UNISDR
The United Nations Office for Disaster Risk Reduction

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Launching UNISDR Science and Technology Partnership and the Science and Technology Road Map to 2030

To promote and support the availability and application of science and technology to decision-making in Disaster Risk Reduction

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Exposure and Vulnerability

1) Overview

The Sendai Framework for Disaster Risk Reduction highlights that: *"Policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be leveraged for the purpose of pre-disaster risk assessment, for prevention and mitigation and for the development and implementation of appropriate preparedness and effective response to disasters."*

The UNISDR defines vulnerability as *"the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards"* (UNISDR 2009).Vulnerability may vary within a population by subgroup (e.g. income level or type of livelihood) and may change over time, adding further complexity to vulnerability measurement and risk estimation (Birkmann et al 2006).

Exposure is defined as *"the people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses*" (UNISDR 2009). Thus, understanding vulnerability and exposure are fundamental to our understanding of risk. Together, increases in vulnerability and exposure dominate the overall increase in risk observed worldwide over the past several decades, and therefore require particular attention in the formulation of policies and actions to reduce disaster risk.

Implementing an all-hazards approach that incorporates natural and mad-made hazards (including technological and biological hazards that can have cascading effects that transcend country boundaries) and incorporating all elements of risk will require an integrated and collaborative approach across disciplines, sectors and institutions as well as cooperation among science and technology S&T networks.

The Work Stream 2 Working Group on 'Exposure and Vulnerability' will address how to promote a common understanding of exposure and vulnerability as fundamental elements of risk assessment through a partnership of the scientific community, policy makers and community representatives across disciplines and policy sectors in order to achieve the outcome of the Sendai Framework for Disaster Risk Reduction to reduce disaster losses in lives, livelihoods and health by 2030 (see Annex 1).

2) Stock taking

The severity of the impacts of disasters depends strongly on the level of exposure and vulnerability in the affected area, and evidence indicates that risk has increased worldwide largely due to increases in the exposure of persons and assets. For example, increasing exposure has been the major cause of long-term increases in economic losses from weather- and climate-related disasters (IPCC 2012). There have been localised reductions in vulnerability as a result of, for instance, better building standards and compliance (as in Chile), but these reductions are geographically uneven and there are many instances of increased vulnerability, particularly in large urban centres and in developing countries. This has created new risk and a rise in disaster losses particularly at the local and community level with the poor and marginalized, minority populations, women and children, and those dependent on single sector economies disproportionately affected (UNISDR 2015, Cutter et al 2003).

Both exposure and vulnerability are dynamic, vary across temporal and spatial scales, and depend on economic, social, geographic, demographic, cultural, institutional, governance-related, and environmental factors. Moreover, factors affecting exposure and vulnerability vary considerably by hazard context, disaster stage and national setting (Rufat et al 2015). High exposure and vulnerability are linked to skewed development processes, such as those associated with environmental mismanagement, rapid demographic changes, rapid and unplanned economic processes, urbanization in hazardous areas, poor governance, and the scarcity of livelihood options for the people particularly the poor (Cardona et al 2012). Inequality also affects response and coping mechanisms putting more people at risk.

Measuring vulnerability and exposure requires an integrated understanding of components and how these factors combine to contribute to the resilience[1] of communities (Carreno et al 2007, Burton et al 2014). These approaches include methods that use predominantly statistical data gathered from published sources, and approaches which involve surveying local populations.

Efforts to quantify risk have typically considered a limited number of dimensions like the physical dimension (e.g., buildings and mortality) and/or economic aspects of vulnerability, but social vulnerability is poorly understood and difficult to measure. Useful approaches exist such as examining vulnerability and its relationship to inequality in the social and health sciences and (see the Social Determinants of Health approach (WHO 2008).

In most countries, vital statistical information is collected through a national census, but this information seldom incorporates information on the construction of buildings, or social demographic data vital to assessing vulnerability of populations. Moreover, this type of statistical data is often only available at a level of geographic aggregation that makes it difficult to use effectively in risk assessments. Issues also include access to proprietary data, privacy, accuracy, consistency and lack of openness.

Opportunities

Significant advances have been made in using many sources of statistical data to develop exposure models. However, the development of exposure databases that are fit for purpose for risk assessments across geographic scales and for different hazards and types of risks represents a significant challenge. The challenge is compounded by the fact that exposure data is multi-faceted and complex, and seldom if ever the responsibility of any one organisation to collect and maintain.

An important area of research is in the development of exposure databases from remote sensing satellites and computer-based techniques such as crowd-sourcing and drones which can provide highly accurate descriptions of population distributions and physical attributes of the natural and built environment. Such approaches are even more powerful when combined with ground-based data from imagery or statistical data.

Four distinct and largely independent research and policy communities – disaster risk reduction, climate change adaptation, and environmental management and poverty reduction have been working to reduce vulnerability to hazards but face challenges in terms

[1] Resilience is defined as “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions” (UNISDR 2009)

of facilitating learning and exchanging information (Thomalla et al 2006). Applying multidisciplinary and multisectoral approaches can help to build on complementarities while avoiding duplication of efforts.

3) The Way Forward

In light of the stock taking, there is a need to examine how the Sendai Framework's scientific recommendations on vulnerability and exposure in understanding risk (listed below) can be implemented. The approach needs to address the challenges of measurement, exchanging information across disciplines and communities and the development of comprehensive exposure and vulnerability databases to produce useful, usable and commonly utilized risk information. Key elements proposed for discussion in this working group include the need to:

- Identify main gaps and challenges in the development of vulnerability data and models, considering physical, socio-economic, institutional and environmental factors.
- Identify the interdependencies between social, biophysical, and built-environment systems that produce risk.
- Identify key markers of socio-economic vulnerability and develop socio-economic scenarios and methodologies for socio-economic vulnerability assessment.
- Identify needs for improved understanding and models for community resilience.
- Identify mechanisms for and opportunities to improve exposure databases and exposure models, emphasising issues of scale, data access, types of data and advanced analysis approaches.
- Consider how to encourage the use of and strengthening of baselines, and periodically assess disaster risks, vulnerability, capacity, exposure, hazard characteristics and their possible sequential effects at the relevant social and spatial scale on ecosystems, as appropriate for the local, national and regional context.
- Before disasters, commit to collection and dissemination of datasets fundamental to assessing exposure and vulnerability, such as up-to-date disaggregated census data, type of construction, poverty and household surveys, and sectoral data (e.g., educational and healthcare infrastructure)
- Post-disaster, commit to systematic post-disaster analysis of building and infrastructure failure and socio-economic impacts on communities, bearing in mind that different approaches may be required for different hazard events.
- Promote the development, accessibility (e.g. open-access existing data) and dissemination of non-sensitive exposure data and models and multi-hazard vulnerability models to all government agencies, the private sector, academia, bilateral and multilateral agencies and private citizens.
- Promote proven and innovative approaches to the collection, storage and dissemination of exposure data and models. For example, crowd-sourcing approaches such as OpenStreetMap, Big Data and drone technology all offer new methods to collect exposure data.

- Incorporate where appropriate geospatial information technology for updating and disseminating location-sensitive vulnerability and exposure information to decision makers, the general public and communities at risk.

The following main areas of focus will be over the next 15 years, which are linked to the UNISDR ST Roadmap key actions as outlined in the table below

Priority for Action 1: Understanding Disaster Risk		
Expected Outcomes	**Key Actions**	**Review Progress and Needs**
1.1 Assess, and update the current state of data, scientific knowledge and technical availability on disaster risks reduction and fill the gaps with new knowledge.	• Develop, update periodically and disseminate risk information to build awareness and knowledge of disaster risk. • Establish datasets of, update periodically and disseminate risk information, including on exposure and vulnerability, to build awareness and knowledge of disaster risk • Promote community engagement in risk data collection	• Improved and accessible data and integrated metrics on exposure and vulnerability from local to global scale. • Global Network for sharing disaster data and statistics. • Periodic reports on state of Global Risk Knowledge • Guidelines for national and regional, multi-hazard, risk assessments and mapping; • methodologies and guidance for post-disaster review and damage assessments; and • guidance for reporting disaster risk knowledge. • Improved and accessible data and integrated metrics on exposure and vulnerability from local to global scale. • National, multi-hazard risk profiles; • global network for sharing disaster data and statistics

1.2 Synthesize, produce and disseminate scientific evidence in a timely and accessible manner that responds to the knowledge needs from policy-makers and practitioners;	• Engage scientific focus on disaster risk factors and scenarios, including emerging disaster risks • Develop methods, models and tools for national risk assessments.	• Good practices on use of indigenous and local knowledge • National open-data platforms for DRR in alignment with the SDGs and other global agreements
Priority For Action 2: Strengthening Disaster Risk Governance to Manage Disaster Risk		
Expected outcomes	**Key Actions**	**Review Progress and Needs**
2.1 Ensure a stronger involvement of science in policy- and decision-making at all levels	• Raise awareness and improve understanding of disaster risks and their impact on societies and their transboundary and global impact • Promote the mainstreaming of disaster risk assessments and mapping into land-use planning and other policy development and implementation, and rural development planning and management	• Information sharing of case studies of strong involvement of science in policy and decision-making to improve implementation • National and regional Communities of Users and Practitioners
Priority for Action 4: Enhancing Disaster Preparedness For Effective Response, and to "Build Back Better" In Recovery, Rehabilitation and Reconstruction		
Expected outcomes	**Key Actions**	**Review Progress and Needs**
4.1 Identify and respond to the scientific needs of policy- and decision-makers at all levels to strengthen preparedness and resilience	• Develop, maintain and innovate technology for people-centred, low cost early warning systems and emergency communication mechanisms. • Develop, disseminate quality standards, codes, and operational guides on	• Periodic national and regional reporting on early warning systems and emergency communication mechanisms; in place and planned • Legislation and policies integrating DRR in building

	contingency planning and protection of critical infrastructure and basic services and promote their use at national and regional levels • Support the development of resilient systems and services	codes and protection of critical infrastructure
4.2 Build capacity to ensure that all sectors and countries understand, have access to, and can use scientific information for better informed decision-making	• Establish / strengthen existing training and education mechanisms and peer learning • Promote transdisciplinary work in disaster risk reduction research. • Enhance knowledge and technology transfer and promote the use of global technology pools to share know-how, innovation and research	• National and regional training and capacity building programmes in DRR

Can these proposals be strengthened further? Are there specific next steps to strengthen capacity building, for example to strengthen the science-policy-practice nexus at local, national, regional and global levels in DRR? What are priority areas of investment? Participants are also invited to consider the following areas of focus and challenges to make further proposals to inform the Road Map activities over the next 15 years:

The following are proposed as priority areas to guide the key actions and review of progress of the Road Map over the next 15 years:

A. Vulnerability research and models

Metrics within the dimensions of social, physical, economic and environmental vulnerability, developed by scientists from natural, environmental and social scientists should be further developed and integrated into all-hazard risk assessments and post-disaster assessments to provide more comprehensive risk assessments.

B. Data: a participatory approach

The data from geospatial information systems and field surveys can be employed in the development of exposure and vulnerability models. The participatory approach for data collection and use by communities can complement, if not fill, gaps in scientific data in assessing vulnerability and therefore risk. Specific examples of new approaches include: community-based/crowd-sourcing (bottom-up) versus statistically-based (top-down)

approaches; hazard-specific vs. hazard independent vulnerability and resilience; classification by and scaling of data from local to national to global; community engagement and ownership; mapping of vulnerable groups.

C. Vulnerability and exposure assessment methods: integration

The assessment of vulnerability and exposure range from global to local-scale participatory approaches, which need to be integrated using appropriate platforms. The appropriateness of methods used for these assessments depends on the purpose of the analysis, time and geographic scale involved, the resources available, the number and type of actors, and economic and governance aspects. Such differences and how they can be overcome to promote integration of the different dimensions of vulnerability and exposure needs be addressed and could be examined using case studies.

D. Exposure and vulnerability information to develop risk indicators and monitor risk

Vulnerability and exposure information are often used as indicators of relative risk and, in particular, the evolution of risk over time and geographic dimension. Thus, greater emphasis needs to be placed on the collection and analysis of vulnerability and exposure information in order to inform the development of risk indicators and the process of monitoring risk over time and space. Several indicators of physical and socio-economic vulnerability/exposure require statistically robust information regarding the nature of the built environment (e.g., building stock, lifelines, critical facilities), which is often not available even in developed nations. The employment of advanced models to predict the geographical distribution, susceptibility to damage and loss, and value of the elements exposed to the hazards will be fundamental in these cases. Such models can be verified using appropriate data from different regions.

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Annex: Sendai Framework on Disaster Risk Reduction statements on Exposure and Vulnerability

I. Preamble

4 …. Evidence indicates that exposure of persons and assets in all countries has increased faster than vulnerability has decreased, thus generating new risks and a steady rise in disaster related losses, with a significant economic, social, health, cultural and environmental impact in the short, medium and long term, especially at the local and community levels…... Evidence indicates that exposure of persons and assets in all countries has increased faster than vulnerability

6 Enhanced work to reduce exposure and vulnerability, thus preventing the creation of new disaster risks, and accountability for disaster risk creation are needed at all levels…

II. Expected outcome and goal

17. To attain the expected outcome, the following goal must be pursued:

Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience.

Priority 1: Understanding disaster risk

23. Policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. ….

National and Local

24 (b) To encourage the use of and strengthening of baselines and periodically assess disaster risks, vulnerability, capacity, exposure, hazard characteristics and their possible sequential effects at the relevant social and spatial scale on ecosystems, in line with national circumstances;

24 (c) To develop, periodically update and disseminate, as appropriate, location-based disaster risk information, including risk maps, to decision makers, the general public and communities at risk of exposure to disaster in an appropriate format by using, as applicable, geospatial information technology;

24 (d) To systematically evaluate, record, share and publicly account for disaster losses and understand the economic, social, health, education, environmental and cultural heritage impacts, as appropriate, in the context of event-specific hazard-exposure and vulnerability information;

24 (e) To make non-sensitive hazard-exposure, vulnerability, risk, disaster and loss-disaggregated information freely available and accessible, as appropriate;

24 (j) To strengthen technical and scientific capacity to capitalize on and consolidate existing knowledge and to develop and apply methodologies and models to assess disaster risks, vulnerabilities and exposure to all hazards;

24 (n) To apply risk information in all its dimensions of vulnerability, capacity and exposure of persons, communities, countries and assets, as well as hazard characteristics, to develop and implement disaster risk reduction policies;

Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

32. The steady growth of disaster risk, including the increase of people and assets exposure, combined with the lessons learned from past disasters, indicates the need to further strengthen disaster preparedness for response, take action in anticipation of events, integrate disaster risk reduction in response preparedness and ensure that capacities are in place for effective response and recovery at all levels. …..

VI. International cooperation and global partnership

General considerations

41. Disaster-prone developing countries, in particular the least developed countries, small island developing States, landlocked developing countries and African countries, as well as middle-income countries facing specific challenges, warrant particular attention in view of their higher vulnerability and risk levels, which often greatly exceed their capacity to respond to and recover from disasters. Such vulnerability requires the urgent strengthening of international cooperation and ensuring genuine and durable partnerships at the regional and international levels in order to support developing countries to implement the present Framework, in accordance with their national priorities and needs. ….

42. Disasters can disproportionately affect Small Island developing States, owing to their unique and particular vulnerabilities.