A Global Outlook on
Disaster Science

An analysis of recent scholarly output and impact in disaster science according to the Sendai Framework for Disaster Risk Reduction, aiming to provide insights to governments, research institutions, and funding agencies

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Prefaces

Elsevier

Every year, natural and man-made disasters destroy and displace lives, and the frequency of disasters has increased over the past 50 years. Disasters lead to loss of property and disrupted infrastructure, and slow societal development. The increase in the earth's population and its concentration to cities and coastal areas have made us more vulnerable to disasters and have exacerbated disaster impact. Climate change demands a greater sense of urgency for us as a society to prepare and build resilience against, for instance, sea level rise and heat waves. Policies and actions, by corporations and governments alike, are urgently needed to mitigate anthropogenic and natural hazards and support disaster risk reduction as well as disaster relief.

Science and technology have an important role to play in reducing disaster risk, for instance, via improved weather predictions, the development of earthquake-resilient infrastructure, and the development of pandemic vaccines. In 2015, at the Third United Nations (UN) World Conference on Disaster Risk Reduction, the UN facilitated the adoption of the Sendai Framework for Disaster Risk Reduction 2015-2030 by 187 member states. The framework calls for a stronger role for science and technology in practical risk reduction and in supporting response and recovery after disasters. In a wider context, disaster management is featured in 25 targets in 10 of the UN's 17 Sustainable Development Goals (SDGs).

As a global information analytics business specializing in science, technology, engineering, and health, Elsevier provides a platform for the interaction of scientific and policy communities in the field of science for disaster risk reduction. We do so through the publication of relevant journals, such as the *International Journal of Disaster Risk Reduction*↗, through our books on the topic, and increasingly through our data analytics and engagements. For the current report, *A Global Outlook on Disaster Science*↗, we partnered with leading international institutions and drew upon high-quality global data to examine the state of worldwide disaster science research. With this report, we wish to describe the field of disaster science and contribute to evidence-based disaster risk reduction policy development and implementation.

This report is part of Elsevier's continued commitment to support the UN SDGs, and follows our reports *Sustainability in the Global Research Landscape*↗ and *Gender in the Global Research Landscape*↗, as well as our engagement of the RELX Group SDG Resource Center↗. On behalf of Elsevier, I wish to extend our sincerest appreciation to our partners and experts for their advice on this report's development, including their input on the research questions, methodologies, analytics, and their comments on the policy context. Our hope is that the data and insights in this report will inspire further discussions on how disaster science can support disaster risk reduction, response, recovery, and how science can help build a safer and better world.

Ron Mobed
Chief Executive Officer
Elsevier

International Council for Science (ICSU)

The impacts of disasters around the world are increasing, as has been, and very unfortunately, demonstrated by the devastating storms, hurricanes, and flooding in late summer and early fall of 2017 in the Caribbean. There is an urgent need for integrated, science-based actions to address these disasters to reduce their impacts on all countries. The mission of the International Council for Science (ICSU), the leading non-governmental global science organization, is “to strengthen international science for the benefit of society.”

To do this, we need a world where excellence in the sciences is effectively translated into policymaking and socioeconomic development. ICSU has co-sponsored the World Climate Research Programme since its founding in 1980 and now is a major co-sponsor of the Integrated Research on Disaster Risk (IRDR) program, Future Earth: Research for Global Sustainability and Urban Health and Well-Being. ICSU has also been a major scientific contributor to the Agenda 2015-2030, the Paris Agreement on Climate Change, the Sendai Framework for Action, and the UN Sustainable Development Goals. These international agreements need strong and continuing scientific input to achieve their targets. The IRDR program, formally established in 2008 with the International Social Sciences Council (ISSC) and United Nations Office for Disaster Risk Reduction as co-sponsors, is a leading example of the type of integrated, transdisciplinary approach to disaster science that is needed for the benefit of all societies. The IRDR objectives are to support science that is focused on understanding and predicting hazards, vulnerability and risk; effective decision making and improving risk interpretation to action; and strategies for reducing risk and curbing losses. A dozen IRDR International Centers of Excellence are now established around the world. It is critical that this research be supported and its results are communicated to the global community, and that leading scientists worldwide are involved in disaster science research and the communication of knowledge and advice to the global community, including policymakers and disaster risk reduction managers.

For these reasons, ICSU is dedicated to working with the international governmental community to ensure that there is universal and equitable access to scientific data and information, all countries develop scientific capacity, scientists have the freedom to do science, and science is translated into effective policy.

Gordon McBean
President
The International Council for Science (ICSU)

Association of Pacific Rim Universities (APRU)

For this ground-breaking report, Elsevier has convened key international leaders in the field to bring into focus the state of disaster science research. APRU is pleased to be a partner in this endeavor and is committed to connecting international science to policymaking through this collaboration.

One of APRU’s major initiatives, the APRU Multi-Hazards Program, has been a key player in building disaster science-to-policy connections. Led by the International Institute of Disaster Sciences (IRIDeS) at Tohoku University, this program harnesses the collective capabilities of APRU universities around the Pacific Rim for cutting-edge research on disaster risk reduction and contributes to international policymaking processes. For the past five years, the APRU Multi-Hazards Program has been shaping educational outputs, research impact, and trending topics in disaster risk reduction research, both globally and within Asia. The APRU Multi-Hazards Program and IRIDeS have collaborated with Elsevier to conceive and develop this benchmark report.

With the increasing intensity and frequency of extreme disaster events, this report is timely. It provides an invaluable snapshot of the current status of disaster science research.

Together with our partners, we intend that this report will make a strong contribution to policymaking globally, improving the way we forecast, prepare for, and respond to disasters at a time of urgent need.

Christopher Tremewan
Secretary General
The Association of Pacific Rim Universities (APRU)

International Research Institute of Disaster Science (IRIDeS)

Disaster science is a truly inter- and transdisciplinary academic field that contributes to the international society by addressing global issues to reduce the damage and loss associated with disasters. Yet in its current state, it is insufficient to tackle the various challenges posed by disasters or reduce their risks; it is critical that disaster science covers the whole disaster management cycle. Action-oriented research is key in each stage of the cycle, generating knowledge through collaborative interactions between academia and practitioners and integrating and disseminating scientific discoveries for the benefit of the world.

A new global strategy, the Sendai Framework for Disaster Risk Reduction, was adopted at the United Nations World Conference on Disaster Risk Reduction in 2015, and proposed that academia should play a more prominent role in contributing to the development of societal resilience to disasters. The Sendai Framework expects academia to support local actions and build an interface between policy and science for more informed decision making. To achieve this goal, collaboration among various stakeholders is indispensable, but is also a major challenge.

The International Research Institute of Disaster Science (IRIDeS) at Tohoku University was established following the catastrophic disaster of the 2011 Great East Japan Earthquake and Tsunami, with the aim of becoming a world-leading research institute in collaboration with various international organizations. It is our role and responsibility to pass on experience and disaster science research outcomes to future generations, as well as respond to research needs from all over the world. Furthermore, in collaboration with the Association of Pacific Rim Universities (APRU), IRIDeS initiated the Multi-Hazards Program in 2013. The Program contributes to enhancing inter- and transdisciplinary disaster science research and collaboration among various stakeholders, which is critical to the implementation of the Sendai Framework.

The findings of this report highlight the stages of the disaster management cycle for which we need to further strengthen our research and the challenges and issues that face disaster science researchers and policymakers. The report findings may be of interest to both researchers and non-researchers, such as funding agencies, policymakers, and disaster science practitioners.

Fumihiko Imamura
Director
The International Research Institute of Disaster Science (IRIDeS) of Tohoku University

Key Findings

2012-2016

Death toll versus publications

countries with the highest death tolls from natural disasters tend to have low volumes of disaster science scholarly output

Economic loss versus publications

countries with the highest economic losses from natural disasters tend to have the largest disaster science scholarly output

27,273

the number of recent scholarly output in disaster science

0.22%

the share of recent global scholarly output belonging to disaster science

9,571

the number of recent disaster science publications on geophysical disasters

>5,000

the number of recent disaster science publications on each of the following disaster types: geophysical, meteorological, chemical & radiological, and hydrological

China

the most prolific country in disaster science scholarly output overall and disaster prevention scholarly output

USA

the most prolific country in disaster preparedness, response, and recovery scholarly output

Japan

the most specialized prolific country in disaster science, overall and in research on each disaster management cycle stage

Philippines, Indonesia, Bangladesh, Japan, New Zealand, Thailand, Taiwan

territories with 125+ recent papers in disaster science that are 50%+ more specialized in disaster science than the global average

Executive Summary

Every year, disasters impact human lives and take a significant economic toll. Science plays a key role in reducing disaster risk and mitigating impact. The importance of disaster science is reflected in the Sendai Framework for Disaster Risk Reduction,[1] which links research to key priorities, including understanding disaster causes, investing in resilience, and strengthening governance.[2,3] In this report, we examine the link between man-made and natural disasters on the one hand, and disaster science scholarly output on the other. We uncover the focus areas of disaster science and zoom in on the most prominent countries involved in disaster science research.

In the last five years, more than 27,000 disaster science papers were published globally, representing 0.22% of the world's total scholarly output. Disaster science encompasses research on several disaster management cycle stages, various disaster types, and specific disaster events. As such, it requires multidisciplinary approaches across fields, and transdisciplinary engagements across sectors. Research on the disaster management cycle appears to span across multiple disaster management stages. Nevertheless, scholarly output is relatively more focused on disaster prevention and preparedness, and relatively less on recovery. Across the various disaster types, geophysical disasters have been the most heavily researched.

Disaster science output seems to follow the global distribution of overall scholarly output, in that prolific countries overall tend to have relatively large outputs in disaster science. They also suffer the highest economic losses from natural disasters. Both of these observations may be influenced by the size of these countries' economies; however, there are subtle deviations from the expected patterns. On a global level, the relative size of the scientific output on specific disaster types tends to align to the relative frequency and impact of the disasters themselves. Asia has a particularly strong position in the field: of the top ten prolific institutions, nine are in Asia. Nevertheless, many emerging countries that experience very high economic or human disaster-related losses publish few disaster science papers.

The disaster science community is responsive: research on recent disasters appears quickly in the disaster science literature. While Japan has substantial research activity related to geological disasters, following the 2011 Great East Japan Earthquake and triple disaster, a significant increase is seen in research related to chemical & radiological disasters in Japan. Interestingly, many papers related to chemical & radiological disasters published in Germany, the United Kingdom (UK), and France (all of which have their own nuclear power generators and nuclear safety programs) also discuss the consequences of the Fukushima nuclear accident, and make connections to the Chernobyl nuclear accident.

Zooming in on specific countries, we note that research tends to focus on major disasters that occur in the region, e.g., Japan focuses on earthquakes and tsunamis, the United States on meteorological and biological disasters, Brazil and India on environmental disasters, and China on climatological disasters. European countries tend to be less specialized in disaster science, but have a robust scholarly output and high citation impact, in line with their overall research performance. Disaster burden is heavy in Japan, and the country's focus on disaster science is strong. Indeed, Japan has the highest disaster economic loss as a share of GDP among comparator countries, and is the most specialized comparator country in disaster science.

Disasters can have global and diverse repercussions, and there is often a disconnect between where most of the disaster impact is felt and where most of the disaster science research is done. In addition, some countries seem to focus their research on disaster types with a high domestic relevance. This poses the question of whether there are aspects of disaster science that are particularly relevant to emerging countries with a high disaster burden, and whether these are currently under-researched. It also raises the question of whether more local research and knowledge transfer are needed to effectively reduce disaster risk and impact.

International, interdisciplinary, and cross-sector scholarly collaborations may help answer pressing challenges posed by disasters worldwide. Further analysis is needed, in particular an exploration of the current state of collaboration in disaster science research, and how it might be leveraged to help achieve better outcomes for all.

1 United Nations Office for Disaster Risk Reduction (UNISDR). *Sendai Framework for Disaster Risk Reduction 2015-2030*; 2015. http://www.unisdr.org/we/inform/publications/43291

2 Murray, V., Maini, R., Clarke, L., Eltinay, N.; International Council for Science, Integrated Research on Disaster Risk. *Coherence between the Sendai Framework, the SDGs, the Climate Agreement, New Urban Agenda and World Humanitarian Summit, and the Role of Science in Their Implementation*; 2017. https://www.icsu.org/cms/2017/05/DRR-policy-brief-5-coherence.pdf

3 European Commission. Joint Research Centre. *Science for Disaster Risk Reduction*; 2014. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC76764/jrc_disater%20reportweb.pdf

Contents

Introduction

The World Economic Forum identified major disasters as one of the top five global risks in 2017.[4] The risk and impact of major disasters have been exacerbated by climate change, growth in population and urbanization, and environmental degradation.[5] These risk multipliers combine with other underlying factors—poverty, poor governance, and a degraded infrastructure—which further increase the severity of disaster impact on communities and populations. Disasters can be particularly devastating in poorer areas that are not as able to respond, putting a significant strain on humanitarian efforts to meet the needs of affected populations.[6] The growing impact of disasters has led to efforts to reduce the vulnerability and improve the resilience of nations, regions, and communities against disasters. As gains made by countries and regions toward sustainable development are often lost after a major disaster—for example, through destruction of human settlements and infrastructure, food production capacity, and sources of safe drinking water—it is increasingly understood that disaster management activities are essential to achieving the majority of UN sustainable development goals (SDGs).[7] In turn, sustainable development through land management, ocean conservation, and combating climate change can help reduce the risk and impact of disasters.

From disaster response to disaster management

During the last three decades, there has been a significant shift in focus from disaster response to a more comprehensive concept of disaster management. In 1994, the Yokohama Strategy for a Safer World was adopted at the World Conference on Natural Disaster Reduction, which recognized that directing resources towards natural disaster response was not only costly, but provided only a temporary benefit to affected communities.[8] The UN called for strengthening resilience to reduce the human and economic impact of natural disasters by addressing the entire disaster management cycle—prevention, preparedness, response, and recovery—through an integrated, cooperative global effort.[9] These efforts were also more explicitly linked to environmental protection and sustainable development. The Yokohama Strategy was reviewed in 2005 and led to the development of the Hyogo Framework for Action,[10] which further described the integration of natural disaster risk considerations into sustainable development policies to improve the resilience of communities to specific hazards.

In 2015, these two previous documents were expanded to create the Sendai Framework for Disaster Risk Reduction at the third UN World Conference on Disaster Risk Reduction.[11] The Sendai Framework outlines a global strategy for reducing disaster risk, increasing resilience, and decreasing the impact of disasters by: (1) supporting research to assess hazard characteristics, local exposure, local capacity to respond, and vulnerability; and (2) applying this knowledge to develop and implement evidence-based policy. Notably, the Sendai Framework expands the scope of disaster management to include all types of disasters and at all scales, with an emphasis on understanding disaster risk and building capacity for collaboration and information sharing across international, national, regional, and community levels and private and public sectors. This more holistic view of the disaster management cycle aims to build a strong science-policy interface with the capacity to evaluate the root causes and risk multipliers of disasters on a macro level, to inform data-driven policy.[12]

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4 World Economic Forum. *The Global Risks Report 2017*. 12th Edition. Geneva, Switzerland: World Economic Forum; 2017. http://www3.weforum.org/docs/GRR17_Report_web.pdf

5 United Nations Office for Disaster Risk Reduction (UNISDR). http://www.unisdr.org

6 United Nations Office for Disaster Risk Reduction (UNISDR). *UNISDR Strategic Framework 2016 – 2021*. Geneva, Switzerland: UNISDR; 2016. http://www.unisdr.org/files/51557_strategicframework.pdf

7 United Nations. Sustainable Development Goals. http://www.worldbank.org/en/topic/disasterriskmanagement; PreventionWeb. *Sendai Framework: Sustainable Development Goals with Targets Related to Disaster Risk*. http://www.preventionweb.net/drr-framework/sdg/target

8 United Nations. *Yokohama Strategy and Plan of Action for a Safer World. Guidelines for Natural Disaster Prevention, Preparedness and Mitigation*; 1994. https://www.unisdr.org/we/inform/publications/8241

9 United Nations Office for Disaster Risk Reduction (UNISDR). *Words into Action Guidelines*. Geneva, Switzerland: UNISDR; 2017. http://www.preventionweb.net/files/53055_npslpswiapublicconsultation2017.pdf

10 United Nations Office for Disaster Risk Reduction (UNISDR). *Hyogo Framework for Action 2005 – 2015: Building the Resilience of Nations and Communities to Disasters*; 2005. http://www.preventionweb.net/files/1037_hyogoframeworkforactionenglish.pdf

11 United Nations Office for Disaster Risk Reduction (UNISDR). *Sendai Framework for Disaster Risk Reduction 2015-2030*; 2015. http://www.unisdr.org/we/inform/publications/43291

12 Oliver-Smith, A. Alcántara-Ayala, I., Burton, I., Lavell, A.; *International Council for Science. Integrated Research on Disaster Risk. Forensic Investigations of Disaster (FORIN): Towards the Understanding of Root Causes of Disasters*; 2017. https://www.icsu.org/publications/disaster-risk-reduction-policy-briefs-2017; United Nations Office for Disaster Risk Reduction (UNISDR). *Work Programme 2016 – 2019*. Geneva, Switzerland: UNISDR; 2016. http://www.unisdr.org/files/51558_workprogramme.pdf

What is disaster science?

While the Sendai Framework emphasizes the critical role of science in developing evidence-based disaster risk reduction policies, the field of disaster science can be difficult to define.[13] It encompasses both the qualitative and quantitative study of disasters and their risk and impact. It can focus on specific types of disasters or individual disaster events, or investigate specific aspects of the disaster management cycle: prevention, preparedness, response, and recovery. It certainly entails a transdisciplinary approach that relies on input from and data sharing between academic researchers, policymakers, and practitioners at multiple levels, across both public and private sectors, and working on different time scales.

Evidence-based decision-making in disaster management

The importance of disaster science to disaster management is underscored by the Sendai Framework, which lists "Understanding disaster risk" as Priority 1, calling for strengthening "a science-policy interface for effective decision-making in disaster risk management."[14] Achieving this goal requires an expansion and better coordination of scientific activities, a focus on building cross-disciplinarity and communication between researchers, policymakers, and practitioners, greater training and education in disaster risk research, and engagement of both private and public sectors.[15]

> *Better knowledge, stronger evidence and a greater focus on transformative processes and innovation are essential to improve understating of risk, build resistance and risk-informed approaches to policymaking and contribute to smart, sustainable and inclusive growth.*
>
> Disaster Risk Management Knowledge Centre (DRMKC)[17]

Science and technology are critical to addressing all components of the disaster management cycle by informing evidence-based policy and practice.[16] Predicting where a disaster is most likely to occur requires the development and deployment of monitoring technologies and big data analysis. Geology, hydrology, and climatology, for instance, are key to understanding what causes disasters, what can be done to improve early warning systems, and how to lessen the frequency and severity of disasters. Engineering principles can be applied to improve infrastructure, building materials, land-use, and urban planning to lessen the impact of disasters. Science can shed light on the most effective way to deploy first responders and humanitarian aid to rapidly meet the needs of affected populations. Medicine and public health research can provide information on exposure to hazards and the short- and long-term health risks posed by disasters. The social sciences provide critical information about the culture, politics, and economics of at-risk areas to aid in policymaking and investment related to disaster management. Social science also contributes to a better understanding of the factors that underlie vulnerability to disasters—poverty, urbanization, education—and how best to engage communities on the topic of disaster risk. Finally, disaster science provides a mechanism for continuous testing and refining of disaster management processes and policies.

Promising areas of disaster science research identified by the DRMKC include climate services, nature-based solutions for building more resilient cities, dynamic earth observation and monitoring, and humanitarian aid personnel tracking.[17] In the European Union (EU), current research areas for the Joint Research Centre (JRC) include mapping population concentrations and types of buildings and understanding the risk of industrial or technological accidents after a natural disaster.[18] JRC is also a sponsor of INFORM,[19] a global, open-source risk assessment tool that can help inform decisions about disaster prevention preparedness and response. JRC is involved in efforts to improve the monitoring and forecasting of disasters, such

13 United Nations Office for Disaster Risk Reduction (UNISDR). *Words into Action Guidelines*. Geneva, Switzerland: UNISDR; 2017. http://www.preventionweb.net/files/53055_npslpswiapublicconsultation2017.pdf; European Commission Disaster Risk Management Knowledge Centre. *Science for Disaster Risk Management 2017: Knowing Better and Losing Less*. European Union: Luxembourg; 2017. https://ec.europa.eu/jrc/en/publication/science-disaster-risk-management-2017-knowing-better-and-losing-less

14 United Nations Office for Disaster Risk Reduction (UNISDR). *Sendai Framework for Disaster Risk Reduction 2015-2030*; 2015. p. 15. http://www.unisdr.org/we/inform/publications/43291

15 United Nations Office for Disaster Risk Reduction (UNISDR). Launching UNISDR Science and Technology Partnership and the Science and Technology Road Map to 2030. January 27-29, 2016; Geneva International Conference Centre; Geneva, Switzerland. http://www.preventionweb.net/files/45270_unisdrcnws4wg2capacitydevelopment.pdf; Fakhruddin B., Murray V., Maini R.; International Council for Science. Integrated Research on Disaster Risk. *Disaster Loss Data in Monitoring the Implementation of the Sendai Framework*; 2017. https://www.icsu.org/cms/2017/05/DRR-policy-brief-2-data.pdf

16 Basher R. *Science and Technology for Disaster Risk Reduction: A Review of Application and Coordination Needs*. Geneva, Switzerland: United Nations International Strategy for Disaster Reduction (UNISDR); 2013. http://www.preventionweb.net/posthfa/documents/Science-and-Technology-for-Disaster-Risk-Reduction.pdf; UNISDR. *Using Science for Disaster Risk Reduction. Report of the UNISDR Scientific and Technical Advisory Group – 2013*. Geneva, Switzerland: UNISDR; 2013. http://www.unisdr.org/we/inform/publications/32609

17 European Commission Disaster Risk Management Knowledge Centre. http://drmkc.jrc.ec.europa.eu/

18 European Commission. Joint Research Centre. Disaster Risk Reduction Portal. http://drr.jrc.ec.europa.eu/; European Commission. Joint Research Centre. *Science for Disaster Risk Reduction*; 2014. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC76764/jrc_disater%20reportweb.pdf

19 Index for Risk Management (INFORM). http://www.inform-index.org/

as through the Global Flood Partnership,[20] the Global Disaster Alert and Coordination System (GDACS), and European Flood Awareness System (EFAS). Other research is underway on monitoring technologies for rapid post-disaster needs assessment and use of social media and remote sensing technologies for assisting first responders.

> *It is great to see research on disaster risk management grow and to track how the discipline is evolving. GFDRR and The World Bank are helping developing countries create evidence-based risk management policies, using the latest research in the field. This report helps us stay up to date.*

Stephane Hallegatte
Lead Economist, Global Facility for Disaster Reduction and Recovery (GFDRR)

GFDRR is a multi-donor partnership, managed by the World Bank that helps developing countries better understand and reduce their vulnerabilities to natural hazards and adapt to climate change. Working with over 400 local and international partners, GFDRR provides knowledge, grant funding, and technical assistance.

Supporting disaster science research on a global scale

Several groups are helping to build the global, collaborative science-policy interface called for in the Sendai Framework, supporting cross-cutting research projects and dissemination of knowledge across all stakeholders. These groups include the International Council for Science,[21] which co-sponsors the Integrated Research on Disaster Risk Program;[22] the Association of Pacific Rim Universities Multi-Hazards Program,[23] initiated by the International Research Institute of Disaster Science;[24] The Risk Academy of the Global Risk Forum Davos;[25] The World Bank's Disaster Risk Management Program[26] and Global Facility for Disaster Reduction and Recovery;[27] and The International Federation of Red Cross and Red Crescent Societies.[28]

An analysis of disaster science research

Across all disaster management organizations, there is a unified call for global cooperation and networking among scientists, policymakers, and practitioners. This would strengthen disaster science research capacity at all levels and in all sectors as well as improve the broad transfer of knowledge and technology. It would also help inform policies to improve resilience to disasters.

Periodic assessment of the state of disaster science is essential to identify gaps in knowledge and review progress in resilience-building programs, investment, and development planning.[29] Elsevier, together with institutional partners and experts and in accordance with the goals of the Sendai Framework, seeks to contribute to these efforts with this quantitative analysis of disaster science research scholarly output from 2012 to 2016. In Chapter 1, the report analyzes global scholarly output in the field of disaster science and the specific topics being studied within research on different types of disasters. Chapter 2 then examines disaster science in the context of the human toll and economic burden of natural disasters, and focuses on the disaster science research being conducted in 10 individual countries in the Americas, Asia, and Europe, assessing which disaster types are being studied and where.

The report also contains insights from key thought leaders in the field of disaster management: Shuaib Lwasa from the Integrated Research on Disaster Risk (IRDR), Chadia Wannous from the UN Office for Disaster Risk Reduction (UNISDR), and Gordon McBean from the International Council for Science (ICSU), Future Earth: Research for Global Sustainability council, and the Institute for Catastrophic Loss Reduction.

The findings of this analysis may assist governments and research institutions in recognizing opportunities to build disaster science research capacity, forge international and regional partnerships, strengthen the science-policy interface, and engage stakeholder communities. In addition, funding agencies will be able to visualize where financial support might be allocated to strengthen disaster science research capacity, responsiveness, and impact.

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20 European Commission Global Flood Partnership. https://gfp.jrc.ec.europa.eu/
21 International Council for Science. https://icsu.org/
22 Integrated Research on Disaster Risk. http://www.irdrinternational.org/
23 Association of Pacific Rim Universities Multi-Hazards Program. http://apru.org/partnering-on-solutions/multi-hazards-program
24 International Research Institute of Disaster Science. http://irides.tohoku.ac.jp/eng/index.html
25 Global Risk Forum Davos. https://grforum.org/
26 The World Bank. Disaster Risk Management. http://www.worldbank.org/en/topic/disasterriskmanagement; World Bank Group, Global Facility for Disaster Reduction and Recovery. *Investing in Urban Resilience*; 2015. http://documents.worldbank.org/curated/en/739421477305141142/pdf/109431-WP-P158937-PUBLIC-ABSTRACT-SENT-INVESTINGINURBANRESILIENCEProtectingandPromotingDevelopmentinaChangingWorld.pdf
27 Global Facility for Disaster Reduction and Recovery. https://www.gfdrr.org/
28 International Federation of Red Cross and Red Crescent Societies. Capacity Building for Disaster Risk Management. http://www.ifrc.org/en/get-involved/learning-education-training/research/capacity-building-for-disaster-risk-management/
29 Aitsi-Selmi A., Murray V., Wannous C., et al. Reflections on a science and technology agenda for 21st century disaster risk reduction. *Int J Disaster Risk Sci.* 2016;7:1-29. doi:10.1007/s13753-016-0081-x

Interview

Shuaib Lwasa

Committee Chair, Scientific Committee,
Integrated Research on Disaster Risk (IRDR)

How have you and the Integrated Research on Disaster Risk (IRDR) program been engaged in the field of disaster science?

My role in disaster science has been on two levels: one as an independent scientist working on disaster issues and the other as science committee chair of the Integrated Research on Disaster Science (IRDR) program. The IRDR is taking an integrated, interdisciplinary scientific approach to understanding disaster risk, as well as developing the interface between science and practice so that evidence informs policy in the disaster risk area. At the IRDR, my specific role has been to respond to the demand for science-informed policy regarding disaster questions. For example, disasters can cause severe economic losses and substantial destruction to governments and institutions at a national level. So, we have conducted research and provided knowledge about ways to mitigate these losses that lead to policy recommendations. We share scientific knowledge and information with different levels of policymaking bodies, for instance the UNISDR in a preparatory meeting for the Sendai meeting, where the Sendai Framework for Disaster Risk Reduction was adopted in 2015. The IRDR has also provided leadership on scientific outputs in the development of a risk reduction framework.

What role does science play in disaster risk reduction?

The impact of disasters is felt on a community scale that is usually much smaller than the geographic scale in terms of area. So, the science that strives to reduce the risk of disasters needs to be linked to those areas where disasters occur. The IRDR International Centers of Excellence in Canada, Uganda, and various areas in Japan, and China, provide leadership and science-based information products to help inform policy to improve disaster response as well as reduce risk. Policies on disaster recovery must take into account disaster risk reduction—development efforts must focus on reducing the impact of future disasters. This is where science is most helpful. As an example, the response to drought risk in large parts of East Africa has included the development of new policies regarding the use of the natural resources of grasslands and water to try and reduce the impact and losses related to drought. Our scientific outputs played a direct role in informing decisions regarding natural resource management. In the USA, the South Carolina IRDR International Center of Excellence has provided real-time data on floods and disaster loss that is now being used to inform risk reduction responses to flooding. IRDR International Centers of Excellence sometimes work with policy makers. In Canada, the International Center for Excellence is providing guidance on the reduction of loss to infrastructure and housing associated with extreme water events locally and in other parts of the world. In each of these examples, disaster risk reduction knowledge is being leveraged directly into policy development.

Is there information in the report that you think is particularly interesting, unusual, or likely to have an effect on the development of the field looking forward?

The link between disasters and the UN sustainable development goals (SDGs), and how disaster risk reduction is essential to meeting several of the SDG targets, is very critical. Another important point is the shift in focus away from disaster response and toward reducing the risk of disasters and building resilience. This is underscored in the report by the impressive volume of publications on prevention and preparedness. The prevention and preparedness work will lead directly to resilience building. If science continues to generate knowledge on prevention and preparedness, we will be better able to inform risk reduction policy.

Thinking about the future of disaster science and the conclusion of the Sendai Framework timeline, where do you think disaster science will be by 2030?

Something that is of great interest to the community at the moment is the move toward integrated, transdisciplinary disaster science. I see this as the future of the disaster science field for 2030 and beyond. I would like to see more capacity building in transdisciplinary approaches that would help with risk-informed policy development. I predict that disaster science will actually change the policy development paradigm in such a way that any future planning for development, investment, economics, and social cultural issues will take disaster risk into account, and in that way, will move societies and countries to build resilience. So in 2030 and beyond, I foresee that the work around preparedness and prevention will intensify, as will application of this research into forging the path to resilience.

CHAPTER 1

Global perspective on disasters and disaster science

For this report, we rely upon the knowledge of internationally recognized disaster science experts to help us define the field of disaster science. The many implications of disasters require multidisciplinary approaches that harness expertise across scientific disciplines.

In addition to disaster science as a whole, we also examine the stages of the disaster management cycle and specific disaster types, following UNISDR definitions.[30,31] This is important as research per disaster category is crucial to understanding and therefore managing disaster risk.[32] Aligning to the Sendai Framework also facilitates potential future analyses to understand the progress made under the framework and how science can further support it.

Identifying scholarly output in disaster science
We adopt a keyword-search approach to identify the relevant corpus of disaster science. We focus our search on those publications that strictly adopt a disaster science perspective, thereby also ensuring consistency across the different corpora. All data are restricted to peer-reviewed publications, so that the publication sets are fundamentally scholarly in nature.

> *To achieve substantial reduction in disasters, we need to shift the focus of our efforts from managing disasters to managing risks. This requires adopting an evidence-based, all-hazards, multi-sectoral approach to disaster risk reduction. By providing a detailed analysis of recent scholarly output and impact in disaster science, this report contributes to the evidence base for disaster risk reduction and will help inform risk reduction policy development and implementation.*

Chadia Wannous
Senior Advisor,
UN Office for Disaster Risk Reduction (UNISDR)

30 United Nations Office for Disaster Risk Reduction (UNISDR). Sendai Framework for Disaster Risk Reduction. *Suggested List of Hazards for the Purpose of Measuring Global Targets of the Sendai Framework.* http://www.preventionweb.net/files/47137_proposedlistofhazardsforglobaltarge.pdf

31 United Nations Office for Disaster Risk Reduction (UNISDR). *Sendai Framework for Disaster Risk Reduction 2015-2030*; 2015. http://www.unisdr.org/we/inform/publications/43291

32 European Commission Disaster Risk Management Knowledge Centre. *Science for Disaster Risk Management 2017: Knowing Better and Losing Less.* European Union: Luxembourg; 2017. https://ec.europa.eu/jrc/en/publication/science-disaster-risk-management-2017-knowing-better-and-losing-less

Disaster science

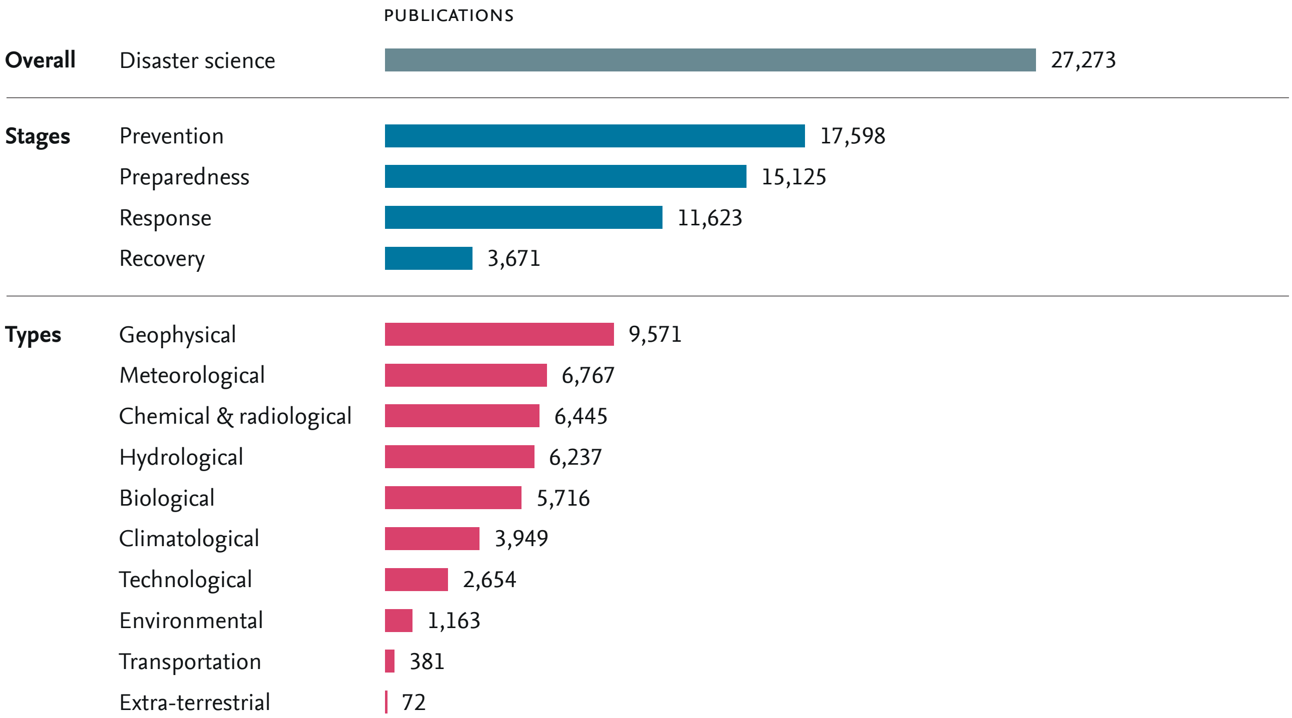
A first examination of the total corpus of disaster science scholarly output, as depicted in *Figure 1.1*, shows three main types of concepts emerging most prominently, revealing the current foci of the field:

- The disaster management cycle as a whole and its stages, most notably disaster prevention
- Specific disasters, most of which are recent, such as the Fukushima nuclear accident, Hurricane Katrina, the Chernobyl nuclear accident, and various earthquakes (Tohoku, Haiti, Wenchuan, Sichuan)
- Specific disaster types such as tsunamis, nuclear reactor accidents, geological disasters, natural hazards, and meteorological disasters

Figure 1.1 *— Most frequent concepts in disaster science relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Figure 1.2 indicates that in the last 5 years, over 27,000 disaster science papers were published globally. This represents 0.22% of the world's total scholarly output. Further analysis indicates that a fairly substantial proportion of disaster science research has an explicit policy focus: 7.5% of disaster science publications contain the word "policy" in their title, abstract, or keywords.

Figure 1.2 *— Disaster science scholarly output overall, by disaster management cycle stage, and by disaster type according to the Sendai Framework; 2012-2016; source: Scopus®.*



> *The extensive body of research summarized in this document represents our continually expanding understanding of the state of disaster science. We generally consider disasters to consist of the four stages of anticipation, mitigation, response, and recovery. While we cannot prevent significant natural disasters, through research and collaboration, we can hope to contain their effects, and to stop them from becoming significant humanitarian disasters.*

John Rundle
Distinguished Professor,
Departments of Physics and Geology,
University of California, Davis

Similarly, 7.4% of disaster science research is firmly rooted in the real word via an explicit mention of the phrase "case study" in the publication title, abstract, or keywords.

Prevention and Preparedness are the most researched disaster management cycle stages, with over 15,000 papers each. Natural Language Processing analyses on the phases of the disaster management cycle reveal that it appears to be more of a continuum rather than a clear-cut juxtaposition of stages. This interlink may also reflect how the research community's work addresses several aspects of the continuum at once, and/or reviews specific stages in the context of disaster management overall.

On a global level, the relative size of output on specific disaster types roughly corresponds to the relative frequency and impact of such disasters, showing an alignment between disasters and disaster science. The UNISDR report *Poverty & Death: Disaster Mortality 1996-2015* states that "of the 1.35 million people killed by natural hazards over the past 20 years, more than half died in earthquakes, with the remainder due to weather- and climate-related hazards."[33] The broader and/or most impactful disaster type categories, such as geophysical, meteorological, chemical & radiological, and hydrological, have over 5,000 papers each in 2012-2016, while the corpus of research on geophysical disasters alone approaches 10,000 papers *(see Figure 1.2 on previous page)*, echoing findings from the 2016 *Association of Pacific Rim Universities (APRU) Impact Report.*[34]

The following analyses show that concepts relating to specific disasters and disaster types may appear in more than one set of publications. This reflects both the non-mutually exclusive nature of the Sendai framework, as well as the multidisciplinary aspect of disaster science itself. Research on specific disaster types also contains several concepts that apply to various disaster management cycle stages. Research on some disaster types seems to be more focused on certain stages of the cycle than others. Disaster management and prevention are particularly frequent in research on geophysical disasters, appearing in 15% or more of papers. They are also present in 10% or more of papers on climatological, geophysical, and meteorological disasters. Disaster prevention appears in 10% of papers on environmental disasters.

> *It is encouraging to see that research into the reduction of technological accident risk is increasingly accepted as an integral part of disaster science. This reflects the recognition that a multi-hazards approach is needed for effective disaster risk reduction globally.*

Elisabeth Krausmann
Principal Scientist,
Directorate Space, Security and Migration,
Joint Research Centre, European Commission

Ian Clark
Head of Unit,
Disaster Risk Management,
Joint Research Centre, European Commission

33 United Nations Office for Disaster Risk Reduction (UNISDR). *Poverty & Death: Disaster Mortality 1996-2015.* https://www.unisdr.org/we/inform/publications/50589
34 Association of Pacific Rim Universities (APRU). *APRU Impact Report 2016.* https://apru.org/about/secretariat/item/660-apru-impact-report-2016

Geophysical disasters

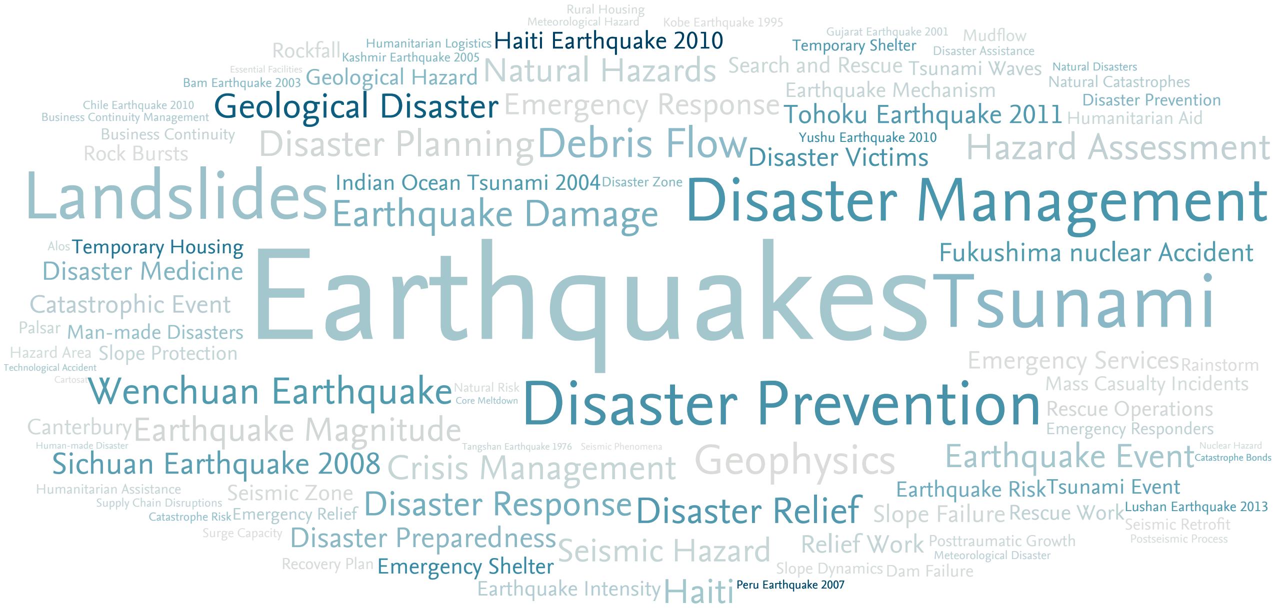


Figure 1.3 shows that research on geophysical disasters focuses on geological hazards, notably earthquakes, tsunamis, and landslides, as well as disaster management and prevention. Concepts mentioning specific recent disasters (e.g., Peru earthquake 2007, Haiti earthquake 2010) are particularly prominent in the geophysical disasters set of papers, reinforcing the close connection between the research and specific disaster events. Disaster response is apparent through concepts such as temporary housing and emergency shelter.

Figure 1.3 *— Most frequent concepts in disaster science on geophysical disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Meteorological disasters

Figure 1.4 shows that the body of research on meteorological disasters contains many publications on storms and floods as well as disaster management and prevention. Concepts mentioning specific recent disasters (e.g., Typhoon Haiyan 2013, Hurricane Sandy 2012, Hurricane Katrina 2005) are particularly prominent in the meteorological disaster set of publications, reinforcing the close connection between the research and specific disastrous meteorological events.

Figure 1.4 *— Most frequent concepts in disaster science on meteorological disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Chemical & radiological disasters

Figure 1.5 shows that research on chemical & radiological disasters includes many publications on accidents, in particular nuclear reactor accidents, and also on nuclear power plants. Relative to the overall frequency of concepts in the whole database, the 2011 Fukushima nuclear accident stands out. Other relatively frequent concepts include oil disaster, chemical hazard release, and several terms relating to biohazard or radioactive pollution, pointing to a focus of research on the consequences of chemical & radiological disasters.

***Figure 1.5** — Most frequent concepts in disaster science on chemical & radiological disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Hydrological disasters

Figure 1.6 shows that research on hydrological disasters contains many publications on floods and landslides as well as disaster management and prevention. These last two concepts are also particularly prominent, as are geological, meteorological, and agricultural disasters, demonstrating the multi-faceted causes and consequences that hydrological disaster events can have.

***Figure 1.6** — Most frequent concepts in disaster science on hydrological disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Biological disasters

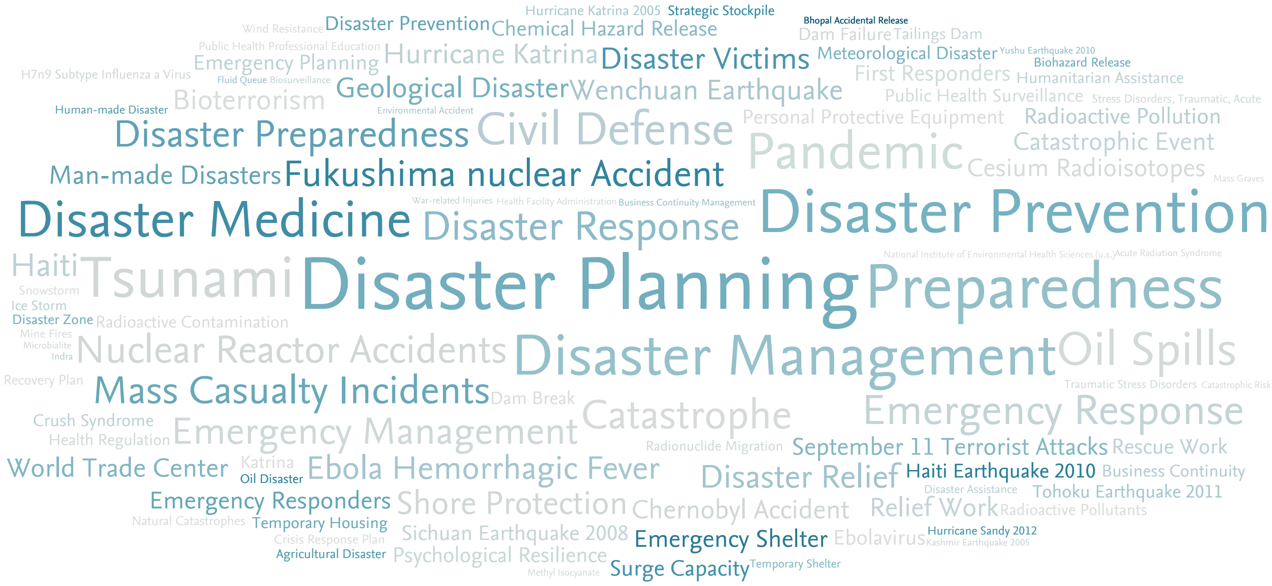


Figure 1.7 shows that research on biological disasters contains many publications on disaster management and various stages of the disaster management cycle, such as disaster planning, prevention, and preparedness. A large proportion of publications also mention specific hazards spanning across various disaster types (e.g., tsunami, pandemic, oil spills, nuclear reactor accident), revealing the variety of origins that biological disasters can have. Specific disastrous occurrences are particularly prominent (e.g., Haiti earthquake 2010, Fukushima nuclear accident, Hurricane Sandy 2012). The importance of studying how to respond to this type of disaster is indicated by the relatively high frequency of concepts such as emergency shelter, strategic stockpile, or surge capacity.

***Figure 1.7** — Most frequent concepts in disaster science on biological disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Climatological disasters

Figure 1.8 shows that research on climatological disasters contains several publications on droughts and fires as well as disaster management and prevention. This last concept is particularly prominent, as are meteorological and agricultural disasters, reflecting how disastrous climatological events may overlap with various disaster types. Hurricane Sandy also has high relative frequency in this set of publications.

***Figure 1.8** — Most frequent concepts in disaster science on climatological disasters relative to the overall frequency of concepts in Scopus®; size represents number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Technological disasters

Figure 1.9 shows that research on technological disasters includes many publications on explosions, industrial accidents, and oil spills, as well as disaster management and prevention. This last concept is particularly prominent, as are oil disasters, chemical hazard release, and mine and gas explosions. The Fukushima nuclear accident also has high a relative frequency in this set of publications. All of these concepts reflect the diverse nature of technological disasters.

***Figure 1.9** — Most frequent concepts in disaster science on technological disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Environmental disasters

Figure 1.10 shows that research on environmental disasters includes many publications on erosion, floods, and landslides, as well as disaster management and prevention. This last concept is particularly prominent, as is geological disaster, reflecting how disastrous environmental events may have diverse causes. There are also several concepts relating to fires that have particularly high relative frequency in this set of publications, reinforcing the preponderance of this hazard type in research on environmental disasters.

***Figure 1.10** — Most frequent concepts in disaster science on environmental disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing the concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Transportation disasters

Figure 1.11 must be interpreted with caution as the corpus of research on transportation disasters is small. Concepts such as accidents, aircraft accidents, and aviation appear in the largest number publications, dominating the corpus because most recent large-scale transportation disasters involve planes. This focus is also reflected in the most frequent concepts relative to the overall frequency of concepts in the whole database (e.g., pilot error, aircraft accidents, aviation safety, aircraft safety).

***Figure 1.11** — Most frequent concepts in disaster science on transportation disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Extra-terrestrial disasters

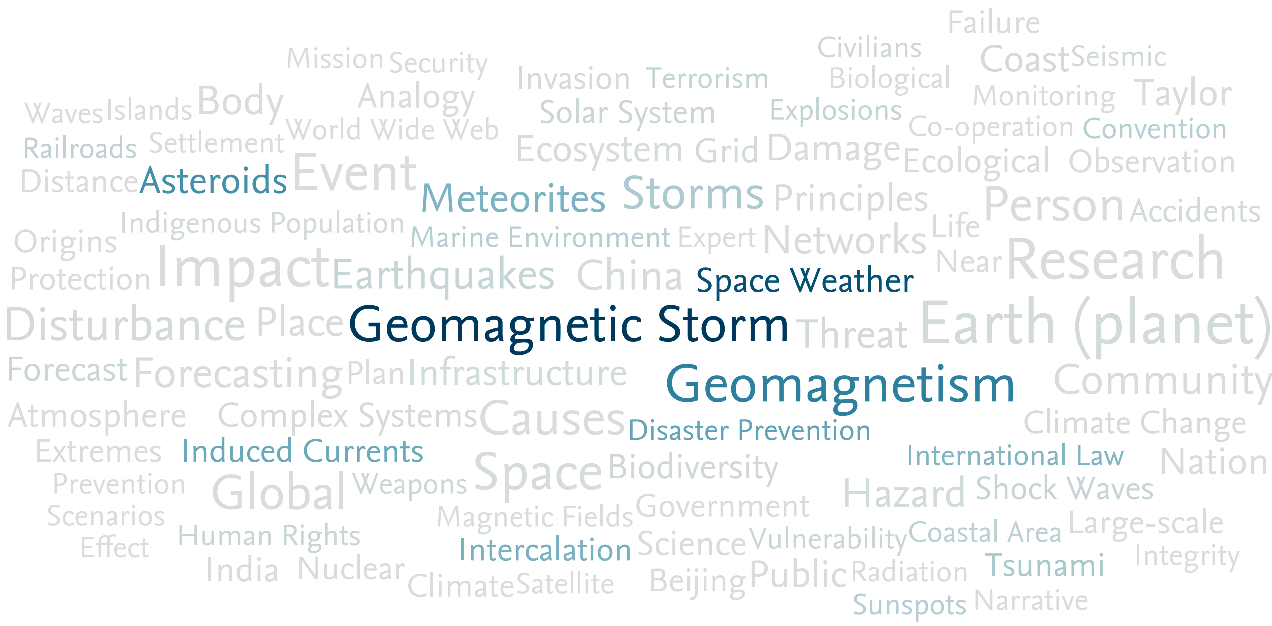


Figure 1.12 must be interpreted with caution as the corpus of research on extra-terrestrial disasters is very small. Concepts such as Earth, impact, geomagnetism, and space appear in the largest number of publications. Relative to the overall frequency of concepts in the whole database, geomagnetic storm, space weather, geomagnetism, and asteroids are particularly prominent in the set of publications, and the most visible disaster management cycle stage is disaster prevention.

***Figure 1.12** — Most frequent concepts in disaster science on extra-terrestrial disasters relative to the overall frequency of concepts in Scopus®; size represents the number of publications containing that concept; shade represents the concept's relative weight; 2012-2016; sources: Scopus® and Elsevier Fingerprint Engine™.*

Interview

Chadia Wannous

Senior Advisor, UN Office for Disaster Risk Reduction (UNISDR)

How have you been engaged in the field of disaster science?

I have been working on disaster risk reduction and emergency preparedness for more than a decade, in close collaboration with researchers and other stakeholders. I joined UNISDR in early 2015, where I have applied my background and experience in the science of reducing risks to the implementation of the Sendai Framework for Disaster Risk Reduction (DRR), paying particular attention to biological and man-made hazards.

What is the role of science in disaster risk reduction?

The role of science and technology in shaping policies and practices to reduce disaster risk is vital. Science is informing evidence-based policymaking in disaster risk reduction, providing data to not only better understand the risks, but also to inform governments and the private sector as they drive investment in sound interventions and assessment of their impact over time. Taking a systematic approach to encouraging greater interaction between scientists, DRR practitioners, and policymakers represents an important step towards enhancing the access and application of science and technology to decision making. In January of 2016, UNISDR organized an international conference attended by 700 scientists, policymakers, and other stakeholders from the private sector, NGOs, and the media. At the conference, the science and technology partnership for DRR was launched and a roadmap was adopted that outlines the key outcomes and actions the science community and its partners need to take to support the implementation of the priorities of the Sendai Framework.

What information in this report did you find particularly interesting or that is likely to have an effect on the development of the field looking forward?

There are two results from the report that I would like to comment on. First, countries with the highest death toll for natural disasters tend to have low scholarly output in disaster science. This is a very important finding not only for the scientific community but also for policymakers—there is a need to invest in more research or seek out partnerships to build research capacity in these countries, including through south-south collaborations. Second, the share of disaster science research to global scholarly output is only 0.2 percent, which is very low. We must work to increase the volume and quality of research being done in the disaster science field to address key gaps in our knowledge. In particular, we need to support local research efforts to focus on smaller and more frequent disasters—what we call extensive risks—that affect mostly developing countries and have a devastating impact on human and social capital as well as on development gains. These countries will benefit from collaborative research and transdisciplinary approaches that link disaster risk reduction to the achievement of sustainable development goals, the Paris Agreement on climate change, and the new urban agenda.

What parts of the report do you think are important for policymakers or institutional leaders?

The report highlights the importance of the social and the economic aspects of disasters and the need for transdisciplinary research to consider issues such as the cost of disasters, social protection and safety nets during and after disasters, and communicating the risks associated with different types of hazards. The report very clearly points out the need for both public and private investments in disaster risk reduction based on the available scientific evidence. The report also highlights the need for more international collaboration between researchers in industrial countries and developing countries to help build research capacity.

Thinking about the future of disaster science and the conclusion of the Sendai Framework timeline, where do you think disaster science will be by 2030?

Currently, there is increased attention on the role of science and technology in addressing global challenges—disaster risk reduction, climate change, and urbanization—in order to achieve the UN's Sustainable Development Goals. As a result, I expect by 2030 we will see more targeted funding for research that specifically addresses related gaps in knowledge, policy, and practice and for solution-driven, interdisciplinary research. We will also see a greater dialogue and collaboration between researchers and policymakers, with researchers sharing scientific evidence in a timely manner with national and local institutions and policymakers and in a way that is adapted to their needs. Among policymakers, we will see an increased commitment to greater application of scientific evidence to develop effective measures to reduce risks. We will also be better at translating research into clear messages about reducing disaster risks that the public can understand and that facilitate their involvement in DRR, particularly at the local level.

CHAPTER 2

Country focus on disasters and disaster science

Disasters come in many forms, as we have seen in the previous chapter. The burden of disaster is not uniform: certain countries appear to be disproportionately affected by specific disaster types. Likewise, disaster science research activity has a distinct pattern across the world. In this chapter, we compare key countries and regions, both in terms of their output specialization and in terms of their scholarly impact.

2.1 Research activity versus disaster impact per country

Natural disasters alone are estimated to have claimed 1.35 million lives in the past 20 years.[35] The human toll of disaster is unevenly spread across regions: eight of the ten countries with the most deaths from disasters in 2004-2013 are in Asia. While overall country and population size plays a part in the absolute number of deaths a country sustains from disasters, it is not a sole determinant: Haiti alone suffered nearly 230,000 deaths from disasters in 2004-2013. It is also the country most affected when deaths are normalized by population size, followed by Myanmar and Sri Lanka. Indeed, the UNISDR finds that "the overwhelming majority of [...] deaths occurred in low- and middle-income countries. The poorest nations paid the highest price in terms of the numbers killed per disaster and per 100,000 population."[36]

35 United Nations Office for Disaster Risk Reduction (UNISDR). *Poverty & Death: Disaster Mortality 1996-2015.* https://www.unisdr.org/we/inform/publications/50589
36 Ibid.
37 United Nations Office for Disaster Risk Reduction (UNISDR). *Global Assessment Report on Disaster Risk Reduction 2015.* http://www.preventionweb.net/english/hyogo/gar/2015/en/home/GAR_2015/GAR_2015_1.html

Economic losses from natural disasters are estimated at USD 250-300 billion per year,[37] and are also unequally distributed, with several large countries heavily affected in absolute terms. When this economic burden is normalized by GDP, Haiti again appears particularly impacted, in second place behind Belize. The top 10 countries on the list are mostly from Africa and Asia, reflecting the heavy economic burden that disasters can have on emerging economies. This is illustrated in the world maps in *Figure 2.1*, in which the shade of each country depicts its death toll (relative to country population) and *Figure 2.2* which shows economic loss (relative to country GDP).

Figures 2.1 and *2.2 (see next pages)* also demonstrate that disaster science scholarly output seems to follow the global distribution of overall scholarly output patterns—prolific countries overall tend to have relatively large outputs in disaster science. China (6,301) and the United States (USA; 6,287) have the largest number of recent publications in the field of disaster science followed by Japan (4,017) and the United Kingdom (UK; 1,351). These countries are also in the global top 5 in recent research overall, but with a different order: the USA has the largest scientific output overall, followed by China, the UK, Germany, and Japan. The fact that China and Japan are prominent in the disaster science field may not be surprising, as the Asian region is prone to many disasters. Looking deeper into the data, nine out of the ten most prolific institutions in terms of scholarly output are in China and Japan, with the Chinese Academy of Sciences being first, and the University of Tokyo second. The first non-Asian institution is Columbia University, ranked tenth in terms of volume.

Beyond China and Japan, other Asian countries are also relatively specialized in disaster science. For instance, among the territories with 125+ recent disaster science papers, the Philippines, Indonesia, Bangladesh, Japan, New Zealand, Thailand, and Taiwan have each published more than 50% as much in disaster science compared to global publication patterns. Among the countries with 50+ recent papers in disaster science, the Philippines, Nepal, Indonesia, Sri Lanka, Bangladesh, and Japan have published more than twice as much in disaster science relative to the global publication distribution. Being more specialized in the field does not mean that all of these countries have large corpora of research on disaster science, however, especially when their overall scholarly output is small.

In fact, many emerging areas of the world with the highest relative burden of disaster cost are limited in scholarly output in disaster science. For instance, Belize has the highest disaster economic loss as share of GDP but only one recent publication in the field of disaster science. Haiti has the second highest disaster economic loss as share of GDP, but only 42 recent publications in the field, while Madagascar has the third highest disaster economic loss as share of GDP but no recent publication in the field.

Counting publications per country
Our analysis makes use of whole rather than fractional counting, meaning that internationally-collaborated papers count once for each collaborator country. So a publication with one author in the United States and one author in China counts as one publication for the United States and one publication for China.

Relative activity index (RAI)
RAI is calculated by dividing the share of a country's output in a particular field relative to the share of the world's output in that same field. It therefore represents how concentrated a country's output is in a particular area relative to the world average and can be used to estimate specialization in a particular field. For instance, 0.66% of Japan's scholarly output is in Disaster Science, compared to 0.22% of the global scholarly output. Japan's RAI in disaster science is therefore 0.66/0.22=3.

Similarly, many emerging areas of the world with the heaviest relative human death toll from disasters are limited in scholarly output in disaster science. For instance, Haiti has the highest human death toll relative to its population. Myanmar has the second highest human death toll relative to its population but only nine recent publications in the field. Sri Lanka has the third highest human death toll relative to its population and although its scholarly output is highly specialized in disaster science, its total recent output in the field consists only of 51 papers.

For the countries most affected by disasters, the current analysis suggests that international collaboration in disaster science research would be particularly crucial, as it would help increase their scholarly output in the field.

> *Until recently, our knowledge of how disasters occur has been empirical. Disaster management as a science is very young. The challenge now is to understand why disasters occur and how they will occur in the future. It is also important to construct a bridge between geological, hydrological, and meteorological events and their social and economic impacts to know more about disasters and work towards disaster risk reduction. A platform that contains global information about the current status of disaster science is very welcome and timely.*

Osvaldo de Moraes
Head, National Center for Alerting and Monitoring of Natural Disasters (CEMADEN), Brazilian Ministry of Science, Technology and Innovation

Natural disasters death toll versus disaster science output & specialization

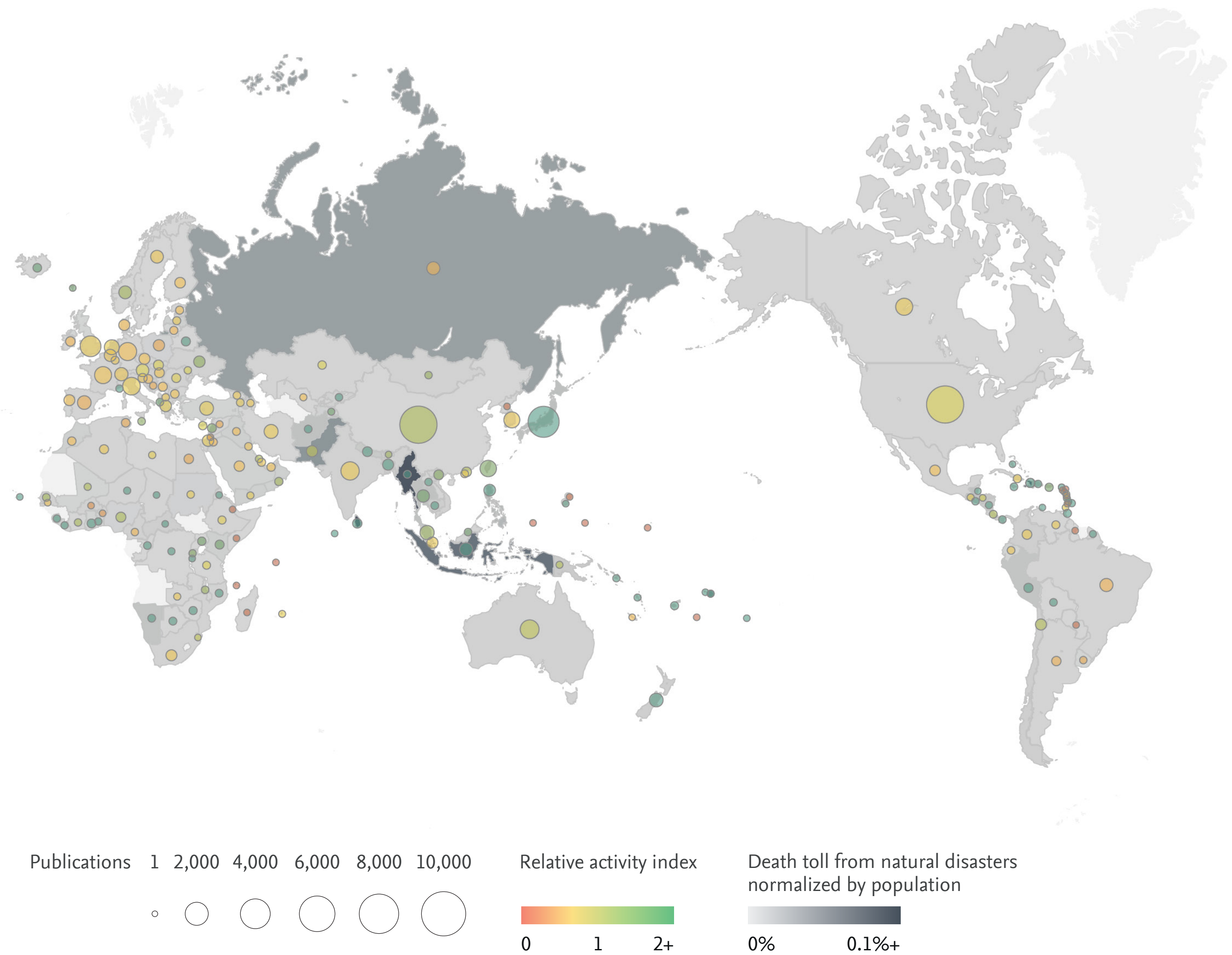


Figure 2.1 *— 2004-2013 natural disasters death toll as a share of population (shade of country), disaster science 2012-2016 scholarly output (size of circle), disaster science 2012-2016 relative activity index (RAI, color of circle); sources: Scopus®, IFRC 2015 Disaster Report, World Bank, and Taiwan Statistical Data book.*

Natural disasters economic loss versus disaster science output & specialization

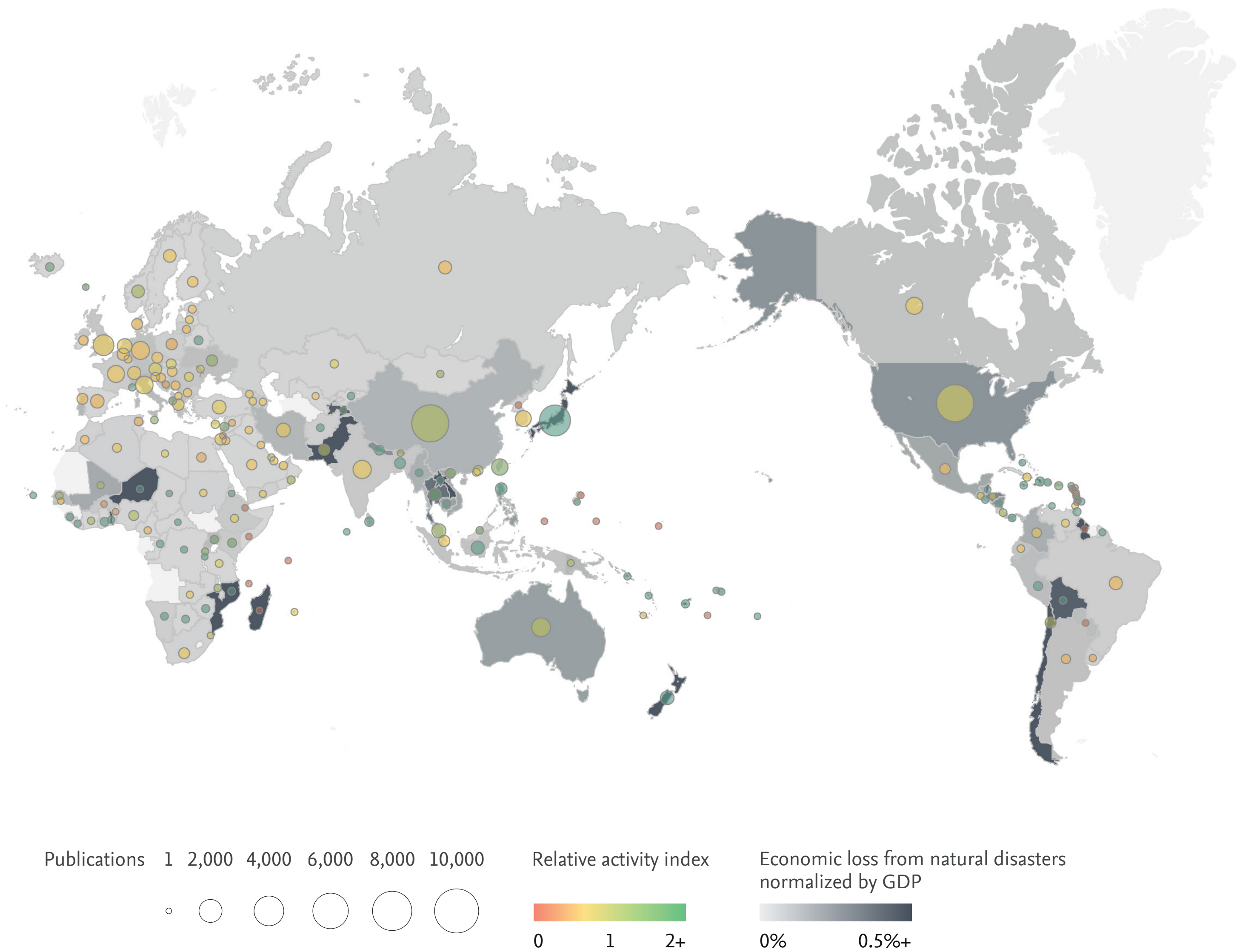


Figure 2.2 *— Natural disasters economic loss, calculated as the most recent available rolling annual average loss normalized to the most recent available annual GDP (shade of country), disaster science 2012-2016 scholarly output (size of circle), disaster science 2012-2016 relative activity index (RAI, color of circle); sources: Scopus®, Global Assessment Report on Disaster Risk Reduction Cycle 2015, and World Bank.*

> Academia and researchers have a certain level of responsibility and play important roles in disaster management – through education, inquiry, and social contribution. The link between disaster research and practice or policymaking is not strong enough, and research outcomes have not been sufficiently leveraged into practice. It is crucial to strengthen the collaboration between researchers, practitioners, and policymakers, to understand local needs, and to conduct collaborative research with countries that are particularly vulnerable to disaster risks.

Takako Izumi
Associate Professor, International Research Institute of Disaster Science (IRIDeS), Tohoku University; Director, APRU Multi-Hazards Program

Do countries that suffer disproportionally from disaster occurrence conduct more disaster research? The previous section gave anecdotal evidence. *Figure 2.3 (see next page)* examines this question systematically, by plotting natural disaster burden against disaster scholarly output for each country, in absolute and relative terms. The data suggests that disaster burden, both human and economic, is unevenly distributed.

Countries with the highest death tolls from natural disasters tend to have low volumes of scholarly output in disaster science. Conversely, countries with the highest numbers of disaster science publications tend to suffer relatively low death tolls *(upper left panel)*. These countries also tend to encounter high economic loss from natural disasters *(lower left panel)*. Countries with the highest scholarly output in disaster science are intensive research nations that also lead in overall scholarly output. It can therefore be hypothesized that one underlying variable in the uneven distribution of disaster science research may be overall GDP. Typically, a higher GDP permits higher investments in research, with more funding for research overall and in disaster science, which leads to greater scholarly output. It may also result in a resilient infrastructure that can help save lives and therefore reduces the human toll of natural disasters. A higher GDP may also allow for a more complex and expensive infrastructure, which in turn may lead to greater economic loss from natural disasters.

These hypotheses are to some extent influenced by size, for which we can account by normalizing the data. We do this by looking at scholarly output specialization in terms of the relative activity index (RAI), while putting the death toll in the context of population and the economic burden in the context of GDP. Still, the proportion of countries that is highly specialized in disaster science is higher among countries with a relatively heavy death toll due to natural disasters than among countries with a relatively low death toll from natural disasters *(upper right panel)*. Similarly, the proportion of countries highly specialized in disaster science is higher among countries with a relatively high economic burden due to natural disasters than among countries with a relatively low economic burden from natural disasters *(lower right panel)*.

> To promote integrated, inter- and transdisciplinary disaster research, we need to focus the mindset of researchers as well as research managers and research funders. It is the overall research ecosystem that needs change, toward need-based innovation in disaster science.

Rajib Shaw
Professor, Keio University; Member, UNISDR STAG (Science and Technology Advisory Group)

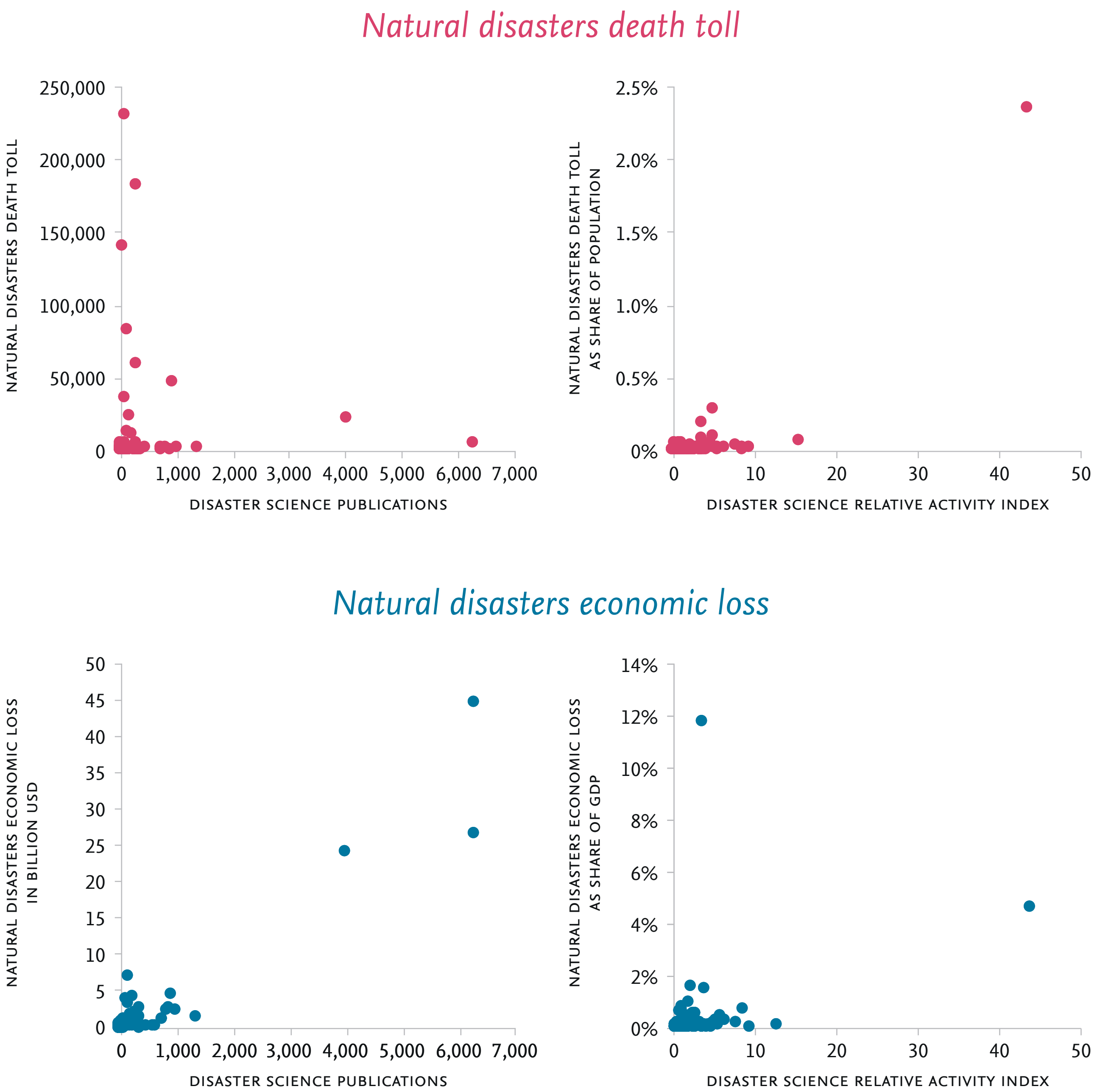


***Figure 2.3** — Upper panel left: 2004-2013 natural disasters death toll versus 2012-2016 publications in disaster science per country. Upper panel right: 2004-2013 natural disasters death toll as share of population versus 2012-2016 relative activity index (RAI) for disaster science scholarly output per country. Lower panel left: natural disasters economic loss, calculated as the most recent available annual rolling average loss, versus 2012-2016 publications in disaster science per country. Lower panel right: natural disasters economic loss, calculated as the most recent available annual rolling average loss normalized to the most recent available annual GDP, versus 2012-2016 RAI for disaster science scholarly output per country. Sources: Scopus®, Global Assessment Report on Disaster Risk Reduction Cycle 2015, IFRC 2015 Disaster Report, World Bank, and Taiwan Statistical Data book.*

2.2 Patterns for key countries in disaster science

Apart from output volume, we look at the impact of research through its field-weighted citation impact (FWCI). *Figure 2.4* shows that Japan stands out. It publishes a lot in disaster science and is also highly specialized (nearly three times as much as the global average) in the disaster science field. In addition, Japan's publications in disaster science are more impactful than the global average and more impactful than its own overall research output. However, high output or specialization in disaster science does not necessarily lead to high citation impact. For instance, although European countries tend to be less specialized in disaster science, they have a strong output and high citation impact in the field, exceeding that of their respective overall research performance. The USA is also not particularly specialized in the disaster science field but nevertheless prolific, and its FWCI is more in line with that of its overall research. Brazil publishes few papers in disaster science, and has little specialization in this area, but it has a high FWCI for its disaster science research output, both in absolute terms and compared to its overall research performance. India's FWCI in disaster science is also higher than the world average and markedly superior to its overall research performance. China shows a reverse pattern, with high output and specialization in the field, but low citation impact, both compared to the world average and its own overall performance. Mexico's extreme FWCI is caused by a couple of highly collaborative papers with very high FWCI that skew the FWCI calculation due to the relatively low number of papers from Mexico in disaster science. As such, it is not an accurate reflection of the overall citation impact of the country in disaster science, but rather shows the effect that collaborations can have on a country's research impact. To a lesser extent, this also affects Brazil's FWCI.[38]

Field-weighted citation impact (FWCI)
Scholarly communications build upon each other: if previously published work is relevant to scientists' research, they will strive to read it and then reference it in their own forthcoming publications. We can therefore evaluate the scholarly impact of research by using these citations. Citation patterns differ by field: there are more, faster citations in the biomedical sciences than in mathematics, for instance. They likewise tend to vary by publication type. Finally, citations take time to accrue: scientists first need to read publications, do their own research, and then publish their own results including any references to previous work. Only when their publications are indexed in a database can the citations be counted. So the longer since a paper has been published, the more time it has had to be read, referenced, and indexed. To normalise for these three factors (scope, type, and age) we use field-weighted citation impact: an indicator of mean citation impact that compares the actual number of citations received by a publication with the expected number of citations for publications of the same document type, publication year, and subject area(s).

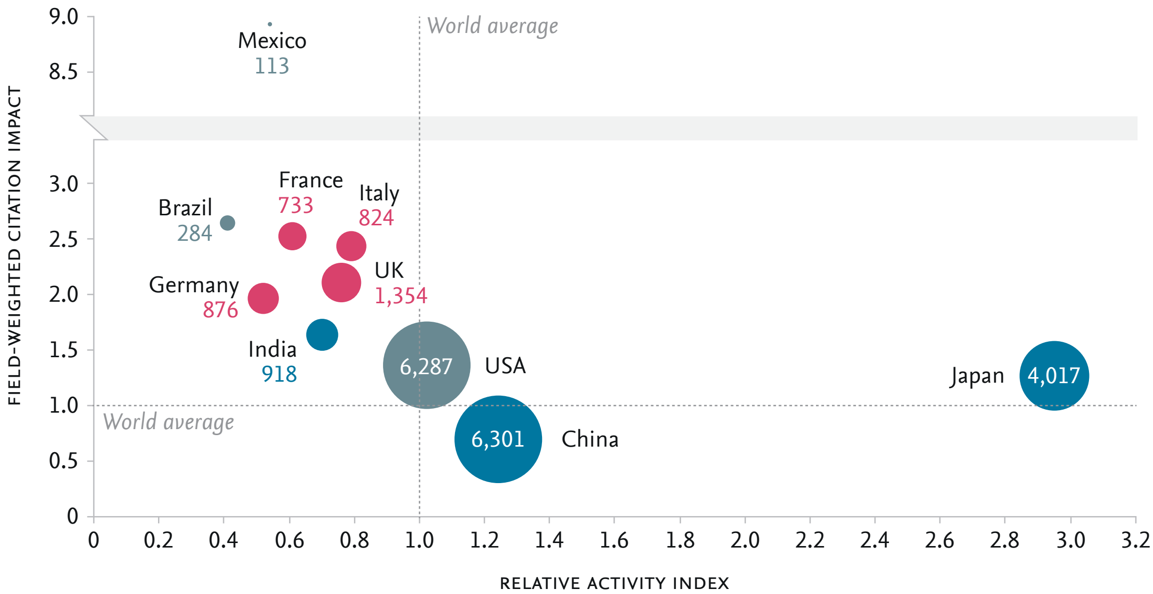


***Figure 2.4** — Disaster science scholarly output (circle size), relative activity index, and field-weighted citation impact per comparator country; 2012-2016; source: Scopus®.*

38 In fact, large-scale collaborations may have a disproportional effect on a small entity's FWCI relative to its actual level of participation in the research. To account for this, we restrict the following analyses to publications with 100 or fewer authors.

We next examine in which areas comparator countries specialize within the field of disaster science, looking first at the stages of the disaster management cycle in *Figure 2.5*.

Americas

The distribution of the USA's output in disaster preparedness and prevention is similar to the world average, and higher than the world average in recovery and response. In absolute scholarly output, the USA leads in disaster preparedness, response, and recovery research.

Both Brazil and Mexico are less specialized in research on all disaster management cycle stages than the global average.

Asia

Japan's output is more than three times as concentrated in disaster recovery as the global output, and more than twice in preparedness, prevention, and response. Japan has been affected by disaster types that usually require extensive rebuilding, which might explain the extra emphasis put on research on disaster recovery in this country.

Relative to global publication patterns, China is more specialized in disaster preparedness and prevention research (in which it also leads in output), but less so in recovery and response research. This specialization pattern may to some extent be influenced by the types of disasters with the heaviest human death toll for China, such as floods.

India's output is less concentrated than the world average in research on all disaster management cycle stages.

Europe

All four comparator countries are less specialized on research on all disaster management cycle stages relative to global publication patterns, although the United Kingdom (UK) and Italy are closer to the world average than France or Germany.

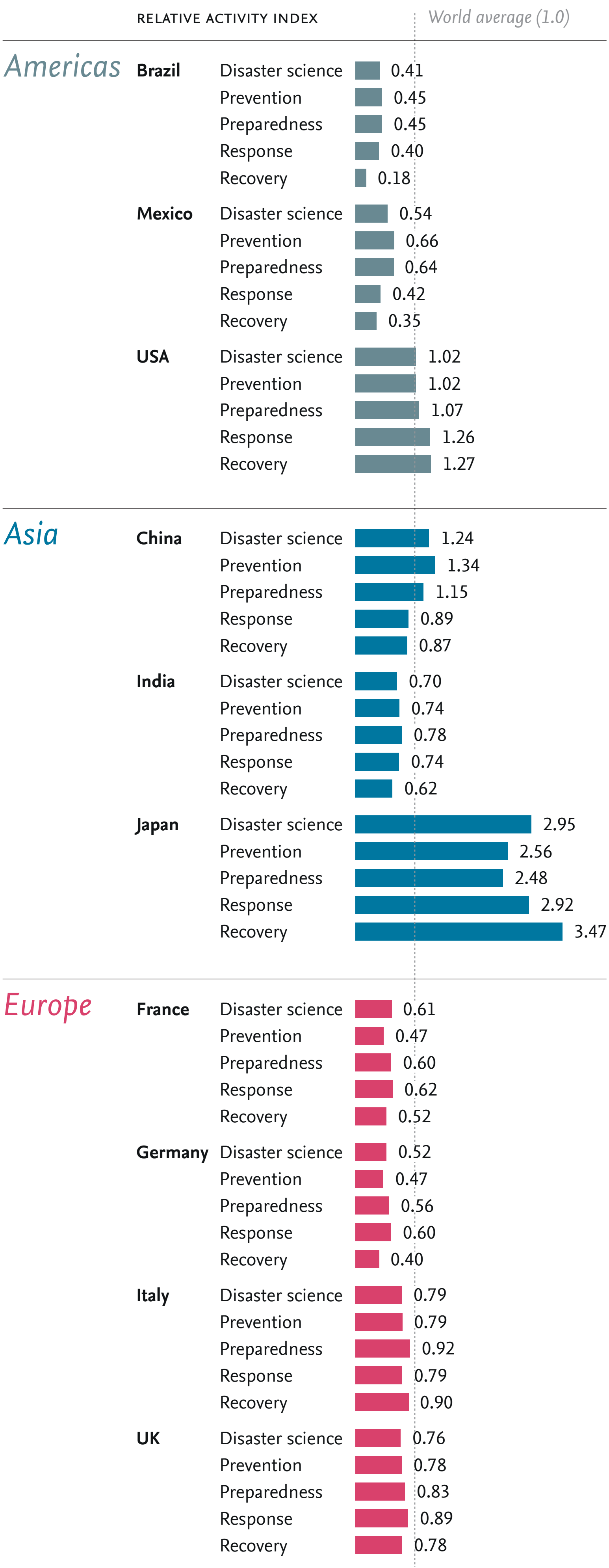


Figure 2.5 *— Disaster science relative activity index (papers with 100 or fewer authors) per comparator country, overall, and per disaster management cycle stage; 2012-2016; source: Scopus®.*

We next examine in which disaster type comparator countries specialize within the field of disaster science in *Figures 2.6, 2.7,* and *2.8.* These analyses show that disaster science in strong research nations tends to focus on the major disasters that occurred in the region, e.g., Japan on chemical & radiological disasters and geophysical disasters; the USA on meteorological and biological disasters; and Brazil, China, and India on environmental disasters. The disaster science community is responsive: recent disaster types appear quickly in the published literature. Japan has a strong research focus on geological disasters, following the 2011 Tohoku Earthquake, which triggered a tsunami and caused the Fukushima nuclear accident. There is also a strong increase in research related to chemical & radiological disasters in Japan. Publications related to disasters are not confined to the region in which they occur: many papers related to chemical & radiological disasters published in Germany, the UK, and France (which all have their own nuclear power generators and nuclear safety programs) also discuss the consequences of the Fukushima nuclear accident, and make connections to the Chernobyl nuclear accident.

Figure 2.6, depicting comparator countries in the Americas, reveals that Brazil publishes the largest proportion of its disaster science scholarly output on hydrological disasters, but is more specialized, relative to global publication patterns, on environmental disasters. This appears consistent with the frequent floods and mudslides that affect the country (e.g., the January 2011 disaster event in several towns of the mountainous region of the state of Rio de Janeiro). Brazil's research on geophysical disasters is cited 22% more than the world's. Relative to global publication patterns, Mexico is less specialized in disaster science and research on all disaster types. It publishes few papers in disaster science, and most of these are on geophysical and hydrological disasters. The USA publishes the largest proportion of its disaster science scholarly output on meteorological and biological disasters—the former might be accounted for, to some extent, by the relatively heavy death toll of storms in that country. Relative to global publication patterns, meteorological and biological disasters are also areas of high specialization for the USA, alongside research on technological and transportation disasters. The USA's research on all disaster types is highly cited, in line with the citation impact of the USA's overall scholarly output. Among comparators, the USA also has the most publications explicitly mentioning policy in their title, keywords, or abstract (more than 2.5 times as many as its closest comparators Japan, China, or the UK). As disaster

Americas

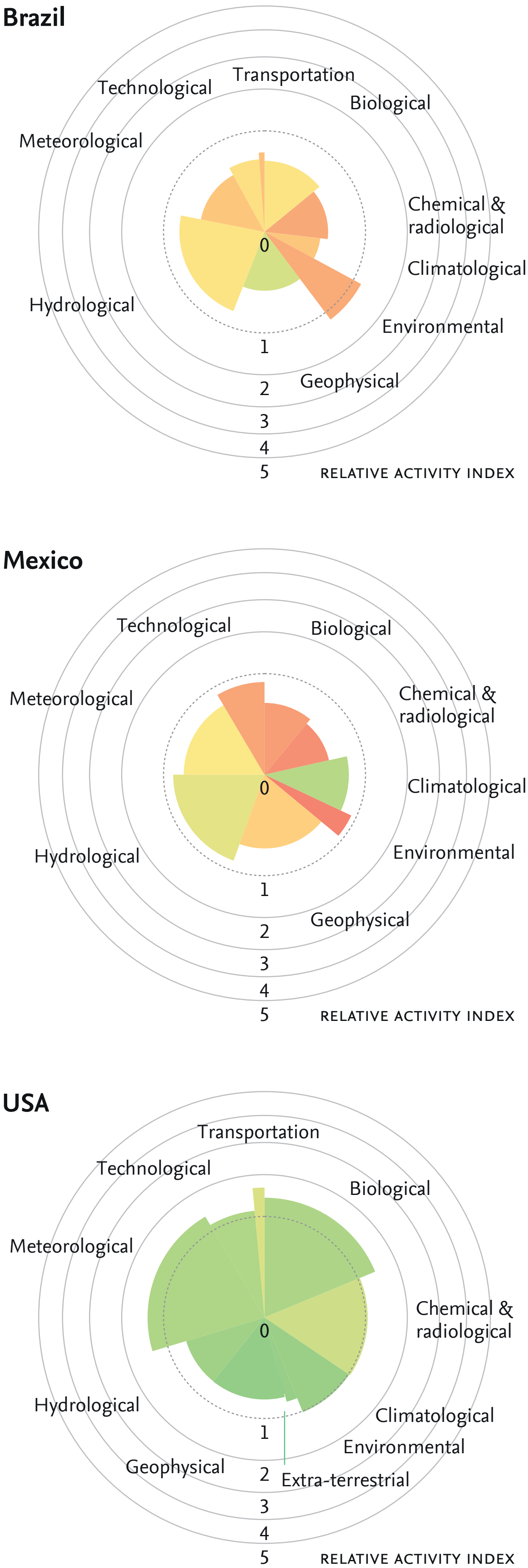


Figure 2.6 *— Disaster science scholarly output (angle of slices), relative activity index (length of slices), and rebased field-weighted citation impact (color), for papers with 100 or fewer authors per comparator country in the Americas and per disaster type; 2012-2016; source: Scopus®.*

Field-weighted citation impact 0 1 2+

science should have a strong influence on policy, it would be worthwhile to examine this result in more detail in subsequent studies.

Figure 2.7, focusing on Asia, demonstrates that China publishes the largest proportion of its disaster science scholarly output on geophysical disasters, but it's in hydrological and climatological disasters that its output is concentrated 50% or more relative to global publication patterns. The former specialization may be influenced by the relatively heavy human death toll due to floods in China—the country has experienced six of the world's most deadly floods and landslides, and three of the ten most fatal earthquakes.[39] India publishes the largest proportion of its disaster science scholarly output on geophysical, hydrological, and meteorological disasters; this specialization may be affected by the relatively high number of human deaths due to floods and extreme temperatures in India. However, India is more specialized, relative to global publication patterns, on environmental disasters, and its research in this subfield is cited 28% more than the world's. Japan publishes the largest proportion of its disaster science scholarly output on geophysical and chemical & radiological disasters, in which it is also highly specialized relative to global publication patterns. This reflects recent disaster occurrences in Japan, the most earthquake prone country in the world,[40] with 10% of all active volcanoes.[41] The citation impact of Japan's disaster science research is at or higher than the world average in all disaster types except environmental disasters.

Figure 2.8 (see next page), featuring European countries, illustrates that relative to global publication patterns, Germany publishes comparatively few papers in disaster science. Most of these are on chemical & radiological disasters. Perhaps this focus is due to some extent to the country's nuclear program, experience following the Chernobyl accident, and decision to phase out nuclear energy.[42] The citation impact of Germany's disaster science research is at or higher than the world average in all disaster types, in line with the citation impact of Germany's

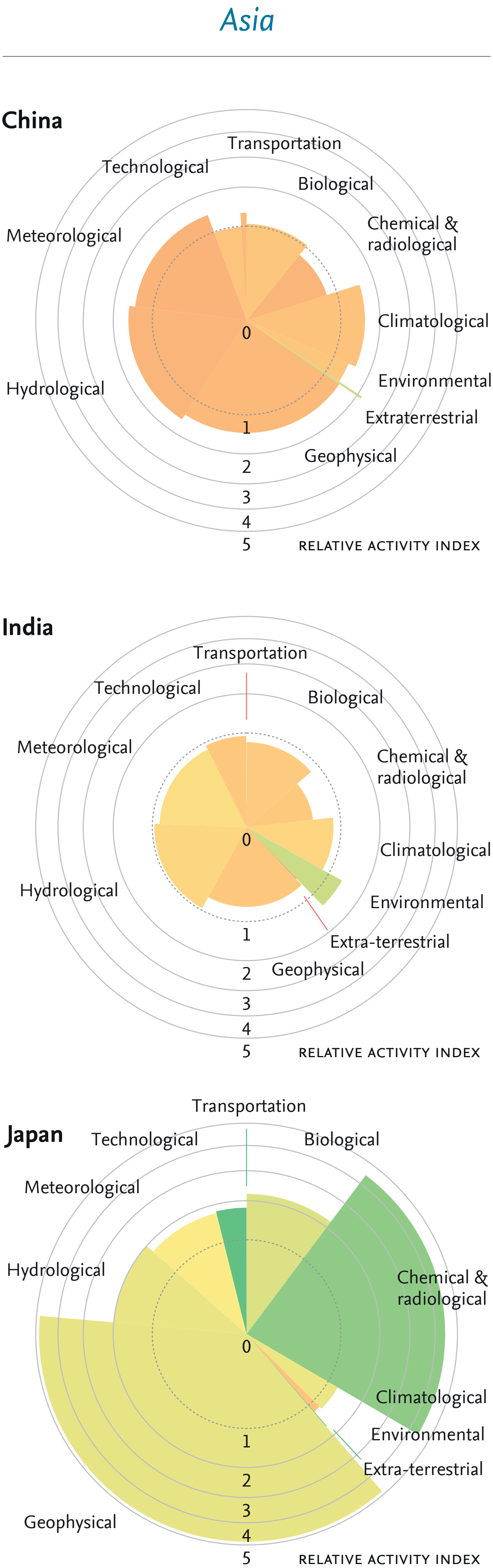
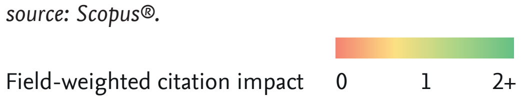


***Figure 2.7** — Disaster science scholarly output (angle of slices), relative activity index (length of slices), and rebased field-weighted citation impact (color), for papers with 100 or fewer authors per comparator country in Asia and per disaster type; 2012-2016; source: Scopus®.*



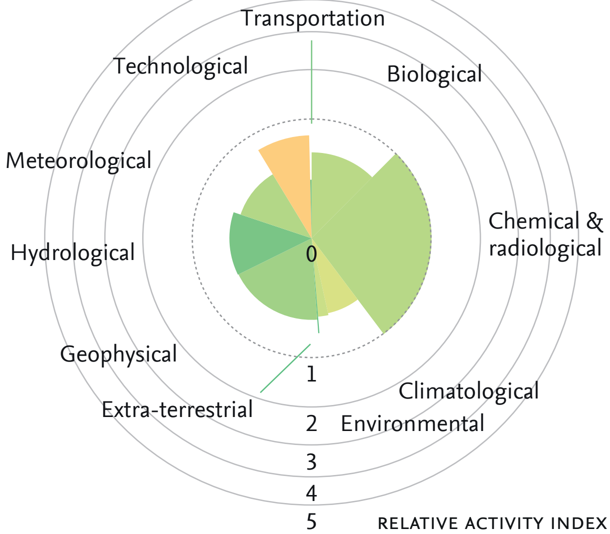
39 "Natural disasters in China." Wikipedia. 2017. https://en.wikipedia.org/wiki/Natural_disasters_in_China
40 Skymetweather.com. "10 earthquake prone countries in the world." https://www.skymetweather.com/content/earth-and-nature/10-earthquake-prone-countries-in-the-world/
41 Volcano Discovery. "Volcanoes of Japan." https://www.volcanodiscovery.com/japan.html
42 BBC News. "Germany: Nuclear power plants to close by 2022." May 30, 2011. http://www.bbc.com/news/world-europe-13592208

overall scholarly output. Relative to global publication patterns, France is less specialized in disaster science and research on most disaster types except chemical & radiological disasters, on which it publishes as much as the global average. Chemical & radiological disasters are also the subfield in which it publishes most of its disaster science scholarly output. Perhaps this focus is also due to the country's nuclear safety program, as well as the experiences and learnings from the Chernobyl and Fukushima nuclear accidents. The citation impact of France's disaster science research is at or higher than the world average in all disaster types except for technological disasters, in line with the citation impact of France's overall scholarly output. Relative to global publication patterns, the UK is less specialized in disaster science and research on most disaster types. It publishes comparatively few papers in disaster science, and most of these are on geophysical and chemical & radiological disasters. The citation impact of the UK's disaster science research is at or higher than the world average in most disaster types, in line with the citation impact of the UK's overall scholarly output. Italy publishes the largest proportion of its disaster science scholarly output on geophysical disasters, and is as specialized as the world average in this field, relative to global publication patterns. This may be due to recent geophysical disasters in this country. Italy is most specialized, however, in research on technological disasters. Italy's research on all disaster types is highly cited, in line with the citation impact of Italy's overall scholarly output.

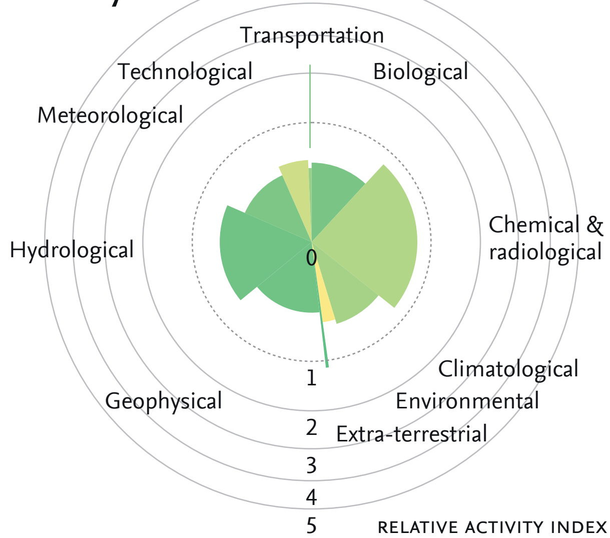
Figure 2.8 — *Disaster science scholarly output (angle of slices), relative activity index (length of slices), and rebased field-weighted citation impact (color), for papers with 100 or fewer authors per comparator country in Europe and per disaster type; 2012-2016; source: Scopus®.*

Europe

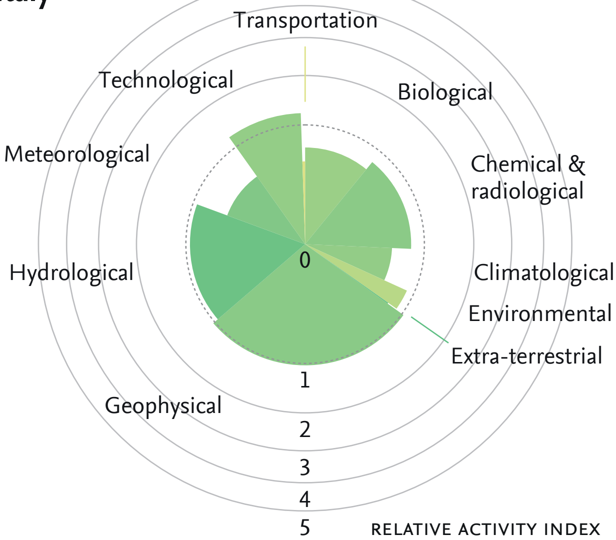
France



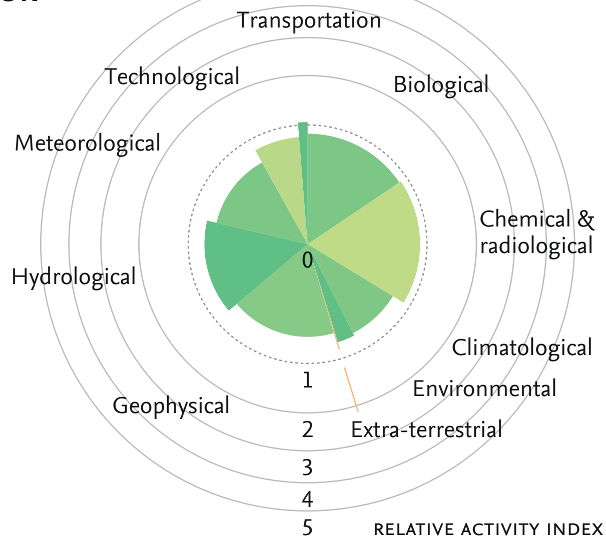
Germany



Italy



UK



Interview

Gordon McBean

President, International Council for Science (ICSU); Co-Chair, Governing Council, Future Earth: Research for Global Sustainability; Director, Institute for Catastrophic Loss Reduction; Professor Emeritus, Department of Geography, Western University

What roles have you and the International Council for Science played in the field of disaster science?

As an atmosphere-ocean physicist, I have studied storms, been head of Canada's weather service and, since 2000, been at the Institute for Catastrophic Loss Reduction, Western University. I chaired the Planning Group, then Science Committee for the Integrated Research on Disaster Risk↗ (IRDR) program. I continue to be involved in Canadian and international disaster science and policy and led the science delegation at Sendai. The International Council for Science↗ (ICSU) is the leading non-governmental international science organization. It partners with UN and other organizations to co-sponsor major global research programs, including the IRDR, World Climate Research Programme and Future Earth: Research for Global Sustainability↗.

How do you see the role of science in disaster risk reduction?

Science is very important in disaster risk reduction. Disaster science leads to understanding the hazards causing disasters, enabling prediction of their timing, location and magnitude and provision of information and early warnings for action. Natural science, social science, engineering, health and economics are all important in reducing exposure and vulnerability, developing resilience of people and communities and reducing disasters' impacts. Excellence in disaster science requires a transdisciplinary, integrated approach to address disaster risk reduction.

What information in this report did you find particularly interesting or that is likely to have an effect on the development of the field looking forward?

It is very interesting to see the distribution of disaster science publications in terms of topics, issues, authors and origins. There were about 9,000 citations to earthquakes and about 15,000 to meteorological, climatological, and hydrological events. Understanding of transport events led to the IRDR Forensic Investigations of Disasters (FORIN) program, which integrates approaches from the transportation sector to understand what goes wrong and why in other disasters. Understanding the statistics on publications within the disaster science field is important because it can help us find the gaps in knowledge and better understand the relationships between scientific capacity and disaster impact in developed and developing countries. Research in disaster science has multidimensional value, and understanding the different kinds of disasters, and how different disasters happen in different countries, requires that we bring scientists together as an international community. We need to make sure that the report's information is used to support disaster science research and has a positive impact on societies around the world through informed policy and actions.

What parts of the report do you think are important for policy makers or institutional leaders?

I think the numbers on the impact of disasters - 230,000 recent disaster-related deaths in Haiti alone - really emphasize the need for the international scientific community to help building disaster resilience in developing countries. These countries do not have the resources to support disaster science programs, but the international disaster science field can help them use the resources they have and use them in the optimal way to reduce their vulnerability to disasters. These kinds of reports can be very useful for policy makers. We need to get more scientists working with stakeholders to better communicate the information in the report about disaster risk in ways that stimulates evidence-based policymaking.

Thinking about the future of disaster science and the conclusion of the Sendai Framework timeline, where do you think disaster science will be by 2030?

I am optimistic about the progress that will be made by the programs and projects that we have in place globally and nationally. But there needs to be more investment in disaster science, which needs to be integrated across the issues of sustainable development, climate, disasters, and health, in ways that produce evidence-based guidance that has greater impact. There is value in taking a narrow scientific approach, but to address the big, cross-cutting issues in disaster management, we need to have a transdisciplinary approach. I think that is starting to happen now and will continue into the future.

Future Outlook

Despite the key role science plays in the implementation of the Sendai Framework for Disaster Risk Reduction, disaster science represents only 0.22% of the world's total scholarly output. Asia appears to have a central position in the disaster science field. Worldwide, many emerging countries with high burdens of disaster-related human or economic loss publish few disaster science papers.

The data suggests that countries focus their research on disaster types with high domestic relevance. In the context of the United Nations Sustainable Development Goals (UN SDGs), two questions come to mind. First, are there research areas within disaster science that are under-researched globally, because they have relatively low relevance to the top research countries? On disaster types, we argue in Chapter 1 that this is not the case; however, we have not looked at the question at a more detailed level. Secondly, to what extent are research results transferrable between geographies? Or in other words, to what extent is local research in the countries bearing the highest burden necessary to effectively reduce disaster risk and impacts?

This disconnect between where most of the disaster impact is felt and where most of the research is done could be to some extent addressed by international, interdisciplinary, and cross-sector scholarly collaborations and knowledge transfer. While it is beyond the scope of the present report to examine the detailed collaboration patterns of disaster science researchers, a few comments on the topic of collaborations provide an interesting context. Disaster science has an overall degree of international collaboration of 20%, which is slightly higher than the global average in all fields of science of around 18% during the time period covered.

While China overall has a few more publications, the United States (USA) is the top collaborator for all countries included in the comparative section of this report. China is among the top five collaborators for the United States, Japan, and the United Kingdom (UK), while for Brazil and Mexico, China is not even among the top 15 collaborators. Furthermore, collaborations between the five most research-intensive nations in disaster science (China, USA, Japan, and the UK) is to a large extent bilateral rather than multilateral. For the two largest research nations in disaster science, China and the USA, this follows the general collaboration pattern. For Japan and the UK, as an example, in science overall there is a higher degree of collaborations beyond bilateral collaborations.

> “*Disaster science is a critical part of understanding the factors that contribute to risk and vulnerability, and developing pre-emptive actions that can be taken to save lives. With the increasing data available on geological, hydrological, and climatological hazards, better predictions can be made, and mitigation and adaptation mechanisms can be put in place to ensure better outcomes for people.*

Jemilah Mahmood
Under Secretary General,
The International Federation of Red Cross and Red Crescent Societies (IFRC)

Many of the multilateral collaborations in disaster science are related to larger longitudinal studies, for instance in the medical area. Collaborations, notably between research-intensive nations and emerging nations, are expected to improve disaster science scholarly output. Further analysis is needed, in particular, to explore the current state of collaboration in disaster science research, and how it might be leveraged to help achieve better outcomes for all.

Research on the disaster management cycle is not limited to single stages, instead covering a continuum of interlinked stages. The disaster science community is also responsive to recent disasters. The multifaceted nature of the issues at stake and complex implications of disaster impacts require expertise that spans the whole scholarly landscape and includes cross-sector approaches to improving disaster resilience and mitigation.
Further analysis is needed of interdisciplinarity, transdisciplinarity, and cross-sector collaboration and how these might be optimized to accelerate the pace of research in the disaster science field.

Relating to the priorities of the Sendai Framework, notably Priority 4, on enhancing disaster preparedness for effective response—to “Build Back Better” in terms of recovery, rehabilitation, and reconstruction—it would be interesting to study whether more research on the science-policy-practice nexus is needed.[43] As disaster science should have a strong influence on policy, it would be worthwhile to look into the connections between disaster science scholarly output and policymaking in more detail in subsequent analyses.

43 Aitsi-Selmi A., Blanchard K., Al-Khudhairy D., et al. *UNISDR STAG 2015 Report: Science is Used for Disaster Risk Reduction*; 2015. http://preventionweb.net/go/42848

Appendices

Appendix A
Acknowledgements, Subject Experts, & Project Team

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Author

Designer commissioned for this report

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Appendix B
Rationale & Methodology

Rationale

Our methodology is based on the theoretical principles and best practices developed in the field of quantitative science and technology studies, particularly in science and technology indicators research. *The Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems* (Moed, Glänzel and Schmoch, 2004)[44] gives a good overview of this field and is based on the pioneering work of Derek de Solla Price (1978),[45] Eugene Garfield (1979)[46] and Francis Narin (1976)[47] in the USA, and Christopher Freeman, Ben Martin and John Irvine in the UK (1981, 1987),[48] and in several European institutions including the Centre for Science and Technology Studies at Leiden University, the Netherlands, and the Library of the Academy of Sciences in Budapest, Hungary.

The analyses of bibliometric data in this study are based upon recognized advanced indicators (e.g., the concept of relative citation impact rates). Our base assumption is that such indicators are useful and valid, though imperfect and partial measures, in the sense that their numerical values are determined by research performance and related concepts, but also by other influencing factors that may cause systematic biases. In the past decade, the field of indicators research has developed best practices that state how indicator results should be interpreted and which influencing factors should be taken into account. We believe in using a basket of various metrics complemented by qualitative inputs to present a holistic picture of the various outputs and impacts of research, and our methodology for this report builds on these practices.

Methodology

In this report, we rely upon the knowledge of internationally recognized disaster science experts to help us define the field of disaster science for our analyses. Disaster science is a complex field in its essence. The many causes and implications of disasters require research that draws from various regions of the scholarly landscape and harnesses expertise across scientific disciplines.

We therefore adopt a keyword-search approach to define the field of disaster science, to avoid restrictions to any particular subject areas that may ignore a significant portion of the relevant corpus of research publications. We focus our search on those publications that explicitly adopt a disaster science perspective, thereby also ensuring consistency across the different sets of publications included in the analysis. In addition to disaster science as a whole, we also examine disaster types per the Sendai Framework and disaster management cycle stages. Full definitions of search criteria are available in the separate *Appendix D*.

44 Moed H., Glänzel W., Schmoch, U. *Handbook of Quantitative Science and Technology Research*, Kluwer: Dordrecht; 2004.
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Appendix C
Glossary of Terms & Data Sources

Glossary of terms

A **paper** or **publication** refers to an article, review, or conference proceeding indexed in the Scopus® database. **Scholarly output** for an entity is the count of articles with at least one author from that entity. All analyses make use of whole counting rather than fractional counting. For example, if a paper has been co-authored by one author in Japan and one author in the USA, then that paper counts towards each country's scholarly output. Total counts for each entity are the unique counts of publications.

A **citation** is a formal reference to earlier work made in an article or patent, frequently to other journal articles. A citation is used to credit the originator of an idea or finding and is usually used to indicate that the earlier work supports the claims of the work citing it. The number of citations received by an article from subsequently published articles is a proxy for the importance of the reported research.

The **relative activity index (RAI)** is calculated by dividing the share of a country's output in a particular field by the share of the world's output in that same field. It therefore represents how concentrated a country's output is in a particular area relative to the world average. As such, it can be used to analyze specialization. For instance, 0.66% of Japan's scholarly output is in disaster science, compared to 0.22% of the global scholarly output. Japan's RAI in disaster science is therefore 0.66/0.22=3.

Field-weighted citation impact (FWCI) is an indicator of mean citation impact, and compares the actual number of citations received by an article with the expected number of citations for articles of the same document type (article, review, or conference proceeding paper), publication year, and subject area. When an article is classified in two or more subject areas, the harmonic mean of the actual and expected citation rates is used. The indicator is therefore always defined with reference to a global baseline of 1.0 and intrinsically accounts for differences in citation accrual over time, differences in citation rates for different document types (reviews typically attract more citations than research articles, for example) as well as subject-specific differences in citation frequencies overall and over time and document types. It is one of the most sophisticated indicators in the modern bibliometric toolkit.

Data sources

Scopus®↗ is this report's source of research performance data. It is the largest abstract and citation database of peer-reviewed literature, with over 68 million records. These span over 22,500 titles from more than 5,000 international publishers. Scopus® coverage is global; titles from all geographical regions are covered, including non-English titles as long as English abstracts can be provided with the articles. In fact, approximately 21% of titles in Scopus® are published in up to 40 languages other than English (or published in both English and another language). In addition, Scopus® offers broad coverage of the peer-reviewed literature and quality web sources across science, technology, and medicine (STM), as well as social sciences and arts & humanities (A&H).

The **Elsevier Fingerprint Engine™↗** applies a variety of Natural Language Processing (NLP) techniques to mine the text of any scientific document. Key concepts that define the text are identified in thesauri spanning all major scholarly disciplines. The Elsevier Fingerprint Engine™ creates an index of weighted terms that defines the text, known as a semantic fingerprint. This consists of all the key concepts derived from a piece of text, weighted to reflect their relative importance. The advantage of using key concepts based on semantic fingerprint technology is that the resulting terms are of higher quality and are more representative than standard sets of keywords, which often contain duplicates, synonyms, and inclusion of irrelevant terms. Semantic fingerprints can be used for describing themes and are ideal for describing groups of articles and identifying articles that are related to one another in terms of subject area.

We also use disaster economic loss data featured in the *Global Assessment Report on Disaster Risk Reduction Cycle 2015* at our experts' recommendation. In the country profiles, the data is credited as coming from **OFDA/CRED**, the International Disaster Database from the Université Catholique de Louvain. To make these disaster economic data more comparable across countries of different sizes and with different resources, we normalize them by GDP data from the **World Bank**.

We also use disaster death toll data featured in the *IFRC 2015 Disaster Report*. To make these disaster economic data more comparable across countries of different sizes and with different resources, we normalize them by population data from the World Bank and **Taiwan Statistical Data book**.

This report was prepared by Elsevier. Elsevier's Research Intelligence portfolio of products and services serves research institutions, government agencies, funders, and companies. For more information, visit elsevier.com/research-intelligence↗

Notes

Periodic assessment of the state of disaster science is essential to identify gaps in knowledge and review progress in resilience-building programs, investment, and development planning. Elsevier, together with partners and experts and in accordance with the goals of the Sendai Framework, seeks to contribute to these efforts with this quantitative analysis of disaster science research scholarly output from 2012 to 2016.

The findings of this analysis may assist governments and research institutions in recognizing opportunities to build disaster science research capacity, forge international and regional partnerships, strengthen the science-policy interface, and engage stakeholder communities. In addition, funding agencies will be able to visualize where financial support might be allocated to strengthen disaster science research capacity, responsiveness, and impact.

APRU

Cemaden
Centro Nacional de Monitoramento e Alertas de Desastres Naturais

European Commission

IRDR
Integrated Research on Disaster Risk

災害科学国際研究所
IRIDeS
International Research Institute of Disaster Science

UNISDR
United Nations Office for Disaster Risk Reduction

ELSEVIER