UNDERSTANDING DISASTER RISK IN AN EVOLVING WORLD

A Policy Note

GLOBAL FACILITY FOR DISASTER REDUCTION AND RECOVERY

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1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org

FOREWORD

In the late 19th and early 20th centuries, cities across the world experienced catastrophic fire-related disasters. In this brief period, Boston, Chicago, San Francisco, Tokyo, Baltimore, Houston, Atlanta, Toronto, and Seattle all burned completely to the ground. Then, after enough was lost, cities stopped burning. Why?

Governments, the private sector, and citizens responded in concert after these great fires to make the following changes: (a) building codes were improved and rigorously enforced; (b) land-use planning focused on expansion of roadways and public spaces; (c) infrastructure to support emergency services was enhanced and maintained; (d) emergency service providers were professionalized, with robust training; (e) insurance rewarded those with fire-resilient practices; and (f) information was put in the hands of citizens so they could manage their own fire risk. As a result of these changes, catastrophic urban fires were consigned to history.

While it is unfortunate that such catastrophes had to occur before meaningful action was taken, the larger story shows that with the right information at the right time and in the right hands, we can reduce our risks and lessen the tragic price paid by citizens, cities, and governments in the aftermath of disasters. Such results are evident today: when Cyclone Phailin made landfall in Odisha late last year, the region experienced a 99.6 percent reduction in fatalities from the comparably intense 1999 Odisha cyclone, in large part due to targeted interventions to lower disaster risk.

Underpinning successes like these is accurate and actionable risk information. This policy note highlights recommendations that will help ensure that risk information developed in the future enables decision makers to better reduce existing risks and avoid the creation of new risks. These recommendations build on the collective experience of innovative and influential technical specialists, institutions, and governments around the world that have made significant progress toward improving the quality, transparency, and accessibility of risk information.

In this effort, we still have far to go—but if achievements over the next 10 years match the scale of achievements in the last decade, we will be well on our way toward improved resilience.

Francis Ghesquiere
Head, GFDRR Secretariat, Manager DRM Practice Group, The World Bank

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Introduction

The foundation for DRM is understanding the hazards, and the exposure and vulnerability of people and assets to those hazards. By quantifying the risks and anticipating the potential impacts of hazards, governments, communities, and individuals can make informed prevention decisions. Such information can be used to set priorities for development and adaptation strategies, sector plans, programs, projects, and budgets.

–World Bank, *The Sendai Report: Managing Disaster Risks for a Resilient Future* (2012)

Economic losses from disasters triggered by natural events are rising—from $50 billion each year in the 1980s, to just under $200 billion each year in the last decade (World Bank and GFDRR 2013). In addition, the economic losses sustained by lower- and middle-income countries alone over the last 30 years are equivalent to a third of all development assistance in the same time period, offsetting the tremendous development efforts of governments, multilateral organizations, and other actors.

In the context of rapidly growing disaster losses and high-profile catastrophic disasters, it is often difficult to imagine reducing the impact from hazard events. But societies have successfully overcome similar challenges in the past. For centuries, urban fires were a global concern for the public, private, and finance sectors, as well as for the communities directly affected. Urban fires devastated Rome in 64 CE, London in 1666, Moscow in 1812, Chicago in 1871, and Boston in 1872; the 1906 San Francisco fire destroyed nearly 95 percent of the city, and the Tokyo fire of 1923 killed over 40,000 people. Yet we do not see catastrophic urban fires any more, and this hazard has largely been consigned to history. The reasons—implementation of modern building codes, land-use planning, establishment and expansion of emergency services, greater citizen responsibility, and insurance regulations—are essentially the same levers that we can apply today to consigning natural disasters to history. Disaster risk assessments can assist us by uncovering these policy levers and helping to build a compelling case for action.

Risk assessments provide an opportunity before a disaster to determine the likely deaths, damages, and losses (direct and indirect) that will result from a hazard event, and to highlight which actions will be most effective in reducing the impacts on individuals, communities, and governments. This ability to model disaster loss and to provide robust analysis of the costs and benefits of risk preparedness, reduction, and avoidance has made disaster risk assessments a powerful tool in disaster risk management (DRM). As a result, the number of risk assessments being undertaken is growing, innovation has flourished, and a vast array of approaches, experiences, and lessons learned now exists.

As the Hyogo Framework for Action period ends against a backdrop of challenging disaster risk trends, and consultations toward a post-2015 framework move forward, it is important to reflect on the role of disaster risk assessments in achieving disaster and climate resilience, and on the contributions risk assessments have made over the last 10 years. This policy note is founded on, and framed by, the accompanying publication *Understanding Disaster Risk in an Evolving World: Emerging Best Practices in Disaster Risk Assessment*, which features case studies that span 40 countries and that showcase emerging best practices, demonstrate how risk assessments are being used to inform DRM and broader development, and highlight lessons learned through these efforts. Taken as a group, these case studies demonstrate the need to continue investment in accurate risk information and suggest recommendations for the future of risk assessment.

Risk Information as the Basis for DRM Decision Making

A risk assessment represents the start and not the conclusion of a DRM process. A disaster risk assessment provides a foundation for long-term engagement and investment focused on reducing existing risk and avoiding the creation of new risk. Proactive responses to new risk information include retrofitting buildings to withstand the assessed hazard levels, developing new land-use planning guidelines, designing financial protection measures, and equipping and training emergency responders.

Risk information provides a critical foundation for managing disaster risk across a wide range of sectors. Risk information is beneficial for a range of sectors: In the insurance sector, the quantification of disaster risk is essential, given that the solvency capital of most non-life insurance companies is strongly influenced by their exposure to natural catastrophe risk. In the infrastructure sector, quantifying the potential hazard expected in the lifetime of a building, bridge, or critical facility ensures resilient construction, and drives the creation and modification of building codes. In the land-use and urban planning sectors, robust analysis of flood risk likewise drives investment in flood protection and possibly effects changes in insurance as well. At the community level, an understanding of hazard events—whether from living memory or oral and written histories—can inform and influence decisions on preparedness, the location of important facilities, and life-saving evacuation procedures.

Managing disaster risk is just one of myriad challenges faced by governments, communities, and individuals, and it is one that may be easy to neglect. Because the actual cost of historical disasters is not widely known, and the potential cost and impacts of future disasters—including infrequent but high-impact events—may not be known at all, DRM may be given a low priority. But risk assessment is an essential tool for conducting risk identification activities, which then support virtually all subsequent DRM actions that fall under the four areas described below—risk reduction, preparedness, financial protection, and resilient reconstruction.

Appropriate communication of robust risk information at the right time can raise awareness and trigger action to reduce risk. However, communicating disaster risk in a way that triggers action requires an understanding of the development and social processes that underlie and drive the generation of risk. For example, the decision of an individual or government to construct a building that is resilient to seismic events will result from a complex interplay between awareness of, belief in, and acceptance of the potential risks; the financial and technical capacity to design and construct the resilient structure; and the appropriate (enforced) legal, institutional, and regulatory framework (e.g., enforcement of building codes). Similarly, land scarcity in rapidly developing urban environments forces uncomfortable trade-offs between the urgent need of today, such as the need to build on vacant land near employment and educational opportunities, and the potential risk of tomorrow, such as a 1-in-20-year flood event.

Drawing from the DRM framework proposed in the Sendai report (World Bank 2012), we highlight the role of risk information as the foundation for four key areas of DRM decision making.

1. *Risk reduction: Informing policies, investments, and structural and nonstructural measures intended to reduce risk*. Hazard and risk information may be used to inform a broad range of activities to reduce disaster risk, from improving building codes and designing risk reduction measures (such as flood and storm surge protection), to carrying out macro-level assessments of the risks to different types of buildings (for prioritizing investment in reconstruction and retrofitting, for example).

2. *Preparedness: Informing early warning systems and emergency measures and supporting contingency planning at various levels*. Understanding the geographic area that will be affected by a hazard event, along with different events' intensity and frequency, is critical for planning evacuation routes, building shelters, and running preparedness drills. Providing a measure of the impact of different hazard events—the potential number of damaged buildings, fatalities and injuries, secondary hazards—makes it possible to establish detailed and realistic plans for better response to disasters, which can ultimately reduce any event's severity.

3. *Financial protection: Developing financial applications to manage and/or transfer risk*. Disaster risk analysis was born out of the financial and insurance sector's need to quantify the risk of comparatively rare high-impact natural hazard events. As governments increasingly seek to manage their sovereign financial risk or support programs that manage individual financial risks (e.g., micro-insurance or household earthquake insurance), developing robust and scientific risk information is critical.

A Framework for Quantifying and Understanding Risk

In its most simple form, disaster risk is a function of three components–hazard, exposure, and vulnerability [see figure]. However, within this simple framework a multitude of possible approaches to risk assessment and risk modelling is possible.

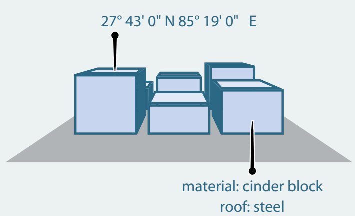
The Components for Assessing Risk

HAZARD

The likelihood, probability, or chance of a potentially destructive phenomenon.

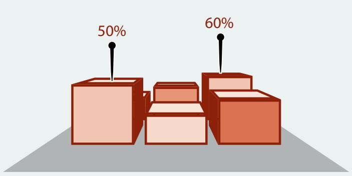
EXPOSURE

The location, attributes, and values of assets that are important to communities.



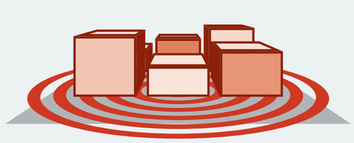
VULNERABILITY

The likelihood that assets will be damaged or destroyed when exposed to a hazard event.



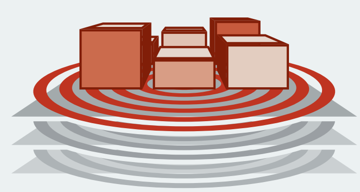
IMPACT

For use in preparedness, an evaluation of what might happen to people and assets from a single event.



RISK

Is the composite of the imacts of **ALL** potential events [100s or 1,000s of models].



4. *Resilient reconstruction: Informing early and rapid estimates of damage and providing critical information for reconstruction*. Risk assessment can play a critical role in impact modelling before a hazard event strikes (in the days leading up to a cyclone event, for example), or it can provide initial and rapid estimates of human, physical, and economic loss in an event's immediate aftermath. Risk information for resilient reconstruction needs to be available before an event occurs, since after the event there is rarely time to collect the information needed to inform resilient design and land-use plans. Risk information generated by risk assessments ex ante is therefore extremely useful for recovery and reconstruction.

Recommendations to Improve the Quality and Uptake of Risk Assessments

Below is a series of recommendations for DRM practitioners, government officials, donors, and nongovernmental organizations commissioning and generating risk information. The recommendations are based on the collective experience of the World Bank Group and other institutions active in disaster risk assessment and aim to ensure that any investment in risk information promotes more-resilient development and communities. In particular, we stress that the best outcomes are likely to be achieved when those investing in risk information and those producing it work in concert and share a common understanding of the undertaking.

1. *Clearly define the purpose of the risk assessment before analysis starts.*
   Risk assessments commissioned in response to a clear and specific request for information have tended to be more effective in reducing fiscal or physical risk; see the Costa Rica case study for an example. In contrast, risk assessments initiated without first defining a question and an end-user typically become mere scientific and engineering exercises. Risk assessments that are properly targeted suit their intended purpose and avoid being over-engineered and/or over-resourced.

2. *Promote and enable ownership of the risk assessment process and efforts to mitigate risk.*
   Ownership is critical for ensuring that knowledge created through a risk assessment is authoritative and therefore acted upon. It is certainly possible for experts to generate risk analysis without ever engaging with local authorities; but experience has shown that regardless of the sophistication or accuracy of their analysis, there will be limited uptake of this information. Given the political, social, and financial costs of relocating communities away from high flood risk areas, for example, the involvement of local authorities is essential. Because translating risk information into action often depends on sensitive negotiations between public officials, affected communities, and financial providers, there is a clear need for authoritative information that is built into a regulated framework and backed by the necessary legal and institutional context. Successful assessments are typically those that partner risk experts with government counterparts to design, implement, and communicate the results of the risk assessment. The rise of open data has enabled citizens to map entire cities; but the data they generate are more likely to be used when the government is also engaged in this process.

The Assessment of Seismic Risk to Costa Rican Water and Sanitation Systems

In Costa Rica, water and sanitation officials seeking to ensure continuation of services following an earthquake requested support for a risk assessment for their sector. The development of the objectives, collection of data, and presentation of results were all aimed at the very specific goal of understanding how an earthquake would affect the water and sanitation systems. Focusing on this goal ensured that resources were well targeted and results appropriately communicated, and allowed the stakeholders to immediately consider integrating results into mainstream operations

3. *Cultivate and promote open data practices.*
Experience gained in the last decade strongly speaks to the need to encourage the creation and use of open data. The analysis of natural hazards and their risks is a resource- and data-intensive process, whereby the return on expended resources can be maximized if the data are created once and used often, and if they are iteratively improved. Current approaches to developing open exposure data on the location, type, and value of assets continue to be improved, and volunteered geospatial information and remote sensing products offer new opportunities to collect and update fundamental data.
That said, despite the progress made, some fundamental data gaps prohibit meaningful and accurate assessments of disaster and climate risks. For example, most parts of the world lack global digital elevation data at resolutions appropriate for analyzing the potential inundation from flood, storm surge, sea-level rise, tsunami, and so on. Similarly, the absence of historical hydrometeorological data in many countries is creating significant challenges in quantifying the climate risks of today and those of the future.

4. *Make better communication of risk information an urgent priority.*
Clear communication throughout the risk assessment process—from initiation of the assessment to delivery of results and the development of plans in response—is critical for translating risk information into action. Experience has shown that progress from increased awareness to action can be very difficult to achieve—see the Padang case study—especially given the social, political, cultural, and financial complexities involved in decision making at any level, from individual to government.

The Rise of Open Data

The Global Facility for Disaster Reduction and Recovery and World Bank launched the Open Data for Resilience Initiative in 2011 to foster and catalyze the open data movement for climate and disaster resilience. Under this initiative, web-based geospatial platforms (GeoNodes) in more than 20 countries have been used to open more than 1,300 geospatial data sets to the public and to catalyze community mapping of buildings and infrastructure.

Promotion of OpenStreetMap in Sri Lanka is a prime example of a government-led volunteer geospatial initiative: in a two-month period, more than 30,000 individual buildings were mapped as part of a broader risk identification program.

The Experience of Padang: Translating Risk Awareness into Action

A massive "Build Back Better" campaign led by the government of Indonesia in the aftermath of the 2009 Padang earthquake demonstrates conclusively that well-targeted education and communication about risk can increase awareness of natural hazards and their potential impacts. Analysis also shows, however, that progress from increased awareness to substantive action is very difficult to achieve, even in a community that has witnessed at first hand the devastation of an earthquake. Overall, analysis shows that homeowners can be motivated to put risk knowledge into practice and build more resilient homes if they are offered the correct combination of timely information, technical training, community supervision, and financial and nonfinancial incentives and disincentives.

Communicating "What If…?" through Tools Such as InaSAFE

The InaSAFE project in Indonesia demonstrates some of the improvements that can be made in communicating risk at the subnational and city levels. Among the key partners in InaSAFE's development were Indonesian authorities, who realized the need for interactive risk communication tools that could robustly and simply answer "what if?" questions. InaSAFE is demand driven; it included user participation in its development, uses open data and an open model, and offers extensive graphical displays (provided by a GIS system) and an extensive training program. Communication was frequent and wide-ranging throughout the development of InaSAFE and continued during the collection of data, the use of the model, and the formation of response plans. The software has won awards and is being used in other countries, including the Philippines and Sri Lanka.

Four Examples of Multi-institutional Networks

- The Global Earthquake Model brings together public institutions, private sector institutions (most notably insurance and reinsurance agencies), nongovernmental entities, and the academic sector, all with the goal of improving access to tools, data sets, and knowledge related to seismic risk.
- The Willis Research Network initiative links more than 50 international research institutions to the expertise of the financial and insurance sector in order to support scientists' quantification of natural hazard risk.
- The Understanding Risk community of practice, made up of more than 3,000 practitioners from across all sectors in more than 125 countries, is creating new partnerships and catalyzing advances in understanding, quantifying, and communicating natural hazard risk.
- The Bangladesh Urban Earthquake Resilience Project is a platform for addressing urban risk that brings together officials in planning, governance, public service, and construction code development as well as scientists and engineers, and that fosters consensus on how to overcome institutional, legislative, policy, and behavioral barriers to a more earthquake-resilient city.

Capturing Dynamic Seismic Risk in Kathmandu, Nepal

Few risk assessment efforts have addressed evolving exposure and vulnerability, along with the resulting change in risk, in urban environments. While the contribution of urbanization to greater exposure is widely recognized, studies rarely consider how changes in urban construction practices affect building vulnerability–often for the worse. The recent study of evolving seismic risk in Kathmandu offers an important example of this approach. The study shows that the incremental construction of houses in Kathmandu, where stories are added to buildings informally over time, has increased both exposure and vulnerability in the area. Using a single-scenario earthquake event, a reproduction of the 8.1 magnitude Bihar earthquake of 1934, the analysis finds that the potential number of buildings sustaining heavy damage or collapse in this event has increased from ~50,000 in 1990 to ~125,000 in 2010, and that it may be as high as 240,000 by 2020 if action is not taken.

Rapidly Growing Flood Risk in Dhaka, Bangladesh

Considering global changes in hazard and exposure for flood offers some sobering statistics for the future: "middle-of-the-road" socioeconomic changes and climate change could increase riverine flood risk for between 100 million and 580 million people by 2050, depending on the climate scenario. At a city level, changes in exposure and flood hazard for Dhaka, Bangladesh, were found likely to increase the annual average loss by a factor of 20 to 40. Moreover, while both climate change and socioeconomic development were found to contribute importantly to this increase in risk, the individual contribution of socioeconomic development was predicted to be greater than that of climate change.

Communicating risk information must be customized to the audience. Metrics like annual average loss and probable maximum loss, for example, are of interest and relevant to the financial sector, but they are poor metrics for communicating with national- or subnational-level decision makers involved in DRM. These decision makers may prefer interactive tools that enable people to answer "what if?" questions robustly and simply ("What if an earthquake/cyclone/other natural hazard hit my community—How many buildings would collapse or be damaged?"). Tools of this type already exist—see the InaSAFE case study for an example—but there are immense opportunities to increase the number and availability of interactive, highly graphical visualization tools, which would enable all decision makers, from individuals to national governments, to meaningfully interact with risk information.

5. *Foster multidisciplinary, multi-institutional, and multi-sectoral collaboration at all levels, from the international to community level.*

To generate a usable risk assessment product, technical experts and decision makers must consult with one another and reach agreement on the purpose and process of the assessment. The actual development of risk information is clearly a multidisciplinary effort that takes place through collaborations ranging from international efforts to multi-institutional arrangements at national and subnational levels. There are many efforts currently under way that speak to the success of this approach. However, success has been comparatively limited in merging community-level understanding of risk with a national or subnational understanding of risk. This is a missed opportunity, given that a common understanding of the risks and necessary steps to reduce them could trigger greater action.

6. *Consider the broader risk context.*
Rarely do countries, communities, or citizens face potential risks from only one hazard, or even from natural hazards alone. Our complex environments and social structures are such that multiple or connected risks—from financial hazards, multiple or cascading natural hazards, and anthropogenic hazards—are the norm. Just as multi-peril risk calculations are required for many financial applications, territorial planning should draw on information from assessments of multiple hazards (flood, landslide, and earthquake, for example) in order to reduce risk. We know that failure to consider the full hazard environment can result in maladaptation (heavy concrete structures with a ground-level soft story for parking can protect against cyclone wind, for example, but can be deadly in an earthquake), whereas adopting a multi-hazard risk approach leads to better land-use planning, better response capacity, greater risk awareness, and increased ability to set priorities for mitigation actions. Particular caution should be taken with risks in food security and the agricultural sector, and we recommend that these risks be considered alongside flood and drought analysis.

7. *Keep abreast of evolving risk.*
Risk assessments need to account for temporal and spatial changes in hazard, exposure, and vulnerability, particularly in rapidly urbanizing areas or where climate change impacts will be felt the most. A risk assessment that provides an estimation of evolving or future risk is a way to engage stakeholders in carrying out actions now in order to avoid or mitigate the risk that is accumulating in their city or country; see the Kathmandu case study. Risk analysis offers an opportunity to quantify the decrease in future risk that arises from better enforcement of building codes, for example, and hence demonstrates the benefit of spending additional funds on building code enforcement.
Given that "a changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events" (IPCC 2012), there is increasing interest in understanding the impacts of climate change, specifically with respect to calculating the loss under future adverse climate events. Using the modelling techniques and approaches developed to model disaster risk, experts have demonstrated the potential to determine future loss under climate change; see the Dhaka case study. However, it is important to recognize that the fundamental data sets that enable the risks of today to be quantified are the same as those required to determine the impacts of adverse events in the future.

8. *Understand, quantify, and communicate the uncertainties and limitations of risk information.*
Once risk information is produced, all users must be aware of and knowledgeable about its limitations and uncertainties. Failure to consider these can lead to flawed decision making and the inadvertent increase in risk. A risk model can produce a very precise result—it may show, for example, that a 1-in-100-year flood will affect 388,123 people—but in reality the accuracy of the model and input data may provide only an order of magnitude estimate. Similarly, sharply delineated flood zones on a hazard map do not adequately reflect the uncertainty associated with the estimate and could lead to decisions such as locating critical facilities just outside the "flood line," where the actual risk is the same as if the facility was located inside the flood zone. It is incumbent upon specialists producing risk information to clearly and simply communicate uncertainties and limitations.

9. *Ensure that risk information is credible and transparent.*
   Risk information must be scientifically and technically rigorous, open for review, and transparent regarding its limitations and uncertainties, which may arise from uncertainties in the exposure, hazard, and vulnerability functions. The best way to demonstrate credibility is to open data, models, and results for review by independent, technically competent individuals. As risk modelling has become more technically complex it has also become more accessible, and therefore anyone can feasibly run a risk model—but without the appropriate scientific and engineering training and judgment, the results may be fundamentally incorrect and may mislead decision makers.

10. *Encourage innovations in open tools for risk identification.*
    In the last 10 years, immense progress has been made in creating new open source hazard and risk modelling software. More than 80 freely available software packages, many of which are open source, are now available for flood, tsunami, cyclone (wind and surge), and earthquake, with at least 30 of these in widespread use. Significant progress has also been made in improving open source geospatial tools, such as QGIS and GeoNode, which are lowering the financial barriers to understanding risks at national and subnational levels. Yet all this innovation has created challenges around assessing "fitness-for-purpose," interoperability, transparency, and standards. These need to be addressed in a way that continues to catalyze innovation and yet also better supports risk model users.

Further Information

Please refer to *Understanding Disaster Risk in an Evolving World: Emerging Best Practices in Disaster Risk Assessment* for case studies and further information on the development and use of risk information.

Alternatively contact Dr. Alanna Simpson at GFDRR for more information: asimpson1@worldbank.org.

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Across the globe, a consensus is emerging on the central importance of risk information in disaster risk management. When risks are quantified and the potential impacts of hazards are anticipated, governments, communities, and individuals are able to make more informed decisions.

This publication highlights some of the influential efforts—by technical specialists, institutions, and governments around the world—to create and communicate risk information quickly and at low cost, to improve the quality and transparency of risk information, and to enable more local engagement in the production of authoritative risk information than ever before. Case studies spanning 40 countries and contributed by more than 50 institutions showcase emerging best practices, demonstrate how risk assessments are being used to inform disaster risk management and broader development, and highlight lessons learned through these efforts. Taken as a group, these case studies evidence the need for continued investment in accurate and useful risk information and provide recommendations for the future.

ABOUT GFDRR The Global Facility for Disaster Reduction and Recovery (GFDRR) helps high-risk, low-income developing counties better understand and reduce their vulnerabilities to natural hazards, and adapt to climate change. Working with over 300 national, community level, and international partners GFDRR provides grant financing, on-the-ground technical assistance helping mainstream disaster mitigation policies into country level strategies, and thought leadership on disaster and climate resilience issues through a range of knowledge sharing activities. GFDRR is managed by the World Bank and funded by 21 donor partners.

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