Re: revisions to **nhess-2016-307**

Dear Thomas,

Attached please find a revised version of our manuscript and our responses to reviewers.

Following the reviewers' comments, we have made major revisions to the paper. Specifically, the paper is much shorter and more clearly focused on the Danube and the Tisza as illustrations of the limits of separate disaster response frameworks. We have also added more pertinent references illustrating the European experience with more holistic frameworks following the suggestions of reviewer #2.

Response to Reviewer 1 comments

We have added several references following the reviewer's comments. We have also substantially streamlined and shortened the paper following the comments of Reviewer #2.

Response to Reviewer 2 comments

We very much appreciate the thorough comments of the reviewer. We have addressed each of them specifically below. In general, our paper addresses the artificial distinction in response frameworks in an international context using the Danube and the Tisza as case studies. Some of the reviewer's comments showed that this point was not very clear in the paper, and it got lost because we were sidetracked multiple times – we have clarified it throughout, and in the abstract. We specifically added at the outset of the paper that "We focus on transboundary response frameworks because they present exceptional logistical and technical challenges, particularly in watersheds such as the Danube and the Tisza, where countries have very disparate histories, levels of economic development, and are governed by different statutes." The paper is now considerably shorter (3000 words) and more focused.

Also note that, following comments, the sections have been thoroughly re-numbered, the figure has been amended, the meanings of international and regional in the context of the paper have been clarified, and citations have been added.

Comment 1 (line 41) - The begin of the introduction is rather abrupt with these questions. The authors do not lead the reader to these questions. Furthermore, according to the abstract, the paper rather focuses on the question of why THE RESPONSE to natural and man-made disasters, respectively, is managed separately; and whether these policy distinctions are useful. These are completely different questions than posed here.

The introduction has been amended, and these questions have been taken off.

Comment 2 (line 49) - Sources are missing.

Source added

Comment 3 (line 51) - I don't quite get how this conclusion is drawn by the preceding argumentation. In your abstract, you indicate that historically, response to man-made and natural event has been managed separately. From this it would be logical if you discussed here along one of the following two lines:1) you show how the responses to historical events has been insufficient due to the distinction made between natural vs. man-made;2) you show how the nature of events has changed; e.g. that cascading events are getting more probable due to e.g. enhanced industrialization of the area or something the like. If you do so, please support it by a sufficient body of literature and/or data. If there is no data or body of literature, you will have to put it as a hypothesis.

We clarified our point here.

Comment 4 (line 61) - Here, you state yourself that the dichotomy of nature vs. man-made is not your question as a solution already exists. You thus have to focus more specifically on your question: the dichotomy in response.
"Commonly referred to" => you need to give some sources, otherwise it is a claim, not a statement.

Citation added and point taken for the rest of the paper.

Comment 5 (line 72) - I would like to suggest to delete these lines, since they are off-topic. Your concern is the dichotomy, not national capacities for dealing with events. If it is of concern for your argumentation, you'd need to explain it.

As the title states, and as noted in the general response, our concern is how the dichotomy affects international response frameworks in these international basins. If national capacity is not exceeded, the international frameworks are not triggered. We have clarified this in the text.

Comment 6 (line 88) - As I understand your abstract and the rest of the paper, this is not quite your research question. I would strongly suggest to further streamline your abstract: Focus on one question and the argumentation around it. You've got too many things on the go at once.

See response above.

Comment 7 (line 95) - I still do not quite understand why this is necessary. To me, the next section - differences in disasters response management for man-made and natural disasters, respectively, is completely sufficient to make your point. From your introduction as well the rest of the paper it seems that you have many different points on your agenda: 1) discussing the distinction between man-made/natural disasters, 2) showing international developments vs. strategies in the Danube region, and 3) somehow also when and how nations are incapable of dealing with disasters on their own (maybe there are even more points on your agenda). This is the reason why the reader quickly loses an understanding of the aims of the paper. The paper sections are rather adding up different aspects than discussing one question in depth.

We have made changes to focus on response to disasters and not disasters, as suggested by the reviewer, and clarifying that our focus is on transboundary responses.

Comment 8 (line 114) - Here, you'll have to differentiate. Or do you really want to state that democracy, amongst other things, leads to rural decline, increased poverty etc.? If so, this needs thorough discussion.

Line was deleted.

Comment 9 (line 115) - Here, you'd need to explain why this is important for your argumentation. If it is not important, I'd suggest to delete lines 112-115.

Clarified.

Comment 10 (line 116) - Source is not given.

We made the map ourselves.

Comment 11 (line 127) - page number is not given.
Internationally, cited numbers are treated as direct citations in that sense that you need to provide the page number, too, and not only author and year.
Number has been taken out.

Comment 12 (line 158) - Suggestion to delete this sentence here and to insert it in line 163 (as last sentence of this sections), as it disturbs the flow of argumentation here.

Sentence has been moved.

Comment 13 (line 168) - Consider rephrasing - this sentence takes 6 lines and is very difficult to read. I'm not a native speaker, but I think there are several structural and grammar mistakes.

Sentence has been broken up and restructured.

Comment 14 (line 173) - For the purpose of this paper? Otherwise the context and the scope of the interviews should be mentioned.

The interviews were specifically conducted with three research questions in mind and this paper's was one of them.

Comment 15 (Table 1) - ?

Typo corrected.

Comment 16 (Table 1) - ?

Typo corrected.

Comment 17 (Table 2) - Since the discussion of these bilateral agreements should probably show a development with time, I'd suggest a temporal order instead of an alphabetical one.

Comment 18 (Table 2) - Suggest re-formatting. The table design can be improved.
Suggestion to have the table on one page, not splitted on two.

Temporal order for agreement initial date followed – table reformatted.

Comment 19 (line 194) - Please specify - what were the criteria for choosing interviewees?

Specification given.

Comment 20 (line 200) - Perceptions with respect to what? The strengths and weaknesses of the monitoring and response mechanisms?
In general, I do not quite see in how far these interview questions refer to the aim of this paper. The research question of the paper is (according to the abstract) whether the distinction of the response policies for natural and man-made disasters, respectively, is functional. The interview questions, however, focus on the implementation of the policies.

The questions focused both on frameworks and how the frameworks affected policies and their implementation. Reworded to clarify.

Comment 21 (line 220) - Please be coherent with respect to the terms being used in the text.

Term changed.

Comment 22 (footnote 2) - These two are normative postulations - you indicate by your question that there are gaps and that there are constraints. Hence - most probably - you get the outcome you wanted: the interviewee will indicate that there are gaps and constraints.

We appreciate the comment regarding the third question. However, the forth question asks about both constraints and opportunities, therefore we do not believe the question was leading.

Comment 23 (line 231) - No! these are events! A hazard has a harmful or potential negative effect on people. An earthquake in an unpopulated area with no assets damaged is an event, not a hazard.
For definitions etc. it is international standard to provide the source!

We clarified the definition and provided a source for it.

Comment 24 (line 232)- More correctly: disrupt the functioning of societies!

Amended.

Comment 25 (line 236) - what do you mean with "more recent history"? In my understanding, more recent history would indicate a rather recent understanding, which is not that of "an act of God".
More basically I do not quite understand why this is of any importance for your line of argument? (Especially as the next sentences make no reference whatsoever to the previous ones)

We clarify the argument by linking the two sentences.

Comment 26 (line 252) - Is that so? Please give sources and/or data that support this claim. Otherwise, suggestion to delete this sentence.

Comment 27 (line 253) - The term "complex" has a rather specific meaning. Please make sure that you mean "complex" and not "complicated" or "difficult to handle" or something like that.

Comment 28 (line 253) - This is not an example for the preceding sentence. There you state that it is due to multiplication and increased (?) cascading of disasters. The example, on the other hand, is for the difficulties in actually proving liability. But it has to be proven that these difficulties in actually proofing liability has become more difficult.

Sentence deleted, passage clarified.

Comment 29 (line 256) – Direct citation, hence, page number needs to be given (!).

Added.

Comment 30 (line 264) – Again, I do not understand your reasoning. In the first sentence you state that it is very difficult to predict damage and to give probabilities, especially if clmate change is taken into account (which makes perfect sence). In the next sentence, however, you relate these cases to slow-onset disasters - I think these are two different issues, which should be discussed separately.

Comment 31 (line 267) – Why "therefore"? This conclusion cannot be drawn from the previous sentences. Your line of argumentation is like this:
high uncertainties + slow onset + "mysterious" anthropogenic influences (they are not named) = distinction of man-made vs. natural doesn't make sense.
I cannot follow this line of argument. Since you yourself have stated that the "etiology of disasters" is paramount, you have to be much more coherent in this section. However, I'd suggest a completely different line of argument: You could easily argue that - regardless of the distinction between man-made and natural - it is insufficient and counter-productive to keep this distinction for DISASTER RESPONSE. On the first pages you have indeed started to argue like that, only to suddenly switch to the distinction between natural and man-made itself. I'd suggest to skip this section and to focus on your initial line of argumentation and to bring arguments and examples for why disaster RESPONSE needs to adopt an holistic approach.

We agree and have eliminated the whole paragraph.

Comment 32 (line 272) - Source

Comment 33 (line 272) - source (and maybe even examples)

Sources added, and sentence clarified.

Comment 34 (line 277) - Why from chemical accident response programs? As you state further below, it can also affect nuclear facilities. One could also imagine that "green energy facilities" are affected by a natural disaster, thus prompting an energy blackout. In a nutshell, I think you shouldn't restrict the lack of natech to chemical accident response programs.

We agree – chemical was taken out.

Comment 35 (line 291) - What do you mean by "complex disaster"? Aren't disasters by definition complex? Please stay strict with terms being used - I think you are referring here to events that you've previously termed "cascading disasters".

Yes, cascading disaster and natechs – so both mentioned.

Comment 36 (line 295) - Please be more coherent with respect to terms being used.

Corrected – disaster used.

Comment 37 (line 296) – This clearly might be the case. But again, your line of argument should centre around the question of the distinction in disaster response. This has nothing to do with this question of yours (or if it does, you need to be specific about it). Therefore suggestion to delete the whole paragraph.

Paragraph deleted.

Comment 38 (line 303) – Suggestion to shorten this section. Again, as I understand it the aim of your paper is to show that disaster response should address natural and man-made disasters holistically. If you focus on this aim, this section can be shortened.

Our focus was on the specific case study of the Danube and the Tisza, given our deep knowledge of the legal environment there, and their disaster history. We believe that using a specific study area gives the reader a better sense of the issues involved, with non-generic examples.

Comment 39 (line 326) – Why are you including this table? It does not give any essential information (since you're not even discussing the table), but takes a lot of space. Suggestion to delete the table and to only give some examples and maybe the absolute number of disasters within the text.

Comment 40 (line 333) – Source(s)?
Please re-format, so that table fits on one page.

Table eliminated.

Comment 41 (line 343) - What does this mean in the context of your main research question? If the procedure is different for natural events, say so and use this as argument for an holistic approach.

We amended the sentence and clarified the limits of the UNECE approach.

Comment 42 (line 350) - This information cannot be drawn from table 4 (=list of "natural and man-made disasters").

Comment 43 (line 353) - Suggestion to put sources in brackets here.

Table eliminated.

Comment 44 (line 373) - Different line of argumentation, suggestion to delete the sentence.

Sentence deleted.

Comment 45 (line 377) - Why are you now focussing on "international disasters"? Your research question is on the distinction between response systems for natural and man-made disasters. The fact that - especially for rivers - many disasters are transboundary is very important. But not for your argumentation, since your research question is a different one. Maybe you want to think about writing a second paper where you can address the aspects which are distracting from your argumentation in this paper?

As we have noted in our general comments, the paper discusses the distinction between response systems for natural and man-made disasters in the context of two international basins/sub basins. We believe the specific case studies we use give concrete examples of why the distinction is problematic. We have completely revamped the structure of this section to address the reviewer's comments and clarify our argument. We believe the reviewer was right in pointing out our poor argumentation. We now discuss frameworks related to various kinds of disaster response for the case study basins sequentially on the basis of geographical scope (international, EU, Danube basin and bilateral). We specifically point to some of the problems that these isolated and uncoordinated approaches have caused.

Comment 46 (line 402) - I do not quite understand what is the rationale for the structure of this section. For me, the most logical structure would be to start with the oldest response frameworks in order to show the development of these frameworks. You could discuss improvements and impairments of the frameworks (only in the context of your research question, though).

See response above – structure changed, paper shortened and streamlined.

Comment 47 (line 424) - Please rephrase, incomprehensible.

Rephrased.

Comment 48 (line 425) - Your heading to this section is
"How disasters are treated differently within response frameworks"
I have looked up this heading several times while reading, because I wasn't sure anymore what this section is all about. This might indicate a poor argumentation - your heading suggests that you'll compare the respective response frameworks, but you merely list them and you leave the task of finding the differences to the reader. My suggestion is to considerably improve this section by explicitly referring to differences, pro's and con's - all in the context of your research question (and only that question, not more).

See response above – the heading is gone and the section has been shortened and streamlined.

Comment 49 (line 432) - Please rephrase.

Rephrased.

Comment 50 (line 448) - Again, I understand that this is a very important general problem of transboundary disasters. But your argumentation lacks the link to your research question. How would this be different if disaster response treated natural as well as man-made disasters? This argumentation belongs to a different paper - suggestion to delete the whole paragraph.

Comment 51 (line 455) - Again, this is a different topic. If you had explained this for different types of disaster responses (i.e. natural and man-made), this would fit to your research question. Here, you refer again to the problems of transboundary disasters. As I said before, this is very important, but far off your topic.

We hope that the extensive reorganizing and editing of section 4 has addressed these comments. The passages identified in comment 50 and 51 were deleted since they did not directly link to our research question, as the reviewer noted.

Comment 52 (line 457) - Again: Terms need to be coherent. If you insist on the term "complex disaster", please define.

The complex disaster term is no longer used.

Comment 53 (line 506) – rephrase.

Passage deleted.

Comment 54 (line 514) - Again, different subject.

Passage deleted.

Comment 55 (line 534) - Language, please rephrase

Rephrased.

Comment 56 (line 539) - Important in a different context, but off-topic in this paper, suggestion to delete.

Passage deleted.

Comment 57 (line 546) - direct citation, therefore page number has to be given

Passage deleted.

Comment 58 (line 558) - Here, you only refer to flood events, whilst the begin of the sentence refers to disasters in general.

Passage deleted.

Comment 59 (line 569) - Why "for this reason"? Again, this is not a logical consequence. Suggestion for rephrasing: "This is especially true for natech accidents and other cascading disasters, since simultaneous response efforts are required to attend to the industrial, chemical, or technological accidents as well as the triggering natural disaster.

Passage changed to address comment.

Comment 60 (line 573) Rephrase. You haven't made clear so far how expanded definitions of multiple disasters (?) are helpful for disaster response.

Thank you for catching that! Rephrased, and reason why expanded definitions are helpful included.

Comment 61 (line 582) – You have mentioned this framework before - the explanation of its background belongs there.

Background explanation moved to first mention.

Comment 62 (line 583) – Citation needed!!!!

This sentence was eliminated as part of the streamlining of the paper.

Comment 63 (line 584) – This is not "questioning the distinction", but giving an example for a more holistic approach. (= does not belong to this section)

Section eliminated in the streamlining of the manuscript.

Comment 64 (line 585) – Why "in fact"? How does this sentence relate to the previous one?

This sentence was eliminated as part of the streamlining of the paper.

Comment 65 (line 592) – see above - this is not "questioning the distinction"

Comment 66 (line 604) – This is not "questioning the distinction"

See response to comment 63. Section eliminated.

Comment 67 (line 631) - ??

Sentence language changed.

Comment 68 (line 633) - Where does the "which" refer to?

Sentence language changed.

Comment 69 (line 661) - What do you mean by "hard laws" and "soft laws"?

The meaning of soft laws has been clarified earlier in the text (beginning of section 4)

Comment 70 (line 674) - Your question is about the RESPONSE to disasters. You do not need any discussion on whether disasters are man-made or natural. The important point is that response systems are needed that address those cases where natural and man-made disasters are combined, or where one triggers the other etc.
As the definition of disaster makes pretty clear, a natural event only becomes a disaster when people are effected. Consequently, it was critizised from the beginning by the social sciences that engineers and natural sciences were terming these phenomena "Natural disasters". The discussion is old and of no use for your argumentation. if you streamlined your paper around your research question, it would be a very nice piece of work.

We eliminated the paragraph discussing the distinction between types of disasters. More generally, following the reviewer's comments, we streamlined the paper.

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

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Abstract

This article examines the international policy and institutional frameworks for response to natural and man-made disasters occurring in the Danube basin and the Tisza sub-basin, two transnational basins. ~~Response~~ Monitoring and response to these types of incidents ~~has~~ have 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, illustrate some of the specific gaps in the Danube and the Tisza, a~~s~~nd c~~-c~~oncluded 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 in policies related to disaster response? 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 (Sun, 2016). 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). We conjecture that the tight coupling of human and environmental systems and the intensive nature of natural resource extraction and management, industrial activity and agriculture have increased the risk of cascading events. Thus, the question of eliminating the natural/man-made dichotomy in disaster response policy is brought to the forefront. We focus on transboundary response

[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.

frameworks because they present exceptional logistical and technical challenges, particularly in watersheds such as the Danube and the Tisza, where countries have very disparate histories, levels of economic development, and are governed by different statutes.

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 m³ of metal-contaminated water into the Tisza River, eventually polluting the Danube River and Black Sea. Since the 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 ~~,~~ ~~technological~~ accidents triggered by natural disasters – and ~~for~~ which ~~there exist no federal~~lack regulation to analyze, prepare for, or mitigate ~~these types of complex events~~ (Krausmann, Cruz, Salzano, 2017). 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~~ on 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. Thus, adequate international disaster response frameworks have already been put to task in the Danube and the Tisza. However, w

~~W~~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 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 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 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;~~)~~ ASEAN 2012, BSEC, 1998). 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~~ et al., 2012).

With international policies starting to shift toward more holistic frameworks ~~holistic frameworks~~ of response that incorporate both natural and man-made disasters, this article explores policy frameworks for monitoring and response in the Danube basin and Tisza sub-basin, which continue to distinguish between types of disasters, and resultantly have separate response options depending on the type of disaster, and what ~~this~~ the holistic frameworks trend ~~will~~ could mean for regional institutions ~~in the Danube basin and Tisza sub-basin~~ in the study basins~~, 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 historical distinctions in response 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,~~ and an analysis of the monitoring and response to natural disasters and industrial accidents in the basins~~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 the transition of international policies toward more holistic frameworks for response~~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 km² – 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~~ however, 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 been accompanied by changes in governments and institutions, affecting the continuity of policies and international arrangements which could potentially impact the international frameworks countries adhere to.

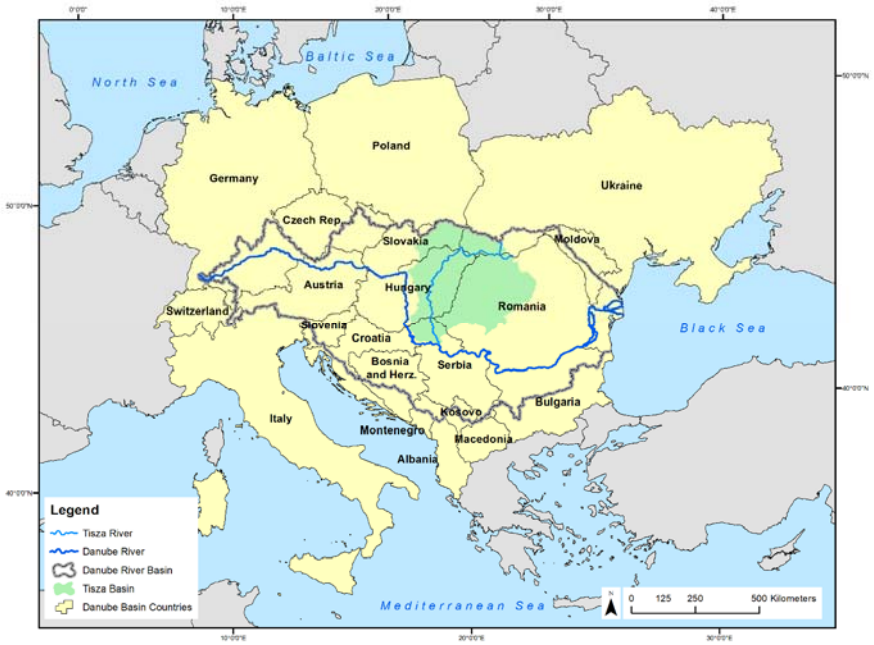

Fig. 1 Map of Danube River basin and Tisza River sub-basin. Source: the authors.

Internation **Fig. 1** Map of Danube River basin and Tisza River sub-basin. lood 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~~ associated 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 in~~s~~ 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 areas suitable for agricultural and urban development. Today, only 12 small reaches (<1 km in length) of the Upper Danube remain relatively

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untransformed (Schneider, 2010, 197). 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 the riverine ecosystem and reduced the resilience~~y~~ 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, 2008~~a~~). 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~~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, 2008~~a~~).

While industrial production has dropped drastically in the Tisza region since the 1990s, ~~there remains~~ a variety of industries- remain~~that contributes 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 sub-basin 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, as exemplified by ~~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). Furthermore, natechs present additional difficulties as they remain absent from disaster response frameworks (Krausmann, Cruz, and Salzano, 2017).

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Methodology

The ~~examination of~~ policy and institutional frameworks for monitoring of and responding to natural and man-made disasters ~~and man-made accidents~~ in the Danube and Tisza ~~occurred through~~were examined with 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, conventions, and directives in the region, including conventions and directives (Table 1). A review of b, of bilateral agreements (Table 2), and a literature review of peer-reviewed publications and white papers on the provision of disaster response within the Danube basin and Tisza sub-basin highlighted the international laws, policies, and institutions present in the region, 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 the 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 Danube Convention for non-EU member states.	Sets basin-level management of water quality and quantity.
European Commission	Floods Directive	Legally binding for EU member states, and through Danube Convention for non-EU member states.	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.

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

Countries	Transboundary Watercourses	Disasters / Emergencies
Serbia and Montenegro – Hungary~~Austria – Czech Republic~~	1955**~~1967*~~	1955*~~1994 (Floods Only)~~
Serbia and Montenegro – Romania~~Austria – Germany~~	1955**~~1987~~	Under Discussion~~1991 (Floods Only)~~
Austria – Hungary	1956	1959 (Floods Only)
Austria – Slovenia	1956***	1956* (Floods Only)
Hungary – Slovakia~~Austria – Hungary~~	1956*~~1956~~	2014 (Floods Only)~~1959 (Floods Only)~~
Austria – Czech Republic~~Austria – Slovakia~~	1967*~~1967*~~	1994 (Floods Only)~~1994 (Floods Only)~~
Austria – Slovakia	1967*	1994 (Floods Only)
Croatia – Slovenia	No Date	1977*** (Coastal Pollution)
Hungary – Romania	1986	2003 (Floods Only)
~~Austria – Slovenia~~	~~1956***~~	~~1956* (Floods Only)~~
~~Bosnia and Herzegovina – Croatia~~	~~1996~~	~~1996 (Natural/Manmade Disasters)~~
Croatia – Hungary	1994	1994 (Floods Only)
Hungary – Slovenia~~Bosnia and Herzegovina – Serbia and Montenegro**~~	1994-	1994 (Floods Only)~~2011 (Flood EWS)~~
Moldova – Ukraine~~Bulgaria – Romania~~	1994~~2004~~	-~~2004 (Floods Only)~~
Ukraine – Slovakia~~Bulgaria – Serbia~~	1995~~Draft~~	2000 (Floods Only)~~Draft (Floods Only)~~
Bosnia and Herzegovina – Croatia~~Croatia – Hungary~~	1996~~1994~~	1996 (Natural/Manmade Disasters)~~1994 (Floods Only)~~
Ukraine – Romania~~Croatia – Serbia~~	1997-	1952*** (Floods Only)-
Hungary – Ukraine~~Croatia – Slovenia~~	1997~~No Date~~	1998 (Floods Only)~~1977*** (Coastal Pollution)~~
Czech Republic – Slovakia~~Czech Republic – Slovakia~~	1999~~1999~~	--
Bulgaria – Romania~~Hungary – Romania~~	2004~~1986~~	2004 (Floods Only)~~2003 (Floods Only)~~
Moldova – Romania~~Hungary – Slovakia~~	2010~~1956*~~	2010 (Floods Only)~~2014 (Floods Only)~~
Bosnia and Herzegovina – Serbia and Montenegro**~~Hungary – Slovenia~~	-~~1994~~	2011 (Flood EWS)~~1994 (Floods Only)~~

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Bulgaria – Serbia ~~Hungary – Ukraine~~	Draft~~1997~~		Draft (Floods Only)~~1998 (Floods Only)~~
Croatia – Serbia	-		-
~~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

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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. Specifically, all individuals interviewed held positions (as reflected in Table 3) within the countries of the Danube basin and Tisza sub-basin, and were contacted through the International Commission for the Protection of the Danube River (ICPDR)~~ICPDR~~ expert groups and through a snowball method whereby one person interviewed would suggest additional people ~~le with which~~

to interview. Given public roles, the interviews are intentionally left anonymous to ensure candidness in the responses. Thus, only the ~~kind~~ type 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 classification distinguishes between international (global) organization experts, professionals working in institutions within the Danube basin (regional), and experts working at national agencies/ministries. The questions focused on how international frameworks affected Danube basin and Tisza sub-basin policies and laws, and how these were implemented in practice. The interviews also ~~, as well~~elicited as the ~~perceptions~~ opinion of the experts regarding the adequacy of existing international frameworks and their impacts on policy 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]

[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?

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* Numbers in brackets refer to interview citations in text.

~~3~~ 4 Distinctions between natural ~~disasters~~ and man-made ~~accidents~~ disasters 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~~either 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.~~

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~~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, with a potential to create losses or dangers to humans (Smith, 2013). If the potential is realized, d~~D~~isasters occur. These disrupt ~~individuals and communities at various scales~~the functioning of societies 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). However, such a dichotomous view masks the fact that ~~The consequences of~~ natural

[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).

disasters ~~become~~ are a function of where people reside and their overall vulnerability, including aging infrastructure, ~~and a function~~and their consequences depend on people's ~~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 disasters 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 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, 1). 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~~

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~~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).~~ ~~Given the anthropogenic influences on natural disasters, and uncertainties from climate change, the differentiation among natural and man-made disasters becomes further debatable.~~ ~~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 of different treatment~~

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Industrial and other man-made disasters are traditionally governed and responded to separately from natural disasters. The fragmented nature of disaster response is a historical artifact, ~~has emerged~~resulting from ~~from~~ the need to address specific types of disasters, in specific regions, or response modalities. More recently, evidence of ~~I~~increased ~~frequency of~~losses due to ~~major~~ disasters (Barredo, 2009; Cutter and Emrich, 2005~~,~~), ~~l~~legal barriers to disaster response (Janssen et al. 2009; Venturini, 2012), 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~~The ~~fragmented nature of disaster response has emerged from the need to address specific types of disasters, in specific regions, or response modalities.~~ However, currently~~, while~~, natural disasters and industrial and nuclear accidents have established frameworks for response, while 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). Nuclear accidents are an exception, as they are holistically covered by the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and the Convention on Early Notification of a Nuclear Accident, which were adopted almost immediately following the Chernobyl nuclear accident. However, ~~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~~ natech~~emergencies~~ accidents 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 cascading disaster or a ~~complex~~ natech ~~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 or~~disasters and man-made accident ~~disaster response. Generally, there is a failure to include non-state actors, the private sector, or individuals in response efforts to disasters, even though they may have specific expertise in disaster response (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~~5~~ Disaster frameworks in the Danube basin and Tisza sub-basin, and their treatment of disasters

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). There have been over 40 reported disasters in the Danube basin between 2000 and 2012, ranging from natechs to earthquakes and industrial fires. A majority of them involved more than one country at the same time (European Commission, 2016). 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.

Response to these ~~natural and man-made~~ disasters ~~, including natech accidents,~~ is governed by a range of global, regional, and national laws, policies, and soft -law instruments, that is, "normative provisions contained in non-binding texts" (Shelton 2000, p. 292). 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~~ their monitoring and response are managed independently, and ~~where~~ consideration for natech accidents is missing from policy guidance. Here, we discuss some of the issues that have arisen from the international/global and regional (EU and basinwide) frameworks for response to natural disasters in the Danube and the Tisza. We consider frameworks in decreasing geographical scope.

At the international level, since there are agencies experienced in particular types of international disasters, but they are often without a mandate or capacity for response, the approaches used fall under the soft law umbrella. For the Danube and the Tisza, 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 resulting 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. This includes 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. 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).

Also at the international level, response for industrial accidents is provided via the United Nations Economic Commission for Europe's (UNECE) Industrial Accident Convention. UNECE applies to land-based, non-military, and non-radiological industrial accidents, and response is provided through bilateral or multilateral arrangements (UNECE, 2009). 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). If an industrial accident occurs as a result of flooding, or other environmental effects, multiple disaster response frameworks must be triggered, therefore the Convention is not comprehensive enough to address cascading disasters in a holistic manner.

At the regional level, in our study areas,

In 1994, the Danube countries developed the Danube River Protection Convention (DRPC), in 1994, which is a legally binding instrument that ensures sustainable management of the Danube River (ICPDR, 1994). Through the International Commission for the Protection of the Danube River (ICPDR), the DRPC requested the ICPDR to coordinate the activities of the

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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. These are necessary considerations when managing disaster response policies as a basin unit, and not by individual country.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]. Thus, the Water Framework Directive and Flood Directive have substantial policy limitations to, as neither of the two directives require the integration of disaster risk of both floods and accidental pollution.

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 listed 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.~~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 ERCC and JEU interface with a diverse system of response 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 – there is no international or regional disaster response system. 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]. Experts also expressed the need for formal agreements with specific language on integrated mapping of cascading 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 Danube 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 the first Danube River Basin Management Plan of 2009, has yet to be realized.

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522 **Table 4.** Natural and man-made disasters in the Danube basin, reported by country, 2000-2012
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Year	Type of Event	Country
2000	Mine tailing	Romania, Hungary, Bulgaria, Macedonia
	failure/cyanide and	Austria, Slovenia
	heavy metal pollution	Bulgaria, Croatia, Slovenia
	(natech)	Croatia, Hungary, Romania, Slovenia
	Landslide/avalanche	Moldova, Ukraine
	Extreme temp./drought	Croatia, Slovakia
	Flooding	Slovenia
	Severe ice storms	
	Wildfires	
	Factory fire	
2001	Mining accident (natech)	Slovenia
	Flooding	Croatia, Hungary, Romania, Slovakia, Ukraine
2002	Industrial fire (natech)at	Slovenia
	waste dump	
2003	Mining accident (natech)	Slovenia
	Extreme temp./drought	Austria, Croatia, Germany, Slovenia, Bosnia and
		Herzegovina
		Hungary
	Flash floods	Slovenia
	/severe storms	
	Wildfires	
2004	Drinking Wwater pollution	Hungary
	(natech)	Romania

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

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 These frameworks for response to natural disasters do not include consideration for man-made disasters, and man-

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made-disaster frameworks often fail to consider natural disasters as well. For example,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). If an industrial accident occurs as a result of flooding, or other environmental effects, multiple disaster response frameworks must be triggered.

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

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~~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).~~The Danube River Protection Convention is supplemented by a series of non-binding Memoranda of Understanding (MOU) referred to as the Danube Declarations, first agreed upon in 2004, revised in 2010, and updated in 2016. Within this umbrella, the Danube River basin countries engage currently in two separate systems: the Emergency Flood Alert System (associated with the EU) for flood monitoring, and the Principal International Alert Centres (PIACs) of the Danube Accident Emergency Warning System (Danube AEWS, not associated with EU institutions) to monitor pollution from man-made accidents. These two separate systems well illustrate the issues associated with separate response mechanisms and institutional arrangements. 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. Note that a MOU has been signed with several, but not all of the Danube countries. The Emergency Flood Alert System provides national authorities the ability to develop 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). The MOU does not

include tributaries draining areas less than 4,000 km², therefore the Emergency Flood Alert System neither addresses flood risks in the Tisza, nor in certain basin countries where significant flood concerns arise, such as Ukraine [1].

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 of a potentially serious accidental pollution is received, the PIAC is responsible for communicating the accident to the ICPDR, it decides whether it is necessary to notify downstream countries and engage experts to assess the impacts of the pollution, and it determines which response activities need to be taken at the national level (ICPDR, 2014). Challenges to the monitoring capabilities of the Danube AEWS 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 a non-comprehensive list of man-made accidents being monitored. The failure to monitor pollution events in a consistent and effective manner creates problems for downstream countries [4]. This is particularly problematic in the Tisza countries where the lack of monitoring

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of both flood and accidental pollution events, combined with limited bilateral agreements, raise concern among several countries [4, 5].

~~Flooding in the Danube in 2013 and 2014 caused approximately €15 billion in damage (Table 5), and while the economic costs 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 appareflentct the need for improved agreements on bilateral or multilateral relief response (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~~

Bilateral agreements are also in place to address

~~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].~~

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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 – there is 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

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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 nateeh accident in the Tisza River sub-basin, sixteen experts from seven countries deployed for response to the nateeh 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

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670 Industry in nearly half of the EU countries is believed to insufficiently consider natech risks in
671 their preparedness response measures (Krausmann and Baranzini, 2012).
672 The EU Floods Directive provides a framework for addressing risk from natural disasters,
673 specifically floods. While inspired not only by the damaging effects of floods, but also by
674 increasing flood risks as a result of climate change, the main objective of the Directive is to
675 require member states to assess and manage risks of flooding and to develop flood risk
676 management plans. Though the plans are restricted to areas considered at high risk of floods,
677 these are not integrated into other types of plans and maps available – such as the Inventory of
678 Potential Accidental Risk Spots in the Danube[4], – nor are they used for developing preparedness
679 response measures in advance of an accident or natural disaster, such as in the case of the Seveso
680 Directive. Though the Flood Directive was expected to reduce flood risk, interviewees voiced
681 disappointment regarding the limitations of integrating disaster risk more broadly, particularly in
682 relation to water quality and accidental pollution [3]. These present as policy limitations to the
683 Water Framework Directive and Flood Directive, as neither of the two directives require the
684 integration of disaster risk of both floods and accidental pollution.
685 The European Union also developed a set of macro-regional strategies for the Adriatic and
686 Ionian, Alpine, Baltic Sea, and Danube regions (European Commission, 2010). While the intent
687 was to not provide new EU funding, these integrated frameworks are supported by EU Structural
688 and Investment Funds in order to address common challenges faced in each defined area. In the
689 Danube Strategy, risks from floods and industrial accidents are reflected known to haveas having
690 substantially negative transnational impacts. These impacts require, and are listed as requiring

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[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).

691 preventive and disaster management measures that are implemented jointly, with the
692 understanding that work undertaken in isolation in one place (e.g., to build levees) displaces the
693 problem and places neighboring regions at greater risk of flooding (European Commission,
694 2010). Other man-made disasters are integrated in the discussion of risks, as well as the need to
695 account for climate change by taking a regional focus at the basin level (European Commission,
696 2010, p. 8). In a 2015 European Commission Communication report, several limitations were
697 highlighted, including: the need to improve efforts to reduce the Danube region's risk of
698 exposure to major floods and accidental hazardous material releases; limited political
699 commitment, funding, and capacity among countries and institutions in the Danube; lack of staff,
700 funding, and expertise impeding participation, particularly in lesser developed areas of Danube –
701 the report also acknowledged that these challenges are more acute in non-EU countries (EPRS,
702 2015). The limitations in funding, technical expertise, and capacity were confirmed in interviews
703 with experts at various levels, who also noted how this leads to uneven implementation of EU
704 Directives within the basin that can create pockets of vulnerability to both flood risk and risks
705 from industrial accidents [2, 3, 4].
706 While the Danube Strategy does not provide a framework for response to natural and man-made
707 disasters, it does highlight the EU's continued support for managing multi-hazard response at
708 multiple levels, particularly through Priority Area 5 "To Manage Environmental Risks."
709 Specifically, it requests that the countries "strengthen operational cooperation among emergency
710 response authorities in the Danube countries and improve the interoperability for risks that are
711 common to an important number of countries in the region (i.e., floods and risks of other natural
712 and man-made disasters)", and advises that each country's civil protection mechanism have an
713 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 cascading 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 Danube 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 the first Danube River Basin Management Plan of 2009, has yet to be realized.

Through Within tthe 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 partiesy, 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

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Danube countries and, to a smaller extent, ~~; however, virtually no bilateral agreements exist regarding~~ to ~~response~~ respond 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**~~

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~~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 provides national authorities the ability to prepare develop 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 neithernot addresses flood risks in the Tisza, nor in certain basin countries where significant flood concerns arise, such as Ukraine [1]. Transboundary floods (which often occur in the Danube basin and Tisza sub-basin) typically affect larger areas, can be more severe, result in a higher number of deaths, and cause increased economic loss than non-transboundary rivers floods (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 of a potentially serious accidental pollution occursis received, the PIAC is responsible for communicating the accident to the ICPDR, and decides whether it is necessary to notify downstream countries, to engages experts to assess the impacts of the pollution, and decides what which response activities need to be taken at the national level (ICPDR, 2014). Challenges to the monitoring capabilities of 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, 2). 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 been realized for the Tisza, but the language in the MOU does reflect an interest at for 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 for floods and man-made hazards.~~

~~5~~6 Building holistic approaches for integrating multilevel disaster response

~~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~~activities.

~~There is an a~~Additional shifts in what is considered ~~truly~~ a natural disaster ~~as well not only from the perspective of mitigation or vulnerability, but~~have come from the ~~in~~ acknowledgement of the anthropogenic influences on natural disasters. Besides c~~C~~limate change,

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~~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~~ these areas are placed at increased risk to natural and man-made hazards (Bruch and Goldman, 2012; Huppert and Sparks, 2006). This is especially true~~For this reason,~~ for natech accidents and other cascading disasters, since simultaneous response efforts are required to attend to the industrial, chemical, or technological accidents as well as the triggering natural disaster. T~~-~~he overlap from numerous responders, the ~~triggering~~activation of numerous – and disparate – response frameworks, and the difficulties in integrating the separate response activities make fragmented frameworks of disaster response costly and ineffective. ~~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 comprehensive response 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, ~~s and~~ to take the necessary measures to reduce the risks of those hazards and to holistically address their impacts. Otherwise, piecemeal, uncoordinated responses may result in duplication of costs and activities and, more importantly, overlooked health and environmental consequences.

~~The 2011 Fukushima nuclear disaster in Japan, triggered by the Great East Japan Earthquake and the resultant tsunami, illustrated the complex relationship of among natural~~

hazards, and the built environment, and human scoail 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]. IIn 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~~ frameworks for responding to natural and man-made disasters ~~in a more integrated manner~~ (i.e., adopting a multi-hazard approach). These ~~processes~~ approaches may be

done implemented at the global (e.g., Sendai), regional (e.g., BSEC), bilateral, and or national levels. By adopting a multi-hazard framework for disaster response, the expertise and practices of responders can be increased enhanced to include improved modeling and assessment approaches, response methodologies and tools, and heightened enhanced 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 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 absent in the framework language or ignored [2, 3, 4, 5, 6] (European Commission, 2010; ICPDR, 2015a). Gaps in monitoring were citedMonitoring gaps are reported along the length of both the Danube and the Tisza in regard tofor both flooding and accidental pollution, and , which should also be improved inthese gaps should be corrected 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 comprehensive 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. Though this is can be challenging, there is a growing literature on the development of the technical and policy tools necessary (Kappes et. al., 2012, Holub and Fuchs, 2009), and on how to address fairness considerations (Thaler and Hartmann, 2016). There are multiple examples of more holistic and comprehensive approaches being used in the EU countries (Greiving et al. 2012, Thaler et. al, 2016). Such approaches emphasize stakeholder involvement and adaptive management, and could form a blueprint for efforts in the Danube and the Tisza.

~~In~~ With regard to the Danube basin specifically, ~~this~~ a more holistic approach that accounts for the specific challenges of the basin could be ~~done~~ implemented 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

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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 (e.g., legal frameworks) can be difficult; countries 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. Often find soft law (e.g., policies and guidelines) can be a more flexible tool. 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.

~~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.~~

The ~~R~~recognition of this ~~zing that the historic distinctions between natural and man-made disasters are no longer relevant, there is increasing recognition~~has resulted in the ~~ 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).

The Danube and Tisza countries have already been affected multiple times by~~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. ~~-~~While the current policy frameworks ~~in the Danube basin and Tisza sub-basin~~ do not address monitoring and response ~~holistically~~ comprehensively 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. Such negotiations

and the resulting increased coordination will become even more critical as climate change is likely to increase the frequency and severity of extreme events in the foreseeable future.

~~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.~~

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