GLOBAL INFRASTRUCTURE RISK MODEL AND RESILIENCE INDEX

FREQUENTLY ASKED QUESTIONS

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1. What is the purpose of GIRI?

- The Global Infrastructure Risk Model & Resilience Index (GIRI) is the first-ever fully probabilistic model to identify and estimate risk associated with major geological and climate-related hazards (Earthquake, Tsunami, Landslide, Flood, Tropical Cyclone and Drought) across critical infrastructure sectors (Power, Telecommunications, Roads and Railways, Water and Wastewater, Ports and Airports, Oil and gas, Buildings, Education and Health) for all countries and territories in the world and taking into account climate change.
- GIRI's purpose is to improve the understanding and make the global landscape of infrastructure risk and resilience visible. In doing so, GIRI provides a globally comparable set of financial risk metrics such as the Average Annual Loss (AAL) and Probable Maximum Loss (PML) for infrastructure assets.
- GIRI can assist in the identification of the contingent liabilities internalized in each infrastructure sector and the implications for social and economic development in the context of climate change. It can, thus, provide the basis for developing national resilience policies, strategies and plans, resilience standards and for correctly integrating disaster and climate risk into investment decisions.

2. How was risk modelled in GIRI?

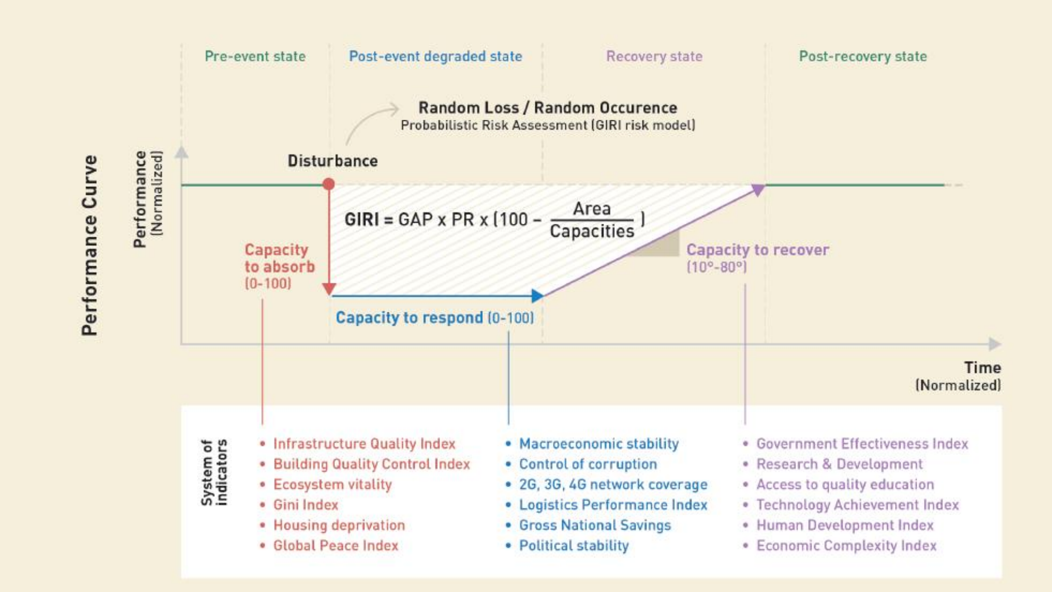
The broad steps in the risk modeling process entailed:

- Hazard is interpreted as sets of events that are mutually exclusive and collectively exhaustive, covering all the possible ways a hazard may manifest in a territory. Each scenario or event includes the spatial distribution of probability parameters to model the intensities as random variables. Hazard input data was obtained by developing comprehensive sets of simulated events accounting for all the possible manifestations of each hazard and providing information about the geographical distribution of the hazard intensities and their frequency of occurrence.
- Hydrometeorological hazards are modified by climate change. The intensities and frequency of the hydrometeorological hazards were modified to account for two future climate scenarios, reflecting a lower and upper bound of climate change, corresponding to the 20th and 80th percentiles of global climate models projections, in accordance with the most recent IPCC future projections. To do this, two scenarios for the year 2100 were used: a conservative one reflecting minimal climate change effects and a more extreme one representing a higher level of carbon emissions. These scenarios align with different pathways defined as Shared Socioeconomic Pathways (SSPs), ranging from SSP1 (minimal emissions) to SSP5 (high emissions), or Representative Concentration Pathways (RCPs), from RCP2.6 (minimal emissions) to RCP8.5 (high emissions). The model also considered existing climate conditions when assessing risk.

- The exposure database was assembled by geolocalizing exposed assets and networks in each infrastructure sector from available public data sources.
- Economic values were assigned to each asset in the exposure database through a detailed process, and the total value of infrastructure assets in each country was adjusted to reflect their capital stock relative to others. The approach combines a top-down valuation of a country's infrastructure with a bottom-up distribution of costs within individual sector elements. The top-down valuation estimates infrastructure as a fraction of the country's capital stock, based on produced, natural, and intangible capital. The bottom-up approach assesses individual elements using consumption, access, and capacity indicators, along with indicative prices. The total value from the bottom-up method is adjusted to align with the top-down valuation, representing the true total infrastructure cost.
- Vulnerability functions for over 50 infrastructure archetypes were developed, including power stations or airports, which connect hazard intensities to expected asset losses in a continuous, qualitative, and probabilistic manner.
- For each asset in the exposure database, the associated damage and losses for each stochastic hazard event was calculated. This enabled the generation of a distribution of potential future losses based on exceedance rates, presenting them as loss exceedance curves and derived financial risk metrics like the Average Annual Loss (AAL).

3. Is GIRI a model or an Index?

- The Model estimates financial risk metrics such as the AAL, estimating the contingent liabilities associated with infrastructure assets in each sector and geography, with respect to each hazard.
- The Index integrates the financial risk metrics from the Model with three different sets of indicators that represent the capacity of a country to resist and absorb, respond, and restore or recover from hazard events. Additionally, the Index takes into account the infrastructure gap, defined as the difference between the infrastructure required to meet the SDGs and the existing infrastructure.
- The GIRI composite indicator has relative values between 0 and 100. The lowest value (0) indicates that infrastructure has low resilience, and the highest value (100) means resilience is high. The figure below shows how the GIRI composite indicator can be disaggregated into the three capacities, each of which, in turn, can be disaggregated into component indicators.
- Please note that the GIRI Data Platform focuses on the Risk Model and does not include the Index in the current version.



Conceptual Framework of GIRI
Source: Cardona et al. (2023b)

4. What is Average Annual Loss (AAL), Relative AAL, Probable Maximum Loss (PML), and Loss Exceedance Curve (LEC)?

a) Average Annual Loss

The Annual Aggregate Loss (AAL), often referred to as the pure risk premium, condenses losses occurring over an extended period into a singular, concise metric. It signifies the expected average loss annually across all possible events, including both frequent and rare significant losses. Essentially, the AAL is calculated as the sum of expected losses multiplied by the annual occurrence probability for each stochastic event considered within the loss model. It indicates the yearly financial resources governments would need to set aside to cover losses.

b) Probable Maximum Loss

This refers to a loss that occurs infrequently, typically over long return periods. While the Probable Maximum Loss (PML) is represented as a curve analogous to the Loss Exceedance Curve (LEC), it is conventionally simplified to a single value by selecting a specific return period. In the insurance sector, for instance, return periods utilized to define the PML commonly span from 200 to 2,500 years.

c) Relative Average Annual Loss

Relative AAL is the ratio of the AAL of any particular sector and the aggregate value of its exposure in US$. The metric provides a perspective on the level of contingent liability in that sector. The formula for Relative AAL is expressed as follows:

Relative AAL (%) = AAL of the sector in US$/ Exposure of the sector in US$ * 100

d) Loss Exceedance Curve

The Loss Exceedance Curve (LEC) encapsulates all essential information for understanding the occurrence of losses. It offers a comprehensive quantification of risk in probabilistic terms. While exact predictions of future disasters are unattainable, with the LEC it is possible to know the probability of surpassing any given loss threshold within a defined timeframe. Metrics like AAL and PML are derived from the LEC, providing a comprehensive view of potential future losses. This knowledge aids decision-making in risk mitigation strategies.

5. What type of data sources have supported the development of GIRI?

- GIRI has been developed from open-source databases such as IBTrACS, OpenStreetMap and other WMO's open-source databases etc. Additionally, GIRI uses some proprietary databases such as MapX.
- Datasets for different hazards were sourced from different globally available sources. For example, for the global flood hazard model, the meteorological datasets used for hydrological simulations were W5E5 and ISIMIP3b.
- GIRI builds on a long trajectory of development of global risk models over the last 20 - years including the pioneering Global Risk Model (GRM) developed for the United Nations and published in the 2017 edition of the Global Assessment Report on Disaster Risk Reduction (GAR). A full range of references are available at: References | GIRI (unepgrid.ch)

6. Who can use GIRI and how?

- GIRI is a multidisciplinary tool that requires collaboration among different professionals, including risk analysts, GIS specialists, economists, engineers, and decision-makers. By integrating hazard data, exposure information, vulnerability assessments, and financial analyses, GIRI facilitates informed decision-making and risk management strategies at various levels, from local infrastructure planning to national policy development.
- As an example, the economic values assigned to each asset in the exposure database in order to determine the total value of infrastructure assets in each country is valuable input data for economists and financial analysts who use sophisticated methodologies to assess the economic impact of potential hazards and calculate financial risk metrics such as the Average Annual Loss (AAL). Similarly, the derived financial risk metrics, such as the AAL and loss exceedance curves (LECs), provide valuable information for decision-makers and policymakers to prioritize investments, develop risk mitigation strategies, and formulate policies aimed at reducing vulnerability and enhancing resilience to hazards.

7. How is GIRI different from other open-source probabilistic risk models?

The model is founded in probability theory, allowing a rational and explicit incorporation of uncertainty into the calculation. GIRI is stochastic and relies upon both the physics of the natural phenomena and the randomness of their occurrence. Many thousands of simulations of hazard events have been generated to build up a reasonably exhaustive set of possible consequences for the infrastructure systems under consideration. The model is also non-stationary. Stationarity can be considered true for hazards such as earthquakes. However, incorporating hazards that can be altered by background trends like climate change, implies a non-stationary model. This translates into a collection of time dependent risk metrics. Further, the model identifies the risks in each infrastructure sector with a national level resolution Above all, it is open access and fully publicly available.

8. What are GIRI's limitations?

- Although based on well-established risk modelling methodologies, GIRI presents a novel approach to model infrastructure risk and resilience. While the financial risk metrics presented in the report are in the correct order of magnitude, the AAL values are likely to evolve as the model is further calibrated and developed.
- GIRI's quality will improve as new hazard and exposure data becomes available. As climate change models become more robust, downscaling to local levels becomes more advanced, and the science of attribution progresses, more precise data on hydro-meteorological hazards will also become available.
- Vulnerability functions are also likely to improve over time as they are used and tested in different applications.
- Estimating asset risk is critical, given that service disruption and broader systemic impact are normally associated with asset loss and damage. While GIRI improves the understanding and estimation of global infrastructure asset risk and resilience, the costs of service disruption have not been measured and identified even though they are often greater than the cost of asset loss.
- Similarly, the model does not estimate the cost of the wider impact of asset loss and service disruption on productivity, employment, health, education, and poverty.

9. What is the purpose of the GIRI Data Platform?

All the datasets produced by GIRI are available through the interactive and interoperable web GIRI data platform that enables the risk metrics to be displayed, analysed, and shared.

a) What datasets are available on the GIRI platform?

- Geospatial Layers: The Map viewer section of the platform includes 113 geospatial layers, primarily produced by the GIRI consortium (CIMA, INGENIAR, GRID-Geneva, and

NGI) for the GIRI project. These layers, along with their metadata, are accessible for display, analysis, and sharing.

- Featured Datasets: Approximately 20 datasets, deemed most representative, are highlighted in a dedicated section called 'Featured'. Users can explore these datasets for specific insights.
- Explore Section: The Explore section provides full access to all available datasets, allowing users to navigate through specific filters based on keywords.

b) How can users analyze data on the GIRI platform?

- Within their personalized space (Pinned), users can manipulate the order of layers and incorporate various visual elements such as 3D views, aerial images, and vegetation coverage for analysis. This feature offers flexibility and speed in data exploration.

c) How can users download and share data from the GIRI platform?

- Download: Each dataset produced for GIRI is accessible in Geo Tiff format. Users can download datasets by providing organization name, optional email (for privacy), and purpose of use.
- Share: The platform enables users to share individual or combined layers with customizable options (e.g., predetermined zoom level) across different platforms and social media channels, leveraging the advanced features of the Sharing Manager.

d) How are risk metrics displayed and analyzed on the GIRI platform?

- MapX Integration: MapX is a geospatial data management and visualization platform developed and maintained by UNEP/GRID-Geneva. It serves as the core of the GIRI platform for managing geospatial data. Built on open-source libraries, MapX allows for the interactive display, analysis, and sharing of geospatial data on natural resources. The GIRI platform utilizes the MapX API (Software Development Kit – SDK) to embed MapX in external websites, offering complete customization of data and graphical user interface (GUI).
- Data Display: The Risk Metrics section offers interactive visualization through charts and maps organized into specific dashboards, presenting information such as performance curves, aggregated Average Annual Loss (AAL) per disaster, exposure by building and infrastructure, and key risk measures like AAL, Probable Maximum Loss (PML), and Loss Expectancy Curve (LEC).
- Data Analysis: Users can analyze risk outcomes through sophisticated dashboards, infographics, and filters, facilitating easy understanding and comparison of data across countries.

e) Where can users find additional information on the GIRI platform?

- Layer Metadata: Specific information about each geospatial layer, including metadata following the ISO 19115 standard, is available in the Map viewer section and included in the downloaded data packages.

- Background Papers: The Documentation/Contribution and Background Papers section provides access to essential documents for in-depth understanding of various topics related to GIRI, including a search function for quick access to articles and direct links to report.