What Does Nature Have to Do with It?
Reconsidering Distinctions in International Disaster Response Frameworks in the Danube Basin

Shanna N. McClain[1], Carl Bruch[2], Silvia Secchi[1, 3], Jonathan W.F. Remo[3]

[1]Environmental Resources and Policy, Southern Illinois University, Carbondale, USA
[2]Environmental Law Institute, Washington DC, USA
[3]Department of Geography and Environmental Resources, Southern Illinois University, Carbondale, USA

Correspondence to: Shanna N. McClain (shannamcclain@siu.edu)

Abstract

This article examines the policy and institutional frameworks for response to natural and man-made disasters occurring in the Danube basin and the Tisza sub-basin. Response to these types of incidents has historically been managed separately, as has the monitoring of these types of incidents. We discuss whether the policy distinctions in response to natural and man-made disasters remain functional given recent international trends toward holistic response to both kinds of disasters. We suggest that these distinctions are counterproductive, outdated, and ultimately flawed, a conclude by reflecting on the lessons learned and by proposing an integrated framework for disaster response in the Danube basin and Tisza sub-basin.

Keywords: International Disaster Response Frameworks; Natural Disasters; Man-made Accidents; Industrial Accidents; Natech Accidents; Danube River basin; Tisza River Sub-basin

1 Introduction

What are the benefits of maintaining the distinction between natural and man-made disasters? What are the consequences of eliminating this distinction? When a disaster occurs, local and national capacities for disaster response can be overwhelmed, often triggering a request for external, international assistance. The actors engaged in disaster response[1] have historically been determined by the nature of the disaster (i.e., natural disaster, industrial accidents, nuclear accidents, marine oil spills) and legal frameworks typically divide response between natural and man-made disasters. However, there is growing recognition that anthropogenic climate change and other human activities such as land use change are driving more extreme and sometimes cascading events. Cascading events refer to cases in which a primary threat is followed by a sequence of secondary or additional hazards that require complex and often overlapping types of response (Pescaroli and Alexander, 2015). Thus, the question of eliminating the natural/man-made dichotomy is brought to the forefront.

In Europe, natural and man-made disasters combined caused total losses of US$ 13 billion in 2015 of which only US$ 6 billion were insured; the predominant losses came from flood events (Swiss Re, 2016). Flooding and pollution are considered to be the primary transboundary pressures of the Danube River basin; however, a number of other man-made accidents occurred in the region (ICPDR, 2015a). Specifically, in 2000, the Baia Mare and Baia Borsa mine-tailing pond failures mobilized approximately 100,000 m^3 of metal-contaminated water into the Tisza River, eventually polluting the Danube River and Black Sea. Since the

[1] While disaster response is considered part of the disaster management cycle, disaster management includes the application of policies and actions regarding disaster risk (i.e., prevention, preparedness and mitigation, response, and recovery). Each have their own set of policy frameworks, actors and mechanisms for implementation. This paper focuses on the disaster response phase specifically, and on the policy frameworks and actors related to requesting and receiving assistance immediately following a disaster, and the legal mechanisms by which responders are deployed.

industrial accidents occurred originally as a result of significant rainfall and flooding, these events are an example of what are commonly referred to as natech accidents, technological accidents triggered by natural disasters. In 2010, an industrial accident occurred in the Hungarian portion of the Danube River when a dam containing alkaline red sludge collapsed, releasing 1.5 million m³ of sludge into the surrounding land (approximately 4000 hectares) and waterways (including Kolontár, Torna Creek, and the Danube River), killing 10 people and injuring several hundred more (ICPDR, 2010). In 2014, following Cyclone Tamara, over 1,000 landslide events occurred in Serbia as well as significant flooding, resulting in damage to properties and infrastructure and the inundation of agricultural land. Due to concern over possible breaches in infrastructure to mine tailing dams in the surrounding area, and the harmful effects ~~to~~ human health, technical experts investigated mining sites and provided recommendations for local evacuations (NERC, 2014). ~~In~~ all three disasters, the need for disaster response exceeded the capacity of national actors; therefore, international response involved the United Nations, the European Commission, and various other international organizations.

While international humanitarian law is generally well defined, the law of international disaster response is still incomplete (Fisher, 2008). Historically, a distinction has been drawn between the scope of response to natural disasters and man-made disasters; however, this distinction is absent from the 2015 Sendai Framework for Disaster Risk Reduction, which adopts a multi-hazard risk approach providing management tools for disasters that are both natural and man-made (UNISDR, 2015). The European Union's disaster response framework is also holistic and includes natural and man-made disasters, and some multilateral sub-regional agreements are also taking similar approaches, such as those adopted by the Association of South East Asian Nations (ASEAN) and the Baltic Sea Economic Cooperation (BSEC). Adopting a multi-hazard, or all-hazards, approach to disaster response allows for recognition of all conditions, natural or man-made, that have the potential to cause injury, illness or death; damage to or loss of infrastructure and property; or social, economic and environmental functional degradation (Kappes, Keiler, von Elverfeldt and Glade, 2012).

With international policies starting to shift toward more holistic frameworks of response that incorporate both natural and man-made disasters, this article explores what this trend will mean for regional institutions in the Danube basin and Tisza sub-basin, whose policy frameworks for monitoring and response continue to distinguish between types of disasters, and resultantly have separate policy response options depending on the type of disaster.

This article begins with an overview of the study area and a description of the methodology. Next is a discussion of the distinctions between natural disasters and industrial accidents – how and why they have been treated differently and how recent developments in international law and practice are raising questions about the merits of these distinctions. It is followed by an examination of the international frameworks governing disaster response in the Danube basin and Tisza sub-basin. Subsequently, the differences in how natural disasters and industrial accidents are monitored, and how they are responded to, are explored. The article discusses the transition of international policies toward more holistic frameworks for response, and concludes with a reflection of how this might affect the Danube basin and Tisza sub-basin.

2 Overview of study area and methodology

The Danube River basin covers more than 800,000 km^2 – over 10 percent of continental Europe – and flows through the territories of 19 countries with nearly 80 million people residing within the basin. Today, 14 of the 19 countries, plus the EU, have committed to transboundary cooperation in protecting the Danube via the Danube River Protection Convention (DRPC), and work jointly toward the sustainable management of the Danube basin and the implementation of both the European Union's Water Framework Directive (WFD) and Floods Directive (EU FD) (ICPDR 2015a).

Among the tributaries of the Danube River, the Tisza sub-basin has the largest catchment area, and covers approximately 160,000 km² (20 percent of the Danube basin's area), with approximately 14 million people (Fig. 1). There exists a distinct socio-economic contrast in the basin between western and former socialist countries, and since the end of communism in the late 1980s, the central and lower Danube has experienced a rapid shift to free market democracy within the context of increased globalization, privatization, and deregulation. This has led to rural decline as well as increased poverty, unemployment, and depopulation (WWF, 2003).

Fig. 1 Map of Danube River basin and Tisza River sub-basin.

International measures regulating the Danube were first undertaken in 1882 for flood protection and navigation. Dams were constructed within the upper basin for flood mitigation, hydroelectric power generation, and regulation of river levels for navigation. The operation of these dams has been ~~attributed~~ with altering the flow regime of this segment of river and consequently varying the ecological disturbance regime within the river and on the floodplain resulting is substantial changes in the riverine ecosystem (ICPDR, 2009a). The flow regulation provided by the dams and the construction of levees has allowed for the conversion of floodplains and riverine wetlands into area suitable for agricultural and urban development. Today only 12 small reaches (<1 km in length) of the Upper Danube remain relatively untransformed (Schneider, 2010). In the Middle and Lower Danube, the river bed has been dredged repeatedly to maintain a navigable river channel. Along these segments of the Danube River, levees and dams mitigate or prevent inundation of over 72 percent of the floodplain. The substantial reduction in Danube's connection with its floodplain combined with wastewater discharge from agricultural and industrial sources, and increasing levels of pollutants along these river segments have substantially altered or damaged riverine ecosystem and reduced resiliency of urban and rural communities to large floods which exceed the protection level of their flood mitigation measures (Schneider, 2010; UNECE, 2011). The degree of industrial development and amount of pollution created by the industrial sector varies among Danube countries. In general, pulp and paper industries represent the largest contributors of pollution, followed by chemical, textile, and food industries (ICPDR 2009a).

The Tisza headwaters are located in the Carpathian Mountains in Ukraine. From these headwaters the Tisza River flows southwest across central portions of the great Hungarian Plain into the Danube River in Serbia (Fig. 1; ICPDR, 2008a). Intense, concentrated rainfall and the steep terrain coupled with deforestation and channelization of many streams result in some of the most sudden and high-energy flooding in Europe (Nagy et al., 2010). The sudden water level rises coupled with the high energy of the flows often threaten human lives and result in substantial damage to infrastructure and croplands (ICPDR, 2008a).

While industrial production has dropped drastically in the Tisza since the 1990s, there remain a variety of industries that contribute to the economy of the region, and the legacy of heavily concentrated industrial activities continues to threaten the surrounding ecosystems. The main industrial regions of the Tisza are located in Romania and Hungary, where the potential for flood damage and losses is also greatest. Chemical and petrochemical industries (including oil refinery, storage and transport) are important for both Hungary and Ukraine, and the cellulose and paper, textile, and furniture industries are also present predominantly in the upper portion of the Tisza in Slovakia, Romania, and Ukraine (ICPDR, 2011).

Mining activities, and the accidental spills of chemical substances, have affected the aquatic environment and water quality within the Tisza sub-basin since the 2000 Baia Mare and Baia Borsa natech accidents (JEU, 2000). Natech accidents present significant challenges, as natural events can trigger multiple and simultaneous accidents in one installation, or depending on the impact of the natural hazard, in several hazardous facilities at the same time (Krausmann and Baranzini, 2012). Furthermore, natechs present additional difficulties as they remain absent from disaster response frameworks (Krausmann, Cruz, and Salzano, 2017). A 2009 assessment identified more than 92 potential sources for industrial and waste deposits; however, the list does not include abandoned mine sites and their mine tailing dams – only those from currently operational mines (ICPDR, 2015a). Therefore, the potential risk of accidental pollution could be substantially higher (ICPDR, 2015a).

Methodology

The examination of policy and institutional frameworks for monitoring and responding to natural disasters and man-made accidents in the Danube and Tisza occurred through a combination of primary and secondary data collection and analysis. The primary data consisted of semi-structured interviews, while the secondary data included analysis of the legally binding mechanisms in the region, including conventions and directives (Table 1), of bilateral agreements (Table 2), and a literature review of peer-reviewed publications and white papers, providing for an analysis of international laws, policies, and institutions within the Danube basin and Tisza sub-basin regarding the provision of disaster response. Semi-structured interviews were conducted over an eight-month period from January to August 2013. This format of interviews was chosen so that the pre-determined set of interview questions could be expanded through the natural course of conversation and allow for a more thorough understanding of what was initially queried – in particular, each expert interviewed was provided with the freedom to express their personal views in their own terms.

Table 1. List of legally binding mechanisms for Danube basin and Tisza sub-basin.

Governing Body	Convention	Type of Instrument	Description of Instrument
UN Economic Commission for Europe	Industrial Accidents Convention	Legally binding for parties to convention.	Determines actions of request for assistance and response for industrial accidents specifically.
European Commission	Water Framework Directive	Legally binding for EU member states, and through	Sets basin-level management of water quality and

		Danube Convention.	quantity.
European Commission	Floods Directive	Legally binding for EU member states, and though Danube Convention.	Requires action regarding flood mapping at the basin level.
European Commission	Seveso Directives	Legally binding for EU member states.	Requires corporations to list possible risk of industrial accident, and develop preparedness plans.
European Commission	Civil Protection Mechanism Directive	Legally binding for EU member states,	First EU-wide law to include multiple-hazards in disaster risk strategies.
International Commission for the Protection of the Danube River (ICPDR)	Danube River Protection Convention	Legally binding for Danube member states.	Provides integrated framework for all Danube countries to participate in basin-level management, regardless of EU affiliation.

Table 2. List of bilateral agreements within countries in the Danube basin and Tisza sub-basin.

Countries	**Transboundary Watercourses**	**Disasters / Emergencies**
Austria – Czech Republic	1967*	1994 (Floods Only)
Austria – Germany	1987	1991 (Floods Only)
Austria – Hungary	1956	1959 (Floods Only)
Austria – Slovakia	1967*	1994 (Floods Only)
Austria – Slovenia	1956***	1956* (Floods Only)
Bosnia and Herzegovina – Croatia	1996	1996 (Natural/Manmade Disasters)
Bosnia and Herzegovina – Serbia and Montenegro**	-	2011 (Flood EWS)
Bulgaria – Romania	2004	2004 (Floods Only)

Bulgaria – Serbia	Draft	Draft (Floods Only)
Croatia – Hungary	1994	1994 (Floods Only)
Croatia – Serbia	-	-
Croatia – Slovenia	No Date	1977*** (Coastal Pollution)
Czech Republic – Slovakia	1999	-
Hungary – Romania	1986	2003 (Floods Only)
Hungary – Slovakia	1956*	2014 (Floods Only)
Hungary – Slovenia	1994	1994 (Floods Only)
Hungary – Ukraine	1997	1998 (Floods Only)
Moldova – Romania	2010	2010 (Floods Only)
Moldova – Ukraine	1994	-
Serbia and Montenegro – Hungary	1955**	1955*
Serbia and Montenegro – Romania	1955**	Under Discussion
Ukraine – Romania	1997	1952*** (Floods Only)
Ukraine – Slovakia	1995	2000 (Floods Only)

* Agreement formed with Czechoslovak Socialist Republic
** Agreement formed with Yugoslavia
***Agreement formed with Union of Soviet Socialist Republics
- No Information Available

Seventy-one interviews were conducted in various locations throughout Europe. The interviews took place with experts in the International Commission for the Protection of the Danube River, the expert groups of the International Commission for the Protection of the Danube River (i.e., Tisza group, river basin management, flood protection, and accident prevention and control), with respondents working at the national ministries, water management directorates, and non-governmental organizations in the Tisza and Danube countries, as well as with experts in the European Commission and the United Nations. Those interviewed were chosen based on their knowledge of and work within the Danube River basin and Tisza sub-basin. Given public roles, the interviews are intentionally left anonymous to ensure candidness in the responses. Thus, only the kind of organization the experts work for is identified - the numbers appearing in brackets in the table below refer to the interview citations in text; multiple interviews were conducted within each level of governance indicated (Table 3). The questions focused on how Danube basin and Tisza sub-basin policies and laws were implemented in practice, as well as the perceptions of the experts regarding the frameworks and implementation of disaster monitoring and response throughout the Danube basin and Tisza sub-basin.[2]

Table 3. Organizations from which experts were drawn for interviews.

International	United Nations, United Nations Economic Commission for Europe, and United Nations Environment Programme (UNEP)/UN Office for the Coordination of Humanitarian Affairs (OCHA) Joint Environment Unit [1]
Regional	European Commission [2]
	International Commission for the Protection of the Danube River (ICPDR) and Expert Groups (Tisza Group, River Basin Management, Flood Protection, and Accident Prevention and Control) [3]
National	National Ministries of Environment, Rural Development, Interior, Environment Agency [4]
	Water Directorates [5]
Non-State Actors	NGOs [6]

***** Numbers in brackets refer to interview citations in text.

3 Distinctions between natural ~~disasters~~ and man-made ~~accidents~~ in policy frameworks

The approaches used for describing, limiting, and categorizing disasters fundamentally shape the methods for monitoring and responding to disasters. They determine the solutions utilized, the resources allocated, and the governance frameworks selected by categorizing the types of disaster into ~~that which is~~ natural or man-made. It is therefore important to recognize the etiology of disaster ~~in order~~ to understand why the distinctions among the various types of disasters still remain. These are discussed below.

[2] Questions relevant to international frameworks for disaster response included: (1) What are the respective roles in multilevel governance in regard to response for natural and man-made disasters? (2) To what extent are natural and man-made disasters included in policy frameworks for response; in what context and at what level, and what is the language being used? (3) What gaps exist between policies and practice in regard to response for natural and man-made disasters? (4) What constraints or opportunities exist in including policies for response to natural and man-made disasters; which type would be most effective and at what level?

3.1 Rationale for different treatment between natural and man-made disasters

Natural hazards are naturally occurring physical phenomena, which can include earthquakes, landslides, tsunamis, volcanoes, and floods. Disasters disrupt individuals and communities at various scales due to hazardous events interacting with conditions of exposure, vulnerability, and risk – leading to human, material, economic and environmental losses and impacts.[3] Natural disasters have historically been characterized either (1) as a direct form of punishment from God for the sins of humanity, or (2) in more recent history as an "act of God" that removed humans from culpability (Rozario, 2007). The consequences of natural disasters become a function of where people reside and their overall vulnerability, including aging infrastructure and a function of their ability to monitor and prepare for these events (Peel and Fisher, 2016). Vulnerability within and between populations can vary, and occurs for multiple reasons – social inequalities, community demographics (e.g., age and poverty), lack of access to health care, and limited access to jobs or to lifelines (e.g., emergency response, goods, services) (Cutter and Emrich, 2006). While building in disaster-prone areas is not the sole responsibility of individuals, they do share responsibility for investing in the risk involved.

Industrial ~~accidents~~ and other man-made ~~accidents~~ are traditionally governed and responded to separately from natural disasters. The role of human agency features even more prominently in these events, due to potential moral or legal obligations to mitigate risk (e.g., preparedness, insurance, disaster aid). Man-made disasters suggest potential moral and legal obligations to both aid the victims of the disaster in a response capacity in the period

[3] Exposure is understood as people, infrastructure and housing, production capacities and other human assets located in hazard-prone areas. Vulnerability is defined as a set of physical, social, economic and environmental factors or processes that increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards. Disaster risk is the potential loss of life, injury, or damaged assets occurring to an individual or community as a function of hazard, exposure and vulnerability (UNISDR, 2015).

immediately following the disaster, as well as to compensate those who are harmed during their long-term recovery (Verchick, 2012). The liability is only effective if a polluter can be identified or liability can be assigned. As disasters continue to multiply, cascade, and their costs mount, responsibility for the disaster also becomes more complex. For example, in assigning liability to the 2010 red sludge spill in Hungary, early reports from the Hungarian Prime Minister Victor Orbán indicated that the breach was likely due to human error, and that "there was no sign the disaster was caused by natural causes, therefore it must be caused by people" (Dunai, 2010). In ongoing efforts to determine human negligence, it was determined that flooding and subsidence led to structural breaches in the reservoir containing the alumina, yet it remained difficult to prove whether officials at the MAL alumina facility knew of the weakened infrastructure (NDGDM, 2010).

The degree of uncertainty related to the amount of damage and probability of occurrence is very high with disasters, particularly those influenced by climate change (Greiving et al., 2012; Munich Re, 2016). Liability can be more difficult to calculate and assign in these cases, in part because disaster loss agencies (i.e., Munich Re, Swiss Re), are often accounting for specific losses from flooding and sudden-onset disasters that are more easily quantified, whereas the impact of slow-onset, or "silent", disasters can be more difficult to quantify (IFRC, 2013). Therefore, due to numerous anthropogenic influences on these events, it is misleading to continue the differentiation in terminology between "natural" versus "man-made" disasters, and the frameworks that govern mechanisms for disaster response.

3.2 Dimensions for different treatment

Increased frequency of major disasters, legal barriers to disaster response, and the absence of unified response have led to increased attention at a variety of levels for more integrated international frameworks (IFRC, 2007). The fragmented nature of disaster response has emerged from the need to address specific types of disasters, in specific regions, or response modalities. Furthermore, while natural disasters and industrial and nuclear accidents have established frameworks for response, natech accidents are often missing from chemical accident response programs (OECD, 2015). Natech accidents can lead to the release of toxic substances, fires, or explosions and result in injuries and fatalities; therefore, the lack of consideration for natech response mechanisms, planning tools or response programs can be an external risk source for chemical and nuclear facilities (Krausmann and Baranzini, 2012). Some international instruments, such as the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and the Convention on Early Notification of a Nuclear Accident apply only to specific types of disaster. While the Nuclear Accidents Conventions were adopted almost immediately following the Chernobyl nuclear accident, there still remains no similar overarching global framework for notification or assistance in response to industrial accidents, or for environmental emergencies more broadly (Bruch et al., 2016). Other disaster frameworks, like the Tampere Convention, apply only to a single sector or area of relief. Conversely, the ability to provide disaster response for natural disasters is quite broad and is included in a number of international frameworks. A question of applicability of agreements arises, however, when a complex disaster occurs and multiple institutions have a mandate for response, but it is unclear which institution should take the lead in responding or coordinating response efforts (Bruch et al., 2016).

An additional challenge with fragmented disaster response frameworks lies in the types of international actors engaged in natural disasters and man-made ~~accident~~ response. Generally, there is a failure to include non-state actors, the private sector, or individuals in response efforts to disasters (IFRC, 2007). The Tampere Convention and the sub-regional Black Sea Economic Cooperation (BSEC) and Association of South East Asian Nations (ASEAN) agreements are exceptions. With the Tampere Convention, for example, the decision to offer assistance, the type of assistance provided, and the terms of assistance are up to the discretion of the non-state actors offering assistance (Bruch et al., 2016). Given the increasing role of private funds in disaster response and relief operations, including these actors in disaster frameworks can be beneficial.

4 Disaster frameworks in the Danube basin and Tisza sub-basin

Response to natural and man-made disasters, including natech accidents, is governed by a range of global, regional and national laws, policies, and soft-law instruments. In the Danube basin and Tisza sub-basin this includes the Industrial Accidents Convention and the Seveso Directive, the Water Framework Directive and the Floods Directive, as well as treaties and policies developed at the level of the Danube and Tisza. As such, natural and man-made disasters continue to be treated as distinct and separate issues, where monitoring and response are managed independently.

In 1994, the Danube countries developed the Danube River Protection Convention (DRPC), a legally binding instrument that ensures sustainable management of the Danube River. Through the International Commission for the Protection of the Danube River (ICPDR), the DRPC requested the ICPDR to coordinate the activities of the EU Water Framework Directive (WFD) and EU Floods Directive among the Danube member states. The WFD and Floods Directive are legally binding to members of the European Union, but through the DRPC become legally binding to all Danube member states, regardless of EU member status.. The WFD combines the monitoring and assessment of water quality in the basin, and the Floods Directive instructs national authorities to establish flood risk management plans by 2015, linking the objectives of the WFD and the risk to these objectives from flooding or coastal erosion through the Floods Directive, and integrating them into basin level activities via the ICPDR. However, because not all countries of the Danube are EU member states, not all measures and outcomes of the WFD and Floods Directive are implemented equally among the basin countries.

The Danube and the Tisza have experienced numerous natural and man-made disasters, including natech accidents (e.g., Baia Mare Cyanide Spill, Hungarian Chemical Accident, and recent Serbian landslides) (European Commission, 2016). These are tallied in Table 4. However, the frameworks for disaster response at the levels of the United Nations, the European Union, and those utilized by the ICPDR are restricted to particular types of disaster – monitoring and response to flooding is the most advanced throughout the basin, while pollution is monitored, but does not have the same frameworks for response. Additionally, there remain a variety of natural and man-made disasters that that are not integrated into any type of basin monitoring or response framework, including fire, and drought.

Table 4. Natural and man-made disasters in the Danube basin, reported by country, 2000-2012

Year	**Type of Event**	**Country**
2000	Mine tailing failure/cyanide and heavy metal pollution (natech)	Romania, Hungary, Bulgaria, Macedonia
	Landslide/avalanche	Austria, Slovenia
	Extreme temp./drought	Bulgaria, Croatia, Slovenia
	Flooding	Croatia, Hungary, Romania, Slovenia
	Severe ice storms	Moldova, Ukraine
	Wildfires	Croatia, Slovakia
	Factory fire	Slovenia
2001	Mining accident (natech)	Slovenia
	Flooding	Croatia, Hungary, Romania, Slovakia, Ukraine
2002	Industrial fire at waste dump	Slovenia
2003	Mining accident (natech)	Slovenia
	Extreme temp./drought	Austria, Croatia, Germany, Slovenia, Bosnia and Herzegovina

	Flash floods/severe storms	Hungary
	Wildfires	Slovenia
2004	Drinking water pollution (natech)	Hungary
	Dam failure	Romania
	Earthquake	Slovenia
	Flooding/severe storms	Hungary, Slovakia
	Drought	Bosnia and Herzegovina
2005	Landslides	Slovenia
	Flooding/Severe Storms	All Danube Countries, except Ukraine
2006	Avian (H5N1) flu pandemic	Hungary, Romania, Slovenia
	Aircraft accident	Hungary
	Earthquake	Hungary
	Extreme Temp.	Bulgaria
	Wildfires	Slovenia
2007	Wildfires/forest fires	Bulgaria, Croatia
	Hurricane	Germany
	Extreme temp./drought	Austria, Bulgaria, Croatia, Hungary, Romania, Slovakia, Bosnia and Herzegovina, Montenegro, Serbia, Moldova
	Flash floods/severe storms	Bulgaria, Germany, Hungary, Romania, Slovenia, Montenegro, Serbia, Ukraine
2008	Transportation accident	Croatia
	Extreme temp.	Bulgaria
	Forest fires	Bulgaria
	Flash floods/severe storms	Hungary
	Flooding	Romania, Slovakia, Slovenia, Serbia, Moldova, Ukraine
2009	Swine (H1N1) flu pandemic	All Danube Countries
	Ice storms/blizzard	Croatia, Romania, Bosnia and Herzegovina, Ukraine
2010	Chemical accident (natech)	Hungary
	Earthquake	Serbia
2012	Ice storms/blizzards	Bulgaria, Hungary, Romania, Montenegro, Serbia, Moldova, Ukraine
	Extreme temp./drought	Moldova

-Note that economic losses, deaths and displacements are not reported to either European Commission or ICPDR.
- Where indicated, natech accidents occurred because of initial flood event that led to subsidiary release of chemicals/pollutants.
-Adapted from European Commission, 2016.

4.1 How disasters are treated differently within response frameworks

Numerous frameworks for response to natural disasters exist (Table 1). Apart from natural disasters, the United Nations Economic Commission for Europe's (UNECE) Industrial Accident Convention applies to land-based, non-military, and non-radiological industrial accidents (UNECE, 2009). Through the convention, response for industrial accidents is provided through bilateral or multilateral arrangements. If no prior agreements exist, an affected country can request assistance from other parties through mutual assistance agreements. However, in these situations, it is the responsibility of the requesting country to cover all costs, unless otherwise agreed upon among the responding countries (UNECE, 2009).

Flooding in the Danube in 2013 and 2014 caused approximately €15 billion ~~in~~ damage (Table 5), and while the economic cost from industrial and other man-made accidents are not monitored or reported in the same manner ~~(Table 4)~~, such accidents have occurred quite frequently and ~~make apparent~~ the need ~~for improved~~ agreements on bilateral or multilateral relief (ICPDR 2015b).

Table 5. Estimated human and economic loss in Danube per flood event, 2002-2014

Flood Year	# Deaths or # Displaced	Economic Losses €
2002	N/A	N/A
2006	N/A	> €6 billion
2010	35 deaths	€2 billion
2013	9 deaths	€2.4 billion
2014	79 deaths; 137,000 displaced	€4 billion

*N/A – Data not available
-Adapted from ICPDR, 2008b and ICPDR, 2015b

The facilitation of international disaster response can be inadequate if mobilization is untimely, or fails to include sufficient financial support. Response frameworks may neglect or place disproportionate attention on certain types of disasters, which could become more problematic with growing concerns over climate change and increased urbanization.

Diverse ~~systems of response~~ are implemented among the Danube basin countries due to the variety of disasters experienced. Some utilize a single Civil Protection Mechanism, while others rely on multiple parties among Ministries of the Interior, Ministries of Rural Development, Water Directorates, and a variety of additional local protection committees [4, 5]. Interviews indicated that not all responders/parties are sufficiently trained, and many lack managerial or technical capacity to manage specific disasters appropriately [4]. There is also large compartmentalization of tasks at lower levels – both regional and local – where integration among the various types of disaster, as well as increased cooperation is needed [2, 3]. Other than the fact that these diverse actors are providing certain types of disaster assistance, there is nothing uniting them – no international or regional disaster response system. ~~Given the increased frequency of natural and man-made disasters and the growing number of actors involved in disaster response efforts, ensuring effectiveness of aid should not detract from response and assistance (IFRC, 2007).~~

~~Besides the diverse ensemble of international organizations with a mandate and capacity for responding to natural disasters and/or specific types of technological or industrial accidents, there are also agencies experienced in particular types of international disasters, but which may not necessarily have the mandate or capacity for response.~~ In 1994, the United Nations Environment Programme (UNEP) and the UN Department of Humanitarian Affairs (DHA, the predecessor of OCHA), developed an administrative arrangement through an exchange of letters (Bruch et al., 2016). The arrangement relies on the environmental mandates of UNEP and the humanitarian mandates of the DHA. Through UNEP's Governing Council Decision UNEP/GC.26/15 on "Strengthening International Cooperation on the Environmental Aspects of Emergency Response and Preparedness", the Joint UNEP/UN OCHA Environment Unit (JEU) plays a leading role in facilitating coordination among international organizations in the event of natural and man-made disasters, including natech accidents, which are more broadly termed environmental emergencies (UNEP, 2011). The JEU has a number of existing agreements and interface procedures in place with these organizations, in order to facilitate response. For example, the JEU facilitated international agreements and interface procedures to aid with response between UN Disaster Assessment and Coordination (UNDAC) and the EU Civil Protection Mechanism to the 2014 Serbian landslides following Cyclone Tamara (NERC, 2014). During the 2000 Baia Mare natech accident in the Tisza River sub-basin, sixteen experts from seven countries deployed for response to the natech accident, and the JEU assisted to coordinate response efforts among UNDAC, the European Commission, the Military Civil Defence Unit, the World Health Organization, and a variety of other actors (JEU, 2000).

At the regional level, the European Union's Civil Protection Mechanism (EU CPM) is an instrument for disaster response that protects people, the environment, property, and cultural heritage in the event of natural or man-made disasters, occurring within or outside of the European Community (European Commission, 2016). Disasters are monitored internationally through the Emergency Response Coordination Centre (ERCC) in cooperation with the JEU and with participating states.

The European Union's Seveso Directives (I enacted in 1982, II enacted in 1996, and III enacted in 2012) are some of the earliest pieces of legislation to address disaster risk (European Community, 1982; European Community, 1996; European Community, 2012). The various iterations of the Directive govern the establishments where dangerous substances are present, and require the establishments to classify and report the amounts, types, and locations of dangerous substances present. The majority of the Directives' focus is on notification requirements and accident prevention (European Union, 2012). The responsibility for response under the Directives falls on the industries for developing preparedness response measures in advance of an accident, and notifying the competent authority in case of a major accident (European Union, 2012). However, a 2012 study by the European Commission indicated that industry in nearly half of the EU countries is believed to insufficiently consider natech risks in their preparedness response measures (Krausmann and Baranzini, 2012).

The EU Floods Directive provides a framework for addressing risk from natural disasters, specifically floods. While inspired not only by the damaging effects of floods, but also by increasing flood risks as a result of climate change, the main objective of the Directive is to require member states to assess and manage risks of flooding and to develop flood risk management plans. Though the plans are restricted to areas considered at high risk of floods, these are not integrated into other types of plans and maps available – such as the Inventory of Potential Accidental Risk Spots in the Danube[4] – nor are they used for developing preparedness response measures in advance of an accident or natural disaster, such as in the case of the Seveso Directive. Though the Flood Directive was expected to reduce flood risk, interviewees voiced disappointment regarding the limitations of integrating disaster risk more broadly, particularly in relation to water quality and accidental pollution [3]. These present as policy limitations to the Water Framework Directive and Flood Directive, as neither of the two directives require the integration of disaster risk of both floods and accidental pollution.

The European Union also developed a set of macro-regional strategies for the Adriatic and Ionian, Alpine, Baltic Sea, and Danube regions (European Commission, 2010). While the

[4] Pursuant to the 2001 Baia Mare natech accident in Romania, the ICPDR conducted a qualitative evaluation of the hazardous locations in the Danube catchment area, with reference to location of possible water pollution. The report of Inventory of Potential Accidental Risk Spots was released in 2001, and has not been updated since (ICPDR, 2001; ICPDR, 2015a).

intent was to not provide new EU funding, these integrated frameworks are supported by EU Structural and Investment Funds in order to address common challenges faced in each defined area. In the Danube Strategy, risks from floods and industrial accidents are reflected as having substantially negative transnational impacts, and are listed as requiring preventive and disaster management measures that are implemented jointly, with the understanding that work undertaken in isolation in one place (e.g., to build levees) displaces the problem and places neighboring regions at greater risk of flooding (European Commission, 2010). Other man-made disasters are integrated in the discussion of risks, as well as the need to account for climate change by taking a regional focus at the basin level (European Commission, 2010, p. 8). In a 2015 European Commission Communication report, several limitations were highlighted, including: the need to improve efforts to reduce the Danube region's risk of exposure to major floods and accidental hazardous material releases; limited political commitment, funding, and capacity among countries and institutions in the Danube; lack of staff, funding, and expertise impeding participation, particularly in lesser-developed areas of Danube – the report also acknowledged that these challenges are more acute in non-EU countries (EPRS, 2015). The limitations in funding, technical expertise, and capacity were confirmed in interviews with experts at various levels, who also noted how this leads to uneven implementation of EU Directives within the basin that can create pockets of vulnerability to both flood risk and risks from industrial accidents [2, 3, 4].

While the Danube Strategy does not provide a framework for response to natural and man-made disasters, it does highlight the EU's continued support for managing multi-hazard response at multiple levels, particularly through Priority Area 5 "To Manage Environmental Risks". Specifically, it requests that the countries "strengthen operational cooperation among emergency response authorities in the Danube countries and improve the interoperability for risks that are common to an important number of countries in the region (i.e., floods and risks of other natural and man-made disasters)”, and advises that each country’s civil protection mechanism have an understanding of neighboring country’s systems so that response teams can function smoothly in case of emergencies (EUSDR, 2015). Experts also expressed the need for formal agreements with specific language on integrated mapping of complex disasters, as well as provisions addressing response to both natural and man-made disasters, particularly if additional grants could be given from the EU to support these activities [2, 3, 4, 5]. Some interviewees reflected that the regional Strategy depended on stronger countries helping the weaker ones, but limitations with funding and capacity are difficult to overcome [2]. In the 2015 Annual Report on implementation of the Danube Strategy produced by the Danube countries, all projects focused on implementation of the Floods Directive. The only mention of industrial accidents was to reflect the failure to include an updated Inventory of Potential Accidental Risk Spots along the Danube, which is also discussed in the 2015 Danube River Basin Management Plan (DRBMP) (EUSDR, 2015; ICPDR, 2015b). Given past issues with mine tailing collapses and other pollution disasters associated with flooding, the 2015 DRBMP acknowledged the need to update the Inventory of Potential Accidental Risk Spots promptly (ICPDR, 2015b). Unfortunately, this recommendation from the 2015 DRBMP, and initially expressed in first Danube River Basin Management Plan of 2009, has yet to be realized.

Through the 1994 Danube River Protection Convention, Article 17 provides for mutual assistance “where a critical situation of riverine conditions should arise”. While “critical situation” is not defined, Article 17 indicates that the ICPDR will elaborate procedures for mutual assistance including the facilities and services to be rendered by the contracting party, the facilitation of border-crossing formalities, arrangements for compensation, and methods of reimbursement (ICPDR, 1994). These elaborations have not occurred through the ICPDR, but rather in the form of bilateral agreements regarding transboundary flood measures among Danube countries; however virtually no bilateral agreements exist regarding response to man-made disasters in the basin (Table 2).

To bridge the gap regarding man-made accidents, some Danube countries have engaged in such agreements. Bulgaria, Moldova, Romania, Serbia, and Ukraine are parties to the DRPC, but have separately engaged in the BSEC Agreement on Response to Natural and Man-made disasters (Bruch et al., 2016). Furthermore, the Danube Delta countries (Moldova, Romania, and Ukraine) are working together with the UNECE Industrial Accidents Convention due to the large concentration of oil-related industries in the area in order to improve hazard management, increase transboundary cooperation, and strengthen operational response [1].

At the Danube basin level, the countries have engaged in a series of non-binding Memoranda of Understanding (MOU) referred to as the Danube Declarations, first in 2004, revised in 2010, and updated in 2016. The Declarations reinforce the language of the 1996 Danube River Protection Convention to sustainably manage the waters of the Danube, and reinforce the countries' commitment to continue the work of the WFD and Floods Directive. The 2016 Declaration recognizes the need for increased investment and improved warning systems for flood protection and contamination, as well as improving the exchange of information throughout the Danube (ICPDR, 2016). The Danube River basin countries engage currently in two separate systems for flood monitoring and monitoring pollution from man-made accidents – the Emergency Flood Alert System and the Principal International Alert Centres (PIACs) of the Danube Accident Emergency Warning System (Danube AEWS), respectively. The Emergency

Flood Alert System has been functioning since 2003 at the Joint Research Centre, a Directorate General of the European Commission, and works in collaboration with the national authorities of the member states and with a variety of meteorological services. The Emergency Flood Alert System provides two medium-range flood forecasts each day, with 3-10 day advance warning for flooding in the main stem of the Danube. An MOU has been signed with several, but not all of the Danube countries (Austria, Bulgaria, Czech Republic, Germany, Hungary, Moldova, Serbia, Slovakia, Slovenia, and Romania, and negotiations are underway with Bosnia and Herzegovina and Croatia), and information is available 24 hours a day through an online service managed by the Joint Research Centre (ICPDR, 2010). The Emergency Flood Alert System gives national authorities the ability to prepare response measures, including opening temporary flood retention areas, building temporary flood protection structures such as sandbag walls, and adopting civil protection measures such as closing down water supply systems (ICPDR, 2009b). These responses reduce further threat of flooding downstream, and prevent loss of lives and infrastructure. The MOU does not include tributaries draining areas less than 4,000 km², therefore the Emergency Flood Alert System does not address flood risks in the Tisza, nor in certain basin countries where significant flood concerns arise, such as Ukraine [1].

Transboundary floods typically affect larger areas, can be more severe, result in a higher number of deaths, and cause increased economic loss than non-transboundary rivers (Baaker, 2009). Therefore, the repeated occurrence of such large, costly flood events (Table 5) highlights the ongoing need for improved strategies for flood preparedness and response, particularly in the absence of coordinated, multi-hazard bilateral and multilateral agreements among basin countries.

The Principal International Alert Centres (PIACs) of the Danube Accident Emergency Warning System monitor accidental water pollution incidents in the Danube River basin. Unlike the Emergency Flood Alert System, which is linked to monitoring conducted by the European Commission and is transmitted to national authorities (without involving the ICPDR in the monitoring process); the Danube AEWS system is managed by the ICPDR, but does not involve the European Commission. While all contracting parties of the DRPC cooperate with the Danube AEWS, they also are expected to have national policies regarding response to accidental pollution in the Danube that connects to the Principal International Alert Centres. The PIACs are expected to operate on a 24-hour basis within each country, and are in charge of all international communications. When a message ~~regarding~~ potentially serious accidental pollution ~~occurs~~, the PIAC is responsible for communicating the accident to the ICPDR, and decides whether it is necessary to notify downstream countries, engage~~s~~ experts to assess the impacts of the pollution, and decides ~~what~~ response activities need to be taken at the national level (ICPDR, 2014). Challenges to the Danube AEWS monitoring include territorial gaps (several areas along the Danube and Tisza are not monitored) [3, 4, 5], a limited number of bilateral agreements for response in case the accident exceeds national capacity (Table 2), and even though a variety of natural and man-made accidents occur (Table 4), not all types of man-made accidents are monitored. Increasing pressures are felt by downstream countries from the failure to monitor pollution events in a consistent and effective manner [4]. Furthermore, in order to keep the AEWS operational, there is increasing reliance on citizen reporting of pollution events in some countries [4, 5]. This is particularly problematic in the Tisza countries where the lack of monitoring of both flood and accidental pollution events, combined with limited bilateral agreements raise concern among several countries [4, 5].

In the most recent Tisza River sub-basin MOU (from 2011), the Tisza countries agreed, among other things, to “take coordinated steps to prevent accidental risks, and develop harmonized mitigation and response measures, with the aim to present an updated Inventory of Potential Accidental Risk Spots by the end of 2012” (ICPDR, 2011). This complements the 2009 request in the Danube basin (but as reflected above, has yet to be updated) (ICPDR, 2015b). To date, this has not ~~occurred~~ for the Tisza, but the language in the MOU does reflect an interest ~~at~~ the sub-basin level to prioritize not only the mapping and development of an Inventory of Potential Accidental Risk Spots, but also the development of harmonized response measures ~~among~~ floods and man-made hazards.

5 Questioning the distinction

While “natural” disasters may be a commonly used term, no disaster can be regarded as entirely natural if people have the capacity to avoid, mitigate, or reduce the risk from it (Picard, 2016). Generally, the vulnerability to lives and livelihoods can be reduced with disaster preparedness and response, such as the proper placement, function, and use of early warning systems, and mitigation works such as levees and controlled flood outlets and properly timed dam releases.

There is an additional shift in what is considered ~~truly~~ a natural disaster ~~as well~~ – not only from the perspective of mitigation or vulnerability, but in acknowledgement of the anthropogenic influences on natural disasters. Climate change is one aspect, but there are also induced earthquakes occurring as a result of slipping faults from fluid injection in hydraulic fracturing (Legere, 2016), landslides from subsidence and increased land use activities including urbanization (Smith, 2013), and pandemics from deforestation and habitat conversion (Greger, 2007), to name a few.

Human, economic, and environmental losses can be worse in highly populated, urbanized areas; with increased urbanization and climate change, they are placed at increased risk to natural and man-made hazards (Bruch and Goldman, 2012; Huppert and Sparks, 2006). For this reason, natech accidents and other cascading disasters are particularly problematic types of disasters. Simultaneous response efforts are required to attend to ~~both~~ the industrial, chemical, or technological accident as well as the triggering natural disaster. Therefore, expanded definitions of that reflect multiple types of disaster, as well as improved frameworks for response to multiple types of disaster, are needed in order to recognize that many disasters can arise from multiple, potentially co-located hazards—and to take the necessary measures to reduce the risks of those hazards.

The 2011 Fukushima nuclear disaster in Japan, triggered by the Great East Japan Earthquake and resultant tsunami, illustrate~~d~~ the complex relationship ~~of~~ natural hazards and ~~the built environment and human factors~~, resulting in natech vulnerabilities. In part as a response to the earthquake, tsunami, and nuclear accident at Fukushima and as a more general approach to providing a comprehensive, multidimensional and multi-sectoral approach to reducing disaster risk, the United Nations member states adopted the Sendai Framework for Disaster Risk Reduction in 2015. To some experts, the preceding 2005 Hyogo Framework for Action focused too much on disaster risk reduction from natural disasters, and ignored industrial accidents and complex accidents like natech accidents [6]. In fact, in a 2011 study by the European Commission, ~~out~~ of 14 EU countries that experienced natech accidents, more than half of the accidents resulted in the release of toxic substances, fires, or explosions (Krausmann and Baranzini, 2012).

The Sendai Framework places unprecedented emphasis on the interaction between hazards (natural and man-made), exposure levels, and pre-existing vulnerability (Aitsi-Selmi and Murray, 2016). It calls ~~to action~~ for improving decision making through a stronger science-policy-practice interface, with four priority areas for action –including strengthening disaster governance with regard to shared resources and at the basin level (UNISDR, 2015).

The Organization for Economic Cooperation and Development (OECD) also provides guidance for the planning and operation of facilities where hazardous substances are located through the use of their 2003 Guiding Principles for Chemical Accident Prevention, Preparedness, and Response. Recognizing the gaps in natech risk management and methodologies, the OECD developed an addendum in 2015 to the Guiding Principles that include 1) an investigation of the prevention of chemical accidents, as well as preparedness for and response to chemical accidents resulting from natural hazards that are not a part of national chemical accident programs; and 2) recommendations for best practices with respect to prevention of, preparedness for, and response to natech accidents (OECD, 2015).

Regional frameworks for response to natural and man-made disasters have been developed by member states of the Black Sea Economic Cooperation (BSEC) and the Association of South East Asian Nations (ASEAN). These regional agreements have also progressed to include national efforts, such as the coordination of technical assistance and resource mobilization during response to natural and man-made disasters (ASEAN, 2010; BSEC, 1998).

6 Building holistic approaches for integrating multilevel disaster response

The transition toward a multi-hazard approach for response to natural and man-made disasters, and the acknowledgement of the risks of natech accidents is occurring at many levels.

It is present in the work of the United Nations and the multilevel response frameworks of the EU Civil Protection Mechanism; some regional agencies are also adopting similar agreements (i.e., ASEAN, BSEC). However, there remains a disparity in managing natural and man-made disasters in a holistic manner at the national level, as well as in the monitoring of these types of events at the Danube basin and Tisza sub-basin levels. The challenges are not insurmountable; this section proposes two sets of options for reducing and eventually eliminating the historic dichotomy among approaches to disaster response and monitoring.

6.1 Multi-hazard approaches

The process of building holistic approaches to planning, preparedness, and response can strengthen ~~systems~~ for responding to natural and man-made disasters in a more integrated manner (i.e., adopting a multi-hazard approach). These ~~processes~~ may be ~~done~~ at the global (e.g., Sendai), regional (e.g., BSEC), bilateral, ~~and~~ national levels. By adopting a multi-hazard framework for disaster response, the expertise and practices of responders can be enhanced to include improved modeling and assessment approaches, response methodologies and tools, and ~~heightened~~ measures to prevent or mitigate the consequences from natech accidents (Krausmann, Cruz, and Salzano, 2017).

The review of legal and policy frameworks and interviews ~~reflected~~ that ~~while~~ some planning and preparedness activities take place regarding flood hazard, this ~~generally~~ is not the case for accidental pollution (at least in the Danube and Tisza context), and natech accidents are largely removed or ignored [2, 3, 4, 5, 6] (European Commission, 2010; ICPDR, 2015a). ~~Gaps in monitoring were cited~~ along the length of both the Danube and the Tisza ~~in regard to~~ both flooding and accidental pollution, which should also be improved in future planning efforts. The Tisza sub-basin and smaller water bodies are beyond the scope of the WFD, consequently, no holistic monitoring or response measures are in place; regional agreements at the basin or sub-basin level could aid in developing improved response frameworks [2, 3] (McClain et al., 2016).

Improving the mapping of hazards to reflect not only flood hazard, but also risks from man-made disasters and natech events – and integrating these risks into a holistic map of vulnerability to disaster – would provide a foundation for more holistic policies and programming to manage disaster risks. It would also aid in improving measures for preparedness at the national and local levels. Multi-hazard response frameworks provide the opportunity to intervene and mitigate the size of future disasters. Interviews indicate that harmonized approaches to natural and man-made disasters offer additional opportunities to strengthen capacity among transboundary actors [1, 4].

6.2 Multi-hazard response modalities

In order to avoid fragmentation among response to natural and man-made disasters, and empower, guide, and facilitate the institutional arrangements and mandates necessary to improve these activities, the legal and policy frameworks need to provide the necessary mandates and procedures – this is accomplished by incorporating an integrated, multi-hazard approach to disaster response. In regard to the Danube basin, this could be done in a variety of ways. The Danube River Protection Convention has not been updated or amended since it was originally drafted in 1994, but it unites all countries of the Danube basin and its tributaries under a formal, legal agreement. Cooperation among Danube countries was generally reported as good [3]; therefore, continuing the use of the ICPDR and its expert groups as a mechanism to gain cooperation among the countries on a regional framework for improving monitoring and response could be considered [3, 4, 5]. Another possibility would be to expand the numerous bilateral agreements among the Danube and Tisza countries regarding flooding to also include man-made disasters and natech events. Working on agreements at a regional level improves communication, breaks down barriers (particularly in transboundary situations), and aids in the development of a common legal language among participating parties [1, 2].

Updating conventions and other hard law can be difficult; countries often find soft law to be more flexible, they are sometimes unwilling to adopt binding obligations, particularly in the face of uncertainty (e.g., climate change), or when they feel there might be a need to act quickly to changing circumstances. In this regard, updating the Danube Declaration and the corresponding Tisza MOUs can provide particularly viable options. Through the Declarations and MOUs, the Danube or Tisza countries could decide whether to engage in a particular action through a separate strategy, or pilot project, or whether to incorporate the issue into the broader basin or sub-basin management plan (e.g., improvement of accidental pollution and flood monitoring, integrated accidental pollution and flood maps). Improved vertical and horizontal cooperation was a request of several interviewees, particularly in regard to the risks posed from man-made accidents and how to respond to these accidents [4, 5].

7 Conclusions

The historic distinction between natural and man-made disasters is outdated, counterproductive, and ultimately flawed. Natural disasters have the potential to trigger simultaneous technological or chemical accidents from one or multiple sources. With anthropogenic climate change influencing the frequency and intensity of disasters, the distinctions in monitoring and responding to disasters from either natural or man-made sources are further called into question. Moreover, increased urbanization and shifting populations are placing more people at greater risk in times of disaster (whether natural or man-made). As a result, it is increasingly clear that there are no purely natural disasters.

Recognizing that the historic distinctions between natural and man-made disasters are no longer relevant, there is increasing recognition of the need to address disasters holistically, regardless of the contributing causes and aggravating factors. This trend is noted in the Sendai Framework, which adopts a multi-hazard risk approach and provides tools for responding to disasters that are both natural and man-made (UNISDR, 2015). While the current policy frameworks in the Danube basin and Tisza sub-basin do not address monitoring and response holistically across types of disasters, the basin countries have several options for more integrated response. A key opportunity is the development or amendment of agreements governing response to natural and man-made disasters. This could be negotiated through updates to the Danube Convention or through bilateral treaties between the basin countries. Improving planning and preparedness through more integrated monitoring and mapping of natural and man-made disasters, such as combining the flood risk areas with the Inventory of Potential Accidental Risk Spots, could be elaborated upon in Declarations and MOUs at the basin and sub-basin levels.

A coordinated approach to natural and man-made disasters, including natech accidents, is currently taken through the European Union Civil Protection Mechanism and BSEC. This is not unique to Europe alone, and other similar regional approaches exist from which to draw lessons (including the ASEAN agreement). The Danube and Tisza countries are well versed in the transboundary impacts from natural and man-made disasters, and natech accidents; climate change is likely to increase the frequency and severity of these events in the foreseeable future. Nevertheless, while approaches for integrating holistic frameworks for disaster response are recognized at multiple levels, implementation within the Danube basin and Tisza sub-basin remains distinct and fragmented.

Acknowledgements

This material is based upon work supported by the United States' National Science Foundation under Grant No. 0903510. Any opinions expressed here are those of the authors and do not necessarily reflect the views of the National Science Foundation.

We thank the Southern Illinois University IGERT Program in Watershed Science and Policy and associated colleagues for their support. The authors are also grateful for the suggestions and comments of Professor Cindy Buys. We additionally thank the International Commission for the Protection of the Danube River (ICPDR) for assisting in obtaining data, and for hosting Shanna while she conducted her research.

References

Aitsi-Selmi, A., and Murray, V. 2016. The Chernobyl Disaster and Beyond: Implications of the Sendai Framework for Disaster Risk Reduction 2015-2030. *PLOS Medicine* 13(4): 1-4.

ASEAN (Association of South East Asian Nations). 2010. ASEAN Agreement on Disaster Management and Emergency Response: Work Programme 2010-2015. Jakarta: ASEAN. http://www.asean.org/wp-content/uploads/images/resources/ASEAN%20Publication/2013%20(12.%20Dec)%20-%20AADMER%20Work%20Programme%20(4th%20Reprint).pdf.

Baaker, M.H.N. 2009. Transboundary River Floods: Examining Countries, International River Basins, and Continents. *Water Policy* 11: 269-288.

BSEC (Black Sea Economic Cooperation). 1998. Agreement among the Governments of the Participating States of the Black Sea Economic Cooperation (BSEC) on Collaboration in Emergency Assistance and Emergency Response to Natural and Man-Made Disasters. http://www.bsec-organization.org/documents/LegalDocuments/agreementmous/agr4/Documents/Emergencyagreement%20071116.pdf.

Bruch, C., Nijenhuis, R., and McClain, S.N. 2016. International Frameworks Governing Environmental Emergency Preparedness and Response: An Assessment of Approaches. In *The Role of International Environmental Law in Reducing Disaster Risk*, Jacqueline Peel & David Fisher eds. Leiden: Brill Nijhoff.

Cutter, S.L., and Emrich, C.T. 2006. Moral Hazard, Social Catastrophe: The Changing Face of Vulnerability along the Hurricane Coasts. *American Academy of Political and Social Science* 604:102-112.

Dunai, M. 2010. Hungary Declares Emergency after Red Sludge Spill. *Reuters*, October 5. http://in.reuters.com/article/idINIndia-51952420101005.

European Commission. 2010. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions: European Strategy for the Danube Region. COM (2010) 715 Final.

European Commission. 2016. EU Civil Protection Mechanism. 2 July. http://ec.europa.eu/echo/what/civil-protection/mechanism_en.

European Community. 1982. Council Directive of 24 June 1982 on the Major-Accident Hazards of Certain Industrial Activities. Official Journal of the European Communities L230, pp. 01-18.

European Community. 1996. Council Directive of 9 December 1996 on the Control of Major-Accident Hazards Involving Dangerous Substances. Official Journal of the European Union. L010, pp. 13.

European Community. 2012. Council Directive of 4 July 2012 on the Control of Major-Accident Hazards Involving Dangerous Substances, Amending and Subsequently Repealing Council Directive 96/82/EC. Official Journal of the European Union L197, pp. 01-37.

European Union. 2012. Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the Control of Major-Accident Hazards Involving Dangerous Substances, Amending and Subsequently Repealing Council Directive 96/82/EC. Official Journal of the European Union L197, pp. 01-37.

EPRS (European Parliamentary Research Service). 2015. The EU Strategy for the Danube Region: Briefing. PE 557.024. http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/557024/EPRS_BRI(2015)557024_EN.pdf.

EUSDR (European Union Strategy for the Danube Region). 2015. Danube Region Strategy Priority Area 5: To Manage Environmental Risks. Coordinated by Hungary and Romania. June.

Fisher, D. 2008. The Law of International Disaster Response: Overview and Ramifications. *International Law Studies* 83: 293-320.

Greger, M. 2007. The Human/Animal Interface: Emergence and Resurgence of Zoonotic Infectious Diseases. *Critical Reviews in Microbiology* 33: 243-299.

Grieving, S., Pratzler –Wanczura, S. Sapountzaki, K., Ferri, F., Grifoni, P., Firus, K., and Xanthopoulos, G. 2012. Linking the actors and policies throughout the management cycle by “Agreement on Objectives” – a new output-oriented approach. *Natural Hazards and Earth Systems Sciences* 12: 1085-1107.

Huppert, H.E., and Sparks, R.S.J. 2007. Extreme Natural Hazards: Population Growth, Globalization and Environmental Change. *Philosophical Transactions of the Royal Society* 364: 1875-1888.

ICPDR (International Commission for the Protection of the Danube River). 1994. Danube River Protection Convention. Vienna: ICPDR. https://www.icpdr.org/main/sites/default/files/DRPC%20English%20ver.pdf.

ICPDR (International Commission for the Protection of the Danube River). 2001. Inventory of Potential Accidental Risk Spots. Vienna: ICPDR.

ICPDR (International Commission for the Protection of the Danube River). 2008a. Analysis of the Tisza River Basin 2007.Vienna: ICPDR. http://www.icpdr.org/main/sites/default/files/Tisza_RB_Analysis_2007.pdf.

ICPDR (International Commission for the Protection of the Danube River). 2008b. The Analysis of the Danube Floods 2006. Vienna: ICPDR. https://www.icpdr.org/main/sites/default/files/The%20Analysis%20of%20the%20Danube%20Floods%202006%20FINAL.pdf

ICPDR (International Commission for the Protection of the Danube River). 2009a. The Danube River Basin District Management Plan: Part A- Basin-wide Overview. Vienna: ICPDR. http://www.icpdr.org/main/sites/default/files/DRBM_Plan_2009.pdf.

ICPDR (International Commission for the Protection of the Danube River). 2009b. Assessment of Flood Monitoring and Forecasting in the Danube River Basin. Vienna: ICPDR. http://www.icpdr.org/main/sites/default/files/OM-12%20-%203.6%20ASSESSMENTof%20Flood%20Monitoring%20FINAL.pdf.

ICPDR (International Commission for the Protection of the Danube River). 2010. New International System for Early Flood Warning in Danube River Basin Launched. March. https://www.icpdr.org/main/sites/default/files/nodes/documents/080310_efas_pr_final_icpdr.pdf.

ICPDR (International Commission for the Protection of the Danube River). 2011. Memorandum of Understanding: Towards the Implementation of the Integrated Tisza River Basin Management Plan Supporting the Sustainable Development of the Region. Vienna: ICPDR.

ICPDR (International Commission for the Protection of the Danube River). 2014. International Operations Manual for PIACs of the Danube AEWS. Vienna: ICPDR. http://www.icpdr.org/main/sites/default/files/nodes/documents/aews_manual_2014_final.pdf.

ICPDR (International Commission for the Protection of the Danube River). 2015a. The Danube River Basin District Management Plan – Update 2015. Vienna: ICPDR. https://www.icpdr.org/main/sites/default/files/nodes/documents/drbmp-update2015.pdf.

ICPDR (International Commission for the Protection of the Danube River). 2015b. Flood Risk Management Plan for the Danube River Basin District. Vienna: ICPDR. https://www.icpdr.org/main/sites/default/files/nodes/documents/1stdfrmp-final_1.pdf.

ICPDR (International Commission for the Protection of the Danube River). 2016. Danube Declaration: Water Management in the Danube River Basin: Integration and Solidarity in the Most International River Basin of the World. Vienna: ICPDR.

IFRC (International Federation of Red Cross and Red Crescent Societies). 2007. Law and Legal Issues in International Disaster Response: A Desk Study. Geneva: IFRC.

IFRC (International Federation of Red Cross and Red Crescent Societies). 2013. Responding to Silent Disasters. IFRC Annual Report. Geneva: IFRC.

JEU (Joint United Nations Environment Programme (UNEP)/Office for the Coordination of Humanitarian Affairs (OCHA) Environment Unit). 2000. Cyanide Spill at Baia Mare Romania: Spill of Liquid and Suspended Waste at the Aurul S.A. Retreatement Plant. Geneva: OCHA.

Kappes, M., Keiler, M., von Elverfeldt, K., and Glade, T. 2012. Challenges of analyzing multihazard risk: A review. *Natural Hazards* 64: 1925-1958.

Krausmann, E., A.M. Cruz, and E. Salzano. 2017. Natech Risk Assessment and Management: Reducing the Risks of Natural-hazard Impact on Hazardous Installations. Amsterdam: Elsevier.

Krausmann, E., and Baranzini, D. 2012. Natech Risk Reduction in the European Union. *Journal of Risk Research* 15(8): 1027-1047.

Legere, L. 2016. State Seismic Network Helps Tell Fracking Quakes from Natural Ones. *Pittsburgh Post-Gazette*. June 26. http://powersource.post-gazette.com/powersource/policy-powersource/2016/06/26/State-seismic-network-helps-tell-fracking-quakes-from-natural-ones/stories/201606210014.

Linnerooth-Bayer, J., Eckenberg, L. and Vári, A. 2013. Catastrophe Models and Policy Processes: Managing Flood Risk in the Hungarian Tisza River Basin – An Introduction. In *Integrated Catastrophe Risk Modeling: Supporting Policy Processes*, A. Amendola et al. Eds., 171-179. Dordrecht: Springer Science.

McClain, S.N., Bruch, C., and Secchi, S. 2016. Adaptation in the Tisza: Innovation and Tribulation at the Sub-basin Level. *Water International* 0: 1-23.

Munich Re. 2016. Group Annual Report 2015. Munich: Munich Re. https://www.munichre.com/site/corporate/get/documents_E1695037882/mr/assetpool.shared/Documents/0_Corporate%20Website/_Financial%20Reports/2016/Annual%20Report%202015/302-08843_en.pdf.

Nagy, I., Ligetvári, F., and Schweitzer, F. 2010. Tisza River Valley: Future Prospects. *Hungarian Geographical Bulletin* 59(4): 361-370.

NDGDM (National Directorate General for Disaster Management). 2010. Red Sludge – Hungary 2010. Ministry of the Interior. Budapest: Ministry of the Interior. http://www.katasztrofavedelem.hu/index2.php?pageid=szervezet_red_sludge_2010&lang=eng.

NERC (Natural Environmental Research Council). 2014. UNDAC Landslide Advisory Visit to Serbia June 2014. Open Report IR/14/043. P. Hobbs Ed. Keyworth: British Geological Survey.

OECD (Organization for Economic Cooperation and Development). 2015. Addendum No. 2 to the OECD Guiding Principles for Chemical Accident Prevention, Preparedness, and Response (2nd Ed.) to Address Natural Hazards Triggering Technological Accidents (Natechs). http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2015)1&doclanguage=en.

Peel, J., and D. Fisher. 2016. International Law at the Intersection of Environmental Protection and Disaster Risk Reduction. In *The Role of International Environmental Law in Reducing Disaster Risk*, Jacqueline Peel & David Fisher eds. Leiden: Brill Nijhoff.

Pescaroli, G., and D. Alexander. 2015. A definition of cascading disasters and cascading effects: Going beyond the “toppling dominos” metaphor. *Planet at Risk* 2(3): 58-67.

Picard, M. 2016. Water Treaty Regimes as a Vehicle for Cooperation to Reduce Water-Related Disaster Risk: The Case of Southern Africa and the Zambesi Basin. In *The Role of International Environmental Law in Reducing Disaster Risk*, Jacqueline Peel & David Fisher eds. Leiden: Brill Nijhoff.

Rozario, K. 2007. The Culture of Calamity: Disaster & the Making of Modern America. Chicago: University of Chicago Press.

Schneider, E. 2010. Floodplain Restoration of Large European Rivers, with Examples from the Rhine and the Danube. In *Restoration of Lakes, Streams, Floodplains, and Bogs in Europe: Principles and Case Studies*, 185–223. USA: Springer Science.

Schneller, K., Bálint, G. Chicos, A. Csete, M. Dzurdzenik, J. Göncz, A. Petrisor, A. Jaroslav, T. and Pálvolgyi, T. 2013. Climate Change Impacts on the Hungarian, Romanian, and Slovak Territories of the Tisza Catchment Area. In *European Climate Vulnerabilities and*

Adaptation: A Spatial Planning Perspective, P. Schmidt-Thomé and S. Greiving, Eds., 205-229. New Jersey, USA: John Wiley & Sons, Ltd.

Smith, K. 2013. Environmental Hazards: Assessing Risk and Reducing Hazard. New York: Routledge.

Swiss Re. 2016. Natural Catastrophes and Man-Made Disasters in 2015: Asia Suffers Substantial Losses. Sigma Report No 1/2016. Zurich: Swiss Re. http://media.swissre.com/documents/sigma1_2016_en.pdf.

UNECE (United Nations Economic Commission for Europe). 2009. Guidance on Water and Adaptation to Climate Change. Geneva: United Nations.

UNECE (United Nations Economic Commission for Europe). 2011. Second Assessment of Transboundary Rivers, Lakes and Groundwaters. New York and Geneva: UNECE.

UNEP (United Nations Environment Programme). 2002. Atlas of International Freshwater Agreements. Nairobi: UNEP.

UNEP (United Nations Environment Programme). 2011. Enhanced Coordination Across the United Nations System, Including the Environment Management Group. Twenty-Sixth Session. UNEP/GC.26/15.

UNISDR (United Nations Institute for Disaster Reduction). 2015. Sendai Framework for Disaster Risk Reduction: 2015-2030. Geneva: UNISDR.

Verchick, R. 2012. Disaster Justice: The Geography of Human Capability. *Duke Environmental Law & Policy Forum* 23: 23-71.

WWF (World Wildlife Fund). 2003. Managing Rivers Wisely: Lessons from WWF’s Work for Integrated River Basin Management. Introduction, Synthesis and Case Studies. Washington, DC: WWF. http://d2ouvy59p0dg6k.cloudfront.net/downloads/mrwdanubecasestudy.pdf.