that is based on spatial criticalities and risks, as well as on potential benefits of adaptation options. This tool included estimating the potential direct damages and people affected in instances of systems failure, as well as the infrastructure most critical to the provision of services.

A series of models was created and was based on geospatial data that detailed physical properties such as the lengths, conditions, and widths of transport network assets. From this outline, a framework based on a system-of-systems methodological approach was designed to analyze the transport multihazard risks for Vietnam from 2016 hazards and from future climate scenarios. Certain locations in the networks were identified to be high-risk for specific hazards and are systemically critical. The project estimated that critical road networks failures can result in high daily losses of up to US$1.9 million per day, while critical railway failures can result in losses as high as US$2.6 million per day. Those types of assessments use asset data—as described by the 2017 guidance note by the World Bank and APEC.[10] The assessments also include additional information about the value of services they provide and model the interconnectedness between different assets. Such assessments can inform the prioritization of resilience measures, as well as identifying the residual risks that need to be managed through financial preparedness.

United Kingdom[11]

In 2018, the UK National Infrastructure Commission started a series of work to examine the resilience of the UK's infrastructure, which explored how the UK's economic infrastructure has been resilient to shocks and stresses over recent years. It also examined the steps needed to maintain a resilient system: (a) having a proactive approach to resilience and (b) facing up to the possibility of different or harder challenges in the future. Multiple streams of evidence were developed as part of the process; among supporting evidence were these:

- A system mapping analysis:[12] The analysis explored how national-level decisions (such as policies, incentives, markets, and other factors) influence levels of service in the water, energy, road, rail, and digital sectors. The study aimed to better understand how decisions relevant to resilience are made in practice and which ones have the greatest significance. Decision-making factors include (a) policy (if about water, what the government's strategic policy for water would be), (b) regulatory action (how water prices are set) (c), markets (how wholesale and retail water markets work), (d) service provision (what the operation and maintenance activities are), (e) emergency service provision (how operators and

[10] "Financial Risk Management of Public Assets against Natural Disasters in APEC Economies," 2017, World Bank Technical Contribution to the APEC Finance Ministers' Process, World Bank Group, http://mddb.apec.org/Documents/2017/MM/FMM/17_fmm_009.pdf.

[11] National Infrastructure Commission, "Summary," Resilience website, https://nic.org.uk/studies-reports/resilience/.

[12] "System Mapping for UK Infrastructure Systems Decision Making," 2020, ARUP, National Infrastructure Commission, https://nic.org.uk/studies-reports/resilience/system-mapping-for-uk-infrastructure-systems-decision-making/.

governments plan for major incidents), (f) customers (domestic, commercial, and industrial water customers), and (g) level of service (reliability of supply and water leakages).

- A pilot system analysis of interdependent network vulnerabilities:[13] The analysis covers the development and test of an approach to understand the main vulnerabilities in the interdependent multisector infrastructure networks. It also draws out vulnerabilities that arise from network architecture. The pilot uses network modeling techniques to capture "functional dependencies"—dependencies where one asset relies on another to function—between the assets in the water supply, rail, strategic road, electricity, and telecoms sectors. The approach models how failures could cascade through the cross-sector system and determines the scale of the impact of disruptions in terms of both the proportion of the population effected and the size of the economic impact.

Implications

The World Bank Disaster Risk Finance and Insurance Program is working with experts across academia, the World Bank, and governments globally to explore how to integrate such tools within approaches to designing national financial protection strategies that will manage the fiscal risks associated with disruptions to services and with protection of the economy and population. A focus on critical services, as well as on individual assets, also provides an opportunity (a) to bring in wider risks to the strategy in a well-bounded and practical way and (b) to build toward a whole-of-government, integrated risk-management approach. In addition, where finances are constrained, a critical services approach helps ensure that limited financial resources for self-insurance or insurance premiums are being spent on the most urgent priorities. One important step would be to conduct systems mapping and analysis that would assess the potential fiscal impact from disruptions to critical services.

[13] "System Analysis of Interdependent Network Vulnerabilities," 2020, ITRC, National Infrastructure Commission, https://nic.org.uk/studies-reports/resilience/system-analysis-of-interdependent-network-vulnerabilities/.

5. Privacy Preserving Analytics of Aggregated Data to Support Risk Management and Disaster Prevention

Author: Sally Sfeir-Tait, RegulAItion

Overview

Climate related risks are relatively new, potentially extreme and rapidly changing. The COVID-19 pandemic has shown the deficiencies in risk management and prevention in an environment where data collection, sharing and analytics is nonexistent (e.g., such as collection of coronavirus symptoms and cases or sharing of medical and insurance data). The global cost to lives and economies is immeasurable.

Similarly, climate-related risk management and disaster prevention require vast amounts of new data from public and private sources (e.g., damages to households from hurricanes, increase of flood-related insurance claims, or impact of weather on the food supply chain). Relevant data are increasingly being captured by both the private and the public sector. However, privacy and data localization restrictions stand in the way of analytics about aggregated data sources. In particular, many countries have stringent restrictions on how data users should collect, handle, and use personal data while protecting an individual's privacy preferences and personally identifiable information (PII).

Better information and analytics can inform decisions at every step, from observing to planning to triggering action and to implementing plans. Technological advances in privacy enhancing techniques provide the public sector with the ability to access aggregated data without compromising privacy or increasing risks (e.g., algorithms travel to the data to extract patterns). The actual data never moves—only the learnings from the data.

By systematically providing data access through a technology platform, governments can create an ecosystem of interconnected parties that leverage each other's data to deliver value for everyone. The AIR Platform is a public-private, cross-sector collaboration funded by the UK government[14] to deliver a data collaboration ecosystem. By deploying next-generation technologies,[15] the AIR Platform enables data access without data sharing, without data transfer, and without data aggregation. Data remain in the secure servers of each data holder. A pre-agreed and prescreened algorithm travels to the data and extracts a pattern of behavior without revealing any personally identifiable information. This approach significantly reduces the risks of data breaches.

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[14] "Cross-sector Consortium to Deliver AI-Driven 'Data Access Platform' for Regulated Industries," RegulAItion, https://regulaition.com/2020/07/27/air-platform-launches/.

[15] Recent advances in technology have proven that data anonymization does not remove the risk or re-identification, https://www.nature.com/articles/s41467-019-10933-3/. Recent studies have demonstrated that cybersecurity attacks in the first half of 2020 have already exceeded the total number of attacks of 2019, https://www.intelligentciso.com/2020/09/17/new-crowdstrike-report-reveals-more-cyberattacks-in-the-first-half-of-2020-than-2019/.

The AIR Platform is a technology infrastructure that does the following:

- Amplifies and supports efforts of the public sector in all areas, ranging from risk management to the fourth industrial revolution[16]
- Identifies data correlations that support effective policy creation
- Supports holders of large datasets who want to develop next-generation products and services (risk management, development of resilient sources of revenue, and transformation)
- Stimulates the economy by attracting technology companies that want to develop next-generation technology products and platforms (such as climate-related artificial intelligence tools)

Critically, governments can work collaboratively on shared risks (e.g., diminishing the shared water resources) before those risks crystallize.

Through a single-technology platform, governments can derive new insights from aggregated private and public data without moving, pooling, or disclosing data, thereby overcoming data localization regulation and cybersecurity risks. The platform allows data holders, academics, and private companies to execute and enforce programmatically their bilateral or multilateral agreements thereby overcoming the usual time-consuming and expensive exercise of data sharing and analytics. Every interaction with the data is captured, thus making every computation verifiable and auditable. This feature powers algorithm explainability and the development of responsible artificial intelligence.

Case Studies

Insurance Group in SE Asia

The public sector gathers workforce information from the private sector (e.g., worker name, date of birth, employment start date). Insurance companies have claims information from their private-sector clients (client industry, client size, client workforce size). Although the public sector may retain a centralized database, each insurance company has access only to its own data. The public sector and the private sector do not share claims related data with each other. The insurance industry knows that there is a correlation between a corporate organization's average workforce age when compared to the average cost of claims by industry. However, those in the insurance industry cannot reveal this correlation accurately without access to the public data and to each other's data.

Revealing this correlation will help insurers build better pricing models (even a less than 0.5 percent improvement results in a cost reduction of millions of US dollars), provide proactive

[16] Klaus Schwab, 2016, "The Fourth Industrial Revolution: What It Means, How to Respond," World Economic Forum, https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.

risk management advice to businesses (such as recommending measures to be taken on construction sites that typically lead to a percentage reduction of workplace accidents), and ultimately reduce workplace fatal injuries to achieve or exceed international recommended standards (which is less than one death per 100,000 workers).

The AIR Platform is a mechanism for all parties to make their private data accessible to algorithms and to learn patterns from their data without ever sharing that data with each other (high risk of compromising data privacy) or aggregating the data into one location (high risk of compromising data security).

Isle of Man

The government of the Isle of Man has committed to achieve net zero emissions by 2050. It has implemented a multiphase action plan and committed to a range of actions. One action is to reduce household emissions from heating of buildings, which contributes 35 percent of the country's emissions. The estimated cost to the government for reducing emissions by 10 percent is £112million (over a 10-year period). Typically, the government would (a) fund a five-year project to assess the likely contributors of high emissions (such as gas boilers), (b) develop hypotheses of the actions to be taken (e.g., provide grants to households to change their gas boiler, or grants to better insulate households), (c) disburse subsidies, (d) verify use of subsidies, (e) capture existing emissions data (two-year retrospective emissions data), and then (f) observe changes in emissions post-implementation of the strategies (another two years of retrospective observation). This process is long, expensive, and uncertain.

By using the AIR Platform, the government is able to confirm its hypothesis and model the expected benefits over a period of 12 months. It can then take required corrective action—and all for a fraction of the price, for one-fifth of the time, and with a significant risk reduction. The government achieves this savings by selecting a sample of households, deploying IoT sensors to capture household emissions before the experiment, making different changes to sample households (changing gas boiler in some, insolating homes in others), and then studying the impact on household emissions for 365 days through all types of weather. All data are captured in real time. All data are kept private at all times. The government agency does not centralize the data, thereby reducing a potential risk to data security.

Implications

The COVID-19 pandemic has accelerated our adoption of digital services. Information gathering and management will continue to drive the proliferation of IoT devices. Data will continue to grow exponentially. Advances in data technologies (algorithms for complex analytics and modeling, privacy preserving data access, and IoT data capture) provide an opportunity for integrated risk management and for improved, real-time decision-making that can enhance opportunities and mitigate downside risk for governments. Supporting the development of a data access infrastructure that is regulatory compliant is a critical foundation for extracting value from data.

6. Future Outlook—Rising Risks from Climate Change and Increased Focus from Regulators on Reporting on Climate, Environmental Risk, and Disaster Risk

Authors: Lit Ping Low, World Bank with Contributions from Matt Scott, former Head of Green Finance, UK Department of Business, Energy and Industrial Strategy

Overview

As climate change drives increasing intensities of extreme events, as well as particular risks to coastal and flood-prone areas, risks to government-owned infrastructure assets are increasing. The benefits of understanding risk, investing in resilience, and ensuring strong financial protection are growing. In addition, as the pressure on climate change action increases globally, there has been an emergence of voluntary initiatives and mandatory regulations concerning the disclosure and reporting about risk and resilience actions.

One area is the increasing pressure by asset owners for transparency about managing climate and disaster risks. Although much attention has been on private-sector owners and investors to date, this focus has increasingly moved toward sovereign wealth funds and pension funds (including public-sector pension funds), as well as toward governments as the owners and investors of assets and infrastructure. Countries such as Japan, Singapore, and the UK, for example, are imposing greater reporting requirements on public-sector asset owners and operators in order to better understand their exposure to climate-related risks.

Increased disclosure of risks is a core enabler of action. Through enhanced measurement and reporting of risks, governments can spur increased investment in resilience and adaptation not only for the public sector but also across all actors. Government departments are able to learn from each other in terms of risk exposure and risk management. Private sector and businesses also will benefit with greater transparency, which benefits the business and investment environment.

Case Studies

Task Force on Climate-related Financial Disclosures Impacts on the Public Sector and Sovereign Wealth Funds

In 2015, the Financial Stability Board Task Force on Climate-related Financial Disclosures (TCFD) was set up[17]. It was led by the former governor of the Bank of England, Mark Carney,

[17] Financial Stability Board, 2019, "Enhancing Climate-related Disclosure by Cities: A Guide to Adopting the Recommendations of the Task Force on Climate-related Financial Disclosures (TCFD)," FSB-TCFD website, https://www.fsb-tcfd.org/about/, and Chartered Professional Accountants Canada, https://www.cpacanada.ca/en/business-and-accounting-resources/financial-and-non-financial-reporting/sustainability-environmental-and-social-reporting/publications/tcfd-guide-for-cities

and by the former mayor of New York City, Michael Bloomberg. Since then, the TCFD developed voluntary and consistent climate-related financial-risk disclosures for use by the private sector in order to provide information to investors, lenders, insurers, and other stakeholders. The TCFD considered what physical, liability, and transition risks were associated with climate change and what constitutes effective financial disclosures across industries.

Although a private-sector initiative, the TCFD's effects have spilled over into public-sector and government-linked entities, such as sovereign wealth funds. In the UK, the Bank of England issued its own climate disclosure. The UK's Green Finance Strategy also included a range of commitments by public bodies as the government aims to lead by example.

In Canada, many cities are starting to use the framework to report on climate risks—for example, Vancouver was the first Canadian city to include disclosure guided by TCFD principles in its annual financial report. The city disclosed various public climate-risk policies and the impacts on its financial planning. Moreover, in its five-year financial plan, which is available publicly, the city now discloses the contingency costs for unforeseen events, such as public emergencies and issues related to climate change or to unusual weather events.

Sovereign wealth funds—including some of the world's largest in Asia such as the Government of Singapore Investment Corporation and Japan's Government Pension Investment Fund—are also conducting climate-related risk analysis and are reporting in alignment with the TCFD.

UK Adaptation Reporting Power (ARP)

Since the establishment of the Climate Change Act 2008 in the UK, the Adaptation Reporting Power has taken effect; it mandates a number of organizations that will provide functions of a public nature (called "reporting authorities") and will produce reports about what the UK is doing to adapt to climate change[18].

Reporting authorities must prepare and send to the central government reports containing (a) an assessment of the current and predicted impact of climate change in relation to the reporting authority's functions and (b) a statement of the reporting authority's proposals and policies for adapting to climate change in the exercise of its functions and of the timescales for introducing those proposals and policies. The reports include organizations that are responsible for important services and infrastructure such as road and rail operators, the

[18] Department for Environment, Food, and Rural Affairs, UK, 2011, "Adaptation Reporting Power: Frequently Asked Questions and Answers," https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/182636/report-faq-110126.pdf; UK Government, "Climate Change Adaptation Reporting: Third Round," https://www.gov.uk/government/publications/climate-change-adaptation-reporting-third-round.

power sector, water companies, and airport and port operators. Additionally, many government regulators and public bodies are also subject to the reporting requirements.

The ARP is currently in its third round of reporting, with increasing participations in each round. Evaluation after the second round[19] revealed that reporting organizations derived good value from both the reporting process and the availability and use of the reports. The added value ranged from further raising awareness, consolidating climate change adaptation activities, and promoting discussions about climate risks and adaptation in the organization, as well as within and across sectors. Reporting organizations also developed interest in using the information to track their progress, share and learn from good practices, and support improved understanding of dependencies and interdependencies with other agencies.

Implications

The trend for greater transparency concerning risk management for climate disasters is continuing for asset owners and operators. On the one hand, there is increasing pressure for governments to provide greater transparency on how they are managing their public assets, plus their financial exposure to climate and disaster-related risks. On the other hand, more resources are available to support governments in the process, to learn from private asset managers and operators, to use similar and relevant frameworks, and to establish good practices for risk management.

By taking ownership of an intergenerational risk early, governments position themselves to effectively manage adaptation over the longer term and to plan interventions that are based on the proximity of risk and the time value of money.

[19] R. B. Street, V. Hayman, and T. M. Wilkins, 2017, “Understanding the Value of the Adaptation Reporting Power Process to the Reporting Organisations Involved,” UKCIP, University of Oxford. UK.

Work Sheet 8. Innovation and the Future for Public Assets Insurance

Test your knowledge and record your insights through this easy, DIY worksheet!

Activity 1. Match the different terms to their definitions.

Match the terms listed with their definitions or descriptions.

Terms			Definitions
Internet-of-Things (IoT)	•	•	It refers to the process of gathering, storing, organizing, and analyzing very large data sets, such as those collated from smart devices.
System Mapping	•	•	The concept that objects (in this case, public assets) may be embedded with smart devices and data connectivity to allow them to be monitored or controlled remotely—typically through the internet.
Stress Testing	•	•	It provides the user with an ability to map and explore complex systems; to communicate understanding; and to allow for the identification of knowledge gaps, intervention points, and insights
Big Data	•	•	It can identify weak points where potential failures are likely to happen, as well as the potential financial impacts under different scenarios.

Activity 2. Identify the most relevant initiatives.

Of the various case studies discussed in this worksheet, can you identify three initiatives that you consider would be most relevant and impactful for your country.

#	Relevant Initiative
1.	
2.	
3.	

Activity 3. Identify whether the statements are true or false.

Identify which of the following statements are true or false.

STATEMENT	TRUE	FALSE
1. Emergence of mandatory regulations, as a result of climate change risks, are imposing greater reporting requirements only on private-sector asset owners.		
2. Vulnerability assessments can identify weak points where potential failures in a system are likely to occur.		
3. Services such as uninterrupted water supply and seamless telecommunication require well-functioning critical infrastructure systems.		
4. Criticality analysis provides the users with an ability to map and explore complex systems, to communicate understanding, and to allow identification of knowledge gaps.		
5. Using Internet of Things and big data within the insured assets can help in overall risk management.		
6. Climate-related risk management and disaster prevention require vast amounts of relevant data that are increasingly being captured by the private and the public sector.		

Activity 4. Reflect on the different technologies and trends

[1] My top two takeaways from this fact sheet are these:

1.

2.

[2] Two concepts or ideas I would like more information about are these:

1.

2.