PROTECTING SCIENCE IN TIMES OF CRISIS

How do we stop being reactive, and become more proactive?

CENTRE FOR SCIENCE FUTURES
International Science Council

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The ISC established the Centre for Science Futures in 2023 to improve our understanding of emerging trends in science and research systems and to provide options and tools for impact and action.
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FOREWORD

In an era marked by escalating geopolitical conflicts, the sanctity and resilience of the global scientific community have never been more crucial. This paper by the International Science Council's Centre for Science Futures, *Science in Times of Crisis: How do we stop being reactive and become more proactive?* emerges at a critical juncture, addressing the urgent need to protect scientists, academics, scientific and educational institutions increasingly targeted during conflict, or subject to losses because of natural hazards or increased climate-induced extreme weather events.

The increasing number of violent conflicts around the world are undermining human development, restricting access to education and scientific endeavour, and diverting resources from other pressing issues such as climate change, resulting in the politicization of scientific research and the use of technology for war. Science and scientists have historically played a vital role during times of conflict and in times of crisis, by conducting critical research, offering scientific guidance to decision-makers, and engaging in science diplomacy. Yet, as this paper notes, a significant gap exists - the science sector as a whole has done little reflection on its own resilience in the face of crises, from scientists becoming refugees to civilian infrastructure being destroyed and knowledge and research lost. This working paper delves into the role of science in protecting and supporting its own scientific communities, science systems, and related infrastructure affected by crises, by addressing the lack of a systematic approach to implementing the 2017 UNESCO Recommendation on Science and Scientific Research, which calls for policies to protect and preserve scientific research, infrastructure, and archives.

Our goal is clear: to establish a resilient, global scientific community capable of withstanding and recovering from the adversities of our time. This paper is a call to action, urging for a collaborative, strategic approach to safeguard the invaluable contributions of scientists and researchers worldwide, at a time when science and scientific endeavour are needed most. It underscores the necessity of more coherent and coordinated strategies by scientific institutions around the world to better respond to crises. It is based on the recognition that a resilient science and research sector will play a crucial role in stabilizing countries and regions during crises and offer a positive base for sustainable development in rebuilding efforts. We hope that its findings will help ISC Members and partners develop new actionable initiatives in support of science and scientists in times of crisis.

In this era of growing crises and geopolitical tensions, this should be our collective goal as a global community - not only for the sake of protecting the right to science and the integrity of science itself, but fulfilling our responsibility as scientists to act for the global public good.

These are not merely aspirations driven by the ISC's principle on the freedom and responsibility of science, but are tangible actions we can incorporate into our scientific endeavours. Let us remember that science and peace are not separate entities but intertwined facets of a better world. By embracing this responsibility, we can contribute to a more robust science system that benefits all.

Salvatore Aricò
CEO
International Science Council

EXECUTIVE SUMMARY

For more than a century, and increasingly in the past decade, scientists, academics and higher education institutions in crisis have been supported by international scientific organizations, science academies, representative organizations for higher education, UN agencies and non-governmental organizations. Their ability to offer temporary academic positions at universities and colleges, and to extend research grants, offers safety to displaced, refugee and at-risk scholars so that their research efforts are not lost, and they can keep working until conditions improve and they are able to return home.

This important collective activity has saved lives, protected families and sustained research efforts to fruition. However, as the range of crises facing the world proliferates, so do the numbers of people at risk, among them scientists and academics. Wars and disasters also have a severe impact on academic and scientific institutions, and on research infrastructure, libraries and data centres.

There is currently no shared understanding of how the global scientific community can respond to crises that affect science and scientists, or of how it can coordinate the rebuilding of science systems affected by crisis. The global scientific community must move from merely reacting to crisis and become proactive in protecting scientists and research in an epoch of polycrisis. We must identify the gaps in current support mechanisms and develop new and more encompassing ways to protect scientists and research in times of crisis.

In this paper, we take stock of what we have learned in recent years from our collective efforts to protect scientists and scientific institutions during times of crisis. It expands our understanding of how the scientific community can prepare for, respond to and rebuild from crises, with the aim of protecting and promoting scientific knowledge as well as scientists and their contributions to society.

METHODOLOGY

The paper looks at lessons learned from the advocacy and solidarity efforts of the International Science Council and its partners. It uses relevant examples and a policy review to examine the scientific community's response to crises affecting science systems including scientists and scientific research, research objects, scientific infrastructures and archives. These findings are supplemented by insights from comparable sectors, culture and heritage, and from experts involved in crisis from disaster risk reduction, humanitarian and international development perspectives. As a working paper, it provides insights intended to help shape future consultations within global and national science systems on how to act on the UNESCO 2017 Recommendation on Science and Scientific Researchers. It suggests ways forward by which the International Science Council and its partners could consider how best to take this work further.

INTERNATIONAL POLICY FRAMEWORKS

There are currently no comprehensive or dedicated policy frameworks to guide the science sector through the complexities of protecting scientists, scientific research, science

institutions and science infrastructure during crises. International policy documents call for states to develop policies for the protection of scientific infrastructures and to protect scientific researchers (examples are listed in Table 2). But what these policies should look like, what they should cover and how they could facilitate international cooperation and solidarity for affected communities, is not addressed.

However, there exists a large body of legal instruments and regulations in other sectors that offer a strong foundation for the support of science in times of crisis. Such policies offer inspiration for legal and regulatory instruments specifically for the science sector, designed to protect the varied elements of the scientific enterprise for future generations. This may be strategically a good first step in the development of an appropriate international policy framework.

EXAMPLES

The paper develops seven examples of crises affecting science systems and institutions. The examples can be grouped under some broad categories:

- Violent conflict: (1) Russian invasion of Ukraine (2022–present); (2) Islamic State of Iraq and Syria (ISIS) occupation of Mosul University, Iraq (2014–2017);
- Disasters: (3) Cape Town University library fire, South Africa (2021); (4) Natural Science Museum fire, Brazil (2018); (5) The Fukushima nuclear disaster, Japan (2011);
- Crisis recovery: (6) war in the Balkans (1991–1999); (7) Japan after World War Two (1945).

The examples can be found in dedicated annexes.

KEY FINDINGS AND SUGGESTED WAYS FORWARD

This paper follows the main phases of the humanitarian cycle: prevention and preparation, protection, and rebuilding. This three-phase approach allows for more systematic, predictable, efficient and coordinated approaches involving actors across science, higher education, government and civil society, and the UN system.

1. Prevent and prepare

The science sector must be made more resilient by developing more predictable, systemic responses that draw upon the expertise of the global scientific community, and which connect scientists, administrators and risk professionals. A focus on crisis prevention and preparedness is needed to minimize crisis-related impacts on the science sector. The sector itself needs to take greater responsibility for its internal risk assessment and mitigation, and for capacity strengthening where needed. Opportunities to make science systems more resilient are lost. Only when they are considered globally and holistically do the costs become clear.

The scientific community is losing research capacity and investment as growing numbers of professional scientists are displaced and science infrastructures are destroyed.

A trustful relationship between science and society at large is critical for the survival of both. Policies and actions that enhance public trust and state support for science are needed. They should be based on shared principles which guide global and equitable scientific responses to crises that affect science.

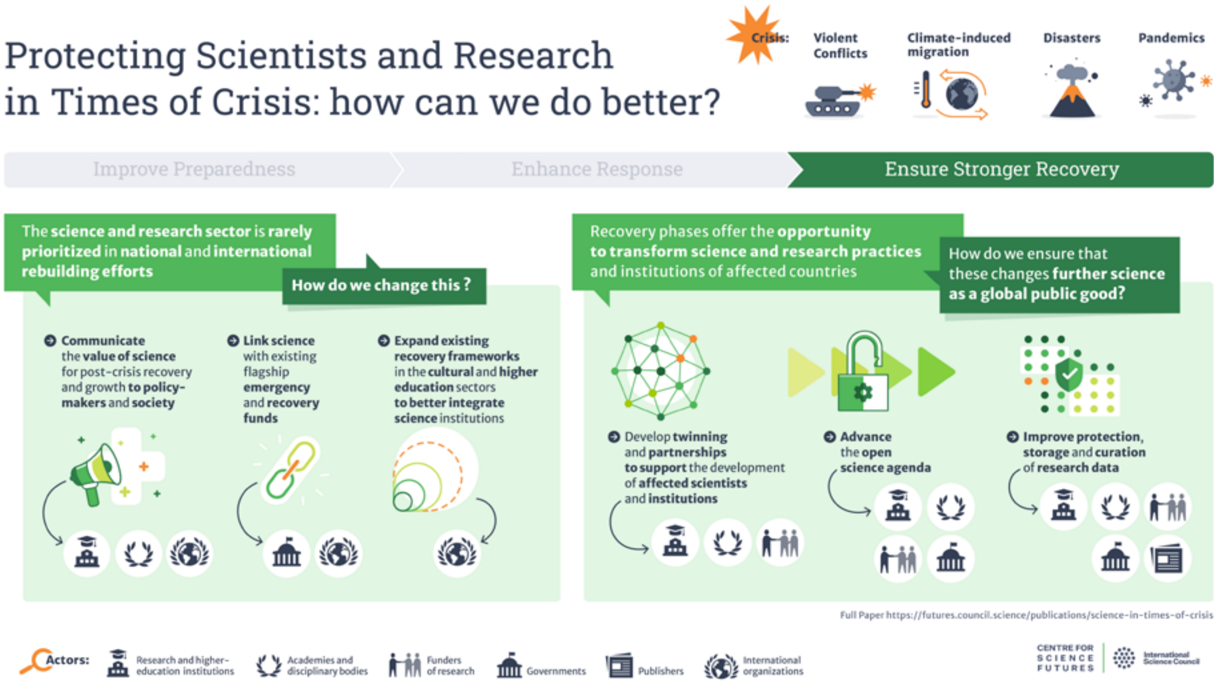
In order to develop consistent and effective responses at each crisis stage, it is essential to build the capacity of scientists and leaders in crisis and risk management, to get more resources for prevention and to help develop action frameworks with partner sectors.

2. Protect

In protect, the crisis response phase, science tends to fall through the cracks. The result is a lack of information about the affected scientists, their needs and even their whereabouts. This knowledge gap damages the effectiveness of coordination mechanisms, and the sector's wider understanding of crisis response. Despite the best efforts of dedicated 'science humanitarians', the response of organized science to an emerging crisis is often ad hoc, reactive and limited rather than there being clarity of sector-wide roles and responsibilities.

There is a need for more programmes and funding that enable scholars to continue with teaching, research and publication, and that support 'brain circulation' rather than brain drain. This might involve support for digitization, mobilization of the scientific diaspora, innovative approaches to scientific exchange and collaboration, participation in conferences and financial support.

International scientific institutions, including universities, funders, governments, academies, foundations and disciplinary unions, are often best placed to address these needs and protect key scientific assets. Yet the longer that human and material needs go unmet, for example with scientists out of work, the likelier it is that key competences and knowledge will be lost. Ways forward include improving mechanisms for coordination and information sharing amongst local and international science actors; working with the humanitarian sector to develop more flexible emergency funding mechanisms to fill the gap when science budgets are diverted to defence or other emergency priorities; and developing action frameworks with key elements of the science sector – such as publishing – to improve access to science resources when they are most needed.



3. Rebuild

There is clear potential for science and research institutions to play an important role in the post-crisis phase. Here, the science and research sector are rarely treated as a priority in the rebuilding efforts of national and international authorities. However, science, higher education and technological innovation are critical elements of post-crisis recovery. Leaders of the science sector must utilize advocacy, diplomacy and modern communication tools to enhance public understanding of the value of science for recovery and rebuilding, and to influence policy response to ensure that science is on the recovery and rebuilding agenda.

By being integrated more proactively into the broader response to crises, science can add value to crisis recovery and make a strong case to governments and funders to prioritize science in the reconstruction phase. This will involve building stronger collaboration between local and international science actors and with the UN and development sectors. Here we see the potential for real transformation and reform. It will involve incentivizing and enabling collaboration between local and international science actors, insisting on standards that cultivate mutual trust and respect, and making use of today's drivers of change, such as long-term international scientific partnerships, young academies, the science diaspora and competitive funding processes with independent evaluation. Ways forward include developing joint action frameworks with the development sector, making 'open science' more of a reality during crisis recovery, and supporting inclusive approaches to the rebuilding of the affected science system in a way that respects local ownership and incentivizes the return of the displaced.

CONCLUSION

The paper advocates for a more proactive, global and sector-wide approach to building the resilience of the science sector. An encompassing policy and action framework for the science sector such as the one proposed here has potential to realize both monetary and social value for science and wider society during times of crisis.

INTRODUCTION

‘There is a need to think more systematically about how science is a global activity that must be sustained: future pandemics, future refugee crises exacerbated by climate change, will likely lead to further geostrategic instability. More systematic approaches for enhancing global scientific cooperation across borders need to be given greater emphasis by countries, requiring investment and effort. Scientific collaboration across borders should become seen as a critical strategic need by all countries.’

Peter Gluckman
PRESIDENT, ISC
Conference on the Ukraine Crisis, June 2022

We live in a time of polycrisis, where crises build on each other because of converging and interdependent factors including climate change, rising social and economic inequality, war and pandemics. One critical driver and consequence of polycrisis is mass displacement. The number of people forced to flee due to persecution, conflict, violence and human rights violations reached more than 100 million in 2022 (UNHCR, 2022). Amongst those fleeing were scientists, scholars, doctors, engineers, professors and university students.

The International Science Council (ISC)’s work on science in times of crisis has focused on how to mobilize scientific communities to protect and support refugee and displaced scientists and their families, how to help them continue to work and engage in international research collaboration, and how to ensure that the contributions of scientists are not lost. In 2017, The World Academy of Sciences (TWAS), Euro-Mediterranean University (EMUNI) and the Italian National Institute for Oceanography (OGS) convened the first global workshop of its kind to discuss and better understand ways to support refugee and displaced scientists. It produced a detailed set of recommendations, ‘Refugee Scientists: Transnational Resources’. In 2020, TWAS, in partnership with the Inter-Academy Partnership (IAP) and the ISC, created the Science in Exile Initiative to build advocacy around this topic, and drafted the Science in Exile Declaration. Launched in April 2022, and endorsed by 77 organizations, the Declaration outlines key global-level commitments for the support and protection of scientists. The ISC also manages the ‘Science in Exile Science Stakeholders Group’ – a forum for sharing insight and support between local and international science actors in specific crisis contexts. To date it has been deployed in response to crises in Afghanistan and Ukraine.

Since the Russian invasion of Ukraine in February 2022, the ISC has focused on supporting and learning from those affected by co-hosting two conferences bringing together the Ukrainian science sector and international partners. The first was in June 2022, on Responses from the European Higher Education and Research Sectors. It put forward seven recommendations for mid- to long-term support, including post-conflict rebuilding of the higher education and research sectors. The second took place in March 2023 on One year of war in Ukraine: exploring the impact on the science sector and supporting initiatives. It explored how needs and responses had evolved and what lessons existed for the year ahead, for future crises elsewhere in the world as well as for Ukraine.

In the course of this work, a gap has become apparent in how science systems and institutions respond to crisis. The issue is how to systematically strengthen the resilience of the science sector itself as crises hit. In recent years alone, scientific institutions, organizations, infrastructure and scientists have been afflicted by war, civil strife, pandemics and disasters. There has been catastrophic damage to research facilities, higher education institutions, academic libraries, laboratories, archives, museums and collections of scientific products and artefacts around the world. Invaluable scientific knowledge for the future of countries or regions has been lost. The human cost has been immense, as is the long-term impact on science systems of losing capacity, research results, data, investment or access to opportunities.

Scientists are very familiar with crises when they act as researchers on the causes, courses and consequences of some issue, or as science communicators and science advisers, engaging with scientific collaboration and diplomacy. However, they are perhaps less used to exploring the role that scientific communities can play in protecting scientists and the science base from conflict or disaster.

This paper seeks to expand understanding of how the scientific community can prepare for, respond to and rebuild from crises, with the aim of protecting and promoting scientists and scientific knowledge, and their contributions to society. It uses practical examples, literature review and an analysis of current international policy frameworks to build a synthesis of the available information on practices, challenges and the needs of scientists, science systems and institutions in times of crisis. It shows how current policy frameworks can be enhanced to protect the science and higher education sectors. The paper then recommends actions that could improve preparation, response and the rebuilding of the science sector after a crisis.

‘It’s much easier to destroy than to build. In particular for scientific activity, we need about ten years to fully train a young PhD fellow. Hence, a hiatus of a few years becomes very significant.’

Mercedes Bustamante
UNIVERSITY OF BRASILIA

RATIONALE

This paper echoes UNESCO's 2017 Recommendation on Science and Scientific Researchers, which called upon Member States to develop policies for the 'protection and preservation of research objects, scientific infrastructure and scientific archives, including in instances of conflict'. Currently there is no systematic mapping of challenges and risks involved in the protection of scientists, research objects, scientific infrastructure and scientific archives in times of conflict or of broader crisis. This paper provides insights which we hope will help shape future consultations within global and national science systems on how to act on the UNESCO 2017 recommendation. These might aim to identify best practice examples, trends in the existing scientific response to crisis, and gaps within the science architecture, and lead to suggestions for areas of further research.

The paper responds to the current geopolitical context in which numerous science systems are facing the challenges of violent conflict. Some are seeking to protect existing assets and plan for recovery in the face of active conflict (for example Ukraine), while others are attempting to drive post-conflict rebuilding and system strengthening (for example Iraq). It also informs and drives other key issues on the global science agenda such as open science.[1] Many of the obstacles making it harder for scholars and systems to recover or continue their work in the face of crisis would be less severe if open science were a reality.

1 The definition of open science as taken by this paper: An inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community. It comprises all scientific disciplines and aspects of scholarly practices, including basic and applied sciences, natural and social sciences and the humanities, and it builds on the following key pillars: open scientific knowledge, open science infrastructures, science communication, open engagement of societal actors and open dialogue with other knowledge systems (UNESCO Recommendation on Open Science, 2021).

METHODOLOGY

APPROACH

This paper is intended to identify frameworks for policy and action which may be applicable to the science sector. To do this, it explores existing policies, approaches and mechanisms within science systems and institutions, and from disciplines including research, higher education, humanitarian response and development, recovery and rebuilding, disaster risk reduction and world heritage and culture. It is based on a literature and policy review as well as key informant interviews. In an effort to explore this emerging field, whose existing literature is limited, seven examples[2] from the past and present across different world regions were selected to give more practical perspectives into the nuances of the topic.

As well as the literature review (see References), there were twelve interviews (see Annex 5), one webinar (see 'Entangled crises: how can the EU help?' in References) and a podcast series (Science in Times of Crisis; ISC, 2022b) as well as the ISC's experience of trying to mobilize support for science systems and institutions in response to different types of crises. A matrix (see Annex 2) was created to structure interviews and guide analysis of the literature. It was based on the three phases of the humanitarian cycle: pre-crisis (prevent and prepare), crisis response and stabilization (protect), and post-crisis (rebuild). In developing the paper, interesting leads, contacts and overlaps with other sectors have emerged. As many of these as possible were explored to bring depth and a more holistic understanding of the topic, a process which had to be limited due to resource and time constraints. When possible, additional suggestions for further reading and additional cases to explore are noted throughout the paper.

The examples were selected on the advice of ISC networks and from existing knowledge of crises affecting science systems and institutions. They were grouped into three categories. Note that hazard profile and hazard subcategory in Table 1 are in line with the joint United Nations Disaster Risk Reduction-International Science Council (UNDRR-ISC) technical review of hazards.

- **Violent conflict** refers to crises where at least two parties deploy physical force to resolve competing interests. Examples of violent conflict in this paper involve both state and non-state actors: the Russian invasion of Ukraine (2022–present), and the ISIS occupation of Mosul University, Iraq (2014–2017).
- **Disaster** refers to a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to human, material, economic and environmental losses and impacts. (See Annex 4 for the rationale for utilizing the term 'disasters' in place of 'natural disasters'). They include the Cape Town University library fire, South Africa (2021); the Natural Science Museum fire, Brazil (2018); and the Fukushima nuclear disaster, Japan (2011).

2 These examples are not research pieces. Rather, they serve as glimpses into examples of crisis and disaster around the world.

- **Historical examples of crisis recovery** refer to actions taken by countries and/or regions to rebuild scientific infrastructure and preserve cultural heritage following a crisis. Here we include the war in the Balkans and Japan after World War Two.

Table 1: Categories, hazard profile and hazard subcategories of crises and selected examples

Case study category	Hazard profile	Hazard subcategory	Case study
Violent conflict	Societal	International armed conflict	1. Russian invasion of Ukraine (2022)
		Non-international armed conflict	2. ISIS occupation of Mosul University, Iraq (2014–2017)
Disasters	Environmental	Wildfires	3. Cape Town University library fire, South Africa (2021)
	Technological	Fire	4. Natural Science Museum fire, Brazil 2018
		Building collapse	
	Geohazard	Earthquake	5. The Fukushima nuclear disaster, Japan (2011)
	Meteorological and hydrological	Tsunami	
	Technological	Nuclear plant failure	
Historical examples of crisis recovery	Societal	Non-international armed conflict	6. War in the Balkans (1991–1999)
		International armed conflict	7. Japan after World War Two (1945)

All the instances of crisis in this paper are definable under the joint *Hazard Definition & Classification Review Technical Report* (UNDRR-ISC, 2020). Many of the crises facing science systems worldwide, including conflict, flooding, power outages, pollution, biodiversity loss, data breaches and even financial shock, are categorized as hazards within the Sendai Framework for Disaster Reduction that frames disaster risk management globally (UNDRR, 2015). The incorporation of a defined hazard classification is crucial at all stages of a crisis. It should guarantee standardization, identification, reporting and cataloguing, which are especially pertinent in an era of polycrisis and multi-hazards.

All 300 or so hazards covered by the **Sendai Framework for Disaster Reduction** are assumed to be monitored by a dedicated UN agency, but to date there has been no systematic review undertaken. It is unlikely that the specific needs of the science and research sector are well covered and addressed by this monitoring.

LIMITATIONS AND ASSUMPTIONS

There were several constraints affecting this paper as follows

- Only a select number of crises were examined. As a result, other relevant and interesting examples were not included. These examples, such as those in the section below, were too volatile, raised significant issues with access to key stakeholders, or were simply outside of the scope of this paper.
- A limited number of people (one to four) were interviewed for each case (see Annex 2 for the interview question framework). Their perspectives and recommendations reflect their own specific experience. Initial interviewees were selected from the research team's network of contacts, and subsequent interviewees were in turn recommended by these initial contacts.
- In some cases, our limited knowledge of the language of the country in question, such as Japan, reduced the potential for the identification of references. Documents were often produced only in the local language, and not in English. This presented a significant gap in the knowledge base for this paper. In future, working with bilingual interviewees, as well as enlisting the skills of translation services, would provide a wider scope and scale of source material and voices.

ALTERNATIVE CONTEXTS AND EXAMPLES

Our seven examples of science crises are a small sample of the possible total. Other crises have impacted science systems or still do. Our ability to learn from them was constrained by the limitations outlined above. As a starting point for further research on the topic, we suggest the following cases, although we recognize that even this list is not comprehensive:

- Global health crises such as the SARS-CoV-2 (COVID-19) pandemic, which brought the world to a standstill and caused upheaval and the questioning of advances in vaccine science. It also left people stranded or unable to travel, and with increased mental health problems (ISC, 2022a). The impact of the pandemic on scientists has been explored elsewhere. (ISC, 2022a; Royal Netherlands Academy of Arts and Science, 2022). Additionally, while a wealth of work and research on SARS-CoV-2 (COVID-19) exists, not enough of it is easily synthesizable at this stage. High-level pandemic preparedness treaties, protocols and plans are advanced, but are currently in a period of negotiation that is likely to last a while (Lenharo, 2023).
- Severe geopolitical tensions involving sanctions regimes, proxy or frozen conflicts. This includes the Cold War (1947–1991), international sanctions on Iran over the past two decades, or the ongoing context in Nagorno-Karabakh.

- State-sponsored takeover of academic and scientific institutions in countries such as Nicaragua, where funding and freedom in science are systematically threatened or attacked.
- Extreme weather events and disasters such as the 2023 earthquake in Syria and Turkey, the 2010 hailstorm in Australia and the 2010 earthquake in Haiti. While often 'natural' in source, events such as these are often worsened and compounded by existing social conditions, such as poverty or limited governance capacity.
- Further historical examples of crisis recovery, such as Germany after World War Two. Although the context for science has changed dramatically since this period, in terms of technological advancement and the development of public science policy at national levels, the past may still provide insights relevant to modern day policy-making.
- Ongoing, complex polycrisis, often involving a combination of the problems discussed above, alongside other additional ones. For example, the polycrisis in Syria involves modern warfare, mass displacement and, more recently, a significant earthquake. These have combined in a devastating fashion. Similarly, current and complex examples of polycrisis, often involving mass displacement, violence and an urgent humanitarian situation, include Afghanistan, Myanmar, Ethiopia, Sri Lanka and Pakistan. Crises such as these are compounded in a polycrisis worsened by climate change, causing severe weather events and disasters such as drought, flooding, cyclones and fatal heatwaves.

As more studies and evaluations of crises affecting scientists and science institutions are completed, including some in the categories listed above, the global scientific community will develop clearer views of how best to prepare, respond and rebuild. The main assumption of this paper is that the findings and proposed ways forward presented here adequately reflect what we currently know.

POLICY FRAMEWORK

To understand the current situation and think about improvements, we must first consider the declarations, conventions, frameworks and policies that guided past actions. We should also see how we can better use or improve these policies, and identify any areas where our thinking or policies might be lacking.

The emerging field of science in time of crisis is complex and sits at a nexus of several sectors. The creation of an international policy framework that addresses all of its various aspects requires a multi-faceted approach. In the course of this project, international policies and documents have been selected from the fields of science, humanitarian response, refugees and migration, human rights, development, disaster risk reduction (DRR), and world heritage and culture. They lay out, in no order or hierarchy, regulations, protections and commitments from states, scientific bodies and other relevant stakeholders enshrined in law.

Table 2 looks at international declarations, conventions, frameworks and policies. They range from hard, enforceable or binding law to soft law which is neither enforceable nor binding.[3] Each relates to science (see Annex 4 for this paper's definition) in times of crisis at a global level. But we recognize too that there is a large body of legal instruments and regulations at regional and national levels. These constitute a significant foundation for individual countries or regions that could be expanded to better cover the needs of science systems and institutions at a more local level. It was not possible for this paper to look at all such regulations.

The international documents from the science sector, including the *Declaration of the 8th World Science Forum on Science for Peace*, *UNESCO Recommendation on Science and Scientific Researchers*, *Bonn Declaration* of UNESCO World Conference on Education for Sustainable Development, and the *UNESCO Recommendation on Open Science*, lay the groundwork for the preservation of scientific knowledge, data and structures, as well as the protection of scientists, in times of crisis. They also recognize the value of scientific research and its contribution to society as a global good. Their polices relating to higher education are closely linked to the science sector, with a focus on scientific research and on learning and teaching about science. The *Global Convention on the Recognition of Higher Education* recognizes the importance of continuing education amid crisis and displacement, with a specific focus on building future generations of highly skilled and educated people.

3 According to definitions by the UN, 'Declarations are not always legally binding. The term is often deliberately chosen to indicate that the parties do not intend to create binding obligations but merely want to declare certain aspirations' (UN Treaty Collection).

'An international convention or treaty is an agreement between different countries that is legally binding to the contracting States [...] A convention becomes legally binding to a particular State when that State ratifies it. Signing does not make a convention binding, but it indicates support for the principles of the convention and the country's intention to ratify it' (UN Enable).

Protocols are 'agreements less formal than those entitled 'treaty' or 'convention'. A protocol signifies an instrument that creates legally binding obligations at international law' (UN Forum on Forests, An Overview of International Law, p.5).

Recommendations are generally considered soft law and are non-binding (Scholars at Risk, 2017).

Principles, Conventions and Declarations on humanitarian response, refugees and migration, which include the *United Nations Convention Relating to the Status of Refugees, Protocol Relating to the Status of Refugees Resolution* and the *New York Declaration for Refugees and Migrants*, outline the global mechanisms around displacement and asylum, and define the term ‘refugee’ and the protections that should be afforded to refugees. Scientists are among those displaced and these regulations would apply should they seek asylum or become a refugee.

The selected human rights documents, which include the *Universal Declaration of Human Rights (UNDR), International Covenant on Economic, Social and Cultural Rights,* and the *International Labour Organization (ILO) Recommendation 205: Employment and decent for work for peace and resilience,* not only outline basic human rights, including the right to live, but also the right to science and the right to decent work. The right to science does not stand alone but rather is reciprocal with other rights, such as the right to take part in cultural life, freedom of expression and freedom of movement. The right to science brings with it scientific responsibilities, and with them questions of governance and democracy. Other important issues are intellectual property protection, open access to scientific information, separating science and religion and ensuring reasonable costs for research products.

Development documents include the *Sustainable Development Goals* and *Agenda 2030*. These are key to forward thinking about rebuilding, resilience and sustainability and to improving conditions for people and the planet. Science plays a central part in achieving these development goals, particularly by driving the agenda and researching the implementation and impact of the goals. The science sector is also a beneficiary if it can practice science in a more peaceful world.

There have been several disaster risk reduction conventions, including the *Sendai Framework for Disaster Risk Reduction* and *Habitat III*, that outline the roles and responsibilities of governments and stakeholders from preventative measures to recovery from disaster. While the sciences have been instrumental in understanding disasters, rarely have they been used to look inward at how disasters may impact the science sector and how the scientific community can prepare for and respond to them.

The sciences may have much to learn from the declarations, conventions, frameworks and policies put in place to protect world heritage and culture. The *UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage* has been in place for 50 years and many sites have been identified and protected. These policies are not intended to cover the needs of the science sector. But they provide examples and inspiration for further legal and regulatory instruments which might protect science for future generations.

Table 2: International Frameworks for Supporting Science in Times of Crisis

Category	Date	Document	Specific articles	Note why important
Science and higher education	2017	Declaration of the 8th World Science Forum on Science for Peace	Entire document	Calls for 'preservation of scientific capacities, threatened by global migration trends', science organizations to act, and governments to include migrant and refugee researchers in the Global Compact for Migration
	2019	Global Convention on the Recognition of Higher Education	Article VII	Includes a special provision for refugees for 'Recognition of Partial Studies and Qualifications Held by Refugees and Displaced Persons'
	2017	UNESCO Recommendation on Science and Scientific Researchers	Entire document	Promotes fair and appropriate status of scientific researchers and policies to ensure that societies use scientific knowledge, including free circulation of scientific data, and provide scientists with financial and institutional support
			Article 25	'Member States should develop policies for the protection and preservation of research objects, scientific infrastructure and scientific archives, including in instances of conflict.'
	2020	Bonn Declaration	Entire document	'Freedom of scientific research is a necessary condition for researchers to produce, share and transfer knowledge as a public good for the well-being of society.'
	2021	UNESCO Recommendation on Open Science	Entire document	Promotes and supports online availability of scholarly information to everyone, free of most licensing and copyright barriers for the benefit of global knowledge flow, innovation and socio-economic development

Category	Date	Document	Specific articles	Note why important
Humanitarian response, refugees and migration	1951	United Nations Convention Relating to the Status of Refugees	Entire document	Defines refugees and gives them legal protections and rights
	1967	Protocol Relating to the Status of Refugees Resolution	Entire document	Further expanded and clarified protections and rights of refugees as laid out in the 1951 Convention, by removing both the temporal and geographic restrictions for refugee status
	2016	New York Declaration for Refugees and Migrants	Entire document	Focuses on supporting those countries and communities that host large numbers of refugees and promoting refugee inclusion
			Annex I: Global Compact for Refugees (GCR)	Provides guidance for achieving sustainable solutions to refugee situations through international cooperation. The Comprehensive Refugee Response Framework lays out concrete measures to meet the objectives of GCR.
			Annex II: Global Compact for Safe, Orderly and Regular Migration	Covers all dimensions of international migration, respects states' sovereign right to determine who enters and stays in their territory, while improving the governance of migration

Category	Date	Document	Specific articles	Note why important
Human rights	1948	Universal Declaration of Human Rights (UNDR)	Entire document; Article 27.1	Outlines human rights, including right to life, freedom of movement, to seek asylum, to education and to work; right to share in scientific advancement and its benefits
	2017	ILO Recommendation 205: Employment and decent for work for peace and resilience	Entire document	Addresses the right to decent work, especially as it relates to crisis situations
	1966	International Covenant on Economic Social and Cultural Rights	Article 15	To enjoy the benefits of scientific progress and its applications
Development	2015	Sustainable Development Goals (SDGs)	Entire document	The 17 goals are a blueprint for peace and prosperity for people and the planet, requiring scientific input
	2015	Agenda 2030 for Sustainable Development	Entire document	Further outlines what can be done by 2030 for people and the planet to strengthen universal peace.
Disaster risk reduction	2015	Sendai Framework for Disaster Risk Reduction	Entire document	Outlines measures for improved understanding of disaster risk, from preparedness to 'Build Back Better'
	2016	One United Nations for Habitat III	Entire document	Looks at the role of science in sustainable development; crucial for implementation of SDGs and Paris Agreement on Climate Change about actions to be prioritized
World Heritage and Culture	1972	UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage	Entire document	Recognizes the value of nature conservation and the preservation of cultural properties in specific locations by calling on national governments to identify, protect and preserve such sites
	2018	Warsaw recommendation on Recovery and Reconstruction of Cultural Heritage	Entire document	Guidelines for the recovery and reconstruction of world heritage sites following armed conflict or disasters

KEY FINDINGS

The key findings of this paper are organized in alignment with the phases of humanitarian response: prevent and prepare (the pre-crisis phase), protect (the crisis response phase), and rebuild (post-crisis phase). The findings draw on the examples described in Annex 1, noting trends, practices, programmes and policies, key learnings and notable gaps and challenges.

A summary of the main findings is given below.

1. PREVENTION AND PREPAREDNESS (Pre-crisis phase)	
Theme of finding	**Summary of finding**
1.1 Developing policy and action frameworks that enhance public trust and state support for science	*Deepening support for science through policy and action frameworks that protect or improve funding, access and communication; these help to build support for science and reduce the likelihood and impact of political attack, disinformation campaigns or funding cuts.*
1.2 Strengthening scientific networks and research collaborations, especially for systems and scientists most at risk	*Improving the personal and institutional scientific networks in place before a crisis increases the resilience and preparedness of individuals and institutions alike.*
1.3 Building cross-sectoral alliances to develop crisis-resilient science systems and leaders	*A disconnect between academic and science decision-makers and the professionals working on risk increases the likelihood of disasters impacting science systems.*
1.4 Taking greater responsibility for risk assessment and mitigation within science	*The scientific community struggles to translate its expertise in risk assessment into more structured approaches to the risks facing the sector itself. Systemic and cultural obstacles reduce capacity for effective leadership, planning and decision-making.*
1.5 Building dedicated resources for prevention and preparedness in science	*Scientists must get involved in grant acquisition and management to build more resilient science systems, especially where they see significant risks to the sector going unaddressed.*

2. PROTECT (Crisis response phase)	
Theme of finding	**Summary of finding**
2.1 Timely and predictable action underpinned by coordination and information-sharing mechanisms that connect local needs to international support	*Solidarity to support those affected by crisis exists. More predictable global standards and information-sharing mechanisms which incorporate local voices are necessary to help science actors meet the needs of those affected.*
2.2 Secure archival practices and digitization of data, records and ways of working	*Digitization allows for data sovereignty, greater mobility and a more flexible response to crisis. The secure maintenance and rescue of archives ensures academic, cultural and historical continuity.*
2.3 Flexible mechanisms for filling the funding gap	*During a major crisis, public money is often diverted to priorities other than science. This puts salaries, research grants and other types of support for science in danger. Alternative, flexible funding mechanisms are needed to fill these gaps.*
2.4 Inclusive, flexible support focused on helping scientists continue their work at home or abroad	*Flexible programme and funding models that enable changes in location, and both remote and in-person participation, help scientists to continue their work, and enable 'brain circulation'.*

REBUILD (Post-crisis phase)	
Theme of finding	**Summary of finding**
3.1 Putting science on the agenda for post-crisis recovery	*Ensuring that science and research are a priority for recovery plans will accelerate the mobilization of useful knowledge, ensure the training of local experts and professors, and support reconciliation and the sense of belonging. International and cross-sectoral scientific partnerships can have a crucial role to play in post-crisis planning and calling for cooperation with development actors.*
3.2 Incentivizing the engagement of scientists and the science sector in fragile and crisis-affected contexts	*Incentives for science collaboration provide little motivation for scholars and institutions to become involved in post-crisis collaborations focused on capacity strengthening or which include aims that are not explicitly academic.*
3.3. Recognizing the opportunities and perils of transforming science systems post-crisis	*When visions and interests align between local and international actors, there is potential for post-crisis reform and transformation. Local scientists should be involved in shaping recovery. It can help avoid the imposition of foreign models onto local scientific communities and science systems.*
3.4 Using the potential for reform in post-crisis recovery to advance 'open science'	*The reconstruction phase creates an opportunity to advance the open science agenda and, in the process, supports the recovery of affected scientists through greater integration in international networks and fairer access to scientific platforms, equipment and technology.*

1. PREVENT AND PREPARE: PRE-CRISIS PHASE

Summary: Scientists bring expertise, insight and focus to crisis research and are invaluable as advisers on crisis to decision-makers. But there is a disconnect between this expertise and the work of administrators and crisis experts to mitigate crisis risks to science systems and institutions. The impact of such crises on science systems and scientists globally is often underestimated, as is the potential value of science-led prevention and preparedness. Investing in policies that engage various publics' understanding of the value of science, and the return on investment in it, is needed to increase trust in and support for science.

Our review has found five factors that significantly improve the ability of scientific communities to prevent or prepare for crises affecting science systems. These are:

- **1.1** Developing policy and action frameworks that enhance public trust and state support for science;
- **1.2** Strengthening scientific networks and research collaborations, especially for systems and scientists most at risk;
- **1.3** Building cross-sectoral alliances that can develop crisis-resilient science sectors and leaders;
- **1.4** Taking greater responsibility for risk assessment and mitigation within science;
- **1.5** Building dedicated resources for prevention and preparedness in science.

Further elaboration of these five factors can be found below.

1.1. Developing policy and action frameworks that enhance public trust and state support for science

Deepening support for science, through policy and action frameworks that protect or improve funding, access and communication, can reduce the likelihood and impact of political attack, disinformation campaigns or funding cuts.

In many places, the main threats to science systems, institutions and scientists are funding shortfalls caused by the lack of political support for science. Senior scientists in Latin America add that for much of the continent, one of the most prominent threats to the functioning of science systems comes from religious and political extremism within government, where scientific freedom may be seen as a threat to governing ideologies. The result is to make science uniquely vulnerable to national politics, exposed to 'widespread questioning of the fundamental value of science and education more widely in society' (Lodinsky, 2022).

The Brazilian National Museum fire in 2018, which destroyed one of Latin America's most renowned natural history museums and most of its 20 million artefacts (Lenharo and Rodriguez, 2022), is illustrative of the risk. In this case, fire safety systems had been too expensive to maintain on the museum's limited budget (Greshko, 2018). Brazil had also seen a long-term trend of declining funding for science. The 2018 election of President Jair Bolsonaro heralded public attacks on the veracity of science, including the discrediting of deforestation data on the Amazon and of vaccine campaigns and public health measures during the COVID-19 pandemic. These led to unprecedented funding cuts for science.[4]

The importance of science and scientists generating understanding and support for science investment is especially evident in the post-conflict context. Here, public understanding of the potential return on investment in science is crucial in the context of governments making political decisions about how to prioritize funding during crises and in the aftermath. In the reality of war, public universities, such as those which make up the majority of Ukraine's higher education infrastructure, had investment and funding immediately cut in service of the necessary military defence budget. Ensuring that science can maintain political and public support and increase its funding at the earliest opportunity will require strategic arguments about the return on investment in science infrastructure. Such claims should be based on the concept of research, innovation and development as the foundation of the future Ukrainian economy, and on attracting back talent that has moved abroad (see Annex 1, case study 1.1).

1.2. Strengthening scientific networks and research collaborations, especially for systems and scientists most at risk

The personal and institutional scientific networks in place before a crisis have a big impact on the resilience and preparedness of individuals and institutions alike.

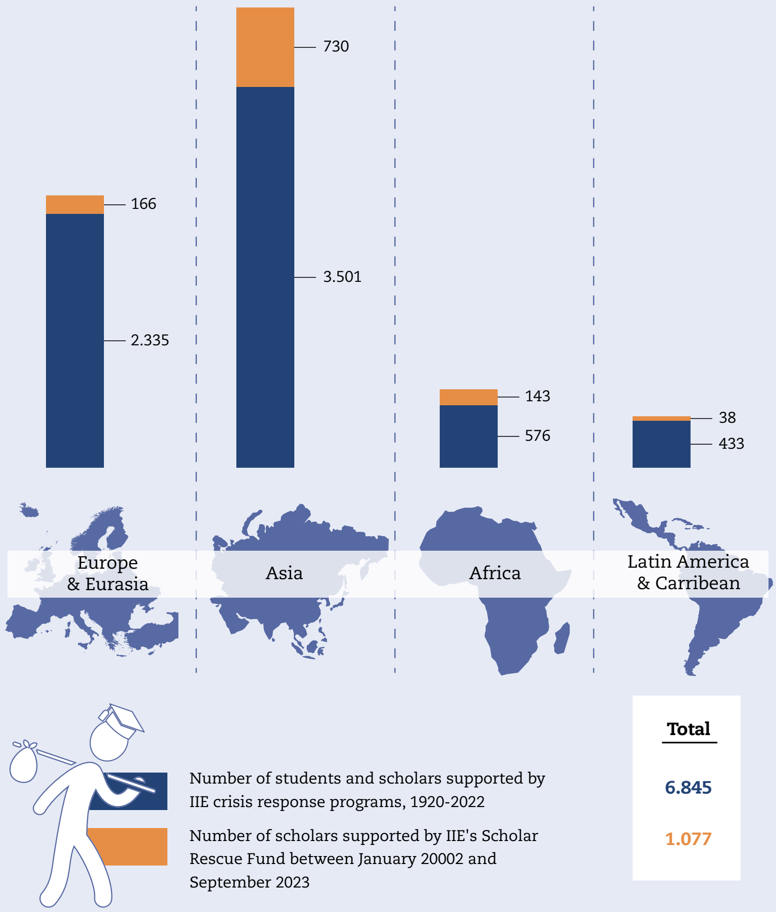
Research by the Young Scientists Council of Ukraine and the Polish Academy of Science found that Ukrainian scientists who left the country after the Russian invasion overwhelmingly moved to places where they already had established professional relationships through multi-institutional research programmes, via university alumni associations or through personal connections (Maryl et al., 2022).

The consequences of a lack of international cooperation are evident in the case of Mosul University after the ISIS occupation from 2014 to 2017. Mosul University scientist Dr Alaa Hamdon describes an almost complete lack of international exchange in place before the crisis. When scientists were forced to flee, many were unable to continue their research. Emergency support organizations including the Council for At-Risk Academics (CARA) in the UK, le Programme d'aide à l'Accueil en Urgence des Scientifiques en Exil (National programme for the urgent aid and reception of scientists in exile, PAUSE) in France, and Scholars at Risk, were able to help some scientists to find new opportunities to work again.

The graphic below shows the number of scientists assisted by the Institute for International Education (IIE) Scholar Rescue Fund (IIE-SRF), a programme that has been arranging, funding and supporting fellowships for threatened and displaced scholars at hosting higher education institutions worldwide, including within their home regions and in non-English speaking placements since 1920.

4 *Science in Times of Crisis* Podcast, Episode 2, Mercedes Bustamante, University of Brasilia.

The Institute of International Education data for Protecting Science in Times of Crisis



IIE's work to safeguard the lives and careers of threatened university students and academics began in 1920, when the Russian Student & Scholar Fund helped over 600 individuals caught in the crossfire of the Bolshevik Revolution and Stalinism to reach safety in Europe and the United States. Since then, IIE has continued its practical support for students and scholars seeking respite from global conflicts and political emergencies, from the mid-century rise of fascism in Europe, to Apartheid in South Africa, to the myriad present-day crises. IIE's Scholar Rescue Fund (IIE-SRF) was established in 2002 and is the only global program that arranges, funds, and supports fellowships for threatened and displaced scholars at hosting higher education institutions worldwide, including within their home regions and in non-English placements.

See www.scholarrescuefund.org/about-us/our-history/ for more detail.

The recent and current wars in Syria and Ukraine have led their domestic science sectors to call for the establishment of standing networks and programmes of support and protection that connect to the wider international scientific community. This suggests that integrating scientists and institutions from at-risk countries into existing collaborations, or at least being clear on the means needed to start new initiatives when a crisis erupts, would be a significant contributor to scientific resilience. One example is the way in which the mechanism for EU COST (European Cooperation in Science and Technology) was able to adapt to emergency circumstances in the wake of the 2022 Russian invasion by quickly recognizing Ukraine as full members, enabling and incentivizing the participation of Ukrainian academics and institutions in COST actions (See Annex 1, case study 1.1).

Multi-country research collaborations also help to improve preparedness against crises involving political and financial attacks on science.

1.3. Building cross-sectoral alliances for developing crisis-resilient science systems and leaders

A disconnect between academic and science decision-makers and the professionals working on risk increases the likelihood of disasters impacting science systems.

Building partnerships that connect science to the disaster risk reduction (DRR) and humanitarian sectors is key to equipping scientists with the skills to manage risk, and to developing risk professionals with a deeper understanding of the science sector. UNESCO's Emergency Preparedness and Response Unit within its Culture Sector, for example, has structured itself with separate teams addressing conflict and disaster. This means that each is more able than before to recognize and address the different hazards, assessments and responses required during the two types of crisis. UNESCO has built key institutional partnerships to deliver training programmes that bring together practitioners, academics and officials in cultural heritage with professionals working in the DRR, development and humanitarian sectors. Some of these programmes are intimately connected to science, such as libraries, archives and museums. Evidence on the ground has taught the immeasurable value of having multi-stakeholder teams responding to a crisis with expertise in both the cultural and DRR sectors. For example, it is important to be able to identify a heritage building and preserve rather than destroy it. A less encouraging example involves major fires in Brazil and South Africa. Here the lack of technical understanding among first responders of how to preserve scientific artefacts was deemed to have contributed to a greater loss of specimens than necessary.

Global mechanisms exist to support greater technical analysis of risk, such as the World Bank's biennial forum on 'Understanding Risk', intended to facilitate cross-sectoral dialogue on the topic, or the UNDRR's 'Cultural Heritage Addendum' to its Disaster Resilience Scorecard for Cities. However, the second of these provides little evidence that science has been considered relevant.

1.4. Taking greater responsibility for risk assessment and mitigation within science

The scientific community struggles to translate its expertise in risk assessment into more structured approaches to mitigating risks facing the sector itself. Systemic and cultural obstacles damage its capacity for effective leadership, planning and decision-making.

The enduring reality of polycrisis is challenging all sectors to approach disaster risk governance more systematically, through a multi-stakeholder process that can help to draw out the systemic causes of risk.[5] Throughout global science systems, there exists a great pedigree and experience of risk assessment through research and the process of providing

5 In addition to the systemic nature of risk, education, accountability and a lack of resources are also essential considerations in understanding risk. After the COVID-19 pandemic, these factors, alongside a multi-stakeholder approach for addressing risk assessment, were reassessed by substantial research, including Maskrey, A., Jain, G. and Lavell, A. (2023) 'The social construction of systemic risk: towards an actionable framework for risk governance'. *Disaster Prevention and Management*, Vol. 32, No. 1, pp. 4–26; and Alcántara-Ayala, I., Burton, I., Lavell, A., Mansilla, E., Maskrey, A., Oliver-Smith, A. and Ramírez-Gómez, F. (2021) 'Root causes and policy dilemmas of the COVID-19 pandemic global disaster'. *International Journal of Disaster Risk Reduction*, Vol. 52, p. 101892.

scientific advice, but this expertise is not applied systematically to assess and reduce risk to science institutions and systems themselves.

The sector's capacity to conduct multi-hazard risk assessments needs to be supplemented by the skills needed to translate those results into concrete plans via risk registers, risk management policy, training and other approaches. This step forward is crucial to enhancing preparedness for emergencies. However, the lesson is often hard-learned. Ukrainian universities occupied in the wake of the February 2022 Russian invasion lacked evacuation plans for scientific equipment, artefacts and data, which were never thought likely to be needed.

Robust structures that can manage risks effectively are crucial. However, they can be undermined by governance structures that do not empower senior leaders to make difficult resource decisions. This was evident in the case of the Brazilian National Museum fire. The director, Dr Alex Kellner, was clear that it was not only budget constraints that had held the museum back from addressing fire risks. The wider obstacle was a lack of incentive for scientists with the right skills to take on the leadership and management of scientific institutions beyond the academic level. The world heritage and cultural sector has confronted this challenge in part by building initiatives that comprise dedicated risk awareness and leadership skills.

Multidisciplinary expertise is key to multi-hazard risk assessments. Internal, historical or structural obstacles still exist within science systems that make this difficult.

1.5. Building dedicated resources for prevention and preparedness in science

The existence of unaddressed crisis risk to the sector calls for more participation and entrepreneurialism by scientists in grant acquisition and management for crisis prevention. Funds are needed urgently to build more resilient science systems before a crisis hits.

When under-resourcing is a critical limiting factor in addressing risks to science, scientists need to be ready to make the case for public funding. Except for science institutions related to national defence or the economy (including nuclear, biological and energy infrastructure), political realities mean funding for risk prevention is too limited. This is in contrast to ongoing emergencies which draw near instant reaction and attention from donors. In a context where the funding for disaster risk management is both very limited and competitive, scientists need to be at the forefront of advocacy by articulating the risk to the sector, and the potential loss to society, if risk prevention and preparation are not invested in. This will involve utilizing the media to make the risk to science institutions more explicit (see Annex 1: case study 3.2).

Science can also look to other sectors for insight or collaboration on potential funding mechanisms. One illustration of an effective funding mechanism for prevention, albeit with limited access to funds, is the UNESCO Heritage Emergency Fund. With the capacity to fund initiatives in prevention and preparedness, as well as crisis response, the core strength of this donor-funded mechanism is being non-earmarked, so allowing grant-makers to take a flexible and needs-based approach across geographies and sectors. Funding can be used for technical support, capacity building, risk assessment and recovery planning at municipal, national or institutional level in support of tangible and intangible heritage. Grants are designed and delivered in partnership between sectoral and local expertise. In recent times, such funds have been used to improve preparedness for flooding in Guatemala City and recovery from hurricane and fire in Cuba and Chile.

2. PROTECT: CRISIS RESPONSE PHASE

Summary: During national or large-scale emergencies, the specific needs of science systems, institutions and scientists tend to fall through the gap during the humanitarian or crisis response phase. The science and research sector needs to respond in a timely and predictable manner, showing agency and solidarity during a crisis. Right now, the response of organized science is ad hoc and limited to a few champion institutions and dedicated 'science humanitarians',[6] rather than there being clear sector-wide roles and responsibilities for meeting needs that scientific institutions are often best placed to help address.

Our review has identified four factors that significantly impact the ability of scientific communities to respond effectively in the short-term to crises affecting science systems. These are:

- **2.1** Timely and predictable action underpinned by coordination and information-sharing mechanisms that connect local needs to international support;
- **2.2** Secure archival practices and digitization of data, records and ways of working;
- **2.3** Flexible mechanisms for filling the funding gap;
- **2.4** Inclusive, flexible support focused on helping scientists continue their work at home or abroad.

Further elaboration of these four factors can be found below.

2.1. Timely and predictable action underpinned by coordination and information-sharing mechanisms that connect local needs to international support

More predictable global standards, and information-sharing mechanisms which incorporate local voices, are needed to help science meet the needs of those affected.

Experience from the recent Syrian and Ukrainian conflicts has demonstrated the importance of listening to the needs of the affected population. Regular surveys of Ukrainian refugee and displaced scientists have shown how needs change rapidly and stress the importance of adapting local and international responses to changing conditions.

Currently, a lack of global standards on information sharing limits the ability of international science and higher education institutions to understand what support the affected scientific

6 Such as officials, NGOs (e.g., SAR, CARA, PAUSE) and UN agencies (UNHCR) with a special mandate to protect and support at-risk, refugee and displaced academics and scientists.

communities need, and to respond in a swift and coordinated manner. A more coordinated information-sharing mechanism is critical. It should enable greater understanding and timely support to affected scientific communities. This mechanism should facilitate all science institutions (including universities, academies, disciplinary unions, associations, research funders and publishers) in helping the affected communities, as well as non-governmental organizations (NGOs) and UN agencies with a special mandate to support at-risk scholars. Without clarity about needs from the ground up, and more means for shared lesson-learning, support programmes for refugee and displaced scientists can put pressure on unprepared host systems. A well-established information system will increase effectiveness and allow sharing of best practices.

2.2. Secure archival practices and digitization of data, records and ways of working

Digitization allows for data sovereignty, greater mobility and a more flexible response to crisis. The secure maintenance and rescue of archives and data ensures academic, cultural and historical continuity.

When Berdyansk University in south-eastern Ukraine was occupied by Russian forces in the early days of the war, there was a significant risk that control of key public and private university content would be lost due to the evacuation and destruction caused by the war. Igor Lyman (interview in 2022) a displaced academic from the university, notes that urgent aid came from the Canadian Institute of Ukrainian Studies at the University of Alberta to save the university's website and back-end data by rapidly uploading it onto the cloud. Elsewhere in Ukraine, the Ukrainian Clinical Research Support Initiative has illustrated that protecting and preserving clinical research data and ensuring scientists can retain ownership of the data they produce and repatriate them safely in due time, is crucial to helping scientists and research and applied institutions continue to do their work, to serve the public and to publish (DIA Global Forum, 2023).

Japan after the Second World War provides ample examples of the risk that archives and other official records will be destroyed by political decision. The historian of science Sayaka Oki (interview in 2022) describes how many official records of historical significance concerning the scientific context of the war were destroyed all over Japan and its occupied territories on the order of government ministries at the end of the war. This was done mainly because of individuals' fears of being tried for war crimes by international society (Kiyofumi, 2019). Statistical data concerning the requisition of the workforce and material resources of occupied nations, and documents relating to military research were especially likely to be destroyed. Doubts on remaining data and missing information left a gaping hole in the understanding of Japan's past.

Many countries do not have a clear policy on archival practice and on the storage of their own non-digitized records in administration and research[7]. Numerous historical examples

7 Note that an archive is not the same thing as a repository. An archive is the documentary by-product of human activity retained for their long-term value, whereas a digital repository is a collection of digital objects of information that are preserved for the long term. A data repository, often digital but not always, therefore collects scientific data objects that are to be preserved for the long term.

show us that the deliberate destruction and removal of important records and research, especially by totalitarian regimes in times of crisis, interrupts and rewrites historical, cultural and scientific accounts, as mentioned in Finding 1.3.[8]

Digitization also speaks to enabling more flexible and accessible ways of virtual working, which can enable continuity and mobility during a crisis. Lessons from working during the SARS-CoV-2 (COVID-19) pandemic are useful and can show ways forward, both in terms of what can be done and how, and what to avoid. Investment in a more secure digital infrastructure also helps to lower barriers to access (ISC, 2022a).

2.3. Flexible mechanisms for filling the funding gap

Crises inevitably create gaps in salary payments, research grants and other types of support for science, as public money is diverted to other priorities. Only alternative, flexible funding mechanisms can address this issue.

Clear evidence from conflict-affected contexts including the Balkans, Iraq and Ukraine shows that government funding for higher education and research usually gets diverted to security and defence efforts when crisis hits. Science may be seen as a luxury compared to other humanitarian priorities, and the UN Refugee Agency experience is that displaced and refugee scientists and academics rarely meet the vulnerability standards to access its emergency funds.

Without a globally coordinated funding mechanism or network for supporting science during times of crisis, scientific institutions become reliant on ad hoc forms of foreign aid. Valuable hosting and support programmes for refugee and displaced scientists are run by organizations such as Scholars at Risk, the Institute for International Education (IIE) Scholar Rescue Fund (SRF), CARA, PAUSE and others. But they lack the scale and predictability needed to reach all those affected at the global level. These two factors are essential in developing long-term, sustainable frameworks for all stages of conflict or disaster (ISC, 2022c).

Crisis conditions are continuously changing, making more adaptable, responsive and flexible approaches to providing support essential. NGO experience shows that small initiatives can be more agile and responsive, particularly during the initial phases of the crisis, while larger international programmes can take up to a year to get off the ground. In response to the escalation of war in Ukraine during 2022 and 2023, several funding agencies, including the Royal Netherlands Academy of Arts and Science (KNAW), Polish and Swiss National

8 Two pertinent examples of secure and relevant archival practices are:

1. Beyond 2022, a project by Trinity College Dublin, in collaboration with the National Archives, the National Archives (UK), the Public Record Office of Northern Ireland and the Irish Manuscripts Commission is an example of how, thanks to digitization, information sharing from around the world can recreate collections. The project is creating a virtual reconstruction of the Records Treasury of the Public Record Office of Ireland, which was destroyed during the Irish Civil War in 1922.
2. The Svalbard Global Seed Vault. More than 1,700 genebanks hold collections of food crops for safekeeping worldwide, yet many of these are vulnerable, exposed not only to natural catastrophes and war, but also to avoidable disasters, such as lack of funding or poor management. The Seed Vault stores duplicates backups of seed samples from the world’s crop collections as a safeguard against such catastrophic loss.

Academies of Sciences, Engineering and Medicine (NASEM) and ALLEA's European Fund for Displaced Scientists (EFDS), developed research calls and programmes that delivered resources and funding to Ukraine while respecting the legal requirements of the contributing agencies.

Alternative institutional funding mechanisms can be established to help support scientists until more sustainable interim or post-conflict models can be installed. The EU's COST (European Cooperation in Science and Technology Actions), established in 1971, is one such grant-funding mechanism. This systematic international support mechanism was designed to be able to adapt to changing emergency circumstances and provide emergency aid, mobility opportunities and assistance in professional advancement. It is important to note, however, that this fund and others have limitations on the eligibility criteria of countries, which put limits on their flexibility. Another relevant flexible institutional mechanism to note, from the Culture and Heritage Sector, is the UNESCO Heritage Emergency Fund (see Finding 1.5).

2.4. Inclusive, flexible support focused on helping scientists continue their work at home or abroad

Flexible programme and grant-funding models that enable changes in location, and both remote and in-person participation, help keep scientists active and enable 'brain circulation'.

Creating opportunities for continuing scientific work during prolonged crises and displacement is crucial – especially when the average length of displacement is currently estimated by UNHCR at 17 years in the case of conflict (UNHCR, 2021). Surveys run by the Ukrainian Young Scientists Council and the Polish Academy of Science since the 2022 invasion have underlined the demand from affected scientists to keep working – whether reviewing articles, publishing papers, speaking about their research or just accessing scientific content.

In the case of researchers looking for a grant or academic position overseas, key barriers include language, given that most opportunities available are in English; the effects of trauma and stress; and disciplinary discrepancies. In the case of Ukraine, most available positions are in fields (science, technology, engineering and mathematics), and the majority of refugee scholars come from the social sciences and humanities. One example where the sector has tried to adapt its support on the basis of surveys from affected communities is the way in which some publishers provide free open access to a vast number of international scientific journals, as well as 'rapid proceedings' for Ukrainian scientists submitting papers. This involves simplifying application and review processes. Similar approaches could be extended to international conferences, ensuring spaces for refugee and displaced scientists to present their research.

Within each of the crises explored in this review, debate has arisen on the cross-border movement of individuals, specifically regarding 'brain drain' and the role that the international science community plays in driving it through the type of support offered. This concern can be mitigated by flexible programme and funding models that enable changes in location and allow for both remote and in-person participation, enabling what the OECD has labelled 'brain circulation' (OECD, 2022). Such models can incentivize some scholars to remain in their home country and accommodate others' desires to relocate abroad, respecting individual perspectives on safety and vulnerability. Other examples of support that avoid geography getting in the way are non-resident access to libraries, as well as research and teaching opportunities in international institutions.

For those displaced outside their country, a more needs-based strategy is to mobilize the diaspora rather than force early return. The Institute for International Education's Scholar Rescue Fund repurposed their Iraqi Scholar Rescue project to a distance learning initiative in 2015 following the ISIS occupation, allowing more than 280 Iraqi academics with fellowships abroad to deliver courses remotely, filling curriculum and expertise gaps at local universities.

3. REBUILD: THE POST-CRISIS PHASE

Summary: Obstacles exist to science bringing its full capacity to bear in the service of post-crisis reconstruction. Incentivizing and enabling stronger collaboration between local and international science actors, and with the UN and development sectors, provides potential for transformation and reform within science during this phase, while increasing the potential for science to be prioritized for funding and support.

This review has highlighted four factors that improve the ability of scientific communities to rebuild science systems effectively following crisis. These are:

- **3.1** Putting science on the agenda for post-crisis recovery;
- **3.2** Incentivizing the engagement of scientists and the science sector in fragile and crisis-affected contexts;
- **3.3** Recognizing the post-crisis opportunities and perils of transforming science systems;
- **3.4** Using the potential for reform in post-crisis recovery to advance 'open science'.

Further elaboration of these four factors can be found below.

3.1. Putting science on the agenda for post-crisis recovery

International and cross-sectoral scientific partnerships can have a crucial post-crisis role. But to be prioritized within recovery plans, science requires closer cooperation with development actors.

Science should be prioritized in post-crisis recovery plans. There is clear potential for science and research institutions to play an important role in post-crisis development if that role is clearly defined in relation to those of key development actors such as the UN, the World Bank and regional development banks. An area of complementarity is in the rebuilding of scientific and research infrastructure, including higher education institutions. The challenge of closer collaboration is that development actors are traditionally less likely to sponsor international research collaboration if it is framed in purely academic terms, while academia is reluctant to sponsor international science capacity building if it is seen to be a development venture outside scientific priorities.

An example of this disconnection occurred in the rebuilding of Mosul University by UNDP (UN Iraq, 2022). Because the programme design came without academic consultation or capacity building for staff, the institution's recovery was far slower than the building's new facade would suggest. Departments lacked essential scientific instruments and the library was struggling to restore its knowledge capacities. Fortunately, the development sector is increasingly understanding the role and potential of collaboration with science and higher education, as evidenced by the 'humanizing higher education'[9] movement, but it is unclear to what extent the science and research ecosystem is ready to respond.

The heritage and culture sector has modelled the potential for post-crisis, cross-sectoral collaboration. UNESCO and the World Bank have developed the CURE Framework (Culture in City Reconstruction and Recovery) to help recovery teams and development agencies in urban contexts to incorporate culture into the recovery process. In other words, more should be done to integrate science into recovery processes.

International scientific collaboration done in a transdisciplinary and cross-cultural manner can deliver on both academic and development aims during reconstruction. Collaboration for reconstruction and development can focus on developing scientific research projects; on building teaching capacity and knowledge production through joint scientific research; on curriculum development and academic programmes; on science management and policy; and on the pairing of research institutions or universities.

One such example of scientific collaboration in the aftermath of crisis is the Rethink Education and Science in Iraq (RESI) partnership between the Universities of Graz (Austria), Mosul (Iraq) and Dortmund (Germany). It shows the value of pairing universities for reconstructing institutions and suggests potential for extending the approach to research councils and academies. This partnership built teaching capacity and knowledge production through joint scientific research, curriculum development and academic programmes. It also contributed to broader developmental aims linked to countering ISIS ideology and supporting reconciliation and healing, by promoting academic discourse and dialogue between academics, students and wider society from different social groups. As a result of their experience in the RESI programme, RESI leader Dr Heike Wendt and colleagues have articulated in detail the key requirements for building effective science partnerships in these contexts (Wendt et al., 2022).

9 The humanizing international higher education movement is defined by a 'respect for humanity, ethical frameworks, co-construction of knowledge that is embedded in a compassionate, kind and empathetic framework, and one that is led by student communities who will lead the co-construction and integration of co-constructed global knowledge perspectives, indigenous knowledge forms and lived experience' (University World News).

3.2. Incentivizing the engagement of scientists and the science sector in fragile and crisis-affected contexts

Current incentives for science collaboration give little motivation for scholars and institutions to become involved in post-crisis collaborations focused on capacity strengthening, or which include aims that are not explicitly academic.

Academics who have been part of scientific initiatives in these contexts, such as Dr Wendt, argue that the incentive structure for universities and researchers rewards quality, measured by proxies such as impact factors, over content and impact. This means that there is little incentive to seek out research partnerships with institutions from typically low-income countries where conflict or disaster may have occurred. They often do not meet traditional academic standards for internationalization.

Instead, such collaborations are seen as serving the goals of the international development sector rather than academia, and so do not attract the engagement and funding that is possible from within the narrower and more closely defined scientific community.

Yet the world needs science from countries affected by crisis, and those countries need science. One obvious example is to maintain health research and clinical trials during a pandemic. Here, new practical and ethical guidance is needed by patients, practitioners and policy-makers. Patients in clinical trials, or who are dependent on disrupted health care systems, are left without clear pathways to navigate either their clinical trials or their care provision. If they wish to leave the country, their personal data is often not transferable across borders. This points to the need for regulatory framework support to ensure the protection of clinical trials and ongoing treatment and care, and the protection, access and transferability of patient data. Examples from other fields of research confirm the importance of continuous collaboration with affected countries.

Addressing this challenge will mean enabling researchers from all regions, including conflict zones, to participate in global scientific discourse and events (Lodinsky, 2022). Conferences should be inclusive and facilitate the inclusion of expertise from countries affected by crisis. This will require support to overcome language, financial and other sociocultural barriers: some academics in Mosul University have never left Iraq (Wendt et al., 2022).

3.3. Recognizing the opportunities and perils of transformation

When vision and interests align between local and international actors, there is great potential for post-crisis reform and transformation. But imposing approaches on the local community without allowing for the voice of local scientists to help shape recovery would reduce the acceptability of reforms.

Crises are almost always a catalyst for change and opportunity. But to realize this potential requires trust between local and international science actors, built on sensitivity to the local socio-historical context. Trust-building and the development of a shared vision for the future are essential to this process. The fraught nature of crisis often creates conditions for mistrust, especially in the context of power imbalances between local and international actors relating to money and security. In these circumstances, a commitment to key principles such as local ownership and good governance, and respect for cultural diversity, are imperative for creating the conditions to build trust. This has been modelled in the development of the Arctic Investment Protocol, supporting the work of the Arctic Economic Council, which has codified values and standards around indigenous leadership, inclusive decision-making and long-term thinking to help participants work more effectively.[10]

In a conflict with significant geopolitical importance, the risk is that the international actors involved in the post-conflict phase will want to advocate for rebuilding in the image of their own science system, often from the Global North. In Ukraine, institutions like the World Bank, supported by many Ukrainian academics, have already made recommendations about reducing the university numbers from the post-Soviet model and building a more entrepreneurial mindset within academia. The task for the international science sector will be to help the country's scientific community articulate and help shape the rebuilding of Ukraine's science system.

Historians of science, such as Sayaka Oki (2022) argue that one way to ensure that past mistakes in the evolution of science systems are not repeated is to invest in maintaining scientific 'memory' – so that future dialogue about reform is informed by an understanding of how the system responded to and rebuilt from crisis in the past (see Annex 1: case study 2.2).

3.4. Using the potential for reform in post-crisis recovery to advance 'open science'

The reconstruction phase creates an opportunity to advance the open science agenda and, in the process, support the recovery of affected scientists through greater integration in international networks and fairer access to scientific platforms, equipment and technology.

Advancing open science is one way to offer greater opportunities for integration in international networks, and better protection of knowledge in times of crisis. Using crisis as a catalyst for advancing the open science agenda improves the resilience of systems for future crises and helps to realize the ambition of science as a global public good in the world.

The experience of scientists on the ground suggests there is still a long way to go to make open science a reality. Academics in Ukraine, such as Igor Lyman from Berdyansk State Pedagogical University, describe how, despite many acts of generosity and the efforts of some science publishers including the Research for Life portal, accessing journals 'depends on the initiative of each individual library, university or journal, or even individual professor'. Global standards around research distribution, access and intellectual property rights need mechanisms in place for when crises occur.

Building a competitive science system in the current context means facing the rising costs of research technologies in several scientific fields, for publishing in elite journals and for journal subscriptions. For many vulnerable science systems, these costs are prohibitive, making it harder to prepare for or recover from crisis. These factors limit the visibility of research findings and affect productivity, as the sense of the value that an institution or individual researcher can create is reduced (see Annex 1, case study 3.2).

10 International Science Council, *Science in Times of Crisis* Podcast, Episode 3, Melody Brown Burkins, University of Dartmouth.

SUGGESTED WAYS FORWARD

In an era where polycrisis is becoming the new normal and competition for resources will only keep increasing, numerous areas exist where science could choose to build its own capacity for handling crises. The literature reviews and interviews for this paper are limited in scope and depth. So rather than outlining a set of prescriptive actions, the following five suggested ways forward aim to provide options for the science sector to explore and research. The sector may be defined as including universities, research institutions, academies, disciplinary unions and associations, science ministries, public funders and publishers, as well as research done in the private sector. The spirit of the suggested areas for action is captured in the following reflection on scientific support for Ukraine:

> *'The international science community should start planning how best to prepare the country's research infrastructure for the end of the war. Long-term partnerships that focus on capacity-building will be crucial, particularly in the areas of management, monitoring and policy. These collaborations must try to sustain day-to-day research as much as possible now, so that the research community can hit the ground running and be much more effective as soon as the conflict ends.'*
>
> 'Rebuilding Ukrainian science can't wait – here's how to start'. *Nature*, Editorial, 22 February 2023 (Vol. 614, pp. 593–4)

1. CLARIFY AND ADOPT PRINCIPLES FOR GUIDING RESPONSE TO CRISIS:
All actors from the science and research sector share a responsibility to prepare for crises. This is the only way to enhance the resilience of the sector as a whole. It includes identifying how they can better prepare their own institutions to manage risk and respond to crisis, and clarifying how they can support scientists elsewhere affected by crisis.

Survey evidence shows the importance of maintaining scientists at work as long as possible during a crisis, and of limiting the time during which they are inactive. Any such effort to help scientists continue their work when crisis hits – whether via reviewing articles, responding to research calls and proposals, publishing papers, communicating their research, accessing content from scientific data repositories and journals, teaching and mentoring – is crucial for avoiding long-term loss of scientific competence and capacity. It will also help recovery, by preserving expertise from the affected country that can support rebuilding efforts.

The ISC and its partners have held two conferences on the science sector's response to the escalation of war in Ukraine. They then used the knowledge gained there to produce principles for action that could guide the international scientific community on future crises.[11]

11 The first was on 15 June 2022: Responses from the European Higher Education and Research Sectors. The second was in March 2023: One year of war in Ukraine: exploring the impact on the science sector and supporting initiatives.

See the box below for a summary of the recommended principles.

Agreed principles from the June 2022 Conference on Responses from the European Higher Education and Research Sectors:

Responsibility	Governments and the higher education, scientific and research community must work together to deliver their national commitments to recognize and support the right to education and science within their country.
International solidarity	Governments, higher education institutions and the scientific and research community must work together to deliver their national commitments to support the participation of at-risk, displaced and refugee scholars and researchers in their home country or another country if necessary.
Openness	The international scientific and research community should empower conflict-affected science systems with the means to rebuild by fully adopting the UNESCO Recommendation on Open Science.
Inclusion	All stakeholders must ensure that programmes and opportunities are designed inclusively to avoid exclusion of specific groups of at-risk, displaced and refugee scholars and researchers on the basis of characteristics such as language, family status, gender, disability, cultural background and psychosocial wellbeing.
Mobility	To ensure that the potential of displaced and refugee scholars and researchers is not lost, stakeholders must work together to develop global mechanisms and coordination structures that facilitate secure academic and scientific mobility.
Flexibility	All stakeholders must recognize the evolving needs of academics, researchers and students by designing flexible programme and funding models that enable changes in location and allow for both remote and in-person participation.
Predictability	To ensure a more predictable and effective approach to the phases of preparedness, response and rebuilding in the aftermath of conflict or disaster, stakeholders must work together to develop sustainable frameworks within and between national scientific, higher education and research systems.

Additional agreed principles from the March 2023 Conference: One year of war in Ukraine: exploring the impact on the science sector and supporting initiatives:

Coordination	Responses to crisis require broader coordination, partnership and collaboration between stakeholders from different sectors and locations. Harmonizing responses will lead to greater efficiency and effectiveness.
Dialogue	Safe places and trusted interlocutors are needed to bring together diverse stakeholders within the international science community around sensitive and complex issues related to crises, to facilitate dialogue that promotes solidarity, collaboration and coordination of responses and solutions.
Agency	When possible, preparedness and responses to crises are best initiated under local leadership in collaboration with foreign initiatives as timing and context allow.

2. Capacity building for scientists and leaders: in several comparable sectors, such as disaster risk and culture,[12] there are areas in which training has been essential for building resilience within leadership and technical roles. They include:

- **Disaster risk management and risk assessment:** engaging with key communities and events, such as the World Bank's biennial 'Understanding Risk' forum, to enhance science's visibility, contribution and learning. Building the capacity of responders, planners and decision-makers at all levels in science systems and institutions. Significant learning comes from the progress of the culture sector in this area.
- **Management, monitoring and policy:** improving the capacity of scientists in facing crisis to design and lead research and development programmes, and to contribute to local and international policy debates.
- **Media and Advocacy:** for scientists to utilize modern communication and storytelling tools to influence public and political opinion, especially during political crises, when science may need to communicate its value directly to different publics.

3. Enhancing international policy frameworks to value science more highly: reaching out to other sectors with influence and expertise in disaster risk reduction, response and recovery to improve risk assessment and find ways to keep scientists in their work during and after crisis. This will involve the scientific community in working with decision-makers and practitioners to ensure practical and actionable frameworks that are aligned with state policies and commitments.

12 Scientists in Ukraine have emphasised specific and contextualised skills as key to enabling them and their institutions to recover and function (see Day 2 of the ISC-ALLEA 2nd Ukraine Conference 2023). It has been vital to share expertise in securing public funding, to build scientific capacity in this area and to engage the public and private sectors in investment in science.

Sectors of key importance here are:

- **Science Sector:** The UNESCO 2017 Recommendation on Science and Scientific Researchers could usefully be expanded to include reference to the protection of refugee and displaced scientists, of research records, datasets, archives, and clinical trials in times of crisis.
- **Refugee and humanitarian sector:** despite the growing phenomenon of 'scientists in exile', there is no clear vision of how science should address the issue, and no pledge of commitment from significant representatives of world science to the agenda of the Global Compact on Refugees. The UNHCR is a natural partner in enhancing cooperation and dialogue on ways that science can support and benefit from the initiatives, expertise and data held by the humanitarian sector. For science to provide more tailored opportunities for scientists to continue work, it will need structured access to disaggregated data on the locations, profiles and needs of affected scientists that allows individuals to be contacted and helped, or greater support to identify academic researchers in refugee camps or humanitarian settings.
- **Development sector:** a coalition of the main international bodies representing the science and research system should engage national and international agencies and funders to better understand the development sector's frameworks and considerations for post-crisis recovery, and where science fits in. This might be in the provision of scientific knowledge, or in agenda-setting exercises in the reform and reconstruction of scientific assets and institutions. It would be worth considering how a greater commitment to international scientific collaboration could unlock diplomatic support to facilitate this work in fragile and conflict environments.
- **Culture sector:** ensuring greater integration of science and research sites, including research libraries, archive centres and research data repositories, into existing frameworks for integrating culture into preparedness and recovery. These include UNDRR's 'Cultural Heritage Addendum' to its Disaster Resilience Scorecard for Cities and the World Bank's 'Culture in City Reconstruction and Recovery' (CURE) Framework.
- **Disaster risk reduction sector:** consider how to better integrate science into the Sendai Framework for Disaster Risk Reduction. This integration would require coordination, partnership and collaboration between stakeholders from different sectors and governments. It would involve drawing up policy and action frameworks for science that are appropriate to a variety of countries and institutions (Cutter et al., 2015).

This coordination should lead to action at a range of local, national and international scales by representative bodies within the science and research system, including academies, disciplinary unions and associations, research councils and universities.

4. Improving resourcing for prevention and emergency response: these are the areas where the sector most struggles for funds. Greater support is needed at the national and international level, starting with these potential areas for action:

- **Flexible multilateral or national funds for science:** mapping government and supranational mechanisms and institutions that support scientific research and cooperation (e.g., European Cooperation in Science and Technology), and exploring with them how to build emergency response mechanisms. This would entail the ability to call down or repurpose allocated funds, shorter grant-making processes and greater flexibility to enable inclusion of countries in crisis.
- **Private sector, foundations, endowments:** mapping the entities that support science in moments of crisis, or might consider doing so, and exploring opportunities for pre-planning and how available funds might be targeted to areas of highest impact or greatest vulnerability. This might involve creating a science-based version of the Heritage Emergency Fund.
- **Heritage Emergency Fund:** exploring how this flagship non-earmarked fund for culture can be linked more explicitly to science or used as a model for the science sector.

5. Specific attention on improving protection, storage, curation and access to data, as well as the production of data documenting the crisis: taking a comprehensive approach to data that mirrors the three phases of the '3PR' matrix requires building the legal framework and infrastructure for the protection, use and production of data in times of crisis. Yet there is currently insufficient understanding of the legal and regulatory framework needed to support data policy in times of crisis. Once crisis hits, evidence shows that significant data assets are lost because of the lack of digitization, and that support for science during a crisis is often slow to arrive or poorly targeted. The reasons for this include a lack of data on affected scientists, and poor channelling and coordination of key information. Priorities for action include:

- **Data policy:** developing an overview of the ethical principles, human rights and humanitarian law necessary to support and shape data policy for preparedness, response and rebuilding science institutions and systems. This includes understanding the implementation precautions and guidelines under the open science umbrella relating to secure archival practices (as outlined in Finding 2.2), since these are critical to the design of data policy for crisis contexts.
- **Data curation, storage and findability:** we need appropriate and protected data storage systems, such as cloud-based technology, with strong relationships between repositories that allow for data to be found and accessed remotely and ensure that data is protected from potential disasters or appropriation.

- **Tailor to the needs of specific research areas:** in designing data policies and storage systems, attention must be given to the needs of specific fields rather than a blanket approach. Cancer research, for instance, needs a regulatory framework ensuring the protection of clinical trials and ongoing treatment and care, and guaranteeing the safe access and transferability of patient data. These needs will differ greatly, for example, from those of an economic historian.
- **Data adequacy**: we need better research data preparation and interoperability to ensure that existing data is available and can be used to respond to crises. Guidance on ethical, robust and timely data generation will be crucial to crisis response, as flawed data serves to fuel infodemics.
- **Delivering digitization:** The preservation of scientific assets by planning and funding the digitization of historical and contemporary scientific writings, documentation, data and other assets online.
- **Community of practice:** Develop a community of data policy practitioners to gather experience in the protection, access and production of new data in times of crisis.
- **Information sharing and convening:** Effective data policies can play a crucial role in spurring prompt and orderly data findability and exchange and management during times of crisis. Access to robust data, including social data, will improve understanding of the situation on the ground and help design better responses. The sector may consider building on existing coordination mechanisms such as the ISC-ALLEA Ukraine Science Stakeholders Group to develop international, regional or national mechanisms, or 'one-stop shops', for accessing data and bringing together stakeholders to coordinate support or develop policy responses.

CONCLUSIONS

The findings of this study suggest that international and national science systems should aim to improve their resilience to crises. To become better equipped to prevent, protect and rebuild, a shift in mindset relating to crisis issues will be required to 'step away from a reactive protection approach to a proactive prevention approach'.[13]

The findings from our work to date suggest that too often, the scientific community's response to crisis remains uncoordinated, ad hoc, reactive and incomplete. The escalation of the war in Ukraine has brought attention to the global consequences of wholesale attacks on higher education and science systems. Only when we think globally and holistically do our shared responsibilities as a scientific community appear clearly. It is thought that some 100,000 professional scientists have become refugees and displaced persons because of wars or forced migration. We cannot collectively afford to lose that research capacity and investment.

The longer scientists are kept out of work, the likelier it is that they will lose competences and knowledge. So, the responsibility of the international science community is to maintain as many as possible in active work, and to bring them back into the scientific fold as quickly as possible. That has direct implications for action, such as the need to identify scientists in refugee camps and humanitarian settings and is a call to all main actors in the system to think about what they can do.

By taking a more proactive, global and sector-wide approach to building the resilience of the science sector, for example through a new policy framework, we can realize both monetary and social value for science and wider society. It is more efficient to invest in preventing or minimizing the impact of crisis than to respond to it after destruction has occurred. Likewise, having a means to support scientists during the early stages of crisis means that they can become more helpful in the post-crisis rebuilding phase, providing support from home or abroad. Finally, better integration of science systems, institutions and scientists into the broader multi-sectoral response to crisis strengthens the case for prioritizing science, naturally alongside other priority sectors, in the reconstruction phase.

13 Taken from an ISC blog post by Heide Hackmann, former ISC CEO & Mami Mizutori, Secretary-General UNDRR (ISC, 2020).

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ANNEX 1: EXAMPLES

1. VIOLENT CONFLICTS

1.1 Russian invasion of Ukraine (2022–present)

The findings of this case study are supported by relevant literature and by interviews with Igor Lyman and Yevheniia Polishchuk. Igor Lyman is the head of the Department of History and Philosophy at Berdyansk State Pedagogical University and a member of the expert council of the Ministry of Education and Science of Ukraine. Yevheniia Polishchuk is a member of the Young Scientists Council at the Ministry of Education and Science of Ukraine. In addition, the authors drew extensively upon the review work of Gerson Sher, former Program Coordinator for the US-Soviet and East European Programs at the National Science Foundation.

This example differs in one important way from the others described here. The events it describes are ongoing, and the response of the international community to the crisis has evolved significantly since the time of the interviews. For these reasons, we remind the reader that this example is not a historical analysis, but a relatively early snapshot (from Autumn 2022) of a crisis that continues to unfold, from the point of view of a small number of affected scientists.

Background

On 24 February 2022, Russian President Vladimir Putin launched a full-scale invasion of Ukraine, marking the start of a protracted crisis and the largest mobilization of armed forces in Europe since World War Two (Bilefsky et al., 2022). The ongoing war reflects growing instability in the global economic and political order. It began eight years after Russia's annexation of Crimea from Ukraine in 2014 (Center for Preventive Action, 2022).

Since the start of the war, thousands of civilians have died and roughly one third of Ukrainians have been displaced (Karasapan, 2022). As of October 2022, the UN listed roughly 7.8 million Ukrainian refugees across Europe, including 2.85 million in Russia. Excluding Russia, Poland hosts the highest number of refugees (1,422,482), followed by Germany and the Czech Republic, while approximately 13 million people remain internally displaced in Ukraine due to fighting, impassable routes, and lack of the resources needed to evacuate (Karasapan, 2022).

The country has sustained severe damage to its urban and residential areas, military assets, hospitals, educational institutions, and communication and transportation infrastructure

(Center for Preventive Action, 2022). Many of Ukraine's universities have suffered bombing or shelling, and Igor Lyman noted that, while the vast majority of scientists were displaced within Ukraine, roughly 5,000 people from Ukraine's research force have left the country. Lastly, the conflict has destabilized global energy and resource markets while compounding other global crises. Military operations and violence exacerbate the existing shortage of resources for humanitarian assistance (Center for Preventive Action, 2022).

Pre-crisis phase

Ukraine's higher education and research institutions were severely underprepared for the Russian invasion on 24 February 2022 (Center for Preventive Action, 2022). While these institutions were aware of the risk of a Russian invasion, the majority of them did not have the processes or personnel needed to coordinate a pre-emptive crisis response. According to Lyman, there were no evacuation plans in place prior to the invasion at Berdyansk State Pedagogical University, nor preparatory planning measures to protect research equipment, knowledge and scientific databases in the event of a crisis. Although a large number of scholar support organizations exist, Ukraine could have benefitted from being a part of an international network of universities which could provide support to members in crisis-affected areas and systematically map international best practices.

'International networks and organizations of universities should have a plan to support their members in emergencies,' Lyman states. He suggests that such support could include temporary placements for researchers, the funding of scholarship opportunities, offering to save research results and knowledge on databases, and twinning programmes between local universities and partner institutions abroad. Although Ukrainian institutions are now part of the International Science Council and various other international support programmes, they were not members before the war began. Yevheniia Polishchuk of the Young Scientists Council stated that being a part of such organizations before the war would have allowed Ukrainian universities to more effectively prepare for and respond to the Russian invasion.

Crisis response and stabilization phase

Ukraine has suffered severe damage to its higher education, research and scientific infrastructure since the start of the war. Given that most Ukrainian universities are state-funded, research funding has been cut significantly and reallocated towards defence efforts, making it nearly impossible for Ukrainian researchers to continue their work in Ukraine. Fortunately, the global scientific community has stepped in and mobilized support for Ukraine by awarding funding and fellowships to Ukrainian researchers and boosting collaboration with Ukrainian colleagues. International support activities for Ukrainian science have emerged across Europe and North America. Igor Lyman received an outpouring of support from colleagues at the COST Action: Women on the Move project, a multilateral effort involving more than 52 countries and transdisciplinary researchers. According to Lyman, institutional guidelines and coordinated decision-making within the organization allowed COST Action to offer concrete support in the form of grants, temporary placements, accommodation and more.

All these offers of support have been well-intentioned, but Polishchuk noted that some institutions outside Ukraine reached out without a full understanding of Ukrainian needs or their capacity to address them. Lyman has corresponded with several to clarify Ukraine's needs. Other universities, however, provided swift and concrete support. The Canadian Institute of Ukrainian Studies at the University of Alberta, for example, offered to help save the Research Institute of Urban History at Berdyansk State Pedagogical University website by uploading all of the website's back-end data to the cloud. Similarly, the University of Toronto offered Lyman a non-resident fellowship with a $2,000 stipend to study an issue related to the Russo-Ukrainian war. As a fellow, Lyman has access to the entire university library and its databases so that he can continue his research from Ukraine. Additionally, Lyman observed that in May 2022, the Massachusetts Institute of Technology (MIT) offered financial support for ten grants for Ukrainian projects.

Despite these successes, Lyman finds that trans-institutional and internationally coordinated support is more valuable than universities or individuals reaching out on an ad hoc basis. And while he believes that foreign grants are 'the main answer' to protecting science systems in crisis, Lyman maintains that both government and university funding schemes remain too rigid to rely on exclusively. These funds are rarely available for timely use.

As Polishchuk points out, there is new a growing recognition that Ukrainian science was perhaps less internationally connected than it could have been. It was only after the conflict started that officials recognized the missed opportunity to enhance the connectedness and resilience of Ukrainian scientists and institutions, for example through university alumni associations, international science networks or scholar support organizations. There have been calls since the war began for standing networks or programmes of support to be established, and for Ukrainian scientists to be integrated into existing collaborations.

Opportunities for effective international responses to crisis arise when there are pre-existing institutional relationships in place, which is why science must invest in international collaboration and network building. According to Polishchuk, a report by the Young Scientists Council showed that Ukrainian scientists who have moved abroad are overwhelmingly relocating to places where they have established personal connections or existing relationships with research institutions. This is reflective of three central barriers that prevent Ukrainian researchers from participating in international support programmes and scholarship opportunities for displaced scientists. According to Polishchuk, the first obstacle that many Ukrainians face when applying is an insufficient knowledge of English, the working language of the majority of programmes abroad. Secondly, more opportunities are being given to STEM researchers despite the majority of Ukrainian scholars being trained in humanities disciplines. Lastly, too many scholar support programmes fall short of providing psychosocial support from which Ukrainians could benefit. Since men are prohibited from crossing the Ukrainian border, Polishchuk noted, women are disproportionately represented among Ukrainian researchers abroad, even if lack of support may result in some coming back to the country.

Post-crisis and rebuilding phase

A critical step towards rebuilding Ukraine's science sector will be to increase Ukrainian representation in the international science community and knowledge commons. This starts with implementing open science principles and global standards around research evaluation, distribution, access and intellectual property rights. This will allow scholars working in science systems affected by crisis to contribute more readily to scientific knowledge production. Traditional metrics of academic excellence assessed during research evaluations disenfranchise Ukrainian scholars, who may not have access to the equipment, funds or educational environments necessary to have their work published in academic journals. Journal databases, Lyman observed, have taken steps to address this issue by offering Ukrainian researchers the opportunity to publish articles at little or no cost. Increasing Ukrainian representation in the international science community also entails amplifying Ukrainian perspectives, which have been both underrepresented and misrepresented by Western 'experts'. 'For Western mass media and society, even famous researchers from Ukraine are interesting often just as victims and as witnesses of this war, but not as equal researchers with Western analysts,' Lyman states.

At the time of interview, many opportunities to support academics, researchers and students are residential, based in host countries, and are hugely beneficial to those who can access them. However, there are often limitations on who is eligible for these opportunities. ScienceForUkraine noted that in its database of opportunities and grants for affected researchers and scientists, virtual mobility grants make up only a fraction of the available grants and opportunities.

It is also worth noting, Gerson Sher stated, that while international efforts to assist Ukrainian scientists had (at the time of interviewing) concentrated almost exclusively on mitigating the challenges faced by refugees from Ukraine, the vast majority of Ukraine's scientists, an estimated 87 percent, have remained in Ukraine.

Ukraine's government and research institutions must support the temporary relocation of scholars if they want to incentivize their return. Polishchuk noted that Ukrainian scientists have overwhelmingly expressed a desire to return once the security risks recede, but also that the government must make their return a possibility by investing in and rebuilding the country's science sector. Ukraine's current research institutions offer subpar facilities, particularly for early career researchers. With funding from development institutions, Polishchuk observes that Ukraine could improve the quality of research facilities by consolidating institutions. 'The war is a chance for Ukrainian scientists to participate in the rebuilding and strengthening of a science system which was not sufficiently invested in to begin with,' she states.

Rather than viewing the relocation of Ukrainian talent as 'brain drain', Polishchuk maintains that host institutions should regard it as 'an investment in Ukrainian human capital'. Host countries can incentivize scholars to stay while accepting that some will leave, by supporting them and creating the conditions in which they can participate in reconstruction. One Ukrainian institution recognized the opportunity to harness relocated scientists' insights by calling their displaced scholars 'Academic Ambassadors' and inviting them to participate in rebuilding initiatives.

Lastly, and as set out in the second Ukraine Conference Report from the ISC and ALLEA, the most urgent need during this protracted phase of the crisis is to support the research system within Ukraine itself, to avoid losing an entire generation of researchers. The current moment must be recognized as an opportunity for reform and transformation. External funding bodies, research organizations and philanthropic foundations need to respond with flexibility and with innovative solutions that are sensitive to local needs, in order to avoid the loss of quality research and researchers.

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1.2 The ISIS occupation of Mosul University, Iraq (2014–2017)

The findings of this case study are supported by relevant literature and interviews with Heike Wendt and Dr Alaa Hamdon. Heike Wendt is a Professor of Education Research at Graz University in Austria and one of the initiators of the RESI partnership. Dr Alaa Hamdon is a senior lecturer at the University of Mosul and director of the university's Remote Sensing Center.

Background

In 2014, extremist militants of the Islamic State of Iraq and Syria (ISIS) captured the city of Mosul, forcing the Iraqi military and nearly 875,000 civilians to flee, while over 600,000 residents remained trapped or internally displaced (Hamasaeed and Nada, 2020). Religious fundamentalism, combined with elements of Arab nationalism and xenophobia towards many religious and ethnic groups in Iraq, provided the ideological foundations for ISIS's occupation of nearly one third of the country by the summer of 2014 (Wendt et al., 2022). When ISIS leader Abu Bakr al-Baghdadi named himself caliph of the new Islamic State in Mosul, he instituted a reign of terror that included bombings and shootings, rape, looting, abductions, mass executions, pillaging, death threats, extortion, seizure of state resources, bans and curfews, and religious indoctrination (Wendt et al., 2022).

In 2015, ISIS seized Mosul University, formerly Iraq's second largest university and one of the top universities in the Middle East (Lodinsky, 2022). More than 150 university buildings suffered damage of 10 to 100 percent, and in total, more than three quarters of the university was damaged (Nabeel, 2021). But in addition to the misuse of buildings, ISIS introduced its own curriculum based on a totalitarian worldview which eschews political pluralism, competition, science and diversity, vilifies Western culture, and criminalizes free thought (Wendt et al., 2022).

However, Mosul University was enabled by funding from Iraq's Ministry of Education to run a university in exile in the Kurdish autonomous region in northern Iraq. It operated undergraduate and graduate programmes for roughly 14,000 students and 1,200 lecturers in exile (Wendt et al., 2022). Engineering and science classes were taught in the city of Kirkuk, humanities classes in Duhok and Sumel and some medicine lectures in Zakho. Other students continued their studies at universities in cities within the Iraqi central state, such as Baghdad and Basra (Wendt et al., 2022). Security risks, Wendt notes, led most of Iraq's academic elite to leave the country, exacerbating the issue of brain drain from Iraq throughout the past two decades.

Mosul University was able to operate this transformative educational programming under ISIS occupation in part due to a partnership entitled RESI (Rethinking Education and Science in Iraq). RESI was a partnership between the University of Mosul, TU Dortmund University in Germany, and the University of Graz in Austria (Wendt et al., 2022). The RESI partnership began in 2015 and was funded by DAAD, the German Academic Exchange

Service (Wendt et al., 2022). The DAAD German-Iraqi University Partnerships programme identifies as its core objectives 'the qualification of Iraqi lecturers, the modernization of the higher education system in Iraq, regional and international network building and the introduction of good governance practices to Iraqi universities' (Wendt et al., 2022, p. 76). The RESI partnership was promoted within each partner university as a way to use science engagement to promote academic capacity building and reconciliation in the context of post-war Iraq (Wendt et al., 2022).

Enabling factors

When orchestrated correctly, higher education partnerships such as RESI can lead to increased international visibility and reputation, the effective sharing of resources, and the modernization of research and teaching (Wendt et al., 2022). Several enabling factors have allowed RESI to become one of the first mechanisms for funding research collaboration in low and lower-middle income countries in the wake of crisis. The first has been a mutual desire among partner institutions to promote academic discourse and dialogue opposing ISIS ideologies, and the desire to contribute to reconciliation and healing processes. These were the main factors motivating the participants' determination to persevere, according to Heike Wendt (Wendt et al., 2022). Secondly, cross-cultural competency and experience, combined with the sense of being a part of a successful team characterized by mutual understanding, respect and trust, has sustained the project for the past five years. Wendt stated that it was essential for university personnel to be 'carefully chosen and have the necessary intercultural, communicative and interpersonal competencies as well as management skills'. Other drivers of success have included support from Mosul University leadership; deploying a steering committee as the central organizational structure; and communicating clearly with partners. Wendt also observed that 'for scientific diplomacy to work, especially between countries with a language barrier between them, communication needs to be transparent and requires using as simple language as possible to avoid misunderstandings'.

Since its inception, the RESI partnership has sponsored a series of interdisciplinary conferences in Iraq. These have created platforms for academic dialogue and reflection on national reconciliation among more than 3,600 students of diverse backgrounds and over 400 scholars across 22 disciplines (Wendt et al., 2022). These conferences, Wendt noted, have invited students and lecturers to engage in questions surrounding what knowledge and frameworks can be used to analyse conflict in Iraq, what additional projects can be undertaken to address these issues, and what further research needs to be done. Wendt also pointed out that science has been used as an entry point to facilitate inclusive discussions on reconciliation. For example, Yazidi and Christian ethnic minorities felt safe being on stage and discussing pressing environmental issues. Conference participants have reported positive experiences with regard to intergroup relations, participation rates, and interest in the activities and issues discussed (Wendt et al., 2022). According to Wendt, these sentiments were reflected in improved student-student and student-lecturer relationships, higher motivation levels, and improved self-confidence among both students and lecturers (Wendt et al., 2022). Such behavioural change had measurable impacts on regular teaching and learning activities and supported collaborative processes. Lastly, the teaching methods and materials developed for workshops were also integrated into standard pedagogical practices at Mosul University (Wendt et al., 2022).

Key requirements for successful post-crisis partnerships such as RESI have emerged from the examples in this paper. They include:

- University leadership committed to science and to quality programmes;
- A host Ministry of Education that values capacity building and is open about its needs;
- Key stakeholders willing and able to build an intercultural team committed to mutual understanding and respect;
- Effective project management with shared decision-making;
- Alignment of goals with community needs, and local ownership;
- Shared recognition and credit for everyone involved;
- Appropriate and well-timed resourcing;
- Intensive technical assistance;
- Formal written agreements; and
- Patience (Wendt et al., 2022).

Inhibiting factors

As with any North-South higher education project, there have also been inhibiting factors which have impacted the efficacy of the RESI partnership and made it harder for RESI to achieve its objectives. Firstly, Wendt observed, German government funds for reconstruction development projects are geared towards 'structure building'. Because academic partnerships have not historically been involved in these projects, they are considered the responsibility of academic institutions. DAAD (the German Academic Exchange Service) gave €100,000 per year to fund a part-time project coordinator at TU Dortmund (TUD) University and flight expenses. However, as Wendt stated, this money did not cover transportation expenses within Iraq or hospitality costs. Mosul University had hoped the programme would also involve material support for rebuilding, but, as Wendt noted, the DAAD did not provide funding for tools or equipment. These funding constraints have limited the scope of cooperation between both partners and caused tensions in project coordination and scope. And because this funding does not cover local travel or venue costs, Wendt observed that transporting students and lecturers to venues in Iraq, as well as negotiating the use of these venues, was also challenging.

Because donors usually prefer universities from the Global North to be the lead partners in collaborations such as RESI, the partnership has been predominantly shaped by the donors' funding framework (Wendt et al., 2022). This dynamic resulted in power asymmetries between Mosul University and its Northern partners, as TUD in Germany largely controlled whose, as well as which, questions were raised (Wendt et al., 2022). Power imbalances also become evident in the resources and capacity of partner institutions, including expertise and prestige, infrastructure, skills and access to knowledge and information (Wendt et al., 2022). From the perspective of the University of Mosul leadership, cooperation with a German university was perceived as being crucial for the improvement of its international reputation, research and teaching. Iraqi partners frequently perceived TUD as sophisticated, well organized and conceptually advanced, and this perspective affected the valuation of knowledge production (Wendt et al., 2022). And scarce resources for Iraqi scholars and limited travel opportunities to Europe also resulted in competition and envy, challenging the project's objective of contributing to reconciliation processes (Wendt et al., 2022).

Even following the University of Mosul's liberation from ISIS, security risks have been a central inhibiting factor for the RESI partnership. Wendt remarked that for partners from Germany and other parts of Europe, access to Iraq depended on evaluations by national security agencies, while high-security travel insurance packages became out-of-pocket expenses. Because of travel warnings and political instability in Mosul, German universities would not easily grant travel permits (Wendt et al., 2022).

Organizers and partners were worried about becoming targets, given the local political context and restrictions on academic freedom. 'There was a concern that having a young female professor be the leader of a partnership programme is a political statement by itself,' Wendt stated. Furthermore, socio-economically marginalized students and lecturers targeted by ISIS would face security threats when crossing checkpoints required for the university in exile to operate (Wendt et al., 2022). As a compromise, project activities were undertaken both in Mosul and Duhok, with conference output limited to virtual contributions and closing activities taking place in Duhok (Wendt et al., 2022). To this day, many lecturers have not returned to Mosul and still live in areas considered safer. Their commute, Wendt commented, can take hours due to infrastructure damage, which has impacted the quality of the partnership's programming.

It is clear, especially in this case study, that the value of scientific diplomacy is still not well understood by post-crisis actors on the ground. This is partly due to a lack of support to enable these science partnerships to take place. Poor institutional understanding of science diplomacy often results in the burden landing on individual academics, who must try to overcome a myriad of obstacles. Wendt remarked that when the RESI programme started in Iraq after the ISIS occupation, researchers were entirely responsible for initiating and building relationships for the programme, but also had to navigate the complexities of international travel including security, visas and insurance. None of the international universities forming part of the programme offered support to address these obstacles. One German academic found the disconnect between the programme and her university was so stark that she, together with the Iraqi partner institution, felt forced to hire lawyers to argue that the German university's concerns about security issues could not overrule her constitutional right to academic freedom.

The challenges of this Iraq case study extended beyond the support of home universities and into relations with the government donor, suggesting a disconnect in the understanding and articulation of the benefits of science diplomacy. The needs of the scientists implementing the programme, Wendt found, were essentially diplomatic, such as the need for local and legal expertise on visas or on arrangements for security. These could be easily addressed by government bodies if these issues were on their agenda.

Lastly, differences in organizational structures and project management styles between partner institutions have inhibited the RESI partnership's success, stated Wendt. At the University of Mosul, the project is coordinated by an individual within the international affairs unit who reports directly to the presidency and who has numerous other professional duties. At TUD, the project is financed by a third party under the leadership of a university professor, with funding allowing for the appointment of a project coordinator. These disparate governance structures frequently made project coordination and administration difficult. Wendt also noted that internal conflicts at Mosul University surrounding leadership appointments after the university's liberation from ISIS created challenges for programme coordination between partners. Finally, University of Mosul leadership regularly expressed a desire to change or rotate members of the steering committee, as it was seen to be unfair that only a few people would benefit from the collaboration. This contradicted the project's central objective of developing sustainable cooperation structures (Wendt et al., 2022).

Looking ahead

Power cuts and infrastructure destruction continue to make RESI programming very difficult, said Wendt, as internet access remains unpredictable. Most project activities have been delayed by the COVID-19 pandemic, and virtual activities have proven insufficient for achieving project objectives (Wendt et al., 2022). However, the lessons learned during ISIS's occupation of Mosul and the duration of the partnership will provide both partners with increased capacity to prepare for and respond to crisis. Dr Hamdon noted that Mosul University has established a Risk and Vulnerability Assessment Committee (RVAC) to identify and mitigate risks ranging from fires to violent conflict, and that the Ministry of Education is encouraging other universities in Iraq to follow in its footsteps. Hamdon, director of Mosul University's Remote Sensing Center, reports to the RVAC with risk analysis on heavy rain and sandstorms and believes that remote sensing has the potential to transform disaster risk reduction processes in the South.

The recent history of Mosul University is a valuable example of the need for higher education to be able to transition swiftly to flexible, virtual ways of working. According to Hamdon, a senior university lecturer, Mosul University had 70,000 students during the ISIS occupation, and undertook a rapid relocation and transition to what became three new teaching 'hubs' in Iraqi Kurdistan. University officials had to rent building space and support staff relocation. Despite the inevitable challenges, thousands of students were able to graduate through this model, rather than lose years of study. Crucial to success were prioritizing locations near to camps and centres for the displaced but which were secure enough to reassure staff and students; and having virtual teaching to address the capacity gap. Thus, the IIE-SRF Iraqi Scholar Rescue project was repurposed to a distance learning initiative in 2015 following the ISIS occupation, allowing more than 280 Iraqi academics with fellowships abroad to deliver courses remotely, filling curriculum and expertise gaps at local universities.

Wendt notes that in the post-crisis phase, narratives which encourage attempts to force scholars to return too early or unwillingly can inhibit international collaboration and rebuilding. An example is the desire for a ‘symbolic return to Mosul’, Wendt remarked. This was peddled by Mosul University leadership after the campus’s liberation from ISIS. This caused students and staff from socially and economically marginalized communities and who feared for their safety, or who did not have the financial means to travel, to withdraw. It also prevented German colleagues from partner universities from providing in-person support for recovery, due to security restrictions in Mosul.

Finally, a key dimension of North-South partnerships in a post-crisis context is to recognize what kind of impact is possible. Partnership and programme objectives should not be limited to knowledge production, but should also include developmental aims (Wendt et al., 2022). Evidence from the Mosul case study shows that the main factor motivating participants to persevere with the project was to counter ISIS ideology by promoting academic discourse and dialogue, thus contributing to reconciliation and healing. Arguably the most significant impact has come through the increased quality and quantity of engagement and dialogue between academics and students. This has created social capital and economically relevant skills which can serve wider society, in turn building ethical norms around responsible citizenship, and ultimately helping to promote understanding between social groups and building a sense of unity amidst diversity (Wendt et. al, 2022).

2. HISTORICAL EXAMPLES OF CRISIS RECOVERY

2.1 War in the Balkans (1991–1999)

The findings of this case study are supported by relevant literature and interviews with Milena Dragićević Šešic, PhD. Dr Dragićević Šešic is a Professor of Cultural Management at the University of Arts in Belgrade, as well as the founder of the UNESCO Chair in Cultural Policy and Management (Interculturalism and Mediation in the Balkans).

Background

The Balkan region has a rich and diverse cultural heritage which spans multiple countries, and centuries of Ottoman rule (Tonta, 2009). However, many cultural riches, Dragićević Šešic remarked, including monuments, artefacts, and intellectual and artistic works, were destroyed in the Yugoslav Wars, for example during the bombing of the National Library of Bosnia and Herzegovina in 1992.

The Yugoslav Wars were a series of ethnic conflicts, independence wars and insurgencies in the Socialist Federal Republic of Yugoslavia from 1991 to 2001. The conflicts ultimately resulted in the partition of Yugoslavia into six independent countries: Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Serbia, and North Macedonia. According to the International Center for Transitional Justice, over 140,000 people died during the wars, which were marked by atrocities including crimes against humanity, ethnic cleansing and mass rape.

Today, approximately 75 million people live in the Balkan Peninsula, excluding the Anatolian part of Turkey (Tonta, 2009). According to Dragićević Šešic, constant political turmoil and liberation wars, as well as differing paces of nation building and cultural and political emancipation, put outsized emphasis on the differences in heritage between the populations of the Balkans, rather than on what they share in common. These forces have also driven significant differences in scientific interpretations – of the past, and of present value systems and cultural phenomena including ethnic origin and language. One consequence of this contestation is the introduction of new 'needs' in scientific research and interpretation with the aim of advancing ideological and nationalist agendas.

Dr Yasar Tonta, a Professor in the Department of Information Management at Hacettepe University in Turkey, has studied this issue extensively, stating, 'Each nation identifies its citizens, not on the basis of civic duties and rights, but usually on the basis of language, religion, ethnic background or a combination thereof. In the end, the cultural heritage of people who lived in the same country earlier but were identified as the 'other' in nation-building processes, tends to get neglected by citizens of the new nation state,' (Tonta, 2009) (ICTJ, 2009).

Science in the Balkan Peninsula

The scientific contributions of Balkan countries have historically been limited due to low levels of academic infrastructure, especially in the humanities and social sciences, Dragićević Šesšc points out. They became even more degraded when public funding for scientific research, especially in the humanities, virtually disappeared during the Yugoslav Wars. Approximately 36.8 percent of the population in Balkan countries has access to the internet compared to 61.4 percent in EU countries overall (Tonta, 2009). While Balkan countries remain underrepresented in the international science community, the COVID-19 pandemic and the shortage of vaccines in many Balkan countries revealed the importance of international cooperation and scientific diplomacy, especially on a regional scale.

(Re)building science in the Balkans

The digitization of cultural material is essential to ensuring the preservation of scientific and cultural heritage in the Balkan region, and to building a science sector with an archive of publicly accessible knowledge. In 2008, the European Commission founded Europeana, a digital library, museum and archive which provides online access to the digital content of museums, libraries, archives and audiovisual collections from over 90 European heritage institutions and 20 national libraries (Tonta, 2009). Nevertheless, scientific diplomacy initiatives, including regional and international cooperative programmes to preserve and manage scientific and cultural information sources in Balkan countries, must still be further increased (Tonta, 2009). Although efforts to digitize works of cultural heritage in Balkan countries have accelerated within the past two decades (Dragićević Šešić and Stefanović, 2021, 2022), successful digitization, protection and management of information sources are closely related to the availability of network facilities (Tonta, 2009). Internet infrastructures in Balkan countries should be examined to identify applications which can support the digitization of science and culture. The regional bibliographic COBISS system, initiated in the 1980s at the University of Maribor in Slovenia, is currently operational and active in most of the territories of the former Yugoslavia.

A flexible policy environment which allows for private or external funds to enter the system is essential to enable the science sector to maintain funding in times of crisis. This was a major challenge for science during and after the wars in former Yugoslavia. Science had been run at the level of each separate republic, and each had its own approach to research. This self-governance model demanded a highly regulated system. It involved taxes for scientific research, which each company had to contribute to each republic's budget, whether in the area of energy, health, research, culture, sport and so forth, referred to as 'self-governing communities of interest'. As the state collapsed, so did the framework for supporting science. By contrast, the arts and culture field sat politically and financially within the civil society domain and was more independent. One study (Markovic, 1987) showed that 80 percent of money spent in the sector was 'private', coming from individuals and companies outside the local and national level self-governing communities of interest described above. As a result, Dragićević Šešić notes, the culture sector was far quicker to adapt and create new structures in the post-war multi-state architecture than was science, which was so tied to Yugoslav heritage that it was far slower to get the legal, financial and societal support it needed to begin recovery.

The Balkans – in this case Serbia – also provide a powerful example of an attempt to reform a science system after conflict but without a shared vision and without strong cooperation between local and international actors. Dr Milena Dragićević Šešŝc, UNESCO Chair in Cultural Policy and Management in Belgrade, describes how the only funding flowing into the cultural and science sectors after the war came from Western institutions such as the EU. The research topics they were prepared to fund were so narrow and prescriptive that many researchers (among them Rastko Mocnik from Slovenia) felt they'd 'had more research autonomy under Tito [the former President of Yugoslavia]'. They remember instances of feeling directed by EU funders not to pursue subjects that were most relevant to the local context. Dr Dragićević Šešŝc believes that there was a lack of mutual trust and local ownership of the West's funding priorities for science and culture. Instead, this post-war phase of science felt like 'switching from a socialist … to a Western, Anglo-Saxon research framework'. As a result, she suggests, there was little substantive redesign of the institutions of the science sector. There was merely some changing of names which sounded 'too socialist', such as the Institute for Marxism becoming the Institute of Labour Movements. So an opportunity for genuine collaboration and transformation was lost. Real efforts to 'decolonise knowledge' have only now got onto the agenda (Gaio et al. 2023).

2.2 Japan after World War Two (1939–1945)

The findings of this case study are supported by relevant literature and interviews with Sayaka Oki. Oki is a historian of science and technology and Professor at the University of Tokyo in Japan, as well as a member of the ISC's Standing Committee for Freedom and Responsibility in Science.

Background

Since the mid-20th century, Japan has occupied a pivotal role in the global research and development sector. With the outbreak of the World War One, foreign technology imports were cut off, resulting in the emergence of flourishing chemical and engineering industries (Watanabe, 2017). During World War Two, however, Japan's scientific research was largely focused on military applications, including the development of new technologies such as radar, sonar and weapons (Watanabe, 2017). The country's universities and research institutions were heavily controlled by the government, Oki noted, and scientists were often forced to work on projects deemed important for the war effort. Scientific disciplines were also split along political lines. Natural science research was almost considered pro-government, while humanities and social science research was suspected of being rebellious, and the sector tended to be divided between supporters and opponents of government policy. Oki noted that some economists, jurists and historians were heavily persecuted during the war years.

After the war, Japan underwent significant political, economic and cultural changes which greatly impacted the development of the country's science sector, including its emerging nuclear power industry. After the United States occupied Japan in 1945, Oki remarked, scientific institutions were restructured, and the academic freedom of universities was assured in 1947 by the nation's new Constitution. Nevertheless, the divide between the natural and social sciences remained. Oki believes that this divide hindered the development of integrated science and disaster risk management processes in Japan.

Japanese science since World War Two

To support domestic industrialization efforts and recast itself as a peaceful country following World War Two, Japan sought to build an economy centred on emerging science and technology (Watanabe, 2017). According to Oki, post-war Japan envisaged a 'revolutionary change' for science and technology, predicated on destroying and rebuilding the entire sector. The United States' occupation of Japan at the end of the war heavily influenced this process. With the onset of the Cold War, Oki noted, one of the key goals of the occupation was to demilitarize and democratize Japan. Part of this process was a restructuring of the country's scientific institutions and the regulation of the country's nuclear energy sector.

The US established strict guidelines for the development of nuclear power in Japan, which included the peaceful use of nuclear energy and the prevention of nuclear weapons proliferation (Watanabe, 2017). The US also provided significant financial and technical support for the development of Japan's nuclear plant industry, including the transfer of technology and scientific knowledge as well as the training of Japanese scientists and engineers in nuclear power technology. Oki stated that Japan's post-war policy of pacifism and non-proliferation meant that its civil nuclear sector remained intentionally separate from the military research sector. So it was reliant on learning from civil nuclear expertise for the development of its risk management processes.

Today's Japanese science system was shaped by profound moments of crisis over the past century. Yet modern scientists lack historical knowledge of how and why the existing structure, and its associated challenges, are as they are. Taking the concept of 'memory' in science more broadly, historians of science argue that consideration needs to be given to understanding how science systems have responded to and rebuilt from crisis. An effective rendering of that history, Oki believes, could be a crucial tool for enabling more balanced, informed and effective dialogue between scientists and different disciplines on how the system needs to change in the future.

Additional reading:

- Marshall, B. K. 1992. *Academic Freedom and the Japanese Imperial University,* 1868–1939. Berkeley, University of California Press.
- Hirakawa, H. and Shirabe, M. 2015. 'Rhetorical marginalization of science and democracy: politics in risk discourse on radioactive risks in Japan'. In: Y. Fujigaki (ed.), *Lessons from Fukushima*. Springer, Cham. https://doi.org/10.1007/978-3-319-15353-7_4
- Nakayama, S. 1989. 'Independence and choice: Western impacts on Japanese higher education'. *Higher Education*, Vol. 18, pp. 31–48. https://doi.org/10.1007/BF00138960

3. DISASTERS

3.1 University of Cape Town fire, South Africa (2021)

The findings of this case study have been informed by relevant literature and interviews with Robyn Pharoah. Pharoah is a senior researcher and programme coordinator at the Research Alliance for Disaster and Risk Reduction (RADAR), with experience across the private, non-governmental and academic sectors.

Background

On 18 April 2021, a wildfire sparked on South Africa's Table Mountain raged across the University of Cape Town's Upper Campus, causing severe damage to several historic structures and campus buildings (Davids, 2021). The fire spread erratically across concrete, tar roads and even brick pathways where there was seemingly 'nothing to burn' (Davids, 2021). The fire destroyed the university's Plant Conservation Unit offices and the Jagger Reading Room, which housed scientific and historical artefacts including paintings by indigenous peoples, maps, manuscripts and government records (McGreevy, 2021).

The inferno also caused damage in Upper Campus residence, Fuller Hall residence and the HW Pearson building, as well as Cadboll House and La Grotta (Davids, 2021). Thousands of students were evacuated from residences and placed in temporary accommodation across the city, and the university suspended academic programmes for a week (Davids, 2021).

Pre-crisis phase

The University of Cape Town (UCT) fire was primarily a case of risk reduction failure and inadequate planning processes. According to UCT emeritus professor of ecology William Bond, wildfires are a natural part of flammable ecosystems, which many life forms depend on to complete their life cycles (Davids, 2021). Although the vegetation on UCT's campus is naturally prone to wildfires, Pharoah noted, it would have been possible for the university to manage fuels on university property to prevent such fires from becoming damaging. The severity of a future fire can be managed by reducing the biomass of flammable vegetation and preventing excessive build-up of leaf litter (Davids, 2021). The university leadership may not have appreciated the university's exposure to wildfires sufficiently. Both the sprinkler and the fire emergency systems are now understood to have been limited, which helped the fire to spread across campus after combining with key ingredients for wildfires: high temperatures, low humidity, gusty winds and dry fuels (Davids, 2021).

The University of Cape Town is located at the interface where the city meets wilderness, and the land where the fire started belonged to the university, Pharoah stated. Poor land management was understood to be a key factor in the build-up of vegetation prone to fire and made the fire considerably worse than it might otherwise have been. The broader point underlined by Pharoah is that institutions must identify the risks in their environment and incorporate appropriate risk reduction strategies into their planning and systems. This applies especially to those, such as UCT, which are located where fire is to be expected. In many environments, fire is an essential part of maintaining a healthy ecosystem. So it is a necessary hazard that only becomes a problem when it meets human settlements or infrastructure that are not sufficiently adapted and so remain vulnerable. 'People aren't taking disaster risk into account when they are planning things, be it buildings or processes for systems … Which, particularly in the context of climate change, is going to become increasingly problematic with the rise of extreme weather events.' In contexts such as South Africa, the underlying issue according to Pharoah is that many institutions and the public do not understand their role in risk reduction, and instead expect government and fire services to take sole responsibility.

Crisis response and stabilization phase

Pharoah is a senior researcher and programme coordinator at the Research Alliance for Disaster and Risk Reduction (RADAR) at Stellenbosch University, also in South Africa. She and her team conduct post-event analyses of declared 'disaster' events in the Western Cape, in collaboration with the provincial Disaster Management Center. These reviews examine events from a scientific and disaster-risk studies perspective, meaning that the primary interest is to understand why disasters occur and what must change to prevent them, rather than examining them from a management perspective. According to Pharoah, this process entails assessing the risk drivers which accumulated to cause the event, followed by an assessment of the event itself and the event response.

The questions that guide these investigations include: *What was the timeline of the event? How did it unfold? Who were the actors? What were the institutional issues around the response to the event?* In the case of the UCT fire, Pharoah suggests that opportunities to reduce risk through better land management may have been missed. Such oversights, she believes, are reflective of a wider disconnect that plays out across sectors, between academic leadership and the risk management and urban planning sectors.

Post-crisis and rebuilding phase

While UCT has rebuilt damaged facilities remarkably fast, restoration and rebuilding processes have failed to include critical stakeholders. Library staff, for example, have 'experienced virtually no contact from central UCT management since the fire, and were the last to be consulted about the restoration' (Davis, 2022).

Ultimately, reducing and mitigating the risk of future wildfires and other climate-induced hazards will require urban planners and planning procedures to connect more closely with the disaster risk management sector. Planning will also need to deepen its links to researchers with knowledge of best practice for disaster risk and response. To bridge the science-policy divide, Pharoah maintained, disaster risk management processes must involve stakeholders from the outset. It must also bring together experts across a range of disciplines, including geographers, environmentalists, DRR professionals, urban planners, engineers, meteorologists and public health specialists. Risk assessments are imperative to implementing formal risk mitigation strategies. However, increasing an institution's awareness of environmental risks, Pharoah notes, will require adequate government investment in disaster risk management, in the Western Cape and in South Africa more broadly.

3.2 Natural Science Museum fire, Brazil (2018)

The findings of this case study are supported by relevant literature and conversations with Elisa Reis, Helena Nader, Alex Kellner and Antonio Carlos De Souza Lima. Elisa Reis is Professor of Political Sociology at the Federal University of Rio de Janeiro, and chair of the Interdisciplinary Research Network for the Study of Social Inequality (NIED). Helena Nader is Professor and head of the Institute of Pharmacology and Molecular Biology at the Federal University of São Paulo (UNIFESP), president of the Brazilian Academy of Sciences and an ISC Fellow. Alex Kellner is the Director of the Brazilian National Museum and Antonio Carlos De Souza Lima is Professor of Ethnology and Social Anthropology at Museu Nacional, Federal University of Rio de Janeiro (UFRJ).

Background

On 2 September 2018, a fire devastated Brazil's oldest science museum, the Museu Nacional in Rio De Janeiro, after it closed to the public for the evening (Greshko, 2018). Although no injuries were reported, the fire destroyed most of the museum's 20 million scientific and cultural artefacts, and consequently, much of the country's scientific and cultural heritage (Greshko, 2018). Much of what was lost is irreplaceable, including the oldest known human remains in Latin America, the bones of long-necked dinosaurs, and Latin America's oldest collection of Egyptian mummies and artefacts (Lenharo and Rodriguez, 2022). The fire also destroyed several artefacts representing the cultural history of indigenous populations, marking what social historian Ananda Machado termed a 'holocaust of national memory' (Lenharo and Rodriguez, 2022). The damage also derailed researchers' careers. Dimila Mothé, a postdoctoral researcher at the Federal University of the State of Rio de Janeiro, spoke on the devastation, stating, 'It's not only the cultural history, the natural history, but all the theses and research developed there. Most of the laboratories there were lost too, and the research of several professors. I'm not sure you can say the impact of what was lost' (Greshko, 2018).

A seven-month investigation found that the fire was ignited by three faulty air-conditioning units which were improperly connected to a single circuit breaker in the ground floor auditorium (Machemer, 2020). A lack of fire safety systems within the museum probably meant that when one unit received a surge of electricity it couldn't handle, a flame erupted (Lenharo and Rodriguez, 2022). The museum's smoke detectors were not set, and there were no sprinklers or fire doors (Greshko, 2018). Additionally, when the fire broke out, the two fire hydrants near the museum were reportedly empty, forcing firefighters to use water trucks and pond water instead (Greshko, 2018). A 2018 inspection of the museum before the fire, conducted by an independent task force, had found that the museum lacked a fire inspection report, as well as fire and panic safety protocols. A 2015 report had stated that the museum failed to pass a fire department inspection, indicating that it lacked a plan for protecting collections in the case of an inferno (Greshko, 2018).

Pre-crisis phase

Brazil has a poor record of safeguarding its museums against fires. Before the 2018 fire, Brazil experienced a string of fires at the Butantan Institute in São Paulo, the Museum of Natural Sciences in Belo Horizonte, the Museum of the Portuguese Language, and the Comandante Ferraz Antarctic Station between 2010 and 2015 alone (Machemer, 2020). In June 2020, there was another fire at the Federal University of Minas Gerais' Natural History Museum and Botanical Garden (Machemer, 2020), which houses over 260,000 artefacts ranging from fossils to folk art, causing significant damage to its collections (Machemer, 2020). According to Elisa Reis, a professor of Political Sociology at the Federal University of Rio de Janeiro (UFRJ) and chair of the Interdisciplinary Research Network for the Study of Social Inequality (NIED), one of the key drivers of poor museum maintenance is the lack of government funding, and of institutionalized support for science more broadly. Similarly, Antonio de Souza Lima, Head of Ethnology at the Federal University of Rio de Janeiro and based at the National Museum in 2018, notes that 'if there's no money to fill fire extinguishers or fund basic maintenance, then there's little point exploring other forms of mitigation because basic protections for science simply aren't there.' The scientists we spoke to in Latin America said this consideration reflects the reality for many science systems throughout the continent.

Since 2014, the Museu Nacional has not received its full annual $128,000 maintenance budget (Greshko, 2018). In 2015, the museum had to close temporarily because it could not pay its cleaning and security staff, and museum curators had to crowdfund to repair termite damage in one of the most popular exhibit halls (Greshko, 2018). In 2018, ten of the museum's 30 exhibits were closed to the public because of disrepair, with Brazilian newspaper *Folha de S. Paulo* reporting that the museum had peeling walls and exposed electrical wiring (Greshko, 2018). With such limited maintenance budgets, fire safety systems are often too expensive for museums to maintain. Responsibility for maintenance funding at the museum sits with the Federal University of Rio de Janeiro (UFRJ), to which the museum was allocated in 1946, via funds from the Ministry of Education. Alex Kellner, Director of the National Museum, believes it is paramount that Brazil addresses this issue of maintenance funding. It must build global confidence that it is doing everything possible to avoid such tragedies if it is to earn the trust needed to generate international support for the reconstruction process.

A closer examination of the issues reveals insufficient capacities required to anticipate and address hazards among the senior leadership of scientific institutions. The consequence of this at the National Museum was a situation where it was widely known that 'fire was the greatest risk' in the 'palace' area of the building. This had been formally noted as far back as 1994 when an international seminar – itself called after a roof leak damaged an Egyptian mummy – determined that the only way to safeguard collections for the future was to remove everything from the area and renovate it into an exhibition space. Yet no substantive action was taken and some 24 years later, 85 percent of the museum's 20 million specimens were lost, all of them in the palace.

Even where effective risk assessment may exist, resourcing the mitigation plans arising from them may prove challenging in budget-strained contexts. Kellner reflected on the temptation for scientists to want to put any available funds into research rather than into necessary maintenance or safety initiatives. This reinforces his view that governance structures are needed that balance staff participation and scientific expertise with enough independence to make difficult resourcing decisions. For example, this would involve ensuring leaders are qualified and go through a rigorous application process before being appointed, rather than being selected purely from the staff group. Staff should still be present, for example through an elected representative, but not with full executive authority.

Alongside the multitude of external factors that contributed to the Museu Nacional fire, and the other events referenced elsewhere in this paper, Kellner also recognizes deeper systemic challenges within the institution that made it possible. Kellner became director just six months before the fire in 2018, after being a researcher there since the 1990s, and has received widespread praise since for his efforts to rebuild and transform it. He underlines that institutions often need to undergo significant change in order to be able to mitigate severe risks such as those in the palace. And yet, the system does not produce leaders who have both the scientific weight to carry the trust and credibility of their peers and of governments, and the practical leadership and management skills to drive through difficult change. He points out that too little is being invested in nurturing leadership and management skills within science, or into proactively identifying the next generation of leaders. As a consequence, 'people like me' – a world-famous palaeontologist with a shelf full of awards and 500-plus publications to his name – 'don't run museums.' Taking on even the most senior of administrative positions often brings too few rewards to justify ending a research career. As he puts it, 'if people who can make a difference don't start leading these institutions, then nothing's going to change.'

Added to this is the electoral system for selecting leaders that still exists in many institutions, which as Kellner points out can become a means to ward off change. In his case, new directors were chosen by a vote of students, professors and technicians, each having a third of the vote. This creates significant pressure for would-be officeholders to avoid proposing unpopular changes that may be necessary to tackle structural risks, like introducing performance evaluation processes that increase accountability in the workplace. This combination of factors had meant that previous leaders of the institution 'had not been pushy enough' when it came to tackling the fire risk. Kellner illustrates this with an example from his first months in the role, when he overcame the lack of a budget for fire security by persuading outside experts to deliver training for free.

Crisis response phase

Given that much of Brazil's indigenous cultural heritage was erased in the fire, museum curators saw an opportunity to reckon with the museum's colonial influences throughout the rebuilding process, by asking indigenous communities what artefacts they wanted displayed (Lenharo and Rodriguez, 2022). According to Brazilian journalist Mariana Lenharo, the Museu Nacional was a 'repository of items plucked, purchased or plundered from indigenous communities, and had presented the people themselves as curiosities, papier-maché figures in dioramas alongside taxidermied animals' (Lenharo and Rodriguez, 2022). The fire incinerated the remains of that colonial legacy, so anthropologist João Pacheco de Oliveira decided to rebuild the museum's ethnology and ethnography division in collaboration with indigenous groups. One of the first people he turned to was his former student Tonico Benites, who grew up in midwestern Brazil on a reserve for the Guarani-Kaiowá, one of the country's 305 surviving indigenous groups (Lenharo and Rodriguez, 2022).

Oliveira and Benitas soon began reaching out to Brazil's indigenous communities, and their team is currently working with over 20 indigenous groups to rebuild museum collections (Lenharo and Rodriguez, 2022). Benites frequently travels between Rio and Mato Grosso do Sul to consult with the Guarani-Kaiowá community on which items they want to include, as well as how they should be identified, stored and exhibited (Lenharo and Rodriguez, 2022). Guarani-Kaiowá artisans have donated personal items and made new objects for the collection, including a traditional head adornment called a jeguaka, and a takuapu, a bamboo percussion instrument which women play in religious ceremonies (Lenharo and Rodriguez, 2022). For many donors, deciding which objects will be held by the museum is a way to reclaim the stories they want to tell (Lenharo and Rodriguez, 2022). The first exhibition of the new ethnographic collection is planned for 2024 and will be called 'Territory Under Dispute', a title which reflects both current and historical struggles (Lenharo and Rodriguez, 2022). The Museu Nacional building is currently under reconstruction and will reopen to the public in 2027 (Lenharo and Rodriguez, 2022).

Post-crisis and rebuilding phase

The Brazilian government has pledged its support for rebuilding the museum, Reis noted, but restoring the building is not enough to remedy this vast loss to Brazilian science. Because Brazil's science sector is so vulnerable to external politics and who is in power, the country has not been able to institutionalize public support for the science sector or for scientific practice. 'We are always starting all over again,' Reis states. In 2017, former president Michel Temer cut science funding by 44 percent to $1 billion, and in 2017 proposed cutting funding by another 16 percent (Greshko, 2018). According to Reis, the Bolsonaro government requested 90 percent of the science sector's funds back during the COVID-19 pandemic, and it remains unclear where that money went. Without policies that ensure the funding of basic scientific necessities, De Souza Lima stated, Brazil's science sector will continue to be vulnerable to environmental risk and government attack. Institutionalizing support for science, Nader observed, will require increasing scientific education and fostering engagement between the science sector and key areas of public interest, such as agriculture and public health.

As was alluded to in Finding 1.5, Pharoah has said that in a context where the funding for disaster risk management is both very limited and competitive, scientists need to be at the forefront of advocacy. They must articulate the risk to the sector, and the potential loss to society, if prevention and preparation are not invested in. Director Kellner in Brazil illustrated this mindset just weeks into his post when he put an article in a prominent newspaper and was explicit about the risks to the museum, declaring that 'I have no money' to address them (he subsequently found more support forthcoming). More broadly, he courted embassies and other public and private budget-holders – for example by engaging them in his inauguration ceremony – in order to deepen relationships and communicate the museum's needs. This stakeholder engagement would pay off just months later, once the fire had hit, when one of those stakeholders, the German Consulate, gave €1 million to the reconstruction effort.

These approaches speak to a certain entrepreneurial outlook that scientists may increasingly need to consider in order to fill the funding gaps for crisis prevention and recovery. This outlook is evident at the National Museum in Brazil where two key routes are being pursued to raise funds to ensure the proper maintenance of new collections. These are the endowment model (developed in North America) and the strengthening of the Museology department. Its expansion increases the museum's capacity to organize itself to maximize its appeal to paying audiences. There has been a quadrupling of the number of staff in this department since the fire. This suggests that a more entrepreneurial stance need not compromise the core mission of scientists and other researchers.

It is also worth noting that changes in the relationship between scientists, the media, government and civil society have increased public demand for access to, and involvement in, scientific knowledge production (Reina-Rozo and Medina-Cardona, 2021). Reis believes that creating a public voice for science, and having media, communication and advocacy skills within science, is important to mobilize local and international support. The Bolsonaro years were marked by intense government disinformation campaigns and the sidelining of scientific knowledge in policy-making. But even then, according to Brazilian scientists Helena Nader and Elisa Reis, young scientists in particular used multiple media (e.g., producing short films, social media memes, advocacy in *Nature* magazine) to reach the public, to generate political influence and support to get particularly damaging government proposals revoked (Vilaca, 2020).

Mercedes Bustamante of the Brazilian Academy of Sciences believes this trend of direct researcher-led communication with the public will 'continue to strengthen and become irreversible' because of the need to increase trust and understanding between the scientific community and the public. Such trust is a valuable protection against government attack (*Science in Times of Crisis* Podcast, Episode 2, Mercedes Bustamante, University of Brasilia). This, Nader noted, is most challenging in the context of government intimidation and manipulation designed to pressure scientists into complicity or silence, as happened during the COVID-19 pandemic in Brazil, or in the sidelining of scientists on government policy committees. Here, international media engagement was crucial to maintaining the resilience of local science communities. 'When important journals like *Nature*, *Science* and others publish editorials about Brazil … this reverberates in the national press.' (*Science in Times of Crisis* Podcast, Episode 2, Mercedes Bustamante, University of Brasilia).

3.3 The Fukushima nuclear disaster, Japan (2011)

The findings of this case study are supported by relevant literature and interviews with Sayaka Oki. Sayaka Oki is a historian of science and technology and professor at the University of Tokyo in Japan, as well as a member of the ISC's Standing Committee for Freedom and Responsibility in Science.

Background

On the afternoon of 11 March 2011, a 9.0 magnitude undersea earthquake struck the east coast of the Oshika peninsula of Japan's Tohoku region. The enormous earthquake triggered a powerful tsunami, which caused a loss of electric power and consequently of cooling capacity at the Fukushima Daiichi nuclear power station, as well as flooding the power station's emergency generators. The power loss from the tsunami at the nuclear power plant led to three reactors overheating, resulting in a fire in the storage reactor, explosions in the outer containment buildings, and the release of toxic radiation into the air and ocean (IAEA, 2011). The earthquake also triggered an SMF (a submarine mass failure, i.e., a submarine landslide) which raised the height of the tsunami yet further (Tappin et al., 2014). In the days following the accident, large amounts of atmospheric radiation resulted in evacuation of an area within a 20 km radius of the power plant.

More than 19,000 people died or are still missing because of the earthquake and tsunami, with 90 percent of deaths in the Iwate, Miyagi and Fukushima prefectures due to drowning (Seto et al., 2019), making it the third largest disaster in modern Japanese history and the second largest nuclear accident after Chernobyl in 1986. It was the first severe nuclear power station accident triggered by a large earthquake and tsunami, and the first example of 'Quake and Nuke Disaster Complex' or 'complex disaster' which seismologists had warned about as early as 1997 (Hasegawa, 2012).

Fukushima nuclear disaster: lessons learned

Opposing visions held by pro-government scientists and other, more progressive colleagues opposed to nuclear proliferation hampered the interdisciplinary cooperation necessary for anticipating the risk of the 2011 Fukushima nuclear disaster. As long ago as 2001, the possible risk of a huge tsunami in Sendai was pointed out but failed to be taken seriously (Sawai et al., 2012).

Sayaki Oki noted that two factors, the unstable funding for risk prevention technology at nuclear plants, and poor integration between Japan's nuclear energy industry and the international military research sector, prevented Japanese scientists from developing the robotic technology needed to respond to the disaster. Scientists who supported nuclear proliferation, Oki stated, were less willing to conduct research that communicated the risk of tsunamis to nuclear infrastructure. In addition, the lack of dialogue between natural and social scientists hindered the deployment of effective risk management mechanisms, as natural scientists might not be best placed to design democratic dialogue between diverse stakeholders. When the Fukushima disaster struck in 2011, the country was wholly unprepared to respond and received little international support.

The scientific fallout of the Fukushima nuclear disaster can in some sense be traced back not only to strong political divisions among scientists in general, but also to the 'history of division' between the natural and social sciences in Japan. This was born of government-led investment in natural science research, which became seen as inherently more supportive of existing power structures, while a minority of liberal natural scientists and many social scientists sat outside the establishment. This fault line was never fully overcome, heavily shaping the debate on nuclear power and risk in the early 2000s. This led nuclear scientists to discredit evidence modelling the risk of tsunamis on Japanese nuclear sites. According to Sayaka Oki, a professor at the University of Tokyo, 'if the division and lack of trust within the science sector had been addressed and enabled dialogue among the scientists, it could have avoided or minimized what happened.' Recognizing the impact of division within the sector, Oki indicated that a number of Japanese universities have since created courses and opened avenues for interdisciplinary dialogue and scientific collaboration, imbued with the values of humility and openness to build trust and improve communication between the natural and social sciences.

Following the events of 11 March 2011, an underlying divide in Japanese society that had opened under the influence of the global environmental movements of the 1970s was exposed. Those with previously held trust in both the government and health officials continued to support nuclear power, while those with an inherent distrust of these same officials sought to abolish nuclear power altogether. Additionally, discussions about whether to consider lessons from Fukushima as universal, or to regard them as context-specific, raised important questions for technological culture regarding 'techno-orientalism' (Fujigaki, 2015).

Finally, Oki stated that the governmental science sector has not fully developed the capacity to learn from the past since its destruction of historical records during the US occupation. This drawback has made it difficult for Japan's science sector to integrate and learn from the Fukushima disaster. However, she also notes that since the disaster, Japanese universities have implemented training programmes to improve communication between the natural and social sciences. Fukushima has also resulted in an increased focus on disaster preparedness and risk management in the scientific community, and the government has established new regulations and guidelines for the safe operation of nuclear power plants (Watanabe, 2017). Lastly, there has been a significant increase in public interest in science and technology, particularly in the fields of nuclear energy and radiation, since the Fukushima disaster. This increased awareness of the potential risks and impacts of nuclear technology has led to a renewed focus on science education and public outreach, with an emphasis on increasing public understanding of scientific concepts and issues related to energy and the environment (Normile, 2021).

Additional reading:

- Aoki, M. and Rothwell, G. 2013. 'A comparative institutional analysis of the Fukushima nuclear disaster: Lessons and policy implications'. *Energy Policy*, Vol. 53, pp. 240–47.
- Cruz, A. M., Steinberg, L. J., Vetere Arellano, A. L., Nordvik, J. P. and Pisano, F. 2004. *State of the Art in Natech Risk Management*. Ispra, Italy, European Commission Joint Research Centre.
- Cruz, A. M. and Suarez-Paba, M. C. 2019. 'Advances in Natech research: An overview'. *Progress in Disaster Science*, Vol. 1, p. 100013.
- Steinberg, L. J., Sengul, H. and Cruz, A. M. 2008. 'Natech risk and management: an assessment of the state of the art'. *Natural Hazards*, Vol. 46, pp. 143–52.

ANNEX 2: RESEARCH/INTERVIEW QUESTION FRAMEWORK

QUESTION MATRIX

Section 1: Understanding the crisis

- Describe the shape of your science system pre-crisis. (i.e., understanding context of lesser and more advanced systems)
- What happened? (i.e., trigger/cause and event)
- How did it impact the science sector?[14] (What elements of the sector were impacted, e.g., people, infrastructure, tech, systems, funds? What assets were the weakest link or most vulnerable, e.g., scientific community, knowledge, data, artefacts, facilities?)

Section 2: Preparing for and responding to the crisis

Pre-crisis phase (Prepare)	Crisis response and stabilization phase (Protect)	Post-crisis phase (Rebuild)
What was in place[15] to prevent/prepare for the crisis, and who was involved from the science sector? (Best practice, gaps, trends)	What happened re responding to the crisis in the short and medium term, and who was involved from the science sector? (Best practice, Gaps, Trends)	What happened re rebuilding after the crisis and when, and who was involved from the science sector? (Best practice, Gaps, Trends)
What ideally would have been in place, and what would the science sector's role ideally be in that? (Gaps, Recommendations)	What ideally would have happened/been in place, and what would the science sector's role ideally be in that? (Gaps, Recommendations)	What ideally would have happened/been in place, and what would the science sector's role ideally be in that? (Gaps, Recommendations)
What do you have in place now and any obstacles to achieving the ideal? (Best practice, Trends, Gaps, Recommendations)	What do you have in place now and any obstacles to achieving the ideal? (Best practice, Trends, Gaps, Recommendations)	What do you have in place now, and any obstacles to achieving the ideal? (Best practice, Trends, Gaps, Recommendations)

14 Interviews will be audio recorded, as long as consent is provided by the interviewee.

15 '*What was in place*' could refer to policies, guidelines, programmes, platforms/fora, funding, staff or other forms of local/international support.

Section 3: Probing questions (examples)

- Any other trends you see in prevention/response/rebuilding? (e.g., we hear that funding for research stops in the aftermath of conflict, therefore recommend for other science foundations to step in to keep research going)
- Key future threats based on this experience and on country context?
- How did politics and political context affect prep/response/recovery? (e.g., post-apartheid political context in South Africa)
- Has new policy translated into people/resources?
- What lessons have been learned? (e.g., where additional resources/funds are especially needed)
- Where is additional research required? (Recommendations)
- **Can you send us any existing/new documentation if in English? (e.g., International Treaty on x, National/Municipal/University policy on x)**

ANNEX 3: ACRONYMS

ALLEA	All European Academies
CARA	Council for At-Risk Academics
COST	European Cooperation in Science and Technology
DRR	Disaster risk reduction
EMUNI	Euro-Mediterranean University
EU	European Union
IAP	Inter-Academy Partnership
IIE	Institute for International Education
ISC	International Science Council
NGO	Non-governmental organization
RESI	Rethink Education and Science
SDGs	Sustainable Development Goals
SAR	Scholars At Risk

SRF	Scholar Rescue Fund
STEM	Science, technology, engineering and mathematics
TWAS	The World Academy of Sciences
UCT	University of Cape Town
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNHCR	United Nations High Commissioner for Refugees

ANNEX 4: KEY TERMS AND DEFINITIONS

For the purposes of this paper, the following definitions have been adapted for the terms below, many of which have been borrowed from widely published documents.

Crisis - Any instance of 'violent conflict, disaster or nationwide state-sponsored takeover of higher education and science systems' including wars, climate-induced migration and significant digital data loss.

Data Policy - Data policy provides an overarching set of rules, principles and guidelines that underpin frameworks for how science engages and makes use of the data, including data governance, data quality and data architecture. Data policy establishes guidance regarding the objectives and methods of collecting, ordering and processing digital objects. It establishes standards for assuring the quality and reliability of the data needed to drive evidence-based scientific conclusions and decision-making based on these conclusions.

Disaster - A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts. The effects of the disaster can be immediate and localized but are often widespread and could be long-lasting. These effects may test or exceed the capacity of a community or society to cope using its own resources, and may require external assistance from neighbouring jurisdictions, or at national or international level. The majority of experts in the disaster risk management sector no longer speak of 'natural disasters'. It is now recognized that disasters result from hazard events interacting with features of society that make people, communities and things vulnerable to their effects. Disasters are more often driven by more generalized features of society, such as poverty or limited governance capacity. Therefore, all have a 'human' component, and the term 'disaster' is more applicable (O'Keefe, Westgate and Wisner, 1976).

Disaster risk management - Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses (UN, 2016).

There is an annotation associated with this definition on pages 15–16:

'Disaster risk management actions can be distinguished between prospective disaster risk management, corrective disaster risk management and compensatory disaster risk management, also called residual risk management.

Prospective disaster risk management activities address and seek to avoid the development of new or increased disaster risks. They focus on addressing disaster risks that may develop in future if disaster risk reduction policies are not put in place. Examples are better land use planning, or disaster-resistant water supply systems.

Corrective disaster risk management activities address and seek to remove or reduce disaster risks which are already present, and which need to be managed and reduced now. Examples are the retrofitting of critical infrastructure or the relocation of exposed populations or assets.

Compensatory disaster risk management activities strengthen the social and economic resilience of individuals and societies in the face of residual risk that cannot be effectively reduced. They include preparedness, response and recovery activities, but also a mix of different financing instruments, such as national contingency funds, contingent credit, insurance and reinsurance, and social safety nets.

Community based disaster risk management promotes the involvement of potentially affected communities in disaster risk management at the local level. This includes community assessments of hazards, vulnerabilities and capacities, and their involvement in planning, implementation, monitoring and evaluation of local action for disaster risk reduction.'

Disaster risk reduction - The updated terminology (UN, 2016) defines disaster risk reduction as the policy objective aimed at preventing new and reducing existing disaster risk, and managing residual risk, all of which contribute to strengthening resilience.

Humanitarian response - The organized efforts and actions taken by individuals, organizations and governments to address and alleviate the suffering of people affected by crises, disasters, conflicts or other emergencies. Humanitarian responses involve providing immediate assistance, protection and support to vulnerable populations, with the aim of saving lives, reducing suffering and preserving human dignity.

Open science - An inclusive construct that combines various movements and practices that aim to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaboration and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community. It comprises all scientific disciplines and aspects of scholarly practices, including basic and applied sciences, natural and social sciences and the humanities, and it builds on the following key pillars: open scientific knowledge, open science infrastructures, science communication, open engagement of societal actors and open dialogue with other knowledge systems (UNESCO Recommendation on Open Science, 2021).

The ISC also notes that open science is 'science that is open to scrutiny and challenge, and to the knowledge needs and interests of wider publics. Open science makes the record of science, its evolving stock of knowledge, ideas and possibilities accessible and free to all, irrespective of geography, gender, ethnicity or financial circumstance. It makes the data and evidence of science accessible and reusable by all, subject to constraints of safety, security and privacy. It is open to engagement with other societal actors in the common pursuit of new knowledge, and to support humanity in achieving sustainable and equitable life on planet Earth.' (ISC, 2021b)

Science - Drawing from the International Science Council, the following definition of science is referred to: 'The ISC has a broad understanding of the sciences, in all their diversity, covering science as a collective institution with a broad range of practices and values, but also scientists as a community .... The word science is used to refer to the systematic organization of knowledge that can be rationally explained and reliably applied. It is inclusive of the natural (including physical, mathematical and life) and social (including behavioural and economic) science domains. It is recognized that there is no single word or phrase in English (though there are in other languages) that adequately describes this knowledge community. It is hoped that this shorthand will be accepted in the sense intended.' (ISC, 2021b).

Scientists - Includes persons who are professionally engaged in and responsible for research and development – involving researchers, academics, students and others teaching, researching or studying at a university, scientific institution, organization or scientific workplace, in natural (including physical, mathematical and life) and the social (including behavioural and economic) science domains, as well as in the humanities, medical, health, computer and engineering sciences.

AVNNEX 5: INTERVIEWEES

Crisis case study	Interviewee (name, title)
Russian invasion of Ukraine (2021)	**Igor Lyman** (Professor of History, Head of Department of History and Philosophy, Coordinator of International Relations, Berdyansk State Pedagogical University, member of the expert council of the Ministry of Education and Science of Ukraine) **Yevheniia Polischuk** (Professor of Economic Science, Kyiv National Economic University; Vice-Head for International Relations at the Young Scientists Council and Scholars Support Office, Ministry of Education and Science in Ukraine)
ISIS occupation of Mosul University, Iraq (2014–2017)	**Alaa Hamdon** (Director of the Remote Sensing Centre, Lecturer and researcher, University of Mosul, Iraq) **Heike Wendt** (Professor of Empirical Research, Faculty of Environmental, Regional and Educational Sciences, University of Graz; Head of RESI Partnership)
War in the Balkans (1991–1999)	**Milena Dragićević Šešic** (Professor of Cultural Policy and Management, Head of the UNESCO Chair in Cultural Policy and Management – Interculturalism and Mediation in the Balkans; University of Arts, Belgrade)
Japan: World War Two (1939–45), and the Fukushima nuclear disaster (2011)	**Sayaka Oki** (a historian of science and technology, and a Professor at the University of Tokyo, Japan)
Cape Town University library fire, South Africa (2021)	**Robyn Pharoah** (Senior researcher, Research Alliance for Disaster and Risk Reduction, Stellenbosch University, South Africa)
Natural Science Museum fire, Brazil (2018)	**Antonio Carlos de Souza Lima** (Professor of Ethnology and Social Anthropology at Museu Nacional, Federal University of Rio de Janeiro) **Elisa Reis** (Professor of Political Sociology, Federal University of Rio de Janeiro, Brazil; Chair of the Interdisciplinary Research Network for the Study of Social Inequality) **Helena Nader** (Head of the Institute of Pharmacology and Molecular Biology at the Federal University of São Paulo) **Alex Kellner** (Director of Brazilian National Museum; geologist and palaeontologist)
Cross-cutting	**Barbara Minguez Garcia** (Assistant Project Officer, Emergency Preparedness and Response Unit, Culture and Emergencies, Culture Sector, UNESCO) **Manal Stulgaitis** (Head of Education Section, Division of Resilience and Solutions, UNHCR)

Podcast	Interviewee (name, title)
Science in Times of Crisis, Episode 1 Link here	**Egle Rindzeviciute** (Associate professor in the Department of Criminology, Politics and Sociology at Kingston University, London)
Science in Times of Crisis, Episode 1 Link here	**Saths Cooper** (President of the Pan-African Psychology Union)
Science in Times of Crisis, Episode 2 Link here	**Mercedes Bustamante** (Professor at the University of Brasilia, Brazil, and member of the Brazilian Academy of Sciences)
Science in Times of Crisis, Episode 3 Link here	**Melody Brown Burkins** (Director of the Institute of Arctic Studies, Dartmouth College)
Science in Times of Crisis, Episode 4 Link here	**Alaa Hamdon** (Senior lecturer and Director of the Remote Sensing Center at the University of Mosul)

Link to all episodes

ANNEX 6: RESOURCES FOR SCIENCE SYSTEMS IN CRISIS

PROGRAMMES SUPPORTING CULTURE AND HERITAGE PRESERVATION

- **The Fund for the Protection of Cultural Property in the Event of Armed Conflict (UNESCO):** 'Assists the States Parties to the 1999 Second Protocol by providing financial as well as technical assistance in relation to emergency, provisional or other measures to protect cultural property during armed conflict, or for immediate recovery after the end of hostilities' (UNESCO, n.d.). Priority funding is given to emerging countries, as well as to emergency requests and requests of a 'preventative' nature (UNESCO, n.d.). There is no formal funding limit, but requests range between 15,000 and 50,000 USD (UNESCO, n.d.). To learn more, visit https://en.unesco.org/protecting-heritage/International-fund#:~:text=The%20Fund%20for%20the%20Protection,armed%20conflict%2C%20or%20for%20immediate

- **International Funds Supporting Culture (UNESCO):** 'The UNESCO Culture Sector, through its Conventions and programmes, maintains several international funds, which aim to promote culture, protect heritage and foster creativity in a variety of ways. Each fund has a distinct scope of application and regime for making contributions or submitting requests for support. The activities financed generate positive changes for local communities and low and lower-middle income countries and contribute to sustainable development that is both social and economic. UNESCO appreciates the generous contributions, whether they are of obligatory or voluntary nature, to these funds made by governments, individuals and the public and private sectors' (UNESCO, n.d.). To learn more, visit https://en.unesco.org/protecting-our-heritage-and-fostering-creativity/international-funds-supporting-culture

PROGRAMMES SUPPORTING SCHOLARS AT RISK

Ukraine

- **ScienceforUkraine Archive of Funding Programmes and Support Initiatives:** An archive of general funding programmes for Ukrainian researchers and students. It 'includes both ongoing and already completed funding programmes. Please note that we do not update the expiration dates of these programmes. … Please inform us about funding and support programmes that are not listed below via email info@scienceforukraine.eu' (ScienceFor Ukraine, n.d.). To learn more, visit https://scienceforukraine.eu/support

- **Science at Risk:** 'a new platform for scientists affected by the war. It is a community and a web platform aimed to promote the expertise of Ukrainian scientists, find international partners and donors, and tell the stories of Ukrainian scientists during the war for a wider audience. Dozens of scientific institutions were destroyed or occupied, and hundreds of scientists were forced to leave their homes, research or workplaces. As part of the platform, Ukrainian scientists work in expert working groups that analyse the situation in the country and look for solutions to both immediate and long-term problems. All publications will appear in English and Ukrainian translations.'. To learn more, visit https://scienceatrisk.org/

International

- **Scholars at Risk:** 'Protects scholars suffering grave threats to their lives, liberty and well-being by arranging temporary research and teaching positions at institutions in our network as well as by providing advisory and referral services' (.). To learn more, visit https://www.scholarsatrisk.org/

- **Council for At-Risk Academics (CARA):** 'Provides urgently needed help to academics in immediate danger, those forced into exile, and many who choose to work in their home countries despite serious risks. Cara also supports higher education institutions whose work is at risk or compromised…. Cara's Fellowship Programme supports academics from any country in the world, on any continent, who are being forced to flee by the risk of imminent imprisonment, injury or death, and works with them to find them temporary refuge in universities and research institutions in the UK until they can one day return home to help rebuild better, safer societies'. To learn more, visit https://www.cara.ngo/what-we-do/a-lifeline-to-academics-at-risk/

- **Scientists and Engineers in Exile or Displaced (SEED):** 'Through the Scientists and Engineers in Exile or Displaced (SEED) program, the National Academies of Sciences (NAS) will support forcibly displaced and at-risk scientists and researchers around the world and promote the development of vulnerable science and research networks of exiled and displaced scientists, engineers and researchers to enhance employment opportunities and connections to the global scientific community. As part of this program, NAS is collaborating with the Polish Academy of Sciences to award grants to facilitate the pursuit of research projects by Ukrainian scientists and researchers' (.). To learn more, visit https://www.nationalacademies.org/our-work/scientists-and-engineers-in-exile-or-displaced-seed-program

- **Institute of International Education's Scholar Rescue Fund (IIE-SRE):** 'The Institute of International Education's Scholar Rescue Fund (IIE-SRF) is the only global program that arranges, funds and supports fellowships for threatened and displaced scholars at partnering higher education institutions worldwide. At the heart of IIE-SRF is the idea that each scholar we support is a beacon of hope in our world'). To learn more, visit https://www.scholarrescuefund.org/

council.science