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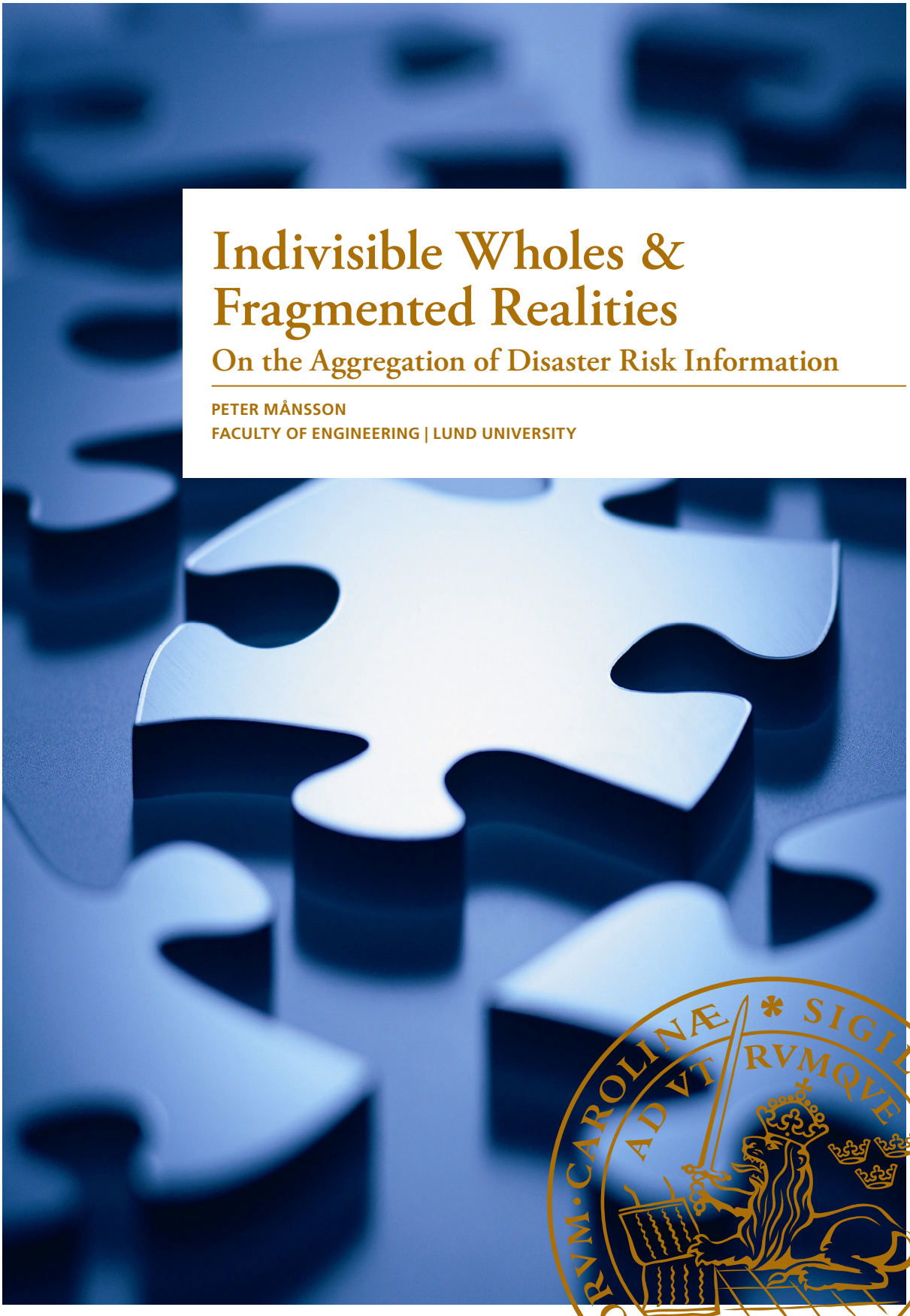

Indivisible Wholes & Fragmented Realities

On the Aggregation of Disaster Risk Information

Peter Månsson

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Abstract

Division of labor and trade have been prerequisites for the development of welfare societies. Ironically, this specialization has caused a fragmentation of the knowledge necessary to understand risks that may undermine societal safety. This has not only prompted a need for inter-organizational exchange and integration of disaster risk information, it has also prompted a need for understanding how it ought to be done.

Using Sweden as a study case, this thesis explores what aggregation of disaster risk information from multiple organizations entails in terms of activities, the challenges involved, and means to address them. Specifically, it focuses on public authorities and their quest to understand and cater for societal safety by assembling, synthesizing, and disseminating disaster risk information, as well as providing feedback on information received from others. Inspired by critical realism and design science, the studies are based on multiple methodologies and sources, involving literature reviews, content analyses, and experiments, as well as extensive interaction (through workshops and interviews) with disaster management professionals. The outcomes include a suggested definition for aggregation in the context of disaster risk management systems, and the identification of the causes and effects of a number of challenges related to its realization. However, the thesis also contains proposals that are likely to facilitate the aggregation of disaster risk information and, hence, the chance to make sound decisions in support of societal safety.

Key words: Societal Safety; Disaster Risk Management; Risk governance; Multi-stakeholder; Risk and vulnerability Assessment; Information management; Aggregation; Holistic

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Indivisible Wholes & Fragmented Realities

On the Aggregation of Disaster Risk Information

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To my loving and beloved family

Summary

Hurricane Katrina, the Indian Ocean tsunami, the crash of Lehman brothers and the 9/11 terrorist attacks are but recent examples of events that have raised questions about our ability to anticipate, and make sense of, disaster risk. However, in hindsight, we easily forget that there always are an infinite number of potential scenarios ahead of us, but only one past, which makes us exaggerate the predictability of events once they have occurred. We may also neglect a number of structural and psychological barriers that, effectively, could obstruct the quest to comprehend the hazards we face.

This thesis focuses on the possibility of understanding disaster risk. Such understanding requires exchange of information between a large number of heterogeneous stakeholders (e.g., public authorities, private companies, and interest groups). Exchanging information is not enough, however; the information must also be integrated in a way that supports holistic decisions concerning which risks we address and how. The way in which this is done is not only decisive for our ability to make cost efficient allocations of limited resources; it also affects the types and magnitude of the consequences that future disasters may bring about.

Using Sweden as an example, this thesis explores what aggregating disaster risk information from multiple stakeholders entails in terms of activities, as well as the challenges involved in trying to do it. The thesis also probes the causes and effects of these challenges, as well as possible means to overcome them. The findings are derived from a mix of theoretical studies and interactions with risk management professionals at all administrative levels in Sweden (e.g., literature reviews, content analyses, experiments, interviews, and workshops).

In the thesis, aggregation is understood as comprising the processes of collecting and synthesizing disaster risk information from different actors (a definition reflecting this conception is also suggested). Aggregation also relates to the processes of disseminating the synthesized results (else the purpose of aggregation will not be fulfilled) and providing feedback on information one has obtained from other actors (as a means of improving the chances of aggregating information in times to come).

A prerequisite for being able to aggregate disaster risk information in an efficient way is to know which information one needs and where to find it. This requires knowledge of one's dependencies on external actors, as well as of the direct and indirect effects of a vast range of potential societal perturbations. Attaining such awareness is complicated by the fact that modern welfare states are based on high degrees of specialization and diffusion of responsibilities, with interdependencies between different societal functions increasing and being subject to constant change. Even *with* this knowledge, inter-organizational risk communication may be hindered

by the need to conceal sensitive information, competition for resources, inadequate dialogue between public and private stakeholders, and costs in terms of time, energy, and money.

Aside from these challenges associated with assembling data, additional challenges arise when trying to make sense of the material one manages to obtain. In Sweden, all local municipalities, regional county boards, and a number of national authorities, are obliged by law to conduct and communicate the results of risk and vulnerability assessments (RVA) to each other. A study of more than 120 reports from such assessments showed large discrepancies regarding how these actors analyze and present risk information. Apart from inhibiting the chances of comparing and synthesizing information, this also creates frustration and resignation amongst risk managers at public authorities, which ultimately may lead to a decreased willingness to use others' data. This scenario is likely to have a detrimental effect on the ability to identify risk, analysing it, and implement suitable risk-reducing measures. Yet, opportunities exist to improve the situation.

Experiments in this thesis strongly suggest that aggregation is facilitated when different actors use the same scales and quantitative units (frequencies, numbers, volumes, areas) when expressing risk as well as supplement their assessments with transparent motivations. Additional measures to this end include promoting trust and partnerships between public and private stakeholders through joint workshops, exercises, and trainings (on the management of sensitive information in particular), and developing common and dimensioning risk scenarios that are applicable to authorities at all administrative levels. Current RVA regulations could also be sharpened by including common consequence dimensions, as well as scales and indicators for assessing the likelihood and consequences of risk scenarios. Moreover, it is suggested to elaborate a common template for conveying the main messages from RVA reports and a checklist to stimulate feedback on inter-organizational risk communication. To reduce the time and cognitive load of processing vast amounts of data, future research should look into the possibilities of making better use of visual aids, including how Geographical Information Systems (GIS) can be applied to support the production of individual RVAs and syntheses of their outputs.

It is important that measures to enhance the possibility of aggregating disaster risk information from multiple stakeholders do not curb their sense of ownership or motivation to produce risk assessments. For this reason, it is argued that initiatives in this field need to be based on a combination of top-down and bottom-up approaches, where central guidelines and directives are negotiated with the stakeholders that are meant to abide by them, and the substance of risk assessments primarily stems from the actors closest to the objects and systems that are being assessed. In this way, comparable risk information may retain the quality needed to make cost-efficient decisions in support of societal safety.

Sammanfattning (summary in Swedish)

Orkanen Katrina, tsunamin i Indiska oceanen, Lehmankraschen och 11-september attackerna är bara några exempel på sentida händelser som väckt frågor kring vår förmåga att förutse och förstå katastrofrisker. I efterhand är det dock lätt att glömma att vi alltid har ett oändligt antal potentiella scenarier framför oss, men bara ett förflutet, vilket kan få oss att överdriva förutsägbarheten för händelser när de väl inträffat. Det finns också en rad strukturella och beteendemässiga faktorer som försvårar våra möjligheter att förstå de faror som hotar oss.

Denna avhandling fokuserar på våra möjligheter att förstå risker för katastrofer. Detta kräver utbyte av information mellan många och olika typer av aktörer (t.ex. offentliga myndigheter, privata företag och intressegrupper). Att utbyta information räcker dock inte. Informationen måste också integreras på ett sätt som skapar överblick och stödjer beslut om vilka risker som bör reduceras och hur. Hur detta görs är inte bara avgörande för vår förmåga att fatta kostnadseffektiva beslut kring fördelningen av begränsade resurser. Det är också avgörande för omfattningen och typen av skador som framtida katastrofer kommer att medföra.

Med utgångspunkt i det svenska krishanteringssystemet undersöks vad aggregering av katastrofriskinformation innebär i termer av aktiviteteter samt vilka utmaningar som finns att utföra dem. Dessutom undersöks orsakerna till och effekterna av dessa utmaningar samt möjliga sätt att bemästra dem. Resultaten bygger på en kombination av teoretiska studier, experiment och interaktion med tjänstemän med ansvar för riskhantering på alla administrativa nivåer i Sverige.

I avhandlingen tolkas aggregering omfatta processerna att samla in och syntetisera katastrofriskbedömningar från olika aktörer, där syntesen innebär att man använder delmängder av information för att skapa en ny, sammansatt bild av verkligheten (en definition som återspeglar denna förståelse föreslås också). Aggregering är även kopplat till processerna att sprida det syntetiserade resultatet (annars kommer syftet med aggregeringen inte att uppfyllas) samt att ge återkoppling på den information man erhållit från andra aktörer (som ett sätt att påverka hur informationen förmedlas och därmed förbättra chanserna att aggregera motsvarande information i framtiden).

En förutsättning för att aggregera katastrofriskinformation på ett effektivt sätt är att veta vilken information man behöver och vem som har den. Detta kräver kunskap om ens beroenden av externa aktörer och om de direkta och indirekta effekterna av ett stort antal potentiella samhällsstörningar. Att uppnå medvetenhet kring dessa aspekter kompliceras av det faktum att moderna välfärdsstater bygger på en hög grad av specialisering, där beroendet mellan olika viktiga samhällsfunktioner både ökar och är under ständig förändring. Även *med* denna kunskap kan utbytet av riskinformation mellan olika aktörer stävjas av behovet att förhindra att känslig information hamnar i

orätta händer, konkurrens om resurser, otillräckligt förtroende mellan offentliga och privata aktörer samt kostnader i tid, energi och pengar.

Bortsett från dessa utmaningar som är förknippade med att samla in information, uppstår ytterligare utmaningar när man försöker skapa mening av den information man lyckats få tag på. En omfattande dokumentanalys av svenska myndigheters risk- och sårbarhetsanalyser visade stora skillnader i hur de analyserar och presenterar riskinformation. Förutom att reducera chansen att jämföra och syntetisera informationen, skapar detta också frustration och uppgivenhet bland tjänstemän vilket i förlängningen kan leda till en minskad vilja att använda riskinformation från andra aktörer. Detta har sannolikt en negativ inverkan på förmågan att identifiera risker, analysera dem och genomföra lämpliga riskreducerande åtgärder.

Möjligheter finns dock att förbättra situationen. Experiment visade att aggregering underlättas om olika aktörer använder samma skalor och kvantitativa enheter (frekvenser, antal, volymer, områden) när de uttrycker risk samt kompletterar sina bedömningar med transparenta motiveringar. Det är också viktigt att främja förtroende och utbyte mellan offentliga och privata aktörer, t.ex. genom gemensamma workshops, övningar och utbildningar (särskilt kring hantering av känslig information). Härutöver föreslås utvecklingen av gemensamma och dimensionerande riskscenarier för myndigheter på alla administrativa nivåer. Nuvarande föreskrifter för myndigheternas risk- och sårbarhetsanalyser bör också skärpas genom att inkludera gemensamma konsekvensdimensioner samt skalor och indikatorer för bedömning av riskscenariers sannolikhet och konsekvenser. Dessutom rekommenderas att man tar fram en mall för att i enhetlig och komprimerad form kommunicera innehållet i RSA-rapporter till allmänheten samt en checklista till stöd för återkopplingar till förmedlare av katastrofriskinformation. För att minska tidsåtgång och kognitiv belastning vid behandling av stora mängder information, bör framtida forskning undersöka möjligheterna att bättre nyttja visuella hjälpmedel, inklusive hur geografiska informationssystem (GIS) kan tillämpas för att stödja framtagning och aggregering av risk- och sårbarhetsanalyser.

Det är viktigt att åtgärder för att öka möjligheten att aggregera katastrofrisk-information inte underminerar enskilda aktörers känsla av ägandeskap och motivation för arbetet att analysera samhällsrisker. Av detta skäl förordas att en fortsatt kombination av ”uppifrån och ned” och ”nedifrån och upp” strategier, där centrala riktlinjer och direktiv tas fram med de aktörer som är tänkta att följa dem medan innehållet i de aggregerade riskbedömningarna främst kommer från de aktörer som är närmast - och har bäst kunskap om - de objekt och system som analyseras. På detta sätt kan jämförbar riskinformation behålla den kvalitet som krävs för att fatta kostnadseffektiva beslut till stöd för samhällets säkerhet.

Preface

Approaching the end of my PhD endeavour, it is time to reflect upon this journey. What brought me here, what have I learnt, and, perhaps most importantly, what are my contributions to the field and ideas for future research?

Unlike most of my colleagues, I am not a fire engineer—or an engineer at all, for that matter. Some 15 years ago, I obtained a Master's degree in political science, majoring in crisis management and international cooperation at Uppsala University. In fact, I was asked about my interest in pursuing a PhD at that time but, having just completed a strenuous Master's thesis, the thought of spending the next 5 years reading and writing was not appealing. Besides, I did not feel that I had a topic of my own; a problem that seemed to warrant putting such time and effort into investigating. Instead, I started a decade-long period of working on disaster preparedness and societal safety at the Stockholm County Administrative Board, the Swedish Rescue Services Agency (SRSA), and the Swedish Civil Contingencies Agency (MSB). This endowed me with significant experience in implementing and facilitating risk and vulnerability assessments, contingency planning, and exercises at local, regional, and national levels in Sweden. Toward the end of this period, I was also coordinating international development projects and humanitarian operations.

As a practitioner, I have repeatedly observed and experienced the necessity and difficulties of integrating information from various stakeholders. This spurred an interest in identifying and exploring ways to overcome the challenges, and I came to realize that I had found a topic which both interested me and was important and urgent to address. I am grateful for having had the chance to pursue a PhD that enabled me to do this.

Having worked in a system that one aims to research undoubtedly has its advantages. For one thing, it provides an understanding of pressing problems associated with the subject area and, thus, a basis for directing the research toward matters in need of investigation and development. Having been part of professional networks also facilitates access to informants and discussion forums. At the same time, one has to be careful that one's own experiences do not give rise to observational biases; i.e., that one's presumptions about problems and solutions do not steer the research output. For instance, even when I was interviewed for the position as PhD candidate, I declared that one of my projected outputs was an updated version of Ibero, a method that sought to enable comparisons between risk and vulnerabilities in different geographical areas (e.g., between different municipalities or counties) and which I had been part of developing during my employment at the Stockholm County Administrative Board. Yet, my supervisor advised me to shift my perspective and think about the purpose of aggregation and the functions that are needed to support it before starting to design tools that, presumably, would meet these ends. After

becoming a little bit wiser and also somewhat frustrated, I gradually came to realize that this is a school, with the main objective being to learn the craft of research. Completing the thesis, therefore, has necessitated a focus on methods, rather than outputs. Despite this, I believe that this exploration of aggregation has resulted in a number of ideas that may enhance the management of risk in practice.

At the time of writing, I am unsure whether I will continue within the academia or return to the "real world." Perhaps I will become a "pracademic," moving in and out of academic and practical communities? In any case, I am grateful for having had the chance to assume a PhD mid-career, and for being surrounded by knowledgeable colleagues that have shared their wisdom and helped me develop some of my own. Since I was born and raised in Lund, I am also glad that I have had the chance to pursue the PhD here, despite a grumpy remark from one of my former professors at Uppsala that I have done it at the "wrong university"!

Adhering to another supervisor's advice ("less is more"), I am going to stop here, realizing that I have not answered all the questions posed in the first paragraph. But, hey, it is only the preface. For those of you who want to know more, I suggest that you continue reading.

Lund, September 2018

Peter Månsson

Acknowledgements

I would like to express my gratitude to a number of persons who in different ways have facilitated the completion of this thesis and contributed to making my PhD-journey enjoyable.

First and foremost, I want to thank my supervisors, Henrik Tehler and Marcus Abrahamsson, for their consistent support and kind words of encouragement, as well as their insightful tips on how to structure individual papers and manage the PhD journey in general. I am particularly thankful for their empowering, listening-based style of guidance, which has allowed me to be in the driver's seat during my research, whilst providing access to valuable feedback when required. The latter support went beyond the call of duty, being provided, at times, during vacations or parental leave. Thank you both for this.

I also want to thank Professor Kurt Pedersen for letting me come on board and for his gentle spirit, which, I believe, has been instrumental in the creation of a positive working environment at the division. This legacy is nurtured by his former colleagues now that Kurt himself has retired. Accordingly, I would like to thank Per Becker, Johan Bergström, Alexander Cedergren, Mo Hamza, Henrik Hassel, Jonas Johansson, Christian Uhr, and Misse Wester for contributing to a friendly atmosphere and for providing me advice on numerous issues. Naturally, I am also grateful to my fellow PhD candidates Björn Arvidsson, Ralf Beerens, Phu Doma Lama, Tove Frykmer, Magnus Hagelsteen, Jenny Iao-Jörgensen, Lexin (Mona) Lin, Hanna Palmqvist, Roshni Pramanik, Emmanuel Raju, Claudia Rivera, Waleed Shoaib, and Linn Svegrup, with whom I have shared this journey of agony, perseverance, and growth. Thanks for the enriching discussions that we have had during shared courses, in the corridor, and during 10 o'clock fikas. Special memories include the annual philosophical talks in the jacuzzi at the Lodge with Magnus, the gyrocopter flight with Johan, hovering above my house in Stångby; the PhD school with Mona in Trondheim (and the quadruple espresso dubbed "Inferno" required to get us there), and the amazing moment (especially considering our focus on risk reduction) when Roshni and I got to cuddle oversized lion cubs in South Africa. I also want to thank Berit Andersson, Ann Bruhn, Heidi Franke, and Johanna Kruse for many talks over lunches and for sorting out all unsortable things with a smile!

Aside from the people at my own division, I would like to express my gratitude to Nicklas Guldåker, who invited me to be part of the ORSA project and has enriched my knowledge of how GIS may be applied in support of risk reduction, and Petter Stenmark, who provided me with the opportunity to conduct experiments together with his students at Mid Sweden University.

I would also like to thank the MSB, which, through the research program PRIVAD (Program for RIsk and Vulnerability Analysis Development), has funded the majority of the research. I am also grateful for having been able to remain an active member of the MSB field-staff roster, which has provided me with the opportunity to take part in training, exercises, and missions during my PhD adventure. Considering that my research have been focused on (but not limited to) the Swedish disaster risk management system, I have also appreciated teaching on the Master's program in Disaster Risk Management and Climate Change Adaptation, which has enabled me to keep abreast of developments in fields such as exercise management, the elaboration of contingency plans, and early warning systems.

Finally, I would like to thank those closest to me. First, my parents, Eva and Bertil, for their constant love, engagement, and encouragement, and for having brought me along on trips that spurred my interest in the world—and for helping me to learn about it. I must mention my sisters, Åsa and Pia, who have contributed to wonderful memories and enriching experiences throughout my life, and continue to be amongst the top people with whom I prefer to spend my leisure time. Above all, I want to thank my wife, Sara, and our two children, Isak and Lina, for their continued belief in me and understanding when I have been a bit grumpy due to sleep deprivation and general bewilderment. I am grateful for the love, support, and excitement that we offer to each other every day, and am proud and glad that I am sharing my life with you.

Appended Papers

I. Månsson, P., Abrahamsson, M., Hassel, H., & Tehler, H. (2015). On Common Terms with Shared Risks - Studying the Communication of Risk between Local, Regional and National Authorities in Sweden. *International Journal of Disaster Risk Reduction 13*: 441-453. doi: 10.1016/j.ijdrr.2015.08.003

II. Månsson, P., Abrahamsson, M., & Tehler, H. (2017). Aggregated Risk: An Experimental Study on Combining Different Ways of Presenting Risk Information. *Journal of Risk Research*, published online. doi: 10.1080/13669877.2017.1391315

III. Månsson, P. (2018). Mapping Challenges and Opportunities for Aggregating Information on Systemic Risks from Multiple Stakeholders, *Procedia Engineering 212*: 736-743. doi: 10.1016/j.proeng.2018.01.095

IV. Månsson, P. (Submitted paper). Uncommon Sense: A Review of Challenges and Opportunities for Aggregating Disaster Risk Information. Submitted to an international peer-reviewed journal.

Related Publications

- Tehler, H., Abrahamsson, M., Hassel, H., & Månsson, P. (in press). Standardization of Disaster Risk Management – Challenges and Opportunities. In K. Voigt Juhl, O. Einar Olsen, & P. Hempel Lindøe (Eds.), *Standardisation of Risk and the Risk of Standardization*.

- Månsson, P., & Tehler, H. (2016). How Form Affects Function: On the Possibility of Aggregating Risk Information. Conference paper presented at *PSAM 13*, International Association for Probabilistic Safety Assessment and Management, October 2-7, Seoul, South Korea.

- Månsson, P. (2015). "Aggregering av Riskinformation". In H. Hassel (ed.), *Slutrapport från Ramforskningsprogrammet PRIVAD*, Rapport 3003. Lund: LUCRAM, 3-13. (In Swedish).

- Månsson, P. (2014). *PM - kommentarer rörande MSBs rapporteringsverktyg för risk- och sårbarhetsanalyser*. (In Swedish). Published: 2014-01-28. http://portal.research.lu.se/portal/files/35551230/PM_MSBs_rapporteringsverktyg_140128_.pdf

- Månsson, P. (2013). Assessing Tools and Implementation of the Campaign "Making Cities Resilient". Summary of briefing on two Master's theses conducted at Lund University, Sweden. Published: 2013-12-02. http://portal.research.lu.se/portal/files/35485015/Summary_of_briefing_at_UNISDR.pdf

- Abrahamsson, M., Hassel, H., Månsson, P., Petersen, K., & Tehler, H. (2012). *Utveckling av kommunala risk- och sårbarhetsanalyser. En studie av Skåne och Örebro län*, Rapport 1021. Lund: LUCRAM. (In Swedish).

- Månsson, P. (2012). Aggregation of Information as a Basis for Risk and Vulnerability Assessments - Challenges and Opportunities. Conference paper presented at *1st Biannual Conference for Disaster Reduction*, Southern African Society for Disaster Reduction, October 10-12, Potchefstroom, South Africa.

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1. Introduction

1.1. Rationale

I told you so might be seen an irritating statement, if implying that one could, and should, have foreseen an event that in some way harmed something of value to us. However, in hindsight, it is easy to forget that we always have an infinite number of potential scenarios ahead of us but only one past, which makes us exaggerate the predictability of events once they have occurred (Becker, 2014, p. 168; Fischhoff & Beyth, 1975; Taleb, 2010). This is especially true regarding risks to societal safety,[1] which often involve numerous interdependencies and potential spillover effects between societal functions, geographical areas, and administrative levels, making them difficult to foresee and address (Ansell, Boin, & Keller, 2010; Hills, 2005; Olsen et al., 2007).

Contemporary socioeconomical, environmental, and political trends (e.g., climate change, globalization, urbanization, and technological advances) exacerbate the risk of large-scale disruptions to societal functionality (Beck, 1992; Boin & Lagadec, 2000; Duit & Galaz, 2008; Giddens, 1990; IPCC, 2014; OECD, 2003; Perrow, 1999). They have also prompted the notion of risk governance, which emphasizes the need of multi-stakeholder approaches to risk identification, assessment, and management (IRGC, 2006; van Asselt & Renn, 2011). This ambition has gained foothold in global and national strategies to reduce disaster risk[2] (FEMA, 2011; IFRC, 2016; Lindberg & Sundelius, 2013; OECD, 2014; UNISDR, 2015; USAID, 2011; WHO, 2009), and is a logical consequence of the specialization that underlies the development of modern welfare states. Although the division of labor has been

[1] *Societal safety* is here understood according to the definition given by Olsen, Kruke, and Hovden (2007, p. 71): "society's ability to maintain critical social functions, to protect the life and health of the citizens and to meet the citizens' basic requirements in a variety of stress situations."

[2] The term *disaster* entails "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceed the ability of the affected community or society to cope using its own resources"(UNISDR, 2009, p. 9), whereas *disaster risk* is defined as "The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity." (UNISDR, 2016, p. 14).

rational and efficient, it has increased difficulties in understanding how vital societal functions[3] are structured and connected. Increasing interdependencies have created complex systems of systems (Calvano & John, 2003; Heylighen, Cilliers, & Gershenson, 2007; Jackson & Keys, 1984) and a fragmentation of knowledge, in which different pieces of information are gathered and interpreted by the different stakeholders[4] within such systems (Almklov & Antonsen, 2010; De Bruijne, 2006; Kramer, 2005; McConnell & Drennan, 2006; Moreland, 1999). These factors create problems when seeking to attain holistic pictures of risks that threaten the functionality of our societies. They also make it imperative to understand and improve the foundations for aggregating disaster risk information[5] from multiple stakeholders.

Obtaining comprehensive pictures of disaster risk is by no means easy and, as suggested by the cover of this thesis, in some ways similar to completing a jigsaw puzzle: the aim is to locate valuable pieces of information and to figure out how they fit together. In contrast with an ordinary puzzle, however, there is no template displaying the solution. The picture that emerges depends on our ability to understand which information we need and where to find it, as well as on the possibility of obtaining it and of making sense of the collected material. In addition, such a sense-making activity may produce new knowledge (i.e., new pieces of the puzzle), which may emerge from integrating existing information about aspects that are related but, previously, have been perceived and managed in isolation from each other. The way that risk information is aggregated[6] is decisive for our ability to prioritize both risks and ways to reduce them—and, hence, for the efficiency with which we allocate limited resources. Consequently, this aggregation is also decisive for the types and magnitude of losses that future disasters may bring about. As inter-organizational exchange and the integration of information are at the heart of this endeavor, and have proven difficult to realize in many contexts (e.g., Komendantova

[3] In this thesis, a *vital societal function* is understood as "a function of such importance that its loss or severe disruption to it could entail major risks or hazards for the life and health of the population, the functionality of society or society's fundamental values." This includes societal functions that have the task of dealing with emergencies or crises so that injury and damage are kept to as low a level as possible (MSB, 2011, p. 10).

[4] The terms *stakeholders* and *actors* are used interchangeably in this thesis to denote organizations, rather than individuals. Here, the attention is focused on the exchange of risk information between public authorities with a formal responsibility for sustaining societal safety, whilst acknowledging the importance of inputs from other types of stakeholders in these endeavors (e.g., private companies and interest groups).

[5] *Disaster* r*isk information* is defined as "comprehensive information on all dimensions of disaster risk, including hazards, exposure, vulnerability and capacity, related to persons, communities, organizations and countries and their assets"(UNISDR, 2016, p. 15).

[6] A general definition of *aggregation* is "the collection of units or parts into a mass or whole"(Merriam-Webster, 2018a).

et al., 2014; Kramer, 2005; Lin & Abrahamsson, 2015; Scolobig et al., 2014), there is a dire need to explore the challenges involved in aggregating risk information from multiple stakeholders, as well as to develop ideas that may facilitate such processes.

I am using the Swedish disaster risk management (DRM) system[7] as a study case in order to extract and expand knowledge that might be conducive to addressing the above need. Specifically, this thesis focuses on the processes and methods that Swedish authorities employ when producing and communicating the results of risk and vulnerability assessments (RVA) of "extraordinary events"[8] that might create large-scale disruptions to societal functionality. However, the ambition to map risks to societal safety is by no means unique to Sweden; and, since most countries are affected by disaster risk, have multiple interconnected vital societal functions, and divide responsibility across several public authorities, they will probably face similar challenges, too. In fact, since 2011, all European Union (EU) member countries have had to identify and assess risks of national concern, and communicate the results to the European Commission to provide a basis for an overall apprehension of risks to societal safety in the EU[a] (Bossong & Hegemann, 2016; Commission European, 2010, 2015). To be able to do this, governments in individual member states have enacted regulations and structures of their own to ensure that they are able to assemble and aggregate the required information (Commission European, 2014; OECD, 2014; Wyman, 2009).

In Sweden, authorities have been legally obliged to carry out and communicate the results of RVAs since 2002, which has led to a wealth of experience and material being available for research. A large number of studies have also been performed, especially through two large research programs funded by the Swedish Civil Contingencies Agency (MSB) and its predecessor, the Swedish Emergency Management Agency (SEMA).[b] The research underlying this thesis has been carried out as part of PRIVAD (Program for Risk and Vulnerability Analysis Development), which was implemented between 2012 and 2017, and built upon a previous program,

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[7] *Disaster risk management* (DRM) is used here when referring to activities aimed at preventing, mitigating, and preparing for disasters. A *disaster risk management system* denotes a set of elements (e.g., organizations, laws and regulations, collaborative agreements, financial mechanisms, and technical systems) established to avoid or to limit the adverse impacts of disasters. As such, a DRM system embraces the actual stakeholders that implement DRM activities. These conceptions are similar, but not identical, to the definitions of DRM and DRM systems provided by UNISDR (2009, p. 10) and Rivera, Tehler, and Wamsler (2017).

[8] The notion of *extraordinary events* was introduced in the Act on Municipal and County Council Measures Prior to and in the Event of Extraordinary Events and during Heightened Alert (SFS, 2006). It was here conceived as pertaining to events that "diverge from what is normal, entail a serious disturbance or an evident risk of a serious disturbance in vital societal functions, and call for prompt action by a municipality or county council" (own translation). However, it is important to note that extraordinary events could be expected to require prompt action by other stakeholders as well (e.g., county administrative boards, national authorities, and government offices).

FRIVA (Framework Program for Risk and Vulnerability Analysis, carried out between the years 2004 and 2011). FRIVA resulted in a number of useful tools, which were designed mainly to encourage organizations to start thinking about risk and vulnerabilities, and to increase awareness and knowledge about them. With PRIVAD, the focus shifted from designing methods that are useful for individual actors to enhancing the usability of the system as a whole (Petersen, 2011, p. 6).

Many studies have been performed since the inception of PRIVAD, but most of these have been confined to assessing risk communication within parts of the Swedish DRM system—e.g., exploring the uniformity of the risk descriptions conveyed by municipalities in a certain county (Abrahamsson, Hassel, Månsson, Petersen, & Tehler, 2012) or the similarities between RVA reports enacted by regional county boards (Abrahamsson & Tehler, 2013). This thesis focuses on the system in its entirety and explores how risk information is communicated between authorities at all administrative levels (i.e., local, regional, and national) in Sweden. In addition, whereas many studies have described the difficulties experienced by DRM professionals when seeking to produce and communicate risk information as a basis for holistic decision-making (Cedergren & Tehler, 2014; Lin, Nilsson, Sjölin, Abrahamsson, & Tehler, 2015; Månsson, Abrahamsson, Hassel, & Tehler, 2015; Vastveit, Eriksson, & Njå, 2014), little research has aimed to produce ideas on how to improve such practices. As highlighted by the MSB's current research strategy, there is a need for normative studies to be conducted and for evidence-based knowledge to be collated in order to support societal safety (MSB, 2014a). This thesis aims to contribute to this ambition.

1.2. Purpose, Objectives and Research Questions

The purpose of this research is to enhance our understanding and possibility of aggregating disaster risk information in the context of disaster risk management systems. This purpose involves an exploration of the rationale of aggregating disaster risk information from multiple stakeholders and the potential effects of failing to do so. It also requires an examination of what aggregating information from multiple stakeholders entails, in terms of processes and activities, as well as the identification of factors that may impede such endeavors. Moreover, it involves the quest of retrieving, constructing, and proposing possible solutions to challenges that are identified.[9] Hence, the research embraces multiple objectives: conceptual and theoretical

[9] *Challenges* are understood here as barriers in processes or deficits in resources that make it difficult to attain goals, such as the aggregation of risk information from multiple stakeholders.

development, descriptive and explanatory studies, and the production of normative ideas. Four overarching research questions may be derived from these ambitions:

1) *What processes and activities are part of, or decisive for the possibility of, aggregating disaster risk information in the context of disaster risk management systems?*
2) *What challenges exist in connection with the implementation of these processes and activities?*
3) *What are the causes and effects of these challenges?*
4) *What measures could reduce the observed challenges and thus enhance the possibility of aggregating disaster risk information in the context of disaster risk management systems?*

1.3. Thesis Outline

The remainder of the thesis is structured as follows. The next chapter gives an account of the notions of risk and vulnerability as well as the risk governance framework, which together provide a theoretical foundation to the research area. This is followed by a description of the Swedish disaster risk management system, with a subsection on the production and communication of RVAs. These sections aim to facilitate the reader's understanding of the design of, and rationale for, the studies performed. Chapter 4 presents the principles of design science and the philosophical assumptions that have guided the research process. In addition, it provides a narrative focusing on formative points in the research process, as well as a description of the connections between different papers and the methodologies employed in these. The assembled results are presented in Chapter 5 and are discussed further in Chapter 6. Finally, Chapter 7 provides overall conclusions and offers suggestions for further research.

Note of clarification

As might have been observed already, this thesis contains both footnotes and endnotes. This strategy has been employed to enhance readability, as substantive contextual information tends to clutter pages and distract the reader from the main narrative. At the same time, it is helpful to have a direct access to definitions to avoid misinterpretations of the running text. Hence, footnotes are used for defining terms and appear at the bottom of pages, being notated with Arabic numbers. Endnotes, on the other hand, are denoted with Latin letters, placed at the end of the document, and employed to provide supplementary and explanatory information.

2. Conceptual and Theoretical Perspectives

The words "risk" and "vulnerability" are frequently encountered in this thesis and in literature on disaster risk management in general. Unsurprisingly, there are several interpretations of these concepts, and it is beyond the scope and purpose of this thesis to make an appraisal of these (for reviews of perspectives on risk, the reader may consult Aven, 2012; Hansson, 2004; Kaplan, 1997, and Renn, 1998; the notion of vulnerability is discussed thoroughly in Adger, 2006; Buckle, 1998; Cardona, 2003; Dilley & Boudreau, 2001; McEntire, 2005; Thywissen, 2006; Weichselgartner, 2001, and Wisner Blaikie, Cannon, & Davis, 2004). Nonetheless, to prevent misunderstandings, I will attempt to clarify the ways in which I view and use the terms here. In addition, this chapter offers an account of the risk governance framework, providing a theoretical background for the subsequent discussion on the structure and functioning of the Swedish DRM system.

2.1. Risk

Uncertainty is an essential part of the notion of risk, and this uncertainty refers primarily to whether a specific event will occur or not and what the consequences will be if it does. If there was no uncertainty regarding these two dimensions, there would not be any risk; only facts (Hansson, 2010). In addition, there are inherent uncertainties related to how we measure risk. It is common here to differentiate between *aleatory* and *epistemic* uncertainty, where the former refers to statistical randomness and variation (which is difficult to reduce) and the latter concerns a lack of knowledge, which may be reduced by gathering more data or refining our models and methods of analysis (Haimes, 2012, p. 1462; Helton, 1994; Hora, 1996; Kiureghian & Ditlevsen, 2009).

Importantly, the way that risk is measured and managed is also dependent on our perspectives and underlying assumptions (Jasanoff, 1998). Aside from the field of economics—where risk is correlated with both losses and gains—risk is associated mostly with negative consequences and threats to something of value to us. This view

also prevails within the field of engineering, which has pioneered the development of risk assessment methodologies (Apostolakis, 2004; Keller & Modarres, 2004). The traditional engineering perspective equates risk with a mathematical product that denotes an event's probability and possible consequences (often expressed as "expected loss" or "disutility"), in which events with the highest scores should be prioritized, in terms of conducting further assessments and providing resources to reduce risk (see, e.g., Ale, 2002; Haimes, 2009 and Kaplan & Garrick, 1981 for corresponding risk apprehensions and methodologies). This technological perspective has also been labeled as "objectivistic," as its proponents have argued that an accurate characterization of risk can be made by stating objective facts about the physical world (Hansson, 2010).

Social scientists have strongly criticized this perspective for being simplistic and disregarding the influence of interests, values, and perceptions. Facts, they claim, cannot be separated from values (Bradbury, 1989), and the acceptability of risk cannot be reduced to the output of mathematical exercises. Aspects such as incertitude, observability, equity, reversibility, catastrophic potential, controllability, and voluntariness are decisive for the ways in which people perceive risk, and should be integrated, therefore, into the management of risk (Klinke & Renn, 2002; Otway & von Winterfeldt, 1982; Slovic, Fischhoff, & Lichtenstein, 1982). Opposition to the technological risk perspective has also spurred the development of a social-constructivist perspective of risk, which underscores its subjective nature. Risk, it maintains, does not refer to any objective facts about the physical world but is, rather, a social construct that exists in people's minds and is influenced by their interests, values, and cultures (Douglas & Wildavsky, 1982; Jasanoff, 1998; Slovic, 2001).

Hansson (2010) contends that neither the technological perspective, nor the socio-cultural risk perspective is tenable, since they both fail to recognize that risk comprises of both objective and subjective components. He proposes two minimal characteristics of the risk concept that are consistent with both perspectives and most definitions of the term: 1) risk refers to undesirable events and 2) risk includes uncertainty about whether those events will occur or not. Whether something is desirable or not is obviously a value-laden question that is overlooked, seemingly, by proponents of "objectivistic" risk assessments, who commonly measure the seriousness of risks (i.e., the degree of the undesirability of events) in terms of the number of people killed. Moreover, whether or not an event occurs is a matter of fact, and this defies the socio-cultural perception that risk does not relate to objective facts about the physical world. In addition, Hansson claims that risk is real in its consequences, as it would be "insincere paradox-mongering" to claim that losing one's leg by treading on a landmine would be a social construct (Hansson, 2010, p. 236).

I concur with the "dual risk thesis" that Hansson (2010) proposes. However, to expand the scope of subjective interpretations of risk, I favor the use of a generic risk definition that accommodates technocratic, as well as socio-cultural and economic, perspectives of risk (i.e., that allows for the option of viewing risk as something positive, rather than just negative). In one of the appended papers (paper I), I have used a definition that meets these criteria. The definition in question is proposed by Aven and Renn (2009, p. 6), who state that "risk refers to uncertainty about and severity of the events and consequences (or outcomes) of an activity with respect to something that humans value." This definition incorporates the three core elements of risk, as discussed above: an event, and uncertainty about both its occurrence (often expressed as likelihood), and the magnitude and type of its consequences (as further explicated in Aven, 2010 and Aven, 2011, p. 518). Moreover, it retains an openness of interpretation; i.e., it allows for different people interpreting the same event in different, even opposing, ways.

Connected to this is differentiation between risk *per se* and descriptions of risk (Aven, 2010, pp. 624-626). Given the inherent uncertainties associated with risk, we have to accept that risk information is unlikely to represent the "real" risk. Instead, this information constitutes descriptions of risk, which are more-or-less-well founded and are contingent upon the background knowledge possessed by the person conveying the description (e.g., knowledge about the typical consequences associated with different hazards or measures and resources available to prevent and manage disasters). This division between objective and subjective reality, as proposed by both Hansson (2010) and Aven (2010), resonates with the philosophical approach of critical realism, which is explained further in Section 4.2.

2.2. Vulnerability

The level of risk can be determined by the degree to which an entity of interest (e.g., a system, an object, a community, or an individual) is exposed and vulnerable to a particular hazard (Cardona et al., 2012, p. 69; Kron, 2002; Tomas et al., 2015; UNISDR, 2013). A hazard is "a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation" (UNISDR, 2016, p. 18). "Exposure" is generally understood to mean being present in a hazardous area and thereby being subject to potential losses (UNISDR, 2009, p. 15), whereas "vulnerability" can be defined as "a propensity to loss" (Buckle, 1998, p. 23) or "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard" (UNISDR, 2009, p. 30).

An entity's vulnerability is determined by a combination of its inherent characteristics and its (in)ability to cope with the hazards that it is exposed to (Cardona et al., 2012). Inherent characteristics (such as the size, material, shape, and weight of objects; the extent, geophysical setting, demography, fiscal capacities, and social capital of jurisdictional areas; or the gender, age, education, language, physical, and mental abilities of individuals), influence the entity's sensitivity to damage (cf. Buckle, 1998; Cannon, 1994; Cutter, Mitchell, & Scott, 2000; Fordham, 2003). Vulnerability is also linked to "coping capacity" (Adger, 2006; Carpignano, Golia, Di Mauro, Bouchon, & Nordvik, 2009; IFRC, 1999, p. 11), which UNISDR (2016, p. 12) define as "the ability of people, organizations and systems, using available skills and resources, to manage adverse conditions, risk or disaster."[c] To this end, an entity's vulnerability may be reduced by its own abilities or by those of other actors who may contribute to, or cater for, its safety (so, while the vulnerability of individuals is affected by their inherent qualities and own preparations, this vulnerability may also be reduced by assistance from neighbors or provision by public authorities, such as the development and maintenance of infrastructure or the procurement of resources to assist citizens in need). Whether internal or external, coping capacity is dependent on financial and material resources, as well as the knowledge and will to use those assets for DRM purposes.

This understanding of vulnerability and its relationship with risk is portrayed in Fig. 2-1. It is also consistent with the definition given by Nilsson (2010, p. 17), who contends that vulnerability can be understood as "the incapability of a person, group, object or system or some other phenomenon to withstand and manage crises and emergencies that arise from specific internal or external factors and that may threaten what is considered valuable and worth protecting." This definition incorporates the words "crises" and "emergencies," but these could be exchanged with "disasters," "extraordinary events," or any other labelling of distressful situations that may threaten what one aims to protect (ibid). As with the definition of risk presented above, this definition of vulnerability also stresses the importance of values and interests that direct our focus of attention (i.e., are decisive for which entities are deemed important to protect and, hence, are incorporated within RVAs).

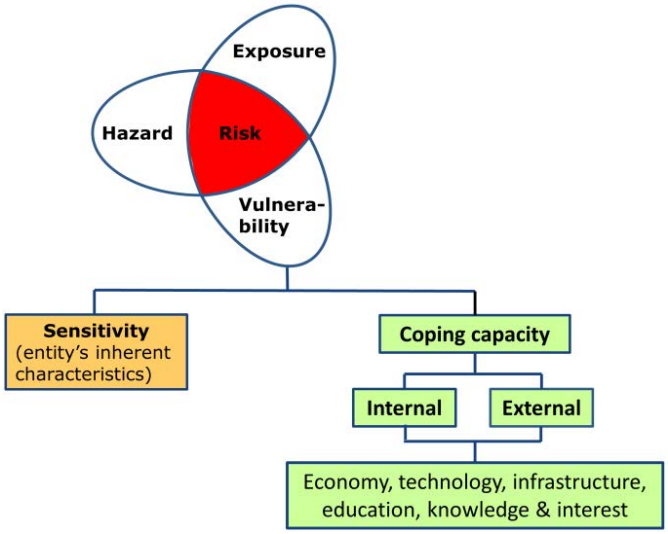

Fig. 2-1. Multi-dimensional view of risk, as determined by an entity's exposure and vulnerability to a particular hazard, where vulnerability is linked to: 1) inherent characteristics, 2) internal coping capacity, and 3) external coping capacity.

Importantly, vulnerability is not a static condition, but a relative and dynamic trait (Cardona et al., 2012, p. 70; Feldbrügge & von Braun, 2002). This is partly because the influence of inherent qualities and coping capacity differs, depending on the types of hazards and the course of events (Adger, 2006; Becker, 2014, p. 141; Buckle, 1998; Wisner et al., 2004). For instance, older persons may be more vulnerable than young in situations that require physical strength (e.g., during evacuations) but their extensive experience may lend a comparative advantage in other cases (Buckle, 1998). Likewise, objects, buildings, critical infrastructures, and DRM systems may be less vulnerable to certain hazards and scenarios than others (Carpignano et al., 2009). This is also why it is important to specify scenarios as bases for RVAs (cf. Section 3.2.1): contextual factors are decisive for the management and consequences of events.

Essentially, vulnerability (and, hence, the degree of risk) is something that we can affect. We may, for instance, reduce exposure by moving out of harm's way or using different forms of barriers (e.g., levees, shelters, protective clothing) to separate the threat from what is to be protected (Cardona et al., 2012, p. 69; Haddon, 1980; Wisner et al., 2004). We may also reduce vulnerability by investing in things that could increase our coping capacities (e.g., improving methods of anticipating events and learning from events; installing communication systems; conducting training and exercises; enacting collaborative agreements with external actors). Hence, there are no "natural disasters"; only natural hazards that may or may not induce disasters, depending on human action or inaction (Cannon, 1994). Conducting risk and

vulnerability assessments is essential to be able to manage disaster risk proactively as their main objective is to identify ways to decrease exposure and enhance coping capacity in relation to different hazards. If we are successful in identifying and implementing such ideas, then we may also reduce the likelihood and consequences of potential disasters—and, hence, reduce risk.

2.3. Risk Governance

Risk governance should be understood in the context of policy sciences, in which the notion of governance was introduced in the 1980s to broaden the perspective on policy making and acknowledge that governments are not the only (and, indeed, maybe not the most important) player in managing and organizing a society (Shiroyama et al., 2012; van Asselt & Renn, 2011). Many classic policy theories share a hierarchical orientation, with government as the central actor that retains power and control (Hill & Hupe, 2002). This is different in the governance perspective, which was propelled by globalization, increased international cooperation, the rise of non-governmental organizations, and the changing role of the private sector, which have gained importance incrementally regarding the provision of vital societal functions (Almklov & Antonsen, 2010; De Bruijne, 2006; Egan, 2009; Hood, 1991). While the governance regime does not preclude the influence of national governments, it emphasizes that power is distributed and perceives governance as consisting of non-hierarchical interplay between governmental institutions, economic forces, and various networks of civil-society actors (e.g., scientists, trade unions, think tanks, non-governmental organizations, and industry representatives) with divergent roles and objectives (Boholm, Corvellec, & Karlsson, 2012; Renn, Klinke, & Van Asselt, 2011). Adopted by the area of risk management, governance has been defined in relation to risk as "the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analyzed and communicated and management decisions are taken" (IRGC, 2006, p. 22).

The notion of *governance* is used both in a descriptive and a normative sense, where the former involves the mapping and depiction of stakeholders, their interests and the processes through which they engage. The International Risk Governance Council has also proposed a prescriptive framework on the implementation of standard elements within the management of risk (i.e., risk assessment, risk management, and risk communication), as well as the advocacy of certain values that are deemed conducive to collaborative efforts, such as transparency, accountability, interjurisdictional coherence, and participatory approaches (IRGC, 2006; van Asselt & Renn, 2011).

In tandem with critical realism and design science (cf. Sections 4.1 and 4.2), the risk governance framework stresses that peoples' risk perceptions vary according to their interests, values, knowledge, and experiences (IRGC, 2009, p. 17). These subjective contexts may consciously or unconsciously shape people's preferences while dealing with risks, and this is true not only for risk management professionals, but also for people in general (Renn, 1998). Proponents of risk governance reject the notion of the objective risk assessment, claiming that risk management professionals have to prioritize and make value-laden choices regarding elements such as the scope and focus of assessments, the methods and models used to assess and present risk, and which risk-reducing measures to advocate (Slovic, 2001). For this reason, it is of utmost importance that experts are explicit about the choices they make so that it is possible to understand and assess the validity of their conclusions (Aven, 2010; OECD, 2003, p. 87). The impact of subjective elements in risk assessments can also partly be counteracted by letting a team of experts with differing types of knowledge and experience carry out assessments together. Besides, different competencies are often needed in order to thoroughly analyze and understand complex problems (IRGC, 2009, p. 13; OECD, 2003, p. 97).

However, risk management professionals are not the sole source of knowledge necessary to understand and mitigate threats to societal safety. Managing risks in a holistic and sustainable way, it is argued, requires a participatory approach, in which all relevant stakeholders (producers, assessors, managers, and bearers of risk, including the general public) have a chance to provide input to the process (Carpignano et al., 2009; van Asselt & Renn, 2011). This is of moral and practical importance. First, it gives people at risk a say on the tolerability of the risk and what to do about it. While this is important for democratic and ethical reasons (and, hence, could be regarded as an end in itself), it also increases the legitimacy of policy decisions and reduces the risk of costly and time-consuming litigation (Boholm et al., 2012; IRGC, 2009, pp. 19-21; Renn et al., 2011). A participatory approach may also enhance the outputs of risk assessment processes as it offers the opportunity to obtain vital information that the local population alone may possess (e.g., past experience of hazard-related events, available resources, existing coping strategies, and the locations of vulnerable people). Aside from this, the quality of experts' analyses is purportedly enhanced through processes in which the conclusions reached have to be explained and justified to the public, with opportunities for public feedback being given (Slovic, 2001). Yet, the time needed for deliberations with the public and other pertinent stakeholders is a major challenge (IRGC, 2009, p. 20; Löfstedt, 2005, p. 11).

However, Klinke and Renn (2002) propose that the relative involvement and influence of experts and laymen in risk management processes can vary and be tailored to the characteristics of the risks themselves. Risk governance literature differentiates between *simple* and *systemic* risks (Löfstedt & van Asselt, 2008; OECD, 2003; Renn et al., 2011). *Simple* risks are characterized by low degrees of complexity,

uncertainty, and ambiguity.[10] They are typically correlated with high probability/low consequence types of events, such as single vehicle accidents, house fires, drownings, or falling accidents. The frequency of these events has amounted in a wealth of empirical data that can be used as basis for risk assessment, as well as for cost-benefit analyses to appraise the viability of different risk-reduction proposals. Moreover, the management of simple risks is often a top-down and technocratic affair that seldom involves deliberations with stakeholders beyond the authorities that are directly involved in proposing, funding, or implementing measures to reduce the risks. The general public is often treated as the passive recipient of risk-reducing regulations or information campaigns to raise awareness about risk.

Systemic risks, on the other hand, are situated on the other end of the risk spectrum. They are typically associated with low probabilities and disastrous consequences that threaten the functionality of the systems upon which human societies depend—e.g., health, transport, environment, and telecommunications (OECD, 2003, p. 30; Renn et al., 2011). Systemic risks are characterized by high degrees of complexity, uncertainty, and ambiguity, which make them difficult to foresee, model, and quantify (OECD, 2003, p. 88). Proponents of risk governance advocate that these types of risks must be managed by participatory approaches and a mix of scientific knowledge and stakeholder interests, values and perceptions (IRGC, 2009, p. 13; OECD, 2003, p. 270; Renn, 2011). This entails open and transparent deliberation between scientists, risk management professionals, decision makers, industry representatives, civil society organizations, and the public to ensure that risk management options are evidence-based, yet accepted by as many parties as possible.

The spectrum between simple and systemic risks is wide and contains an unpredictable number of risks to societal safety with different degrees of complexity, uncertainty, and ambiguity. Klinke and Renn (2002) propose that different management strategies should be used in accordance with the relative presence of these three qualities (where the dominance of complexity and uncertainty generally calls for stronger efforts by experts and scientists to reduce epistemic uncertainty, and great ambiguities justify more deliberative and inclusive approaches). While their propositions may suggest a rational balance between the influence of scientific knowledge and laymen's perceptions, it is obvious that one cannot involve everybody that is affected by risks in the process of managing them. It is notable that the risk governance framework is vague to the point of being void in relation to questions about how to select representatives from the public and how to extract their opinions. The framework has also been criticized for being too generic and decontextualized as

[10] *Complexity* refers to difficulties with identifying and quantifying causal interactions amongst multiple potential agents, and, thus, determining specific outcomes. *Uncertainty* implies insufficient knowledge about the likelihood and consequences of events. *Ambiguity* suggests multiple, and often contradicting, interpretations of the level of a risk and how to address it (IRGC, 2009, p. 11; OECD, 2003; van Asselt & Renn, 2011).

it fails to consider the socio-cultural dynamics of governance, in which, for example, a high degree of trust between regulators and the regulated may offset the need for deliberation with the public. Importantly, Boholm et al. (2012) and Löfstedt (2005) claim that Sweden represents a special case due to its consensual style of regulation and the high level of public trust in science and authorities, which may explain the relatively low degree of public involvement in, and contestation of, the governance of risks to societal safety. Yet, risk governance is relevant in the present context as it addresses and offers insights into many other aspects of the Swedish DRM system, such as governance in a highly distributed decision-making context, the focus on large-scale risks to societal safety, and the inherent uncertainties involved in assessing them. That is not to mention the advocacy of cross-sector and multilevel approaches to DRM that permeates Swedish DRM policies (Lindberg & Sundelius, 2013). Let us now take a closer look at the functioning and structure of this system.

3. Disaster Risk Management in Sweden

3.1. Coordination Structures and Principles

The governance system in Sweden is a blend of top-down and bottom-up approaches, wherein Parliament makes the laws and the Government implements them, with the help of various governmental authorities at national and regional levels. However, these governmental authorities enjoy a great deal of autonomy, in terms of the ways that they choose to follow legislation. For instance, the central Government (ministers) cannot dictate how an authority carries out its obligations. Likewise, national or regional governmental authorities may not intervene in the ways that municipalities choose to handle their responsibilities—e.g., schools, home care services, water, electricity, and rescue services (County Administrative Boards of Sweden, 2018).

The Swedish DRM system involves authorities from all levels of government (national, regional, and local).[d] Whereas the Ministry of Justice carries the overall political responsibility for DRM, the Swedish Civil Contingencies Agency (MSB) is tasked with coordinating the measures that various authorities take before, during, and after emergencies and disasters. Coordination is not equivalent, however, to leading. In fact, in Sweden, it is the municipalities at the local level that are the central players in dealing with disasters. This set-up is reflected and fostered by three guiding principles: proximity, parity, and responsibility (Governmental bill, 2002, p. 22 based on Swedish Government Official Report, 2001 p. 79-80).

The *proximity* principle states that crises and emergencies should be handled where they occur and by those who are closest to them. This typically means at the lowest level of public authority—i.e., the municipalities. Authorities at regional and national levels may support the municipalities with advice and equipment, but the municipalities are expected to assume a primary role in leading the efforts. The *parity* principle implies that localization and organization of activities should, as far as possible, be the same during crises or emergencies as under normal conditions. The principle of *responsibility* entails that whoever is responsible for an activity in normal conditions should maintain that corresponding responsibility during crises or

emergencies (in other words, there are no special disaster-management entities that enter the scene and take over the responsibilities of other players).

The principle of responsibility also encompasses an obligation to cooperate with external players in order to reduce risk or handle ongoing emergencies. To this effect, municipalities, county boards and the government carry a *geographical area of responsibility* that obliges them to coordinate all the actors within their geographical areas (i.e., the municipality, the county, and the country as a whole) that may be affected by or involved in the handling of a disaster. This responsibility is cross-sectorial and applies to measures taken before, during, and after the occurrence of potential disturbances to societal functionality (Government bill, 2008, p. 92). Fig. 3-1 depicts how responsibility for vital societal functions is divided amongst governmental authorities at national and regional levels, local municipalities, and private actors. It also illustrates the cross-sectorial geographical areas of responsibility designated to the central government, regional county administrative boards, and local municipalities.

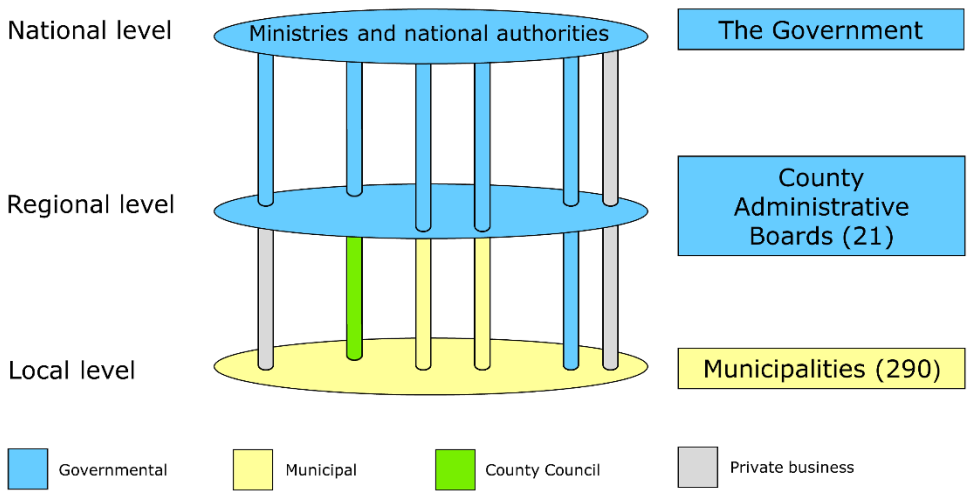

Fig. 3-1. Division of responsibilities for DRM and vital societal functions in Sweden
The geographical area of responsibility is cross-sectorial and exists at three administrative levels. The owners and providers of vital societal functions vary across sectors (vertical bars), with the state being the sole actor in some sectors (e.g., the police and defense), while, in other cases, state responsibility is shared with the municipalities (e.g., water management, rescue services), county councils (e.g., health) and private businesses (e.g., electricity networks). In some sectors (e.g., telecommunications), the vital societal functions are owned and operated solely by private actors (the figure is an adapted version of an illustration in Försvarsmakten, 2016, p. 34).

To enhance interagency cooperation at the national level, the MSB has also created six so-called *forums for crisis preparedness* (MSB, 2014b), at which national authorities with shared responsibilities meet and the collaboration that is required is facilitated to

ensure the functionality of operations within certain societal domains (e.g., transport, financial systems, technical infrastructures, etc.). Collaborative forums also exist at regional and local levels. For instance, three different regional forums—Sydsam, ÖSAM, and Nordsam—have been established by county administrative boards to bring together representatives from the southern, middle, and northern areas of Sweden, respectively, facilitating the exchange of knowledge and experience in a number of fields, including DRM. In addition, most county administrative boards and local municipalities have established crisis management councils that bring together both public and private organizations to support preparedness measures and operations during response and recovery. Inter-organizational cooperation supplements the activities that individual authorities undertake, thus fostering robustness within these operations more broadly. The production and communication of RVAs is central to these efforts.

3.2. The RVA System

According to Swedish legislation (SFS, 2006, 2015) all municipalities, county councils, and county administrative boards,[e] along with a number of national authorities, are obliged to carry out risk and vulnerability assessments (RVAs) to identify and assess risk and vulnerabilities within their areas of responsibility. RVAs are important planning tools and provide a foundation for decisions on measures to ensure societal safety. In fact, the RVA system has multiple purposes and, although the phrasing may vary across different documents (e.g., MSB, 2012, pp. 15-16; SFS, 2006, 2015; Swedish Government Official Report, 2004, p. 89), it is possible to summarize the main general expectations as follows:

- Produces a basis for the planning and implementation of risk-reducing measures
- Increases disaster preparedness at individual authorities and in society more broadly
- Increases awareness and knowledge of risk amongst decision makers and the general public
- Generates a comprehensive overview of risks, vulnerabilities, and disaster risk management capabilities at all levels (local, regional, and national)[f]

Hence, it is clear that RVAs are supposed to support preparedness work at individual authorities, as well as in society in general.

In addition, the legislation stipulates that RVAs should focus on extraordinary events, which has a bearing on both the processes and methods employed. Extraordinary

events are associated with a low likelihood and substantial damage to societal functionality (see definition in footnote 8). In essence, risks associated with extraordinary events are akin to "systemic risks" (see Section 2.3.) and as such, difficult to assess. Given the poor statistical basis and the multitude of possible indirect effects (due to the complexity of the interconnected web of sectors and vital societal functions), it is not viable to assess such events using mathematical formulas developed for industrial risk within well-defined technological systems (An, Qin, Jia, & Chen, 2016; Aven, 2010, pp. 629-630; Démotier, Schön, & Thierry Denoeux, 2006; van Asselt & Renn, 2011). Rather, one is left with expert judgments and qualitative assessments or simple quantitative assessments (e.g., using intervals instead of point estimates—see paper I), the quality of which is dependent on the collective experience and knowledge possessed by the individuals who perform them (MSB, 2012). Since extraordinary events typically transcend sectorial and geographical borders, they require a holistic approach that uses information from numerous stakeholders, if their complexity is to be captured (IRGC, 2009; MSB, 2012).

3.2.1. The Typical RVA Process used by Swedish Authorities

Since RVAs are a central part of this thesis, it may benefit the reader to understand how Swedish authorities typically carry them out. The description here is based partly on my own experiences as a participant in/facilitator of a number of RVAs at Swedish authorities, as well as on guidance booklets issued by the MSB (2012, pp. 37-57), its predecessor, (SEMA, 2003a, pp. 30-36; 2006a, pp. 23-39; 2006b, pp. 15-54), the Swedish Defence Research Agency (FOI, 2011), and Lund University Centre for Risk Assessment and Management (Hallin, Nilsson, & Olofsson, 2004, pp. 19-26). Whilst acknowledging that many authorities may conduct RVAs in ways that differ from this portrayal, the intention is to elucidate the general elements of RVAs and the process that tends to be used to implement them. It is also important to point out that the description refers to assessments of extraordinary events, in accordance with SFS (2006, 2015); it does not apply to risk assessments that authorities conduct on the basis of other legislation.

RVA processes can generally be divided into three phases: preparation, analysis, and communication of the results. At the beginning of the work process, it is recommended that Swedish authorities appoint a process leader and a group of experts representing different organizational units in order to ensure that the assessment addresses all core areas of the authority's responsibilities (MSB, 2012, p. 39; SEMA, 2003a, p. 12; 2006a, pp. 23-24). Using a cross-functional group of assessors also facilitates the identification of risks, capability[11] gaps, and duplications,

[11] I use the terms *capacity*, *capability*, and *ability* interchangeably to denote the extent to which an actor possesses knowledge and material resources to obtain certain objectives.

as well as the mapping of internal and external suppliers of critical goods and services (SEMA, 2006a, p. 27). In addition, it is instrumental in the creation of networks and trust between the representatives of various functions, which can enhance the capacity to manage complex situations (Hallin et al., 2004, p. 24; Hassel, 2010, pp. 92-93; Nilsson, 2010, p. 22). Once assembled, the group embarks on a process similar to the one illustrated in Fig. 3-2.[g]

A fundamental step in any RVA is to define the values that one seeks to protect (step 1). These values will be decisive for the types of consequences (dimensions) that the assessment will embrace (MSB, 2012, p. 40). Amongst Swedish authorities, it is common to include life and health, the environment and the economy (cf. paper I), but the authorities can choose which dimensions they prefer as the RVA regulations do not stipulate what must be included here.[h]

The next step is to define the scope of the assessment in terms of time and space. This entails defining the time period that should be used as basis for assessing the likelihood and consequences of risk scenarios, and also involves delimiting the functional or geographical areas that should be assessed (which, where authorities are concerned, typically coincide with their legal responsibilities—SEMA, 2006a, p. 10).

Establishing these analytical boundaries is crucial for identifying the entities (e.g., people, objects, systems, and functions) that one needs to protect in order to safeguard the overall values, as stipulated in step 1.

These entities and their dependencies are subsequently described in text or by functional and structural models (MSB, 2012, p. 42). Defining the analytical scope is also essential for identifying the hazards which may threaten these entities (step 4).

Fig. 3-2. Common components and steps in the RVA processes

Note: the figure should be read from the bottom up, thus indicating that values are fundamental to the RVA process and outputs.

The identified hazards are often categorized according to risk source (e.g., natural hazards, technological failures, antagonistic threats, etc.) and assessed roughly in terms of their potential consequences and likelihoods (the outputs of these assessments are often visualized with the help of risk matrices).[i]

The hazards associated with the biggest risk are prioritized (step 5) for a more detailed analysis[j]. Before this, however, most authorities elaborate specific risk scenarios[12] (step 6), which help to frame the subsequent analysis of existing capabilities to withstand and manage the hazard. The scenarios include information on decisive factors for the types and magnitude of the consequences that may arise as well as for the possibility to manage the events (e.g. affected area or location of event, time of year/day, temperature, wind direction and speed etc.). The scenarios function as points of reference, without which it is difficult to assess whether existing capabilities are sufficient. They also enable measures to decrease vulnerability to be identified (paper I).

Having identified the existing capability to prevent, mitigate, respond to, and recover from the scenario (step 7), it is possible to identify and assess the types and magnitude of the consequences in relation to the values that were deemed important to protect (step 8).[k] During these discussions, it is common (and, indeed, desirable) for the participants to identify additional measures to enhance capability and, thereby, reduce risk. The assessment concludes with prioritizing these different ideas via a discussion regarding their potential costs and benefits (step 9). The process ends with a presentation for the decision-makers, who decide on which risks to address and how (step 10). In addition, the main findings of the RVA should be compiled in a report and communicated to external stakeholders, in accordance with SFS (2006, 2015), as described below.

3.2.2. Communication of and Feedback on the Results of RVAs

The process through which Swedish authorities produce their RVAs is in line with the overall bottom-up approach to DRM, where municipal RVA reports are used as bases for assessments carried out by regional county administrative boards, which, in turn, are fed into RVAs at the national level. Based on the RVA reports communicated by county administrative boards and other national authorities, the MSB is supposed to enact a cross-sectorial, national RVA that depicts risk and vulnerabilities across Sweden as a whole. Finally, government offices (and primarily the Ministry of Justice) are briefed on the contents of the national risk assessment, in

[12] A *risk scenario* is "a representation of one single-risk or multi-risk situation leading to significant impacts, selected for the purpose of assessing in more detail a particular type of risk for which it is representative, or constitutes an informative example or illustration." (Commission European, 2010, p. 12).

addition to receiving RVA reports from individual national authorities and county administrative boards. Conversely, authorities at national and regional levels are expected to provide feedback on the information they receive from authorities at lower administrative levels, and to communicate their own picture of risk and vulnerabilities to external actors. These processes are illustrated by Fig. 3-3.

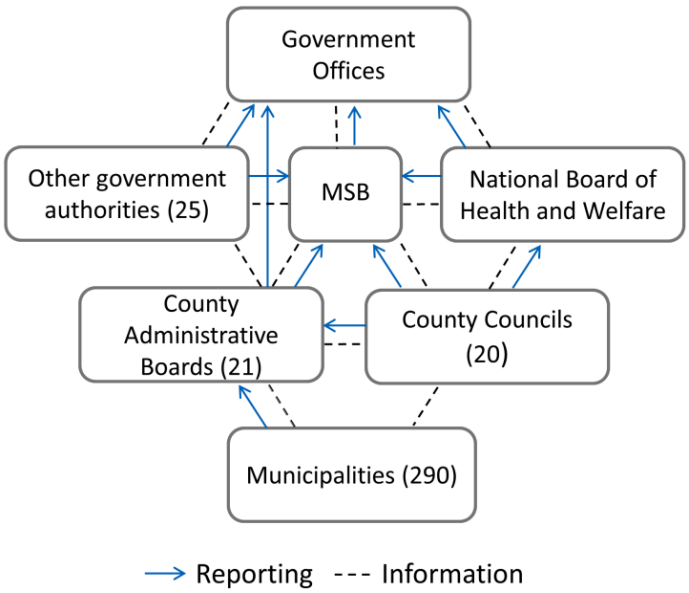

Fig. 3-3. The flow of risk information and RVA reports in Sweden
The numbers in brackets represent the number of units of different types of stakeholders involved. The dashed lines indicate two-way communication involving, e.g., feedback, requests for clarifications and supplementary information (adapted from MSB, 2012)

As illustrated by Fig. 3-3, the quality of individual RVAs, and, indeed, the overall output of the RVA system, is dependent on the abilities of authorities to exchange information with a variety of actors. The system requires vertical and horizontal exchange of information (i.e., municipalities and county administrative boards have to collect information from relevant public and private actors within their geographical areas, as well as collecting and conveying information across administrative levels). Such processes naturally require that the results of individual RVAs can be communicated to, and understood by, external actors. Moreover, attaining an overview of risk at different administrative levels requires that the information attained from multiple actors (e.g., municipalities and county administrative boards) can be compared. A number of initiatives have been undertaken to enable this.

Following the introduction of the first RVA-related legislation in 2002, SEMA began work to develop a common methodology for RVA performance and the reporting of outputs. However, the idea was soon abandoned as it was not expected that a methodology would be produced that could accommodate the heterogeneous needs of the different stakeholders (SEMA, 2004, pp. 21-22). Besides, issuing compelling regulations concerning RVA methodologies did not comply with the bottom-up approach to DRM which recently had been established through the principles of responsibility and proximity. Instead, and with financial support from the Government, individual authorities, research groups, and consultant companies started to elaborate their own methods for assessing the risk of extraordinary events (MSB, 2012, pp. 63-76; SEMA, 2006a, pp. 43-44). This resulted in a number of varied approaches which produced heterogeneous data that were hard to compare and aggregate. Concurrently, SEMA issued a series of guidance booklets on how to carry out and report on RVA work (SEMA, 2003a, 2003b, 2006a, 2006b, 2008). However, this advice was only designed as a set of recommendations and, gradually, it became apparent that something had to be done to increase the possibility of using individual organizations' RVAs as a basis for generating comprehensive pictures of risk in society as a whole. Accordingly, in 2010, the Swedish Government granted MSB the right to issue compelling regulations to enhance the uniformity and comparability of RVAs produced by different authorities. The regulations (MSB, 2010a, 2010b) set out a common structure for RVA reports and focused on the presentation of information, rather than on the production of it (i.e., the regulations refrained from stipulating a certain RVA methodology).

The effects of these regulations were later evaluated and found to have increased uniformity, in terms of how the reports were structured; large discrepancies remained, however, with regard to their substance (Abrahamsson et al., 2012; Eriksson, 2012). The regulations have since been updated and supplemented with an appendix, which clarifies the information that is sought in relation to each of the points that the RVA reports need to address (MSB, 2015a, 2015b, 2016). In addition, the new regulations have an expanded glossary to unify the ways in which different stakeholders perceive key terms. National authorities and county administrative boards have also been granted more time to produce RVAs (they now generate reports at 2-year intervals, as opposed to yearly). Municipalities and county councils complete the process once every 4 years. Since municipalities and county councils have not yet based their RVAs on the new regulations, it is still too early to assess whether or not the new regulations have increased the uniformity of the information that authorities at different levels convey.

Aside from updating the regulations, the MSB has also developed a new digital reporting system, which is intended to protect sensitive information better, streamline the structure and content of RVA reports, and facilitate the sharing of the information between different stakeholders in the DRM system (MSB, 2015c).

During my PhD studies, I have taken part in evaluating a prototype of the tool and could clearly see its benefits from the perspective of aggregation; there is also a need, however, to make the tool more attractive for individual organizations to ensure that they would use it as otherwise there will be no information to aggregate (Månsson, 2014). The first version of the reporting tool has since been developed—currently, its use is voluntary, and it remains an open question as to whether its intended effects will be realized. In any case, the MSB has not deemed it viable to base the national risk assessment solely on the RVAs that regional and national authorities produce. Since the introduction of the EU requirement for the production of national RVAs, therefore, the MSB has organized a series of workshops to attain an overview of risk and vulnerabilities in relation to certain scenarios of national concern (MSB, 2016b). These workshops have included representatives from all levels of government, as well as private enterprises and organizations, and are a good complement to (but not a substitute for) individual RVAs (paper I).

This account of the Swedish RVA system and its development reflects a delicate struggle to balance the needs of individual organizations with the ambition to use their RVAs as input for a holistic understanding of risk in the country overall. Following this contextual background, the next chapter presents the process, tools, and materials that were employed to understand and further enhance the possibility of aggregating disaster risk information from multiple stakeholders.

4. Research Process and Methodologies

4.1. Design Science

The research underpinning this thesis has been conducted in line with the design science approach. The notion of design science was introduced by Simon (1996, original work published in 1969), who initiated a discussion about the differences between traditional explanatory sciences (natural and social sciences) and the "sciences of the artificial" (design sciences). The former aim to obtain knowledge in order to explain, describe, and predict the behavior of *existing* systems and objects, whereas the latter aim at improving situations by inventing *new* things to meet unfulfilled needs (Simon, 1996, p. 114; van Aken & Romme, 2012). Whilst emphasizing prescriptive knowledge, design science also draws upon traditional sciences where relevant because development efforts must be based on an understanding of the cause-effect relationships related to the situation one wants to improve. As such, design science embraces descriptive *and* prescriptive elements, and offers useful models for both types of research (Baskerville & Pries-Heje, 2010; Gregor & Jones, 2007; Walls, Widmeyer, & El Sawy, 1992; van Aken & Romme, 2012).

Contemporary definitions of design science suggest that it is "the scientific study and creation of artifacts as they are developed and used by people, with the goal of solving practical problems of general interest" (Johannesson & Perjons, 2014, p. 7). While design science is applied most often in the context of designing and constructing physical artifacts and systems,[13] several researchers argue that it can also be used in the process of developing methods, since methods *per se* can be viewed as abstract systems of thought/concepts aimed at solving particular problems (Checkland, 1993; Gregor & Jones, 2007; Hevner, March, Park, & Ram, 2004; March & Smith, 1995). In the present context, the artifacts of interest are the Swedish RVA system (its structures, processes, tools, methods, associated legislation, and outputs), and existing and prospective means for supporting the system.

[13]The term *artifact* is used here to describe something that is artificial or constructed by humans, as opposed to something that occurs naturally (Simon, 1996). In this thesis, the term is utilized to refer to physical and conceptual objects (e.g., products and tools or methods and systems) created by humans to reduce disaster risk.

The two main research activities related to design processes are *building* and *evaluating*, where building is "the process of constructing an artifact for a specific purpose" and evaluation is "the process of determining how well the artifact performs" (March & Smith, 1995, p. 254). Design research commonly starts with definition of the purpose(s) of the prospective artifact, followed by an examination of why (and to what extent) *existing* tools, methods, or systems fail to meet that purpose. This knowledge is then used in the establishment of a set of *design criteria* (i.e., required functions) that correlate with the purpose and will guide the development of new artifacts. Ideally, the purpose, design criteria, and construction of artifacts should be elaborated and established through an iterative process that involves mediation between the needs of potential users, the existing "knowledge base" (e.g., previous research and existing methods related to the problem at hand), and the potential constraints inherent in the socio-political environment in which the artifact will be used (e.g., legislation and policies). As proposed in Fig. 4-1, a successful balance between these elements will ensure the relevance and rigor of the proposed solutions (Hevner et al., 2004). Such solutions may be expressed initially as *design propositions*—i.e., *if you would like to achieve A in context B, do something like C*—before materializing as models or samples of artifacts (Denyer, Tranfield, & van Aken, 2008; van Aken, 2004). It is essential to note that an artifact may stem from a combination of various design propositions.

Design science stresses the need to investigate and explain *generative mechanisms*, i.e. *why* particular interventions lead to prospected outcomes and not only observe and state that something "works" (Denyer et al., 2008; van Aken, 2004). Testing and evaluating design propositions and artifacts are important for being able to acquire knowledge about cause-effect relationships. When doing so, it is important to consider (and sometimes replicate) the context in which the design proposition or artifact is intended to be used, since adherence to contextual aspects is a key part of the development process (Carlsson, Henningsson, Hrastinski, & Keller, 2010; Gregor & Jones, 2007, p. 325; cf. "the environment" in Fig. 4-1). Design propositions and artifacts may be tested and evaluated in different ways. Carlsson et al. (2010, pp. 117-119) differentiate between alpha (α), beta (β), and gamma (γ) types of evaluation, where α-tests are performed by those engaged in the development of the artifact and are based on discussions about whether a prototype or proposition meet the design criteria, while β-tests entail that researchers who are independent of the development process scrutinize the (tentative) artifact and assess the validity of the assumptions (including design criteria) which guide the development process. Finally, γ-tests are fully fledged try-outs of the finalized artifact by its projected users in its intended context and for the purposes it was meant. Naturally, γ-tests are the strongest form of evaluation, but the other types of tests can be performed along the way during the incremental process of refining ideas and products, and changing the actual into the preferred state of affairs. Hence, α and β-tests may induce amendments that lead to

modifications to the product or idea, which are then tested and evaluated. This iterative process is depicted in Fig. 4-1 and is a process that continues until the researchers find outcomes that are satisfactory in relation to the given design criteria (Hevner et al., 2004; van Aken & Romme, 2012).[1] The word *satisfactory* is of importance here as it reflects the difficulties in finding *optimal* solutions to complex problems (such as aggregating information about disaster risks from multiple stakeholders), given that they entail numerous challenges that can be addressed in an infinite number of ways. Indeed, it is unfeasible to identify all potential design solutions, let alone to compare their relative merits (Gregor & Jones, 2007; Hevner et al., 2004; Simon, 1996, pp. 119-121).

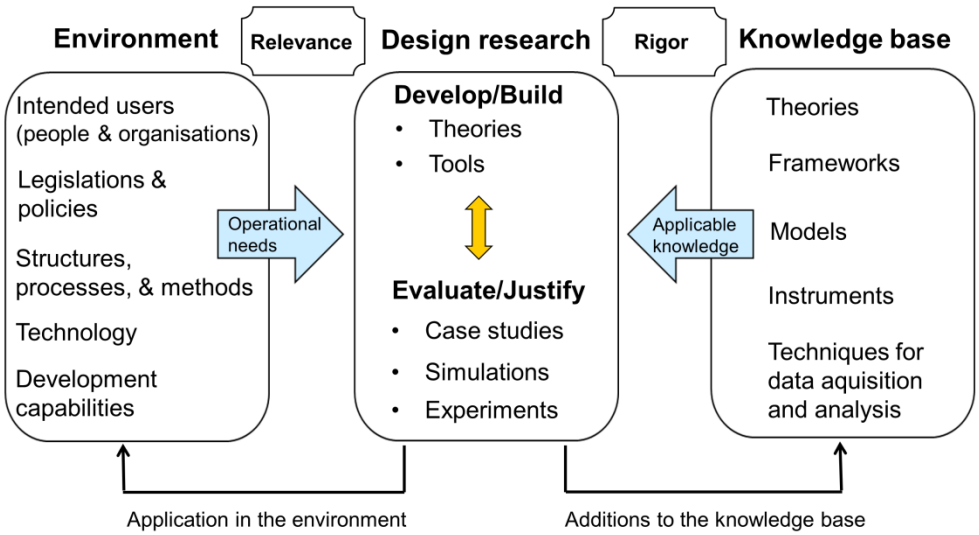

Fig. 4-1. A conceptual framework for design science, as adapted from Hevner et al. (2004).

When building and evaluating design artifacts and propositions, it may be useful to employ Rasmussen's (1985) abstraction hierarchy, which forms a basis for the logic of design and identifies five different levels of system representation, starting from the concrete, physical appearance and ending with the overall functional purpose. However, for the purposes of this thesis, it is sufficient to use a simplified version of Rasmussen's model, as proposed by (Brehmer, 2007, pp. 212-214), which consists of three levels. These levels are also linked to questions used to describe the artifact from different perspectives. The highest, most abstract, level is represented by the *purpose*, and answers to the question of *why* the system or artifact was (or should be) constructed. Next is the *function* level, which concerns *what* the system or artifact does (or needs to do) in order to fulfill its purpose. Finally, the *form* level relates to the question of *how* the system or artifact is constructed in ways that enable the

required functions to be performed. It is important to understand that an artifact or a system can have several purposes, and that these purposes may be met through a variety of functions and many more forms of the artifact or system. For instance, the purposes of a watch can include synchronizing activities and measuring how fast something or someone is, whereas the required functions may include the possibility of measuring time in hundredths of an hour, being portable, being luminous, and being water resistant. Naturally, such requirements can be met by numerous types of watches—i.e., variations at the form level, in terms of aspects like material, size, shape, and color. This type of reasoning can also be applied when studying systems and processes intended to support the coordination of human activities (such as the Swedish RVA system). In such endeavors, it is important to understand that a means-end relationship exists between the different abstraction levels, where lower levels exist to fulfill functions and requirements at higher levels, and, hence, a bottom-up approach might be necessary to identify the causes of system problems (Rasmussen, 1985). One may note that the means-end relationships between the abstraction levels represent generative mechanisms (or cause-effect logic) as mentioned above.

The design perspective can be useful in various different contexts. It can be used descriptively—i.e., to explain the characteristics and properties of systems and their components, and how they relate to each other. It can also be utilized to evaluate the performance of a system by comparing its outputs and purpose(s). Finally, it can be used normatively to suggest which components and processes are needed to fulfill intended purposes (Baskerville & Pries-Heje, 2010; Cedergren & Tehler, 2014; Walls et al., 1992). In the present thesis, the design perspective has been used for all of these purposes. The abstraction hierarchy utilized here has been instrumental in directing the research efforts and enabling the interpretation of results. It has also been helpful in the process of ensuring that all abstraction levels were considered, when investigating challenges within the Swedish RVA system and potential measures to enhance the aggregation of risk information therein. In line with the overall design approach, the ambition has been to produce findings of high relevance and rigor by obtaining knowledge about the environment and the knowledge base through a combination of extensive interactions with DRM professionals and thorough investigations of scientific literature related to the problems observed.

4.2. Philosophical Assumptions

Philosophical assumptions are important because they influence how knowledge is created and form the basis for research paradigms, which rationalize and legitimize what is considered valid knowledge (Niehaves & Stahl, 2006). The philosophical perspective that corresponds best with the work underpinning this thesis is *critical*

realism, as introduced by the English sociologist Bhaskar in the 1970s (Bhaskar, 1975, 1979; Collier, 1994).[m] With regard to ontology (i.e. questions about the nature of reality, the entities that exist, and how these entities relate to each other) and epistemology (how we can obtain knowledge about that reality), critical realism holds a middle ground between positivism and constructivism. Positivists believe that there is a single reality that can be measured and known, preferably by quantitative methods, and keep an objective and "value-free" distance from the objects of study (Grant & Giddings, 2002). Constructivists, on the other hand, deny the existence of a single or "true" reality. For them, multiple interpretations of reality exist, which can be disclosed best by the use of qualitative methods and often necessitate close interaction with the study objects (Johannesson & Perjons, 2014; Scotland, 2012).

Critical realism combines ontological realism with epistemic relativism, and highlights the aspiration of mind-dependent subjects to understand a mind-independent world (Archer et al., 2016). In conjunction with a positivist stance, critical realism suggests that a real world exists beyond the perception of our senses (hence the word "realism"). However, akin to constructivism, this theory also asserts that we are incapable of viewing the world in a non-biased way and that we perceive it in accordance with our awareness, knowledge, and experiences. Since people vary in these regards, they will carry subjective—and often divergent—perceptions of the objective world (Healy & Perry, 2000). Moreover, as we cannot detach ourselves from our sensory filters, it is not possible for us to determine how far our subjective interpretations of reality are from the real, objective world (Easton, 2010). It is also impossible for researchers to discern their own biases and their magnitude. Researchers need to be aware of this and must try to counteract it by remaining critical (examining) regarding the observations and information they obtain through their research—and, indeed, their own interpretations of such material (hence the word "critical"). This means, *inter alia*, that researchers' conclusions may diverge from the positions of their informants, and different interpretations and extrapolations of the information received may be made. It also suggests that researchers should triangulate by using multiple informants and methods (qualitative as well as quantitative) to obtain answers to their research questions (Archer et al., 2016; Robson, 2002, pp. 370-373). Critical realism holds that we will be able to understand (and change) phenomena only if we identify the mechanisms that generate them. The critical-realist position thus stresses the value of *abduction*, i.e., engaging in an iterative cycle of knowledge-producing activities, moving from observations of unexplained phenomena to proposing hypotheses regarding their generative mechanisms (e.g., why and how an artifact works). These hypotheses are tested subsequently through further observations, which may strengthen the hypotheses or prompt generation of new ones, and so on (Archer et al., 2016; Carlsson, 2006; Easton, 2010; Johannesson & Perjons, 2014).

In essence, critical realism offers a perspective that can guide a researcher in the sense of offering an overall strategy to produce knowledge, but it does not constitute a tangible method through which to conduct the research *per se* (Archer et al., 2016; Uppström, 2017). Here, design science can be employed in a complementary role as it concretizes the process of knowledge production and shares important premises with critical realism. First, critical realism assumes an emancipatory axiology—i.e., it includes the notion that research ought to be used for the benefit of individuals and of societies more broadly (Easton, 2010). This correlates with the overall ambition of design science, which is to enhance situations by creating artifacts that reduce observed problems. Second, the abductive approach to research is particularly useful in relation to design science because the latter champions the circular process of developing and testing both artifacts and the hypotheses on generative mechanisms that underlie their design (Carlsson, 2006). In addition, design research often engages with ill-defined problems that are either too new or too complex to investigate by the use of deductive approaches, such as testing hypotheses through empirical observations. "Wicked" problems that entail numerous and dynamic interdependencies (such as the aggregation of risk information from multiple stakeholders) often require an iterative approach of framing and reframing problems, and probing tentative solutions, in order to understand and formulate hypotheses about causes and effects more effectively (Withell & Haigh, 2013). In relation to this thesis, the abductive approach was particularly significant when conducting LFA workshops as basis for paper III, and was also relevant in relation to the interviews underpinning paper I. To ensure the relevance and rigor of propositions, I also sought to follow the critical-realist axiom of triangulation by using several types of methodology and informant (cf. Section 4.4).

4.3. Research Process

This section presents the research process, focusing on the rationale of, and relationships between, the appended papers. In addition, it highlights a portion of the activities that I deem as having been formative for my research endeavors and scientific development. This section mentions the methodologies underpinning the different studies only briefly, as this will be accounted for further in Section 4.4.

At the outset of my PhD venture, I was fortunate to be engaged in a study commissioned by the MSB that was closely related to the research area I was about to enter. The study aimed to scrutinize the effect of the introduction of a new regulation in 2010, which sought to increase the uniformity and comparability of the RVA reports that Swedish authorities produce. Our task was to investigate developments at the local level. To this end, we compared RVA reports produced by municipalities in

the counties of Scania and Örebro before 2010 and in 2011, after the regulation had been introduced. The study was based on content analysis and an electronic questionnaire surveying perceptions of the new regulation amongst officials in charge of producing RVAs. The study concluded that uniformity had increased, in terms of how the reports were structured, but that it was difficult to detect significant differences regarding comparability (i.e., concerning the alignment of the substance under each headline, as proposed by the regulation). The study was reported to the MSB (Abrahamsson et al., 2012), but not used as basis for a scientific article at the time. Instead, I became engaged with reading on risk governance and design science, and examining previous dissertations written as part of the FRIVA program, a process which expanded my awareness of researchers and theories relevant to the challenges of risk aggregation. It also helped me to formulate a theoretical framework for my forthcoming research, which was presented and discussed at a conference in South Africa (Månsson, 2012).

During my first two years as a PhD student, I was engaged in different "real world" projects that, it was hoped, would provide useful insights into my research area. First, I took part in the development of a methodology aimed at enabling the Swedish National Food Agency to produce RVAs based on inputs from all major public and private actors involved in the production, distribution, or supervision of the food supply in Sweden (Engqvist & Wennerström, 2014). Second, I was part of the reference group of "ORSA," which was a two-stage project focused on the utilization of Geographical Information Systems (GIS) to support: 1) RVAs in individual municipalities and 2) aggregation and the production of regional RVAs based on inputs from several municipalities (Blom, Guldåker, & Hallin, 2013; Nilsson, 2015a, 2015b). During these projects, I acted partly as an observer but was also asked to take an active role in discussions, as well as to provide feedback on key project documents.

In addition, I participated in several workshops connected to two projects run by the MSB. The first was aimed at updating the RVA regulations based on user experiences and the other sought to develop a new software platform to enable the communication of RVAs across authorities at different levels. This new tool was supposed to enhance the information security and protection surrounding RVA reports, which, thus far, had largely been sent by email. An additional aim was to make the presentation of RVA information more unified and comparable (MSB, 2015c). The division of Risk Management and Societal Safety at Lund University was asked to test and review a pilot version of the software, after which I summarized our reflections and recommendations in a memorandum to the MSB (Månsson, 2014).

At the beginning of 2014, I began producing my first paper, which was based partially on the study conducted for the MSB in 2012. Given my interest in obtaining a "systems perspective," I decided to expand the study to incorporate all administrative levels within the Swedish RVA system. Hence, the previous study of

the impact of the RVA regulations at the local level was supplemented by new analyses of the effects of the regulations on RVAs produced by regional county administrative boards and national authorities. The results showed large discrepancies in the ways that authorities described risk, and it was also found that this creates many different negative effects at all levels of the RVA system. During the study, the ways that authorities described risk were categorized into five classes, reflecting the specificity with which they assessed the likelihood and consequences of scenarios (ranging from "no assessments" and "very lucid qualitative expressions" to "quantitative estimates"). Although the study showed that authorities prefer using qualitative ordinal and semi-quantitative scales, it could not reveal which of the five types of risk descriptions were best for the purpose of aggregating RVA information from multiple authorities. This required further investigation.

To explore the matter, my next study (paper II) comprised a series of experiments to elucidate how useful different combinations of risk descriptions (replicating the types identified in paper I) were perceived in relation to aggregation. The combinations consisted of risk assessments conveyed by two fictive municipalities, and participants were asked to rate how useful the combinations were for the purposes of: 1) comparing levels of risk at the municipalities and 2) making decisions on risk-reducing measures in the area covered by both municipalities (see Section 4.4.3 for details on the experimental set-up). In general, the study showed that combinations of similar types of risk descriptions (e.g., two qualitative or two quantitative) were considered more useful than mixed combinations (e.g., one qualitative and one quantitative), and that quantitative types of risk descriptions were preferable to qualitative ones. Moreover, the study elicited the value of narratives (i.e., background information providing a rationale for given assessments), which may counteract the difficulties inherent in combining risk descriptions of different types.

Whereas paper I focused on mapping the extent and character of disparate ways of describing risk in the Swedish RVA system, paper II sought to determine the effects of these differences on the perceived possibility of aggregating risk assessments from several stakeholders. However, both papers focused on a situation where the task was to synthesize information already obtained from external actors. As indicated already, aggregation also encompasses the quest to obtain information in the first place, which, in itself, may involve challenges. This prompted the development of paper III, which sought to identify and explore challenges related to other parts of the process of aggregating risk information. The research required access to persons with extensive and relevant experience, and a method to extract their knowledge. Where informants were concerned, officials responsible for producing risk and vulnerability assessments at county administrative boards seemed a perfect fit, as they need to produce and convey RVAs to national authorities based on the aggregation of several municipal RVA reports, as well as provide guidance and feedback to the municipalities on the generation and presentation of their RVA information (cf. Section 3.2). Regarding

methodology, I chose to make use of the Logical Framework Approach (LFA), which I was familiar with from my previous employment at the MSB. This approach is used widely within the field of development aid and is tailored to ensure that a participatory, systematic, and transparent process is utilized when identifying and mapping both the root causes of problems and the means to address them (the LFA methodology is explained further in Section 4.4.4). I also made use of the collaborative forums that county administrative boards utilize to discuss issues of common concern (see Section 3.1), and arranged three separate LFA workshops in conjunction with RVA meetings in Sydsam, ÖSAM, and Nordsam, respectively. These methods gave me the opportunity to acquire input from the officials responsible for RVAs at all 21 Swedish county administrative boards. The workshops centered on identifying challenges to the activities involved in the aggregation of risk information, as well as measures for handling them. The outputs were the basis of paper III and provided the foundation for the problem-and effect trees presented in Chapter 5.

The content analyses and interview studies for paper I and the LFA workshops for paper III provided a solid basis for identifying and comprehending challenges to the possibility of aggregating risk information within the Swedish RVA system. These studies were instrumental, therefore, in developing my understanding of the "environment" and for enabling the creation of design propositions for handling identified challenges (cf. Section 4.1). Some of these design propositions (hypotheses about the character of risk descriptions) were subsequently tested and evaluated through experiments in paper II. Although some normative ideas had been obtained already (notably through the LFA workshops for paper III), it was time to focus on the prescriptive elements of the research and to identify measures to enhance the possibility of aggregating risk information from multiple stakeholders.

While literature studies were integrated in the development of the previous papers, paper IV added rigor by the conduct of a thorough and systematic scoping study of relevant scientific literature. As stated in the introduction, the aggregation of risk information is an undefined research area, with important information about the challenges involved and the means for addressing them being found in a plethora of research disciplines. The objective of paper IV, therefore, was to compare and analyze scientific literature alongside the results obtained in papers I, II, and III in order to form a more "complete picture" (combining research and experiential knowledge) and possibly identify potential solutions to the problems in the Swedish RVA system communicated by DRM professionals. Here, the challenges identified in previous studies were used as a point of departure and were also crucial for assessing the feasibility and relevance of potential measures to enhance the possibility of aggregating disaster risk information from multiple stakeholders. The sub-processes identified during the LFA workshops, albeit slightly adjusted, were also used here to map challenges and enabling factors (cf. Section 4.4.5 for further details on how the

scoping study was performed). Fig. 4-2 is attempt to illustrate this account on how the papers in this thesis relate to each other as well as to the design science framework as presented in Section 4.1.

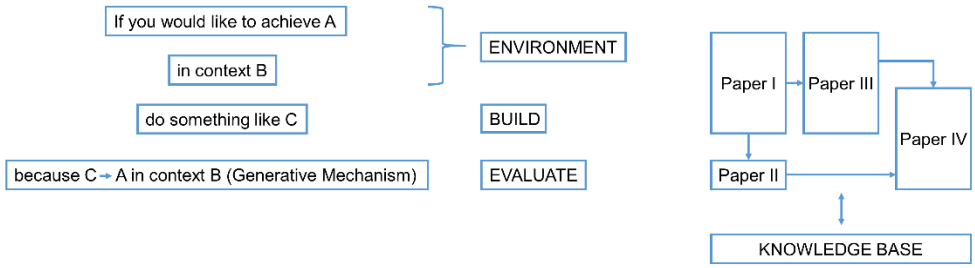

Fig. 4-2. Schematic overview of how the papers relate to each other and to the design science framework The figure depicts how papers I and III were instrumental for gaining knowledge about the environment, i.e. the objectives, challenges and needs of DRM professionals and the socio-political context in which they operate. The outputs of these papers were also partly used to create (build) design propositions, i.e. hypotheses about measures that could reduce identified challenges. Some of these were also tested and evaluated through experiments in paper II. Whereas the knowledge base, through literature studies, was integrated in the production of all papers, paper IV involved a more thorough scrutiny of literature to identify - and assess the suitability of – addtitional measures to address challenges observed through previous papers. Reversely, the outputs of the papers in this thesis are also seen as contributions to the knowledge base.

Alongside my own studies, I have also supervised a number of Master's theses, which, in different respects, have enhanced my understanding of the environment and knowledge base related to my research. These theses included a survey of the strategies and methods that municipalities and county administrative boards use, as well as the challenges they experience, when exchanging information with external stakeholders (Filipek & Laksman, 2013); an interview study examining the drivers, impediments, and prerequisites for public-private collaboration in the food supply sector in Sweden (Gramenius & Svensson, 2013); a content analysis exploring compatibility between different ISO standards related to risk management and societal safety (Klarström, 2014); and a study on the use of Geographical Information Systems (GIS) to support RVAs at the local level (Brudin, 2014).

4.4. Research Methods and Materials

This thesis is based on a mixed-methods approach. In accordance with critical realism, this decision was partly motivated by an attempt to reduce uncertainties through triangulation—i.e., by comparing and assessing results obtained from different sources and methodologies. In addition, the suitability of research methodologies is dependent on the research questions and objectives, and these have

varied across the different papers that underpin the thesis. Interviews, content analyses, and LFA workshops have been used to elicit knowledge in support of a descriptive approach (papers I and III), while prescriptive ideas have been developed on the basis of the LFA workshops, a controlled experiment, and a systematic scoping study (papers II, III, and IV). This section offers an account of these methods, the rationale for their use, the research questions for which they were employed, and the methods used to uphold validity and reliability throughout the research process.[14]

4.4.1. Content Analyses

Content analyses may be employed to reduce large amounts of text systematically into manageable pieces of data that serve the purposes of the investigation (Neuendorf, 2002; Weber, 1990). Such a method was applied in paper I to investigate whether the introduction of the RVA regulation in 2010 had generated its intended effect—i.e., increased the uniformity and comparability of the RVAs that Swedish authorities produce. More specifically, content analysis was used to answer the following research questions:

a) *What is the extent and character of uncommon categorization regarding communication about risk in the Swedish disaster risk management system?*

b) *What development—if any—can we observe with regard to the extent and character of uncommon categorization between the years 2010 and 2014?*

Uncommon categorization refers to the discrepancies between the methods that different stakeholders use to interpret, code, and categorize similar terms and information, which have been shown to impede inter-agency communication and collective sense-making (Kramer, 2005).

Paper I focuses on the presence and effects of uncommon categorization in DRM systems, and utilized the Swedish RVA system as a case. The study involved an analysis of 127 RVA reports produced by authorities at all administrative levels in

[14] Simply put, *validity* regards the degree to which researchers measure the "right things", i.e. have been able to study what they aimed to study and that the results do not conceal confounding cause-effect relationships which may undermine the claims and conclusions of studies. *Reliability* concerns the degree to which researchers measure things in the "right way"; i.e., have been able to generate results which are possible to both assess and reproduce (which entails that other researchers would obtain the same, or at least similar, results if using the same procedures and data). This depends, to a large extent, on the level of transparency with which researchers depict the research processes, methods, and data that support their results (Robson, 2002, p. 93). Although these explanations of validity and reliability correspond with many definitions of the terms, many researchers claim that the concepts need to be interpreted differently in relation to qualitative, rather than quantitative, research approaches (see Golafshani, 2003 for a thorough review of this divide).

Sweden, where each report spanned between 30 and 150 pages. To scrutinize such a vast amount of material, the work needed to be divided between several people and guided by a common structure that would allow for the integration of the assessors' outputs. To this effect, all four authors were involved in the coding of the documents and utilized an analytical protocol originally developed by Abrahamsson and Tehler (2013). The protocol focused on whether and how the authorities described certain key elements, such as scenarios, likelihood, consequences, capabilities, and measures to reduce risk. Inter-coder reliability was ensured by having a common analytical protocol, which the assessors involved tested, before agreeing on ways to interpret issues that might give rise to ambiguity. The reliability was also checked by having any two of the assessors coding the same set of randomly selected RVA reports from each of the three administrative levels (i.e., the order was varied, with regard to whom was cross-checking whom). 40 documents (roughly 30%) were double-coded in this way and subsequently tested for inter-coder reliability using two different procedures: a percentage agreement (Lombard, Snyder-Duch, & Bracken, 2006) and the calculation of a Krippendorff alpha (α) coefficient (Krippendorff, 2004). Both of these methods revealed good agreement regarding the ways that the different authors coded the RVA reports and, as such, the results were considered reliable.

4.4.2. Interviews

Interviews are useful for both descriptive and normative research as they may be employed to obtain information about the context and characteristics of challenges, as well as about ideas to overcome them. Interviews for scientific purposes are often either structured or semi-structured. Structured interviews are based on a set of predefined questions designed to enable comparisons and the aggregation of answers across, for example, geographical areas or sub-segments of populations (Doody & Noonan, 2013). To facilitate quantitative analyses of results, respondents may be delimited to a set of pre-determined response options. Such interviews are akin to questionnaires and are suitable for discerning the extent and magnitude of certain phenomena; e.g., to measure public opinions concerning a proposition. Designing interview protocols for such purposes naturally requires a good understanding of the topic of investigation prior to the interviews being conducted.

Structured interviews are less suitable for explorative purposes—e.g., if a researcher is at the beginning of a process of trying to understand a certain phenomenon, or if interviews are being undertaken to investigate peoples' perceptions on the causes or rationale behind phenomena (e.g., *why* a proposition has been suggested or the reasons why people may support/oppose it). In such a case, semi-structured interviews are a better option. These types of interviews are also based on interview protocols but, typically, contain open-ended questions that invite the respondents to explain

their views on certain topics (Smith, 1995, pp. 11-12). As such, semi-structured interviews allow for flexibility, in terms of answers. Moreover, they allow for flexibility in questions, too; i.e., the interviewer has the ability to refrain from posing certain questions that are deemed to have been addressed already or to add questions to follow up on unforeseen, but interesting, lines of reasoning (Bernard, 2006, p. 212).

In this thesis, interviews were conducted to be able to answer the third research question in paper I:

What are the causes and effects of uncommon categorization in the Swedish disaster risk management system as perceived by the professionals in the system?

The open and explorative character of this question called for the use of semi-structured interviews, but its scope raised questions about validity. How could one ensure that the study would encompass a representative sample of professionals in the Swedish DRM system? To this end, the authors decided to make use of an interview study on critical dependencies between vital societal functions conducted in 2011, which encompassed representatives from 15 municipalities, 5 county administrative boards and 5 national authorities.[n] These interviews were concerned mostly with the inter-organizational exchange of information and were therefore considered relevant to our purposes.

Notwithstanding this, a decision was made to supplement the material by conducting 20 new interviews with representatives from national authorities. The decision to add interviews with informants from national authorities alone was taken in part because the interviews were meant also to support another study on risk communication amongst Swedish national authorities (Lin, 2017). In addition, national authorities carry a distinct area of responsibility connected to a certain functional sector (e.g., health, transport, and food). Moreover, these sectors differ, in terms of the extent of their private-public partnerships, which was deemed as an interesting parameter to consider, when probing challenges to aggregating risk information. In this sense, the responsibilities of each national authority are unique, whereas municipalities and county administrative boards carry the same mandates and legal obligations regardless of their location. Hence, the purposeful selection of 15 municipalities and 5 county administrative boards was deemed sufficient for extrapolating findings on risk communication at and between these administrative levels, whereas the heterogeneous responsibilities of national authorities called for a larger sample of the underlying population (cf. Section 3.1). In total, paper I draws on data from 45 interviews involving 55 individuals, which, altogether, represent 33 authorities at all administrative levels of the Swedish DRM system. The actual selection of the respondents was undertaken by the authorities themselves after they were informed about the purposes of the studies. They were key informants, in the sense that they

were assumed to have the most experience regarding the matters of interest and the majority has been involved in producing and reporting RVA results.

Using two different interview studies to probe a specific research question raises queries regarding the ability to compare and bring together their outputs to obtain an answer. It should be noted that different interview protocols were used for the interviews in 2014 and 2011. The potential reliability problem that this incurs was counterbalanced, however, by the fact that we did not seek to code the answers in relation to certain themes or to track the development of certain parameters over time. Rather, the interviews were used to identify common perceptions regarding challenges to inter-organizational risk communication and ideas about their causes and effects, and to extract quotes that might illustrate the respondents' views and experiences. Regarding validity, it should also be emphasized that the Swedish RVA system was not subject to any major changes in the period between the interviews in 2011 and 2014 (the major catalyst for change—i.e., the introduction of the new RVA regulation—had already taken place when the first set of interviews was conducted). As such, both interview studies can be considered representative of the same system. One important difference between the two sets of interviews was that the interviews in 2014 were conducted in English to enable a Chinese colleague to follow and take part in the discussions. As all the respondents were native Swedes, they were offered the opportunity to express themselves in Swedish where needed, and I translated such parts and then checked whether the respondent in question was in agreement with the translation. This happened on rare occasions and never comprised of more than a few words or sentences. To maintain faithfulness to the material, all grammatical errors made by the respondents were retained. All the interviews were recorded and transcribed, which enabled the researcher to revisit and reflect upon the substance of the discussions.

4.4.3. Controlled Experiments

Experimental methods allow researchers to investigate cause-effect relationships between independent variables (causes) and dependent variables (effects). To be able to take such an approach, researchers must control the environment to avoid the results being affected by variables other than the ones selected for investigation. Often, this requires simplifications, which may limit the validity of experiments and reduce the applicability of the results in the real situations to which they refer (Cunningham & Wallraven, 2011, p. 48). On the other hand, controlled experiments might yield a high degree of confidence in the relationships between the variables that are embraced by the experiments (Brehmer & Dörner, 1993 and Falk & Heckman, 2009 discuss the tension between field research and controlled experiments with regards to the possibility of attaining external/"ecological" validity on the one hand

and establishing correlations between study variables on the other). In this thesis, experiments were used to support the development of paper II. While the methodologies used to support the other studies carried out for this thesis (i.e., interviews, content analyses, LFA workshops, and scoping studies) were suitable for extracting information about the context and for identifying challenges and the means to reduce them, none of them were particularly strong, in terms of testing hypotheses or the validity of design propositions. For such purposes controlled experiments are a better option and, hence, the experiments in paper II supplement the other studies, adding rigor to the overall conclusions derived from the research for this thesis.

The experiments focused on two important objectives of aggregating risk information from multiple stakeholders: 1) to be able to compare the level of risk in different parts of a system (e.g. a geographical or functional area) which supersedes the scope of individual stakeholders' analyses and to 2) produce a basis for decisions to reduce the risk in the system as a whole. To this end, a flood scenario° and fictive municipal risk assessments were constructed, which replicated three of the five types of risk descriptions identified in paper I (qualitative, qualitative ordinal, and quantitative).[15] Then, risk-management students were asked to assume the roles of officials at a county administrative board and to compare the municipalities' risk assessments, evaluating their usefulness as bases for comparing the level of risk in the municipalities and for decisions on risk-reducing measures in the area comprised of both municipalities. To make the study feasible and avoid spurious effects, the experiment was delimited to combinations of risk descriptions from two municipalities. This meant that the experiment embraced six different combinations of risk descriptions. Three of these consisted of two risk assessments of the same type (e.g., two qualitative; termed *pure combinations* hereafter), whereas the others comprised risk descriptions of two different types (e.g., one qualitative ordinal and one quantitative; called *mixed combinations* hereafter). Fig. 4-3 illustrates the procedure, where the participants were shown two of any of the three types of risk descriptions involved (labeled A and B). Participants could, for instance, be shown a mixed combination consisting of a qualitative and a quantitative risk description (e.g., A1 and B3) or a pure combination involving two risk descriptions based on qualitative ordinal scales (e.g., A2 and B2).

[15]For the sake of clarity, the term *qualitative* is used for risk descriptions where assessments of likelihood and consequences are expressed in words only—i.e., without the use of a scale (e.g., "unlikely," "moderate"). *Qualitative ordinal* risk descriptions present assessments with reference to a scale containing sequential steps that indicate a relative rank order (e.g., low–middle–high), while *quantitative* risk descriptions imply the use of frequencies—i.e., the number of events per unit of time and consequences expressed by numeric estimates (e.g., numbers, volumes, areas). This taxonomy is akin to Stevens' (1946) classification and characterization of nominal, ordinal, and ratio scales of measurements.

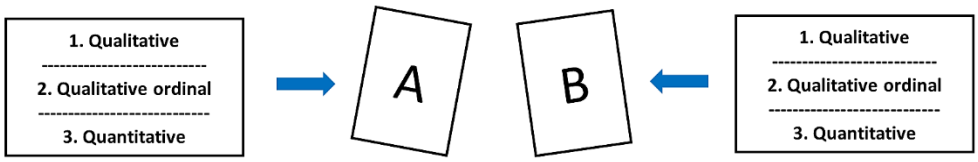

Fig. 4-3. Illustration of the experiment.
Two risk descriptions were shown to the participants (A and B). The descriptions comprised of three types: qualitative, qualitative ordinal, and quantitative (adapted from Tehler, Abrahamsson, Hassel, & Månsson, 2018).

A within-subjects design was used, meaning that each participant was asked to assess all six combinations. To avoid response trends, the order with which the combinations were presented to participants was randomized. In each case, participants used a seven-level Likert-type scale to indicate the extent to which they agreed with a number of statements. The most important of these were: 1) "It is easy to understand which of the two municipalities faces the greatest risk" and 2) "The scenario and risk assessments provide a useful basis for decisions concerning risk-reducing measures in the area concerned (municipalities 1 and 2)."

The objective of this experiment was to obtain a ranking of the perceived usefulness of the various combinations of risk descriptions. Specifically, the experiment sought to answer the following research questions:

a) *Would mixed combinations be perceived as less, more, or equally as useful as pure combinations?*

b) *Would the ranking of the combinations coincide for both purposes (i.e., risk comparisons and decision-making)?*

In addition, we constructed a second experiment to examine the effects of a narrative that provided background information in support of the assessments of likelihood and consequences (e.g., explanations of assumptions and methods employed). This was prompted by a third research question:

c) *Would adding a narrative influence the perceived usefulness of some combinations of risk descriptions more than others?*

The above research questions were coupled with the hypotheses that pure combinations of risk descriptions would be perceived as more useful than mixed, and that narratives would enhance the perceived usefulness of qualitative risk descriptions more than that of quantitative ones.

For the sake of feasibility, we utilized students in our studies. It is possible that professionals with experience of conducting risk and vulnerability assessments and aggregating risk information in practice would regard the risk descriptions used in the experiments differently than the students did. However, to mitigate this gap, we

involved risk-management students, as they were expected to have a preconception of the notion of risk and, hence, be able to appreciate the nuances with which risk was described in the experiments (roughly 20% of the students had, in fact, also been exposed to RVAs in connection with internships at different authorities).

In addition, we let risk-management students from two different scholarly traditions (engineering and sociology) partake in the experiments. This mix was prompted in part by an ambition to reflect the varied educational background of risk managers in the Swedish RVA system. It was also motivated by a concern that the extensive mathematical training obtained by engineering students would lead to their responses being biased in favor of quantitative risk descriptions. Numerical ability has previously been shown to affect the ways that people perceive risk information (Nelson, Reyna, Fagerlin, Lipkus, & Peters, 2008; Peters, 2008; Reyna, Nelson, Han, & Dieckmann, 2009), including their appreciation of narrative information (Betsch, Haase, Renkewitz, & Schmid, 2015; Dieckmann, Slovic, & Peters, 2009). We suspected that the engineering students might not be representative of standard numeracy levels and we wanted to balance their responses, therefore, with participants with less mathematical backgrounds. In this sense, the students who approached risk from a sociological perspective had a suitable, complementary profile. Altogether, the two experiments involved 127 participants, including 53 from the Faculty of Engineering at Lund University (LTH) and 74 from Mid Sweden University (MIUN). Although differences could be observed between the two student groups, they were surprisingly similar in their ranking of the different combinations of risk descriptions. However, one needs to be cautious whilst interpreting the implications of these results, as we did not investigate more advanced quantitative expressions. The descriptions denoted here as "quantitative" were simple and were labelled this way because they, in contrast with the qualitative risk descriptions, included quantitative units (such as frequencies, numbers, volumes and areas). It is possible that introducing more advanced quantitative elements (such as Bayesian probability functions, FN curves, and individual risk profiles) could, in fact, have negative effects; i.e., that they may not be understood or comprehended differently by persons with varying numerical abilities.

4.4.4. The Logical Framework Approach (LFA)

The Logical Framework Approach (LFA) offers a systematic and tangible way to extract and visualize people's knowledge of problems and ways to reduce them. It was developed in 1969 for the United States Agency for International Development (USAID) to enhance the planning, monitoring, and evaluation of international development projects, and has since been adopted by a range of donors and humanitarian agencies (Couillard, Garon, & Riznic, 2009; Practical Concepts, 1979).

Part of its appeal was that it addressed the common dilemma of projects starting without sufficient analysis of the causes of the problems that they sought to address, which often led to superficial changes and unmet expectations. In line with this, the word "logical" refers partially to the need of a rational correlation between activities and problems, and partially to the sequential analysis needed to identify such rational measures.

The LFA consists of nine steps, but the situation analysis (step 3) is, arguably, the most important, as it defines the problems and directs many of the other steps, including the identification of aims and objectives, activities and indicators, required resources, and risks and assumptions for the realization of the project. Situation analysis was also the core of the workshops that supported the current research and thus is in focus here (for thorough accounts of LFA methodology, the reader may consult, e.g., AUSAID, 2005; Örtengren, 2003).

Analyzing the Situation and Ways to Improve it

Situation analysis is carried out at participatory workshops, where relevant stakeholders[P] use sticky notes to create so called "problem-and-effect trees," which enables visualization of the problem's direct and indirect causes and effects (Fig. 4-4 provides a simple example of how a problem tree is structured). Within a problem tree, the causes are the roots of a focal problem, symbolized by the trunk of the tree. The effects of the problem form the top of the tree and demonstrate the arguments (the needs) for implementing the change or project.

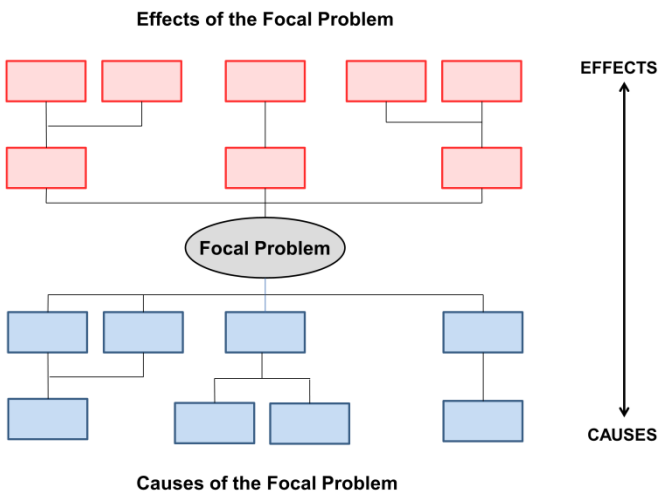

Fig. 4-4. Illustration of the structure of a problem-and-effect tree.

A problem-and-effect tree is read from the bottom up. The causes below lead to the problem and its effects above and, hence, to the causal chain of contributing factors. There may be several causal chains that contribute to the creation of a particular situation or problem; sometimes, these chains also interact. Sustainable results are achieved by identifying and stopping as many of the causal chains as possible, and at as low a level as possible. To find the fundamental causes, facilitators of LFA workshops keep asking the question of *why* a problem or cause exists until there are no more answers. Then, it is time to identify relevant activities to improve the situation. Often, several activities may be needed in order to eliminate one cause, and the participants must assess whether dependencies exist between the proposed measures, as well as evaluating the feasibility of implementing them (e.g., considering the resources that are needed, in terms of time and money). Whereas causes of problems are "treated" by activities, the effects of the problems are handled automatically through treatment of the causes. Thus, no separate activities are needed to handle the effects.

In the present context, the LFA was used as basis for the development of paper III and, more specifically, to answer the following research questions:

a. *What problems do practitioners in the Swedish DRM system perceive with regard to the aggregation of information on systemic risks?*

b. *What measures could reduce observed problems and thus enhance the possibility of aggregating information on systemic risks?*

As stated in Section 4.3, three separate workshops were conducted, which, together, provided the opportunity to obtain input from all 21 county administrative boards in Sweden. All the participants were experienced in aggregating municipal RVAs to create regional RVAs, and were therefore considered key informants within this study.

Structure of and Procedures at the LFA workshops

The workshops, all of which followed a regular round of participant presentations, started with a brief introduction to the LFA methodology and moved on to a group brainstorming session on the effects of difficulties in aggregating risk information from external stakeholders. This approach was taken in part to instill a common sense of the importance of the workshop topic, but also to enable participants to become acquainted with the methodology behind the hierarchical mapping of interrelated causes and effects (a methodology that they were then asked to apply on their own during subsequent workshop activities). Next, the participants were asked to work individually, thinking about potential causes for the difficulties in aggregating information from external stakeholders. They were required to write any causes they

thought of on sticky notes (one cause per note). The notes were compared and duplicates removed.

During the first of the three workshops, the participants and facilitators agreed to categorize the challenges in accordance with the chronological order of activities that was deemed important to the process of aggregating RVA information in the Swedish DRM system: 1) collecting required information, 2) analyzing and synthesizing the assembled material, 3) disseminating the results, and 4) providing feedback on the information received from external stakeholders. This categorization was also essential for the activity that followed, in which the participants were divided into 4 smaller groups of 2–4 people, with the groups being asked to analyze the challenges and related remedial actions for their respective "themes." To allow for comparison and the aggregation of results, this structure was retained for the two following workshops. Thus, the second half of each workshop was devoted to group work, in which each group assessed its "theme" independently from the other groups and then presented the findings to the other groups. During these presentations, the other groups were encouraged to provide feedback and, where possible, to supplement the presentations with additional ideas. To facilitate documentation, the workshops were recorded and the problem-trees were photographed. The records were then used as bases for the problem-and-effect trees that are delineated in Chapter 5 (which are also informed by input from all the studies undertaken for this thesis).

The LFA was partly used because the author is well acquainted with the methodology, but first and foremost because it offers a concrete and logical way in which to discuss and address problems of common concern. It was also intriguing to make use of a methodology that, purportedly, was new to the participants and the context. Potential weaknesses of the LFA include limitations to the workshop participants' knowledge of focal problems and the time available for analyzing them. The participants in the current study were well aware of challenges related to the aggregation of risk information and were eager to share their experiences and ideas with each other. Although the time was relatively short (4 hours per workshop), the division of the participants into themed groups and the replication of three identical workshops helped to generate a large amount and range of ideas that have been of great significance in formulating answers to the research questions.

4.4.5. Scoping Studies

Literature reviews can be carried out in a number of ways. Depending on the processes and objectives involved, the undertaking has also been labelled differently where systematic reviews, meta-analyses and scoping studies are established and frequently referred to approaches (for reviews of these methodologies, see (Denyer et al., 2008; Grant & Booth, 2009; Tricco, Tetzlaff, & Moher, 2011; Whittermore,

Chao, Jang, Minges, & Park, 2014). Systematic reviews and meta-analyses are used widely in the field of medicine, being conducted often to synthesize material and produce statistical summaries of available evidence related to specific interventions. This approach requires the identification of well-defined research questions and a large set of quantitative studies related to the topic of interest. The exclusive focus of both systematic reviews and meta-analyses on scientific papers, however, has raised concerns that they devaluate grey literature[16] (Kayabu & Clarke, 2013). Such publications may very well be incorporated into scoping studies, which also are more inclusive in the sense that they can involve both quantitative and qualitative studies (Davis, Drey, & Gould, 2009). It has been argued that scoping studies are particularly relevant to disciplines in which evidence is emerging, where it may be difficult for researchers to undertake systematic reviews (Poth & Ross, 2009). In these situations, researchers can adopt a range of research strategies alongside database searches, such as hand-searching through reference lists (so-called "snowballing") and holding consultations with experts and professionals, thus allowing input to be received on the design and outputs of studies (Arksey & O'Malley, 2005; Daudt, van Mossel, & Scott, 2013; Levac, Colquhoun, & O'Brien, 2010).

For the purpose of this thesis, a scoping-study methodology was deemed suitable for a number of reasons. First, a lot of interesting information in the disaster-management field is presented in grey literature (e.g., handbooks, best-practice compilations, reports, and guidelines) produced by non-academic organizations such as UN agencies, the Red Cross and Red Crescent Movement, the Organization for Economic Cooperation and Development (OECD), and a range of governmental donor and emergency-management agencies. Given the potentially interesting substance of these documents and the related prospect of achieving a better insight into how DRM professionals view and try to manage challenges connected with aggregating risk information, it seemed unwise to exclude them. Second, the types of challenges involved in the aggregation of risk information from multiple stakeholders was expected to have been studied by the use of qualitative as well as quantitative methodologies, wherefore both types of studies were of interest. Third, the aggregation of risk information is not an established research field; rather, it is beginning to gain interest in the wake of the emergence of risk governance, which became established as a discipline only recently and focuses on dependencies and communication between multiple stakeholders (Renn et al., 2011). Further, the phenomenon of aggregating risk information is not easily delineated, and potentially

[16] *Grey literature* is defined as documents that are produced and distributed outside the channels of traditional commercial and academic publishers (i.e., where publishing is not the primary activity of the body that has produced the material). Common types of grey literature include annual, project, and technical reports; policy documents, standards, and guidelines; and evaluations. Typically, they are issued by government departments and agencies, non-governmental organizations or private companies, and consultants (Schöpfel, 2010).

relevant research on associated activities (i.e., information retrieval, synthesis, dissemination, and feedback to external stakeholders) could be found in many disciplines, including system safety, resilience engineering, organizational science, social psychology, communication theory, decision science, cognitive psychology, and knowledge management. Hence, it was necessary to use a broad and explorative approach whilst searching for evidence that might offer solutions that could lead to reductions in the observed challenges. Finally, consultations with DRM professionals were already integrated into the overall research plan and core aspects of papers I and III. The findings of these studies were also used as input for the design of the scoping study. Thus, the focus on an emerging area of interest, coupled with the explorative nature of the study, the intent to incorporate quantitative as well as qualitative studies (including grey literature), and consultations with DRM professionals made the scoping study an ideal methodological fit.

General purposes of scoping studies include: 1) examining the extent and nature of a research area, 2) investigating what is already known and identifying research gaps, and 3) summarizing and disseminating research findings (Arksey & O'Malley, 2005, p. 21). The scoping study conducted for this thesis sought to fulfill the latter two of these objectives. More specifically, it was carried out to explore how the process of aggregating risk information has been framed or defined, and whether the challenges to the aggregation of risk information found in the Swedish DRM system also are present in other contexts and, if so, to identify means of addressing these challenges not yet tested by risk management professionals in Sweden. Given the above, the scoping study aimed to address the following research questions:

a) *What definitions does literature provide regarding the notion of aggregating risk information that is useful in the context of disaster risk management systems?*

b) *What is known from existing literature about challenges and opportunities connected with the aggregation of risk information?*

c) *Which similarities and differences can be observed regarding findings from literature and the outputs of deliberations with DRM professionals?*

d) *Which findings from literature are applicable to address challenges communicated by DRM professionals?*

Although there are no firm instructions regarding the best way to conduct a scoping study, Arksey and O'Malley (2005) propose a step-by-step approach that has been influential, which others have discussed and sought to emulate (Daudt et al., 2013; Levac et al., 2010), and which has informed the scoping study at hand. A detailed presentation of this framework and the activities performed is given in paper IV, so the process will be described here in brief only.

The study started by identifying valid search strings in which the words *aggregation*, *risk*, and *information* were used as points of departure. This was coupled with a test of the efficiency of 60 synonyms for these terms. The process involved a review of 6700 titles. Ultimately, 22 words were retained, rendering 40 different combinations (individual search strings).as basis for the study These strings were applied to three different databases (Scopus, Web of Science, and Academic Search) and the results exported to the reference-management program Endnote. Duplications across databases were removed, after which filtering of the remaining 6044 publications could start. This involved a three-step process, where the number of publications was reduced gradually, based on scrutiny of their: 1) titles, 2) abstracts, and 3) introductions and conclusions. A set of 87 articles was identified for a full read, which involved charting the articles' substance in relation to the research questions. The reference lists in these publications were also reviewed in order to detect additional relevant documents. In the end, the scoping study entailed a full read and classification of 107 documents.

4.4.6. The Complementary Role of Different Methods

The various methods and techniques applied in this thesis have served different, but complementary purposes. For instance, the interviews and LFA workshops were strong means of exploring the context and generating ideas about the causes of, and potential remedies for, the challenges identified. However, due to potential multiple and complex biases—e.g., respondent bias (cf. Section 6.2.2.), conforming groupthink (McCauley, 1989), and the undue influence of dominant personalities (Anderson & Kilduff, 2009), these methods were less useful for establishing cause-effect relationships. In this case, experiments are a better option as they allow the researcher to isolate and study the influence of individual parameters of interest. The design and results of the scoping study were both informed by and supplementary to the outputs gained using other methodologies. Together, the mix of techniques and materials has assured that the thesis draws equally on information from DRM professionals and on scientific findings, thus ensuring the relevance and rigor of the research outputs.

Ch. 5. Research Contributions

5.1. Overview: Questions, Methods, Materials, and Key Outcomes for Each Paper

In this chapter, I will try to answer the main research questions by drawing on the combined outputs of the various studies underpinning this thesis. Whilst this approach is practical, since the studies complement each other, it is difficult to isolate what the main outputs of each study were. Table 5-1 is presented, therefore, to provide the reader with a quick overview of the outputs of the individual papers, as well as the questions, materials, and methods employed to produce them.

Table 5-1. Research questions, methods, materials, and key outcomes of individual papers.
Note: key outcomes are not necessarily the same as answers to research questions, as unanticipated, but significant, information may appear during the course of research. Here, I have chosen to highlight information that has emerged from the respective studies and has been especially formative for my recommendations and conclusions to the main research questions presented in Section 1.3. Thorough answers to the research questions in the table are provided in the respective papers.

Paper	Research questions	Research methods	Empirical data	Key outcomes
I	*a) What is the extent and character of uncommon categorization regarding communication about risk in the Swedish disaster risk management system?* *b) What development—if any—can we observe with regard to the extent and character of uncommon categorization between the years 2010 and 2014?* *c) What are the causes and effects of uncommon categorization in the Swedish disaster risk management system as perceived by the professionals in the system?*	Content analysis; Semi-structured interviews	128 RVA reports from authorities at all administrative levels in Sweden covering the years 2010 and 2014; 45 interviews with officials producing RVA reports.	There are great disparities in the ways that Swedish authorities describe risk, which undermines the ability and motivation to use other authorities' assessments as a basis for one's own. This results in less comprehensive pictures of risk and a sub-optimal DRM system in general. Causes of this include lack of common RVA methodologies, unclear regulations, local autonomy, time constraints for providing feedback and digesting information (guidelines and handbooks) that could help to align the substance of different RVA reports. Regulations may increase uniformity and comparability of various stakeholders' risk descriptions, but need to be balanced with individual authorities' needs of flexibility and ownership of the RVA process.

II	*a) Would mixed combinations of risk desciptions be perceived as less, more, or equally as useful as pure combinations?* *b) Would the ranking of the combinations coincide for both purposes (i.e., risk comparisons and decision-making)?* *c) Would adding a narrative influence the perceived usefulness of some combinations of risk descriptions more than others?*	Experi-ment, Question-naire, Statistical inferences	4 individual experiments (risk descriptions with or without narratives) conducted with 127 participants at 2 universities representing different risk-management traditions (engineering and social sciences).	Aggregation is facilitated if different actors: - express risks with the same scales - describe likelihood and consequences with a high degree of specificity (simple quantitative or semi-quantitative scales are better than qualitative descriptions or ordinal scales) - motivate assessments with background information ("narrative evidence").
III	*a) What problems do practitioners in the Swedish DRM system perceive with regards to the aggregation of information on systemic risks?* *b) What measures could reduce observed problems and thus enhance the possibility of aggregating information on systemic risks?*	LFA work-shops	Three workshops which, together, involved representatives of all 21 county administrative boards in Sweden.	Aggregation includes or relates to 4 key processes: collecting, synthesizing, disseminating, and providing feedback on information. Challenges exist with regard to all processes, and involve both structural and psychological factors (please see Ch. 5 for details). Cause-effect relationships were delineated for all challenges observed, and were instrumental for identifying measures to address them.
IV	*a) What definitions does literature provide regarding the notion of aggregating risk information that is useful in the context of disaster risk management systems?* *b) What is known from existing literature about challenges and opportunities connected with the aggregation of risk information?* *c) Which similarities and differences can be observed regarding findings from literature and the outputs of deliberations with DRM professionals?* *d) Which findings from literature are applicable to address challenges communicated by DRM professionals?*	Scoping study	Using 40 individual search strings in 3 different databases (Scopus, Web of Science, and Academic Search) returned 6044 documents to screen for relevance. These were gradually reduced based on their: 1) titles, 2) abstracts, and 3) introductions and conclu-sions. In the end, the study involved a full read and coding of 87 scientific papers extracted from databases + 20 documents from "snowballing".	In the absence of existing operational definitions for the aggregation of disaster risk information, a definition was proposed. Expert opinions can be aggregated through behavioral and mathematical methods, although the latter is not deemed feasible in the focal context. Many challenges found in the Swedish DRM system exist in other DRM systems as well. An extended use of visual aids, including GIS, may reduce major constraints (cognitive and time limitations) and support inter-agency risk communication.

5.2 Synthesis and Key Findings

This section summarizes the amalgamated outputs of the different papers in relation to the main research questions introduced in Section 1.3.

5.2.1. Processes that are Part of, or Decisive for, Aggregating Information on Disaster Risk

The answer to my first research question has evolved throughout my research. The primary literature study and interviews undertaken as part of paper I were formative in identifying and structuring the activities involved in the process of aggregating risk information in a multi-stakeholder setting. This initial understanding was further elaborated through the LFA workshops upon which paper III was based. As clarified in Section 4.4.4, the participants were divided into groups according to "themes" representing different processes that the participants deemed relevant to the quest of aggregating RVA information (collecting information; analyzing and synthesizing the assembled material; disseminating the results, and providing feedback on the information received from external stakeholders). However, whether these themes should be regarded as sub-processes of the notion of aggregation was unclear. As my literature studies (including the scoping study for paper IV) did not render any useful definitions of aggregation with respect to disaster risk information (i.e., what it entails, in terms of activities and purpose), I could appeal to standard definitions of the term "aggregation" only, seeking to understand how they apply to my research area. General definitions include: "a group, body, or mass composed of many distinct parts" and "the collecting of units or parts into a mass or whole (Merriam-Webster, 2018a); "a massing together or clustering of independent but similar units, such as particles, parts, or bodies" (The American Heritage Stedman's Medical Dictionary, 2002); and "the act of putting together different items, amounts, etc. into a single group or total" (Oxford Learner's Dictionary, 2018).

These definitions are confined to the process of collecting and synthesizing information (i.e., the first two "themes" covered by the LFA workshops). Indeed, creating a new, more comprehensive understanding by combining different pieces of information (i.e., synthesis) is the purpose of aggregation; obviously, however, this cannot be achieved without the necessary information having been assembled first. Perhaps, then, these two activities should be perceived as the core sub-processes of aggregation, whereas disseminating the results and providing feedback to external stakeholders on the information obtained are supportive to, but not part of, the aggregation as such? Without dissemination, the process of aggregating information would have no, or very limited, use (i.e., it would not facilitate decision-making or raise awareness of risk beyond the persons involved in the aggregation). Hence,

dissemination is a necessary (albeit insufficient[q]) activity for fulfilling the purpose of aggregation. As such, it is clearly linked to the process of aggregating information, but could dissemination also be considered part of the process itself? Well, this depends on the perspective. In the context of multi-level governance, where information from actors on one administrative level should serve as input for analyses and decisions on other levels (such as in the Swedish RVA system), one could argue that the dissemination of, for example, municipal RVAs is part of the aggregation process at regional county administrative boards. However, it could also be viewed as an aspect of the process of collecting information on behalf of the county administrative boards (i.e., "theme" 1, rather than 3). As dissemination of RVA information also serves purposes other than being used as a basis for assessments and decision-making at external authorities (e.g., to raise risk awareness among the general public), I choose to view it as an activity in its own right—not solely as a means to an end, but as an end in itself. Accordingly, I regard dissemination as *important* to the process of aggregation, but not as *part of* it, as such.

Turning to the fourth "theme" (the provision of feedback on the information one receives from external stakeholders), feedback may influence the possibility of aggregating information from several stakeholders strongly, if it induces them to convey information in a more uniform way (Lin & Abrahamsson, 2015; Månsson et al., 2015). Feedback is also important as a motivational factor, as people who do not receive feedback on the information they provide will not understand if, and for what purposes, their information is being used. This, in turn, may make them less inclined to produce useful information the next time external authorities ask for input for their assessments. However, both of these objectives are instrumental, where the possibility of aggregating information is concerned. As such, feedback can hardly be regarded as part of the process of aggregating information; rather, it is a means of facilitating it. In conclusion, and in agreement with conventional definitions of the term, I view aggregation as encompassing the processes of collecting and synthesizing information from various sources, with feedback being essential for aggregating information and dissemination being key to fulfilling the purpose of this aggregation. As a supplement to this conclusion, however, I wish to reduce the risk of misunderstandings by clarifying the meaning of the wording related to the two processes which I do consider part of the notion of aggregation.

First, the verb *collecting* can be misleading, as it may connote that information has been prepared and is readily available, if asked for. Assembling risk information is not like picking apples however. It involves a series of complex activities that begins with an analysis of the information that one needs. This may require an assessment of one's internal and external dependencies in order to map the actors from whom one might need information as a basis for, e.g., RVAs. Having gained this understanding, the next processes are to identify the right people to ask for the information, to motivate them to share it, to agree on a suitable way to do this, and then to obtain the actual

information. As we shall see in the following section, there can be various barriers to these processes, but the most important thing to point out here is that the process of collecting information entails a number of activities which are part of the process of aggregation.

Second, the verb *synthesizing* warrants a similar caveat. It implies making a synthesis, which refers commonly to the putting together of parts or elements so as to form a whole (Webster's New World College Dictionary, 2018). Some definitions suggest that this "whole" should represent something "complex" (Collins English Dictionary, 2018), "new" (Cambridge Dictionary, 2018), "coherent" (Merriam-Webster, 2018b), or express a "higher level of truth" (The American Heritage Dictionary of the English Language, 2018), indicating that syntheses produce insights which cannot be obtained from studying the constitutive elements in isolation. Accordingly, syntheses should not be confused with compilations or summaries of information. A synthesis entails adding something more by examining the relationships between the parts, asking and answering questions about them, and trying to observe patterns in order to draw conclusions about the overall contents (Eaton, 2010; Warwick & Clevenger, 2011). This process of obtaining an added value from combining information retained by different stakeholders is illustrated in Fig 5-1.

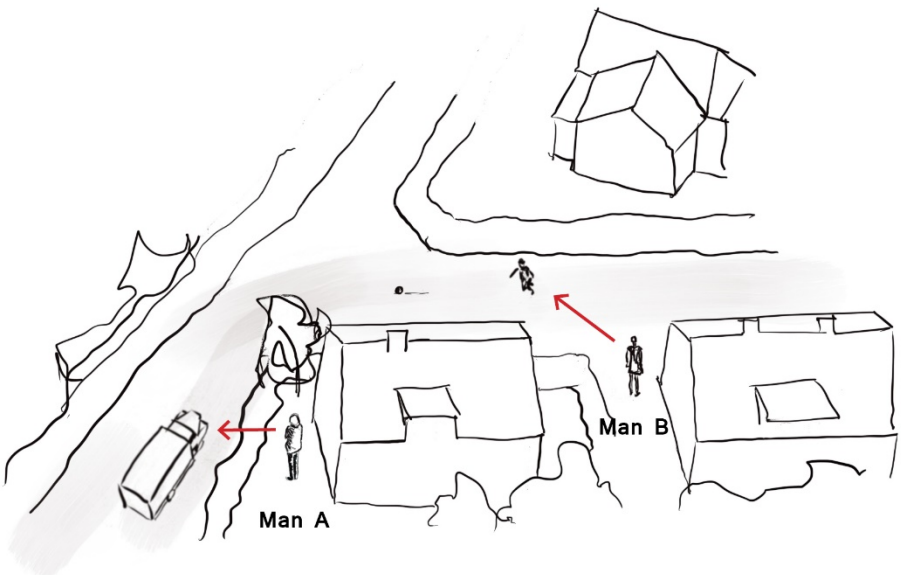

Fig. 5-1. Illustration of the need to obtain and synthesize information as a basis for aggregation and the synergetic effects of doing so.
A boy chases a ball into a junction and does not see the truck approaching. Due to a tree and a house blocking the view, Man A can only see the truck, whereas Man B only sees the boy and his ball. None of the men can perceive the threat to the boy in isolation. The threat can only be perceived by combining their respective information.
Illustration: Pia Månsson

A synthesis can be considered opposite to an *analysis*, which involves breaking down complex topics or problems into smaller parts in order to gain a better understanding of them. However, syntheses and analyses go hand in hand, as it is necessary to analyze and understand the characteristics of individual elements in order to comprehend how they relate to each other and may be combined (Ritchey, 1991). In the present context, an analysis might entail scrutinizing RVA reports from individual authorities in order to comprehend their respective DRM capabilities, whereas a synthesis may involve assessing gaps or redundant elements, as well as identifying possible collaborations and resource-sharing opportunities in a given area (establishing which authorities could learn from which, and in relation to which risks and in what respects; trying to understand to which of the various types of risk the majority of the stakeholders are most vulnerable; isolating which types of risk-reducing measures are most generic, i.e. could reduce risk with regards most types of potential disasters). Cross-comparisons of different RVA reports could also provide insights regarding whether or not different stakeholders interpret similar aspects (e.g., capabilities and concepts) in similar ways. For this reason, the sub-process denoted "synthesis" also presupposes and include the activity of analysis (in this case, analyzing RVA reports from individual authorities).

Following this reflection on the essence of aggregation, and given that I have not found any applicable definition for aggregating information in relation to disaster risk management systems, I will now endeavor to contribute to this emergent area of research by proposing the following definition:

> *Aggregating information in the context of disaster risk management systems refers to the processes of collecting and putting together disaster risk information, including complete risk assessments, from different stakeholders, with the aim of producing a more comprehensive picture of risk than would be possible through analysis of the constitutive parts of information in isolation and is undertaken to support the efficient management of disaster risk.*

The definition integrates the two core sub-processes of aggregation, as delineated above. Whereas the first part focuses on the activities involved in aggregating information, the second part addresses the rationale for this process in the context of disaster risk management systems. Here, "efficient" implies being able to achieve goals (e.g., the protection of societal safety) with as few resources (e.g., time, energy, money) as possible. Aside from including the notions of *disaster risk management systems*, *disaster risk information*, and *stakeholders*, which have already been defined (in footnotes, 7, 5, and 4, respectively), the definition also contains the expression *risk assessments*, which, in the present context, can be understood as estimations of the nature and extent of disaster risks communicated either orally (e.g., during multi-

stakeholder workshops) or through complete disaster risk assessment[17] reports conducted by individual stakeholders (as in the case of RVA reports).

5.2.2. Challenges and their Causes

This section presents an account of challenges to the processes which, in the previous section, were argued either to be part of the notion of aggregating risk information (i.e., collecting and synthesizing information) or to be decisive for the possibility of completing the task and fulfilling its purpose (i.e., providing feedback and disseminating the synthesis to external stakeholders). The challenges have been extracted from all the studies included in this thesis and are thus based on a combination of insights attained from DRM professionals and scientific literature, coupled with my own reflections. As the title of this section suggests, I have chosen to answer the second research question (on the main challenges) and the first part of the third research question (i.e., the causes behind the challenges) conjointly because they are interlinked, an approach which will forestall the repetition of information in different sections. To provide the reader with a quick overview of the challenges and their causes, each subsection will also be supplemented with problem trees (cf. Section 4.4.4).

5.2.2.1. Collecting Required Information

The first challenge to the quest of collecting information on the risk of disasters is their rare and complex nature, rendering little empirical data to use as basis for assessments and to a need to fill the gap with expert judgments (Fallet, Duval, Simon, Weber, & Iung, 2011; Rosqvist, 2003, p. 10; Yang, Khan, Lye, & Amyotte, 2015a). There are ongoing efforts to record the causes and effects of disasters, such as the EM-DAT (CRED, 2018), the GAR risk data platform (UNISDR, 2018a), the DesInventar (UNISDR, 2018b) and the PREVIEW global risk data platform (UNEP/GRID-Geneva, 2018). Whilst these databases provide ample information on losses from past disasters and the exposure of different geographical areas to various hazards, they must be used with caution. Every disaster is unique and a myriad of factors determines the potential damage created by a particular hazard (cf. contextual factors, as addressed in Section 3.2.1). Aside from the fact that stochastic factors may affect the virulence of the hazard *per se* (e.g., location, time of day, temperature, wind direction and speed), the consequences are also contingent on the inherent

[17] A *disaster risk assessment* can be defined as "a qualitative or quantitative approach to determine the nature and extent of disaster risk by analyzing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend" (UNISDR, 2016, p. 15).

characteristics of the entities that one seeks to protect (cf. Section 2.2). It is likely, for instance, that a storm of a particular velocity and duration might have a disparate effect on a Pacific island than on Sweden due to variances in aspects like topography, demography, building materials, building regulations, types of infrastructure, redundancies in infrastructure, and natural defenses (e.g., vegetation and wetlands). In fact, a storm is liable to have different effects even within a nation—if it hits the densely forested, but sparsely populated, northern regions of Sweden, for example, the results might be different than those for a storm affecting the vast farmlands surrounded by highly populated, urban areas that exist in the southernmost parts of the country. The bigger the event (in terms of affected geographical area), the more assets, systems, and vital societal functions will be affected, and the more complex and unique, its effects. For these reasons, it is also easier to extrapolate and generalize the causes and effects of geographically confined accidents (e.g., car crashes, house fires) than of societal disasters. Hence, whilst information on previous disasters is valuable as "food for thought," the multitude of contextually specific, yet decisive, factors for the consequences of disasters makes it imperative to be prudent in using such information as a basis for assessments. To this end, experts may play a significant role in detecting influential differences between varied contexts, as well as what these differences may entail, in terms of the consequences of similar types of events.

An essential aspect of such an analysis is the mapping of providers of vital societal functions, the internal and external dependencies thereof (in terms of goods and services), and the ways in which various societal functions are interconnected. Such a mapping may provide the oversight needed to detect critical dependencies, as well as the potential for cascading effects across societal sectors from various types of events. Moreover, it enables an overview of stakeholders that authorities might need to involve when producing RVAs. However, societal sectors are interconnected in very complex ways (Klinke & Renn, 2006; OECD, 2003; Taleb, 2010; van Asselt & Renn, 2011). In addition, their interdependencies and the set of actors that provide vital societal functions are constantly changing, making vulnerability assessments elusive and imbued with both epistemic and aleatory uncertainties (Haimes, 2012, p. 1462). This generates difficulties in understanding which information one needs, as well as where the information can be obtained, which constitute a second challenge to the quest of attaining a sound basis of information for assessing risk of societal disasters.

Even if the attempt to map bearers of potentially important information is successful, the stakeholders may be unwilling or unable to share the information that they possess. Challenges to the inter-organizational communication of risk information have been observed in various settings, including between intelligence agencies in the USA preceding the 9/11 attack (Kramer, 2005), the production of multi-hazard assessments within the EU (Komendantova et al., 2014), and across administrative and sectorial borders in individual countries, such as Italy (Scolobig et al., 2014) or

Sweden (Lin & Abrahamsson, 2015). There are several reasons for withholding risk information. One understandable motive is that vulnerabilities may be exploited by actors with malicious intentions (e.g., terrorists or competitors). To avoid this risk, Swedish authorities may classify their RVA reports (in full or in part), in accordance with Chapter 18, §13 of the Official Secrets Act (SFS, 2009). Alternatively, authorities and private actors can choose to refrain from sharing information that they deem could undermine public or commercial interests (Fekete et al., 2015, p. 1845; Lin & Abrahamsson, 2015; Zoghlami, Taghipour, Merlo, & Abed, 2016), which can result in potentially important information gaps in the overall DRM system. Participants in the LFA workshops undertaken for this thesis also claimed that it was futile to expect candid discussions about vulnerabilities when inviting competitors to the same meetings (paper III). This is an obstacle to the possibility of attaining holistic understandings of risk in sectors with large numbers of private stakeholders.

However, impediments to inter-organizational communication of risk are not confined to interactions between private stakeholders; they are also present in exchanges amongst public authorities and between public and private stakeholders. Whereas private stakeholders expect public authorities to be in the driver's seat where the management of risks to societal safety is concerned (Gramenius & Svensson, 2013), risk managers at public authorities seem to have difficulties with assuming this role in relation to RVAs. Admittedly, municipalities and county administrative boards have institutionalized private-public partnerships by enacting crisis-management councils at local and regional levels (cf. Section 3.1), but these councils are meant to address matters of strategic concern and, generally speaking, are not engaged in ongoing work to produce local or regional RVAs (examples of the purpose and scope of these councils are provided in (Länsstyrelsen i Jönköpings län, 2015; Länsstyrelsen Östergötland, 2017; SEMA, 2007). At the national level, authorities naturally interact with the private stakeholders whose operations they are meant to regulate and review. However, since the creation of the forums for crisis preparedness in 2002, these have included public national authorities only, despite that a sizeable proportion of vital societal functions is run by private stakeholders.

Nonetheless, since 2011, the MSB has arranged national workshops, at which representatives from both the private sector and public authorities at all administrative levels have come together to assess how Sweden may be affected by different scenarios. These workshops supplement the information the MSB obtains from the RVAs that various authorities produce, and allow access to important information possessed by private stakeholders (Månsson et al., 2015). Similar workshops are rare at regional and local levels, however, and municipalities in particular seem to have difficulty in obtaining information from private stakeholders in support of their RVAs. There may be psychological and structural reasons for this. Gramenius and Svensson (2013) have found, for instance, that some municipal risk managers refrain from inviting private stakeholders to meetings due to a fear of being unable to provide

something interesting in return for their time and information. Yet, the findings indicated that, as long as meetings are perceived by private stakeholders as relevant and efficient, and do not undermine their commercial interests, then they are positive about helping authorities to ensure societal safety. The study concluded that public risk managers need practical advice and training on the instigation and maintenance of public-private partnerships, as well as the handling of sensitive information. An important structural impediment to the communication of risk between private and public stakeholders at the local level has to do with the fact that many private providers of vital societal functions have nationwide operations, and it is not feasible to engage in the production of RVAs at each of Sweden's 290 municipalities (Månsson, 2018). Another structural impediment is that certain information that is attractive for risk management purposes (e.g., maps and images) may have to be bought, which creates a problem for stakeholders with limited budgets (Aggarwal et al., 2010; Fekete et al., 2015).

There are also specific challenges with regard to the communication of risk information between public authorities. Withholding or distorting information may sometimes be explained by turf battles, where possession of exclusive information may be a way of obtaining or retaining status and other resources (Haimes, 2001; Kramer, 2005). Where the Swedish DRM system is concerned, the informants in our studies claimed that authorities might suppress information that could evoke demands for accountability; i.e., information on vulnerabilities that take significant effort, time, or money to address. Withholding information on gaps or deliberate exaggerations of capabilities can also be explained by prestige and the wish to avoid standing out as the "black sheep" among one's peers. On the other hand, the view that RVAs may be used as bases for the allocation of resources may, reversely, lead to underestimations of certain capacities in the interests of gaining additional resources (Månsson, 2018). Hence, there are different challenges to the possibility of constructing holistic, and valid, pictures of risk via the information exchanged between authorities. According to Haimes (2001) and Garnett and Kouzmin (2007), these types of difficulties may stem from a lack of inter-personal relationships and trust.

Another challenge to the collection of risk information is the sheer volume of potentially important sources and knowledge (Chalfant & Comfort, 2016, p. 99). Authorities assert that they do not have the time, analytical resources, or cognitive ability to collect and process information from all contributors or bearers of risks pertaining to their geographical or functional area of responsibility. This is due to their extensive areas of responsibility, coupled with human nature, limited budgets, and the need for prioritization. In general, inter-organizational collaboration and exchange of information requires time, money, and energy (Lin & Abrahamsson, 2015; Mauelshagen et al., 2014). Although fostered by the principle of responsibility (cf. Section 3.1), there are no sanctions connected to the extent to which RVAs are grounded on the exchange of information with external stakeholders. Hence, the

potential gains, in terms of improving the quality of assessments, may be too little of an incentive to offset the costs associated with inter-organizational exchange of information in support of RVAs.

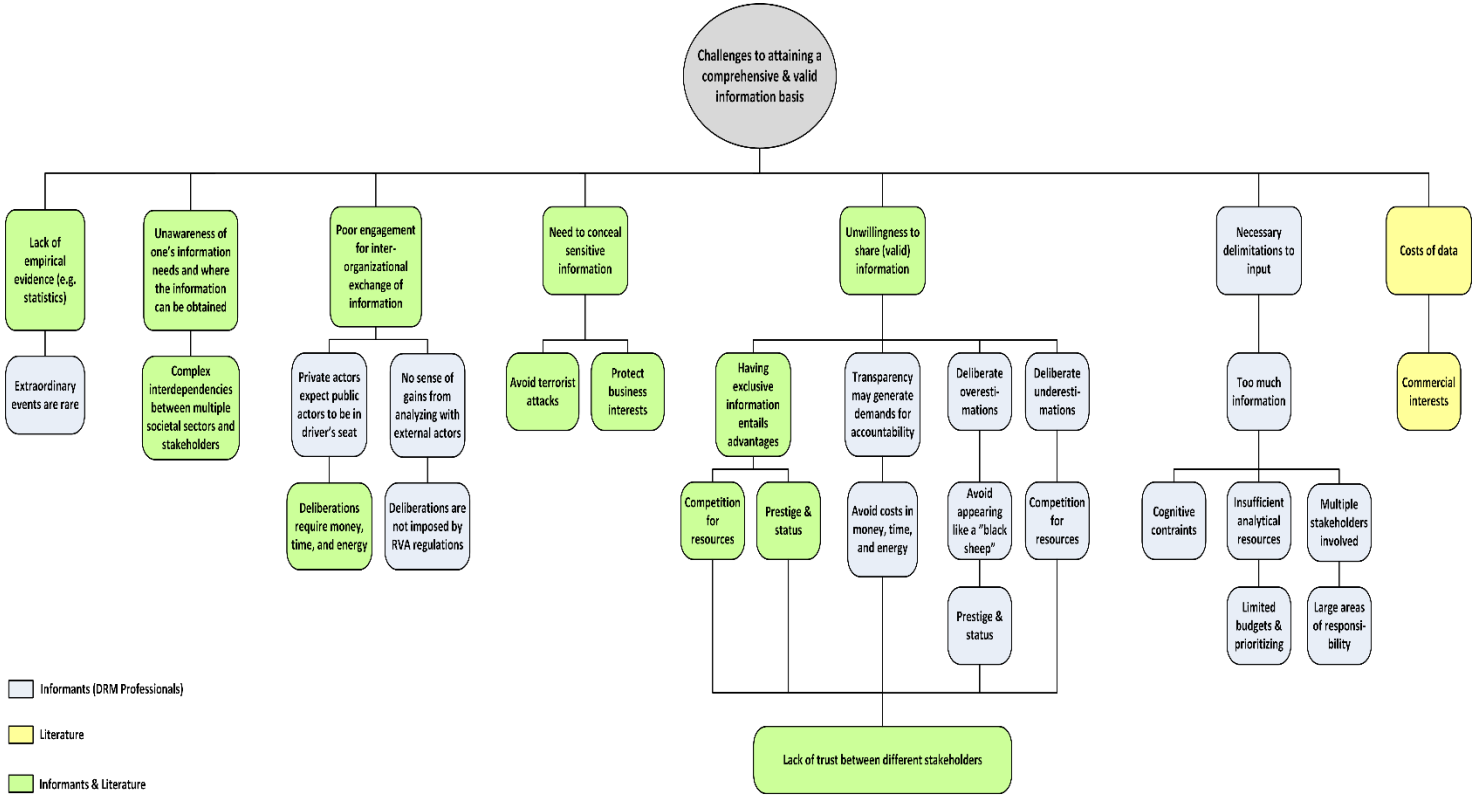

Fig. 5-2. Main challenges and their causes regarding collecting valid information as a basis for comprehensive pictures of risks to societal safety.

Note: the colors indicate the sources from which I obtained information about the challenges and their causes. Green signifies that I attained the information from literature as well as from informants in the Swedish DRM system, whereas blue and yellow indicate that I only obtained the information from either of these types of sources. However, a yellow color does not mean that the view does not exist amongst DRM professionals in the Swedish DRM system (solely that it was not put forth by the respondents in my studies). Similarly, a "blue challenge" could be present in literature that I did not encounter.

5.2.2.2. Synthesizing Collected Information

An obvious challenge to the possibility of synthesizing risk information from various authorities is that they use different scenarios as basis for their assessments (Bossong & Hegemann, 2016; Månsson et al., 2015). The latest RVA-regulation (MSB, 2016) enables MSB to stipulate that governmental authorities (i.e. national authorities and county administrative boards) analyze certain scenarios, but neither MSB nor county administrative boards have the same provisions with regards to county councils and municipalities. Risk information from municipalities and county councils will be much less useful to county administrative boards if they do not analyze the same types of scenarios and is likely to reduce the willingness on part of county administrative boards to devote time and energy to assess their RVAs. Ultimately this threatens the bottom up approach to risk governance in Sweden, i.e. that the RVA-system is fed with information from the actors closest to, and with the best knowledge about, the objects and systems that are supposed to be protected.

Another fundamental challenge to synthesizing information from different authorities is their heterogeneous ways of assessing and describing risks (Lane, 2008; Tomas et al., 2015). The main cause of this is that the MSB has refrained from stipulating the methods with which they perform their RVAs, a position which is motivated by the conviction that different areas of responsibility require different methods to identify and assess risk (MSB, 2014, pp. 4-5; SEMA, 2003a, p. 9). Besides this, ordering authorities to use a certain methodology contradicts the bottom-up approach to risk governance nurtured by the Swedish Government and reflected in the fundamental principles of the Swedish DRM system (cf. Section 3.1). Moreover, there are concerns about undermining the sense of ownership of the process, which could have negative effects on engagement with RVAs and motivation to perform them—and, hence, on the quality of the outputs (Månsson et al., 2015; Tehler et al., 2018). Nevertheless, for some reason, the previous RVA regulations (MSB, 2010a, 2010b) gave a scale and indicators for assessing crisis-management capabilities, although there were no corresponding scales or indicators for assessment of the likelihood and consequences of risk scenarios. Homogeneity in the presentation of information by different authorities was also greater with regards to assessments about capability than likelihood and consequences (Månsson et al., 2015). The challenge of aggregating information from actors that use different methodologies, scales, and indicators as bases for their risk assessments is, by no means, unique to Sweden; it can be encountered, for example, in relation to the ambition of synthesizing national risk assessments within the European Union (Tomas et al., 2015).

An added challenge presents itself due to the qualitative nature of the assessments. As stated previously, the lack of empirical data makes assessments about low probability/high consequences types of events (such as extraordinary events) contingent upon the judgments of experts, who often use qualitative scales and terms

to assess and express likelihood and consequences (Aven, 2010, pp. 629-630; Lane, 2008; Månsson et al., 2015; Tang et al., 2012, p. 18). However, as argued in paper I and supported further by the experiments elaborated in paper II, qualitative assessments are difficult to use as bases for syntheses. As opposed to quantitative units (such as frequencies, numbers, volumes, and areas), qualitative expressions (such as "probable," "unlikely," "serious," "moderate," or "catastrophic") lack common reference points for the people conveying the assessments and those receiving them (Budescu & Wallsten, 1985; Lane, 2008; Restrepo, 1995; Ruth, 1982). The preponderance of qualitative expressions in assessments of extraordinary events makes it difficult, therefore, to make valid comparisons and syntheses of the risk information provided by different authorities.

Beyond the difficulties in decoding expressions on likelihood and consequences, differences in the ways that various stakeholders understand and categorize key concepts (e.g., "risk," "vulnerability," "capability," and "resilience") also affect how they treat and present risk (Komendantova et al., 2014; Kramer, 2005; Mauelshagen et al., 2014; Tomas et al., 2015), and, thus, the possibility of synthesizing their information. The MSB has tried to curb this issue by including definitions of important concepts in the RVA regulations. Whereas the initial regulations from 2010 included the notions of "vital societal functions" and "critical dependencies" only (MSB, 2010a, 2010b), the current regulations also embrace the concepts of "hazard", "risk," "vulnerability," and "crisis preparedness" (MSB, 2015a, 2015b, 2016). Nonetheless, the content analysis of RVAs undertaken for paper I showed that disparate interpretations of well-established and defined concepts such as "extraordinary events" and "vital societal functions" persist in RVA reports. It can be concluded, then, that common nomenclature is a necessary, but insufficient, criterion for the establishment of uniform interpretations of important concepts.

Additionally, the usefulness of risk information for the purpose of aggregation may be compromised, if it is communicated in a format and at a time not suitable for its intended receivers (Aggarwal et al., 2010). This includes the technical ability to understand and apply the outputs of risk assessments (e.g., simulation models and calculations), and compatibility between different software (Aggarwal et al., 2010; Kohler, Muller, Sanders, & Wachter, 2006; Komendantova et al., 2014; Tomas et al., 2015). With regard to the Swedish RVA system, the MSB has tried to harmonize the format of RVA reports. As stated in Section 3.2.2, the initial RVA regulations (MSB, 2010a, 2010b) encompassed a common disposition with predefined sub segments, which increased the structure of the reports (Abrahamsson et al., 2012). The adjusted regulations (MSB, 2015a, 2015b, 2016) contain further details on the type of information required under each of these segments, but it is too early as yet to assess whether this move has increased the comparability of the information. What can be said is that the updated regulations have granted governmental authorities (including county administrative boards) more time to carry out and communicate the results of

RVAs, as the process must now be performed every second year, instead of annually. Municipalities and county councils, on the other hand, have retained their reporting interval; i.e., a full RVA report being required in the first year of every 4-year-long mandate period. All authorities, however (at local, regional, and national levels) have the same deadline for the reports (31 October), which, effectively, undercuts the possibility of using each other's reports as a basis for assessments (Lin & Abrahamsson, 2015). Again, this situation risks undermining the bottom-up approach to DRM, reducing the potential value of aggregation as outputs are based on 2-year-old information, at best.

Another important challenge to synthesizing collected material is the lack of experts needed to process the information. Even if sufficient experts are employed by the authorities that are tasked with performing the synthesis, there may be a lack of willingness to let the experts participate if this means that they will not be able to perform other duties prioritized by their superiors. Such prioritization is based, of course, on certain values and preferences. As such, part of the problem may involve a lack of anchoring of RVA work and a perception that such work is not that important on the part of some decision-makers. Gaining this support can be considered crucial and foundational, however, within any RVA process (FOI, 2011, p. 43; MSB, 2012, p. 38).

A final challenge pertains to whether—and, if so, how—one should weight the contributing pieces or sources of information as bases for a synthesis (Schutz & Wiedemann, 2005). Should vulnerability assessments from larger municipalities, for example, have a greater influence on the aggregated, regional assessment than those from small municipalities? In such a case, what should be the decisive parameter be (number of inhabitants or geographical area)? Should the attribution of weight also reflect the validity of the assessments *per se*? Indeed, the DRM professionals at the LFA workshops conducted for this thesis highlighted the need for, and lack of, transparent accounts of how (e.g., via processes or participants) and why (i.e., motivations) authorities make certain assessments.

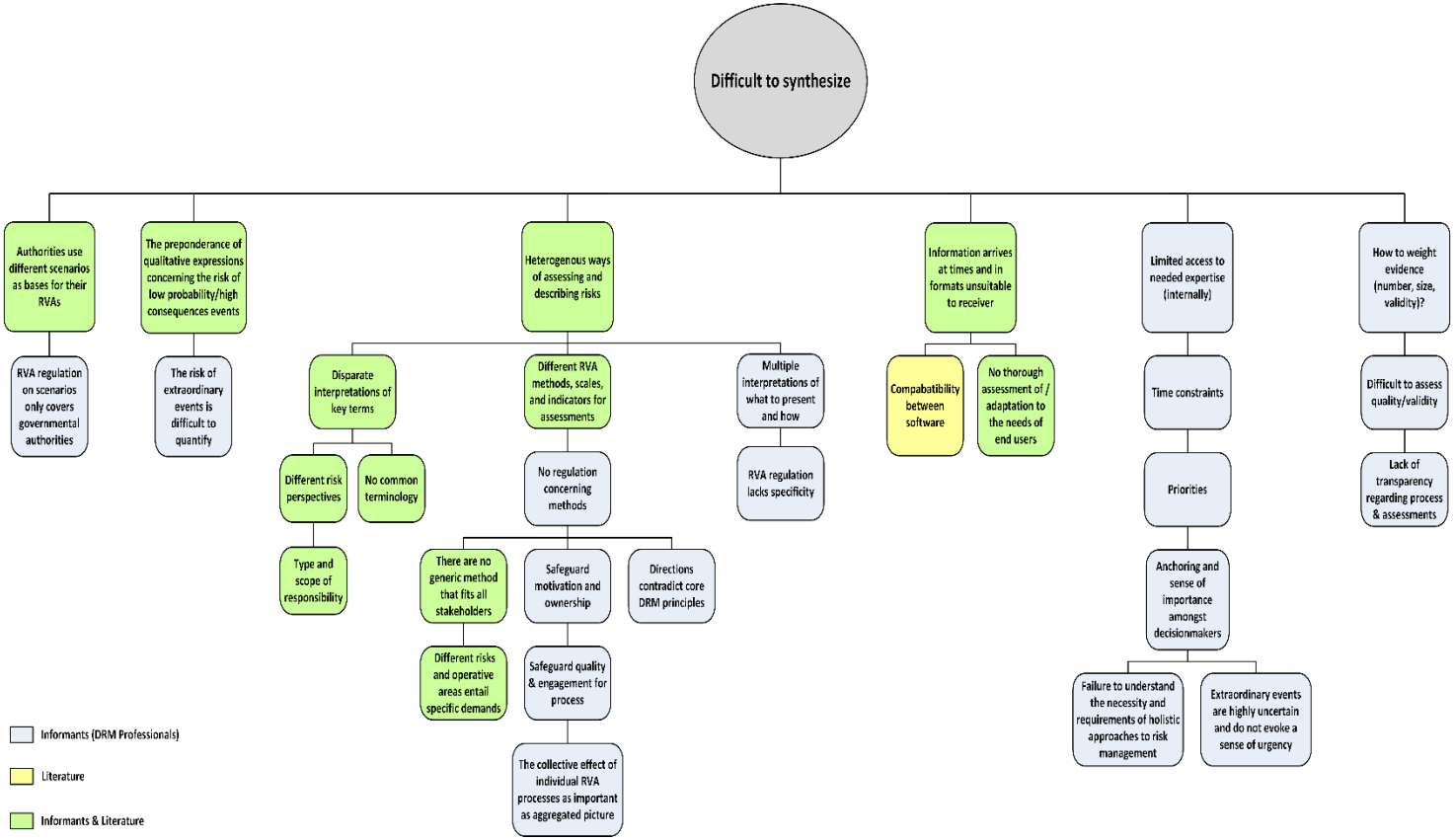

Fig. 5-3. Main challenges and their causes regarding synthesizing information from multiple stakeholders as basis for comprehensive pictures of risks to societal safety.

Note: Please. cf. note for Fig. 5-2.

5.2.2.3. Disseminating Synthesized Information

With regard to communicating the aggregated risk picture, challenges include the need to safeguard sensitive information. As stated earlier, authorities have the option to classify RVA information, and such confidentiality also applies at the receiving agency. In principle, this means, for example, that a municipality can submit its RVA report to a county administrative board without the danger of sensitive information reaching the public. However, even if none of the reports collected from municipalities have been classified, this does not mean that the amalgamated information stemming from these reports is non-sensitive by default. Where protecting sensitive information is concerned, aggregation of information can go in either direction. It might be used to blur the representation of reality by decreasing the possibility of identifying how each individual part (e.g., risk source, individual, or system) contributes to the overall risk or vulnerability (Canavan & True, 2005). This could be achieved, for example, by presenting mean values alone for a certain population or by deciding on a resolution that makes it impossible to identify individual households when displaying geographical information (Fekete et al., 2015). However, as argued above (Section 5.1.1), the synthesis of information entails adding new information by detecting patterns and drawing inferences from the underlying material, where 1+1 may become 3. For this reason, desk officers at county administrative boards and national authorities (including the MSB) need to be prudent and check carefully whether such syntheses need to be classified, even in situations where they draw solely upon open material.

Another challenge pertaining to dissemination is the lack of thorough target-group analyses advising who to inform, as well as the means and formats through which to do this. The RVA regulations (MSB, 2015a, 2015b, 2016) stipulate certain authorities to which the RVA reports need to be communicated (as reflected by Fig. 3-3). However, the purposes of the RVA system (cf. Section 3.2) signal that the outputs of the RVAs should be conveyed to other stakeholders, as well. Primarily, the RVA results need to be shared internally so that the decision-makers within the authorities that have conducted the RVAs are able to reduce risk within their own areas of operation. RVAs should also serve to increase the risk awareness amongst the general public and, hence, authorities need to develop strategies to ensure this.

The purpose of contributing to a comprehensive picture of risk, vulnerabilities, and capabilities at all levels of society obviously entails inter-agency communication, as depicted by Fig. 3-3. However, since vital societal functions are provided, to a large degree, by private actors, there are reasons to include them as a target group for the outputs of RVAs, too. First, authorities are dependent on obtaining information from private stakeholders to ensure societal safety, and the possibility of this is increased, purportedly, if the authorities are able to provide useful information to private stakeholders in return. Moreover, from the perspective of private actors, access to

information about societal risk and vulnerabilities (including on critical interdependencies across different vital societal functions) may entail a competitive advantage, as it increases the chances of taking rational measures to safeguard the continuity of their operations and businesses. Such precautionary measures would benefit societal safety and citizens in general simultaneously; in other words, the exchange of risk information between public and private stakeholders (as opposed to just collection or dissemination) can be a win-win situation. Despite this, as indicated by the participants at the LFA workshops conducted for this thesis, as well as a study by Gramenius and Svensson (2013), it seems as if private actors regard themselves mainly as contributors to, rather than beneficiaries of, exchanges of risk information with public authorities. The workshop participants did not perceive that private stakeholders or the public in general show much interest in the RVA reports that authrorities produce. This may be due to a widespread complacency amongst the general population in Sweden; i.e., that they want and trust the authorities to cater for their safety (Boholm et al., 2012; Enander, 2010, p. 44), and thus do not seek information (at least not in terms of RVA reports) that may help them to prepare for disasters on their own.

When asked whether the perceived lack of interest on the part of private actors and the general public in RVA reports might be due to inefficient ways (i.e., channels and formats) of communicating their contents, informants from authorities at all administrative levels concurred that this may be the case. At the same time, however, none of the respondents had undertaken a target-group analysis to identify stakeholders that might be interested in, or benefit from, RVA outputs, or to ascertain the needs of such stakeholders, in terms of substance, presentation formats, and channels. Undoubtedly, such a mapping takes time and energy and adapting to their needs even more so. Besides, disseminating the final product to stakeholders beyond the ones stipulated by the RVA regulations is not perceived as a prioritized activity.

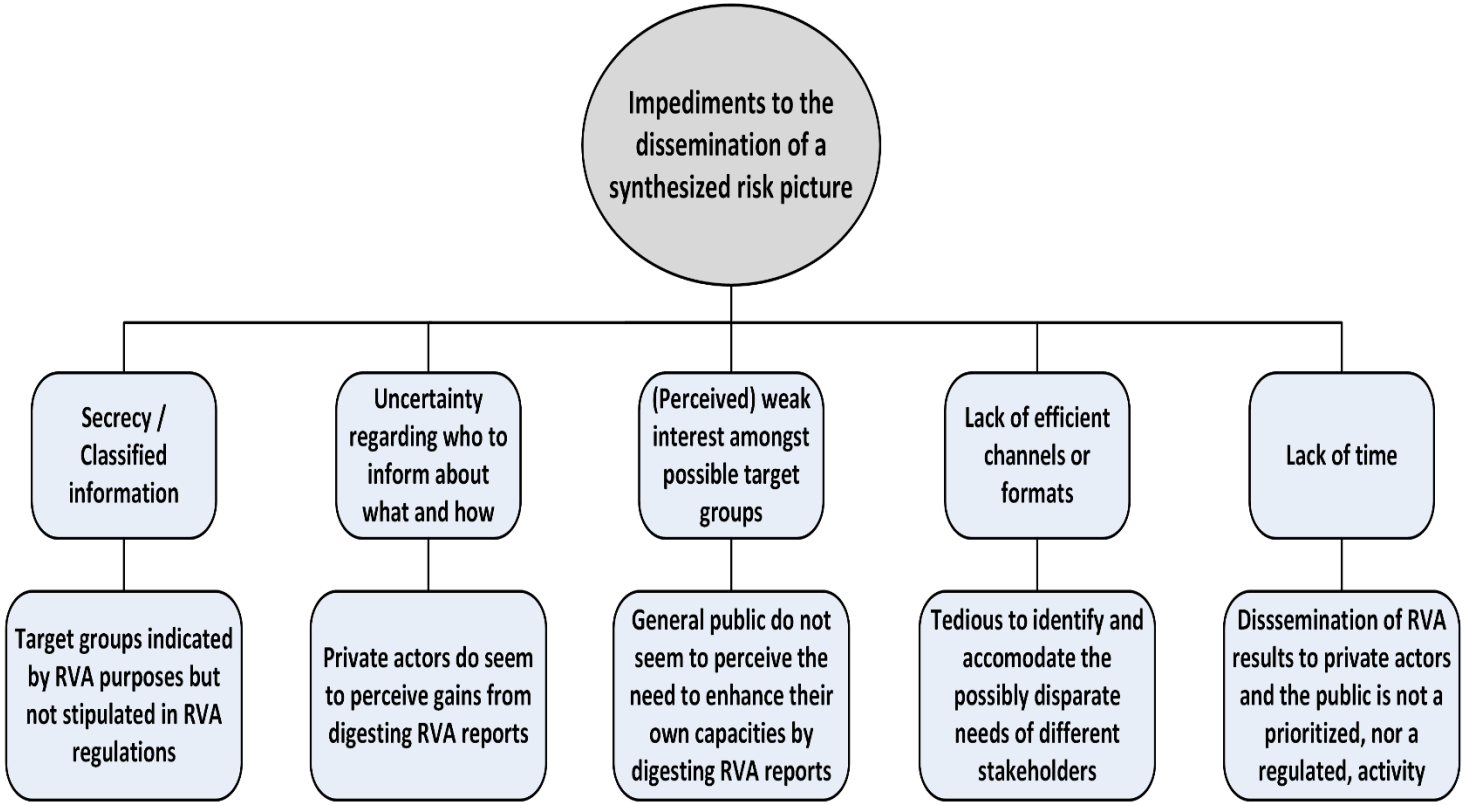

Fig. 5-4. Main challenges and their causes regarding disseminating syntheses of multiple assessments of risks to societal safety.

Note: this part of the research is tightly coupled with the Swedish RVA system and draws entirely on inputs from DRM professionals. Although similar aspects and stances have been observed in literature and case studies elsewhere, I refrain from extrapolating by indicating such correspondence here.

5.2.2.4. Providing Feedback on Received Material

A study by Lin and Abrahamsson (2015) indicates that the efficiency of the Swedish RVA system is inhibited by a general lack of constructive feedback being passed between authorities at different administrative levels. Given that the RVA system requires that recurrent cycles of RVAs are communicated among the same set of stakeholders, there is an opportunity to use feedback to improve the chances of aggregating information throughout the system. Understanding this potential, the MSB has continued to issue reports containing compiled impressions on the strengths and weaknesses of the RVA reports that it receives from other authorities. Yet, DRM professionals at the receiving end consider these reports to be too general and would like more specific feedback on their own RVAs. Listening to this critique, the MSB has chosen, in recent years, to supplement its general feedback with more detailed reviews of certain authorities' RVA reports, a process which has included visits to the risk managers in charge of these reports to enable thorough discussions to be held concerning the merits and drawbacks of their RVAs. During interviews for paper I, a respondent from the MSB conveyed that this initiative has been well received, albeit limited manpower and time has allowed the MSB to undertake thorough reviews of about 5 out of the 46 reports that are handed to them every RVA cycle only. Since the current RVA regulations stipulate that governmental authorities should submit RVA reports every two years, this means that it could take 18 years between the MSB conducting a first and second review of the same authority (if these reviews are performed according to equitable rotating schedule amongst the 46 authorities). Accordingly, the possibility for the MSB to use feedback to influence the way that authorities assess and describe risks is, to a large extent, contingent upon the time and willingness of individual authorities to scrutinize and adapt to the observations that the MSB conveys through its general report.

Perhaps ironically, the very authorities that yearn for feedback from the MSB are not providing much feedback to their own informants. During the interview studies conducted as part of paper I, several municipal representatives complained about the lack of feedback on the material they convey to regional county administrative boards. Some of them expressed that it was as if their reports "disappeared into a black hole"; they were unaware, therefore, of whether (and, if so, how) they affected RVAs at a regional level (Månsson et al., 2015). Representatives from county administrative boards, then sought to justify the lack of feedback by using same arguments conveyed by representatives from the MSB: i.e., shortages of time and manpower. These issues could be explained by prioritization on the part of decision-makers within their own organizations, who may fail to allocate the resources necessary to provide feedback because the activity is not regulated—if such decision-makers do not perceive this process as relevant or cost-efficient, in comparison with other issues that need attention, then it will not be resourced adequately.

Some respondents also complained that parts of the feedback they had received were invalid and reflected a lack of understanding about political, economic, or organizational realities "on the ground". The possibility of providing relevant feedback is also inhibited by the lack of an easy-to-follow checklist on what constitutes a "good" RVA. It might not suffice simply to follow the RVA regulations, and informants from county administrative boards reasoned that a general list of important issues to consider whilst reviewing RVAs could facilitate the task of providing feedback—and, thereby, increase the likelihood of doing so. Many respondents have underscored that it is demotivating not knowing if and how their contributions are taken into account by the actors who ask for them. This could affect their willingness to provide information during RVA cycles to come—and this applies to public as well as private stakeholders. However, given the absence of regulations concerning feedback to external providers of risk information, it remains uncertain whether one should provide feedback and, in that case, to whom and how.

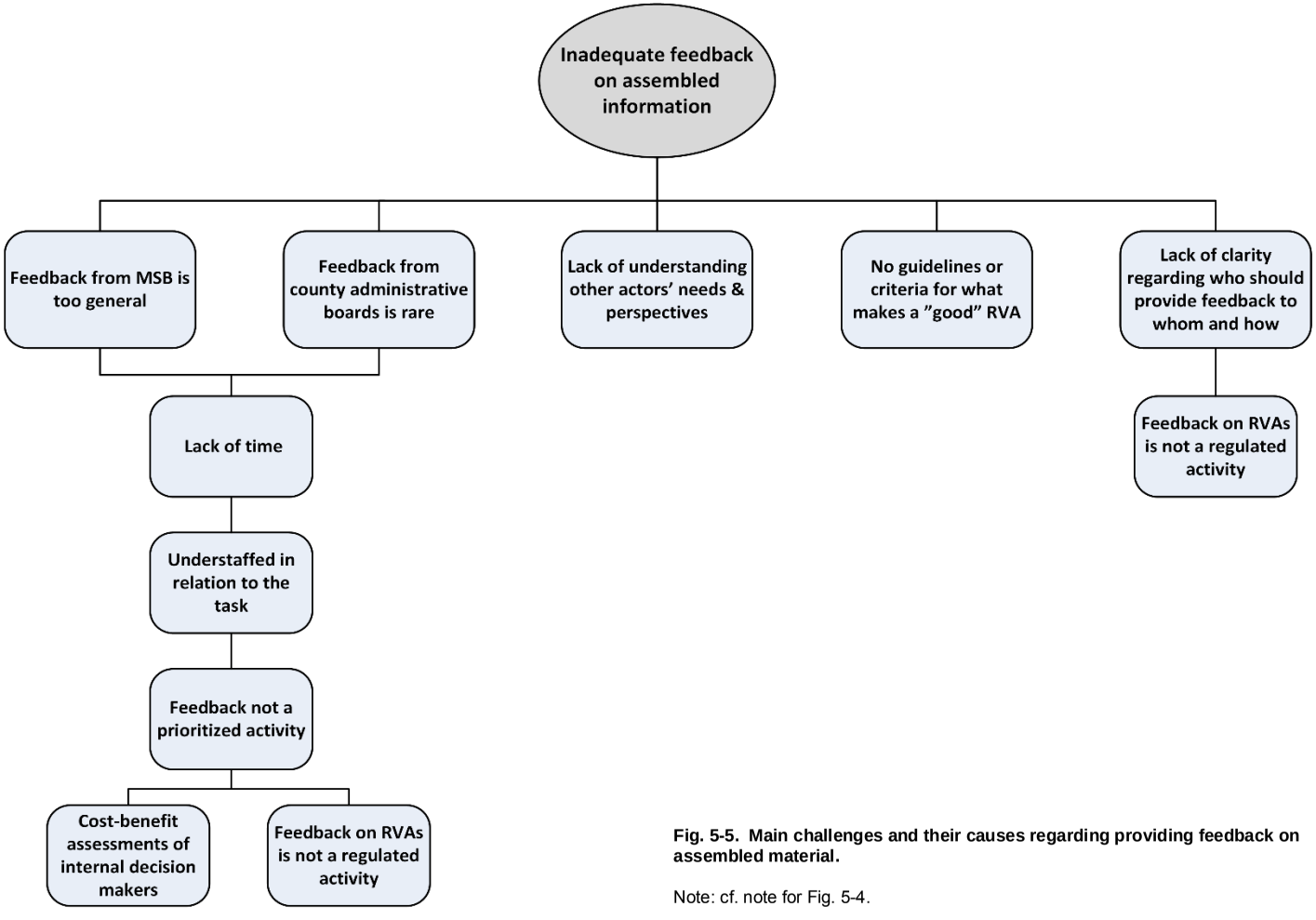

Fig. 5-5. Main challenges and their causes regarding providing feedback on assembled material.

Note: cf. note for Fig. 5-4.

5.2.3. Potential Effects of Difficulties in Aggregating Information about Disaster Risk

This section addresses the second part of research question 3. It draws mainly on input from professionals in the Swedish DRM system and their views on problems stemming from the challenges of aggregating information on disaster risk from multiple stakeholders. Some of the direct effects are already present, whereas the indirect and long-term effects are more speculative and are derived from the brainstorming sessions held during the LFA workshops conducted for this thesis. Nevertheless, to stay true to the material, I have chosen to represent the full spectrum of ideas, embracing both existing and potential implications, as experienced or communicated by the informants. In the same way as for the challenges, the effects and their causal connections are illustrated by means of an illustration (Fig. 5-6) at the end of the section.

The first and most direct effect of the challenges discussed in the previous sections is the existence of sub-optimal bases for decisions on how to manage disaster risk. If one cannot compare the level of risk in different parts of geographical or functional areas, it is not easy to make rational (cost-efficient) decisions on the allocation of limited resources; i.e., prioritizations regarding which risks to address where, when, and how. This not only incurs the risk of sub-optimal allocations of tax money, but also (and more importantly) the risk of unnecessary losses to things of value (e.g., lives, property, the environment, etc.) if disasters occur. Such effects may lead to a loss of confidence in the political leadership and in authorities with DRM responsibilities. Indeed, questions about accountability tend to be high on the agenda in the aftermath of events that incur major losses (Brändström, 2016; Kuipers & 't Hart, 2014). Albeit unrelated to the issue of aggregation, the management of a number of recent events in Sweden has also prompted thorough investigations and led to public resentment, a situation which has forced politicians and senior managers at governmental authorities to resign, as well as inducing calls for structural and procedural changes to the DRM system in general (e.g., the tsunami in Southeast Asia on Boxing Day 2004, Storm Gudrun in 2005, the forest fire in Västmanland during the summer of 2014, and the ongoing scandal involving the National Transport Agency, which outsourced the handling of classified data to companies with no security clearance; cf. (Asp et al., 2015; Brändström, 2016; Länsstyrelsen i Kronobergs län, 2005; Radio Sweden, 2017; Swedish Government Official Report, 2005).

During the LFA workshops, it was suggested that widespread distrust in the ways in which the political leadership caters for citizens' safety may induce people to stop listening to directives and to seek their own solutions. This can create chaos in disaster situations and a "law of the jungle," in which some people's safety is achieved at the expense of others (examples include hoarding necessities such as medicines, food, and batteries, or even buying weapons for self-protection). Such a state of affairs

can endanger the protection of all national goals for the safety of society, including citizens' lives and health, societal functionality, and the maintenance of basic values like democracy, rule of law, and human rights and freedoms (Försvarsdepartementet, 2006, p. 16). Admittedly, attributing such consequences to the difficulties of aggregating information on disaster risk may seem farfetched. Such effects, however, should be considered in light of general discontent amongst the population with the ways that authorities provide for their safety and wellbeing, where the inability to aggregate information to understand disaster risks - and its correlated consequences - may be contributing parts.

More direct and tangible effects of the challenges involved in attempting to aggregate risk information from various stakeholders are feelings of frustration and resignation among the risk managers who are obliged to do it (paper I). Such sentiments may also give rise to a loss of motivation for the task and, hence, may imperil the quality of its outputs. In turn, this could lead to poor bases for decisions and the same spiral of detrimental effects as described above. A final, and interesting, effect is the instigation of national workshops to supplement the information obtained through RVAs. Since the requirement of handing in national risk assessments to the European Commission came into force (cf. Section 1.1), the MSB has conducted annual workshops with representatives from the private sector and authorities at all administrative levels in Sweden to discuss the potential effects of various risk scenarios and ways to tackle them. These workshops would not be necessary if the RVAs themselves were sufficient to construct a holistic picture of risks to societal safety. Moreover, such workshops require additional resources in terms of time, energy, and money.

Nonetheless, the MSB is pleased with the workshops and asserts that they function as a good complement to the RVAs—and even offset some of the challenges involved when trying to aggregate their contents (Månsson et al., 2015). A major benefit is that all stakeholders use the same scenario, scales, and indicators as bases for their assessments. In addition, the workshops provide a chance to gain first-hand information from private stakeholders who are not formally obliged to conduct or communicate RVAs within the Swedish DRM system. Joint discussions with representatives from authorities at all administrative levels also facilitate the identification of functional interdependencies across administrative and sectorial boundaries. As such, the workshops may be instrumental in enabling false assumptions on aspects like redundancies, for example, to be revealed and rectified, or for identifying ways with which the collected resources of the assembled stakeholders might be combined, with synergetic effects. Such ideas do not materialize easily if stakeholders assess their vulnerabilities in isolation; they could, indeed, be seen as the fruits of aggregation. In addition, the workshops help to develop networks and trust between people who might have to collaborate if the risk scenarios occurred, which is conducive to societal safety in itself (Hallin et al., 2004, p. 24; Hassel, 2010, pp. 92-93; Nilsson, 2010, p. 22). However, workshops have some significant drawbacks,

including the resources necessary to arrange multi-stakeholder meetings and also the possibility that dominant persons may assert undue influence over the outcomes of the deliberations (Babuscia & Cheung, 2014; Chhibber & Apostolakis, 1993). Moreover, stakeholders at workshops do not have the opportunity to communicate as much detail about their organizations as they are able to through their RVAs, and the workshops do not engage more than a fraction of people that are involved in working with RVAs (Månsson et al., 2015). Thus, these workshops have both advantages and drawbacks, when compared with RVA reports; they should be used, therefore, as a complement to, rather than a substitute for, them.

In conclusion, the effects of the challenges of aggregating information on disaster risk from multiple stakeholders in the Swedish DRM system have already given rise to negative effects and may even aggravate the situation further. However, the challenges have also prompted the development of innovative ways of resolving them, such as the introduction of multi-stakeholder workshops, which may facilitate aggregation and enhance disaster preparedness more broadly. In the following section, we will consider additional ways of addressing the challenges observed.

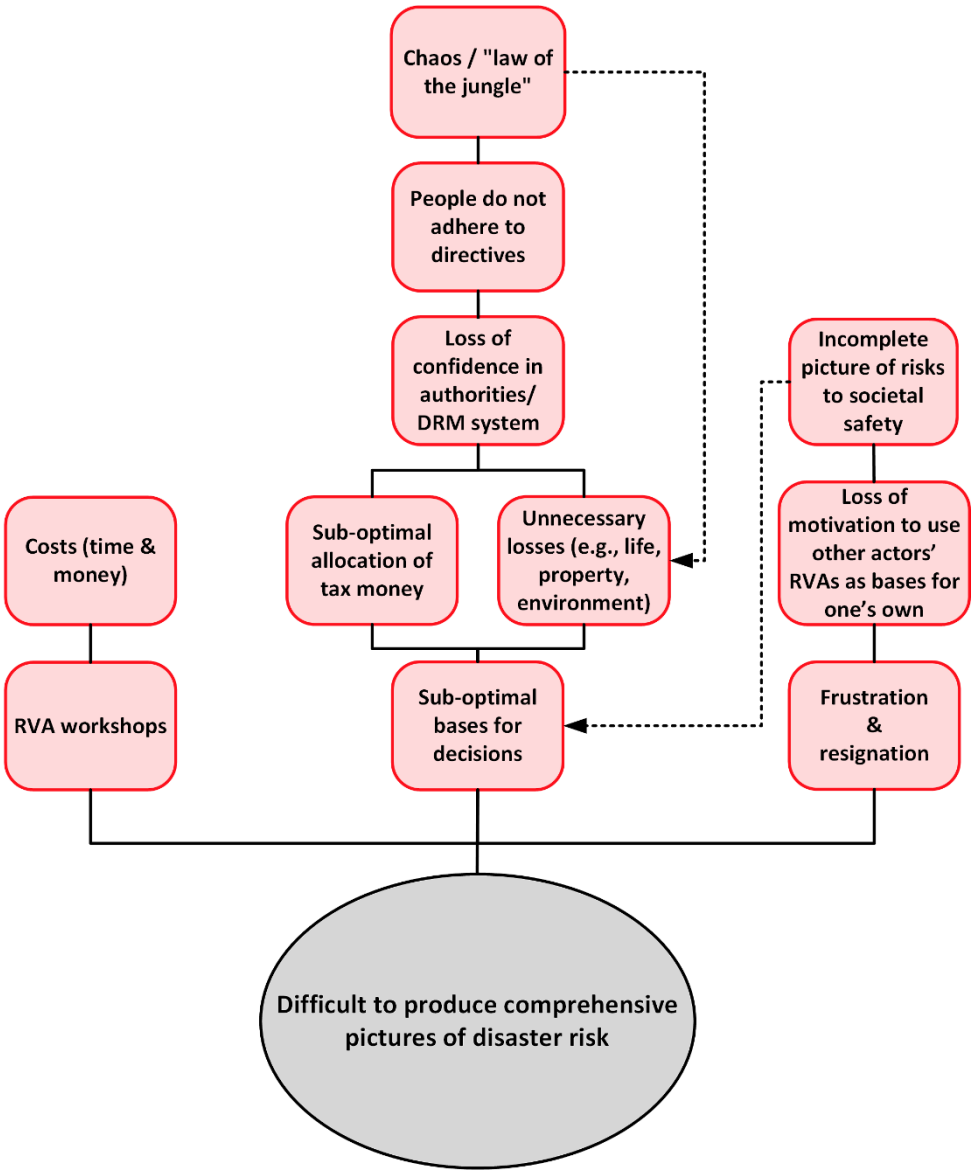

Fig. 5-6. Direct and indirect effects of difficulties with aggregating disaster risk information from multiple stakeholders.

5.2.4. Measures to Enhance the Possibility of Aggregating Information on Disaster Risk from Multiple Stakeholders

As we have seen thus far, the broad scope and explorative nature of the research questions focused upon in this thesis has led to quite a number of challenges being identified, which are dispersed across different processes that are either part of, or deemed important for, the possibility of aggregating disaster risk information from multiple stakeholders. Unfortunately (but unsurprisingly), there is no wide-ranging methodology available as a panacea to resolve all of these challenges. The measures elaborated in this section represent the assorted ideas gathered from the amalgamation of theoretical studies, interactions with DRM professionals, and my own reflections (unless otherwise stated, the suggestions are my own, albeit informed by other sources). The measures are neither comprehensive in the sense of addressing all of the challenges identified, nor have they all been tested and validated through scientific processes; rather, they are grounded in the perceptions of the people who have experienced the challenges and have tried to solve them in practice. As such, they can be viewed as "nudges" toward facilitating the aggregation of disaster risk information from multiple stakeholders. For the sake of coherence, these nudges have been sorted in accordance with the four processes discussed previously.

5.2.4.1. Collecting Required Information

- **Update and promote the mapping of interdependencies between vital societal functions**

To enhance the efficiency with which authorities may obtain information as a basis for their RVAs, it is suggested that the MSB should analyze the interdependencies between each of the 11 sectors it has identified as essential in the national strategy for the protection of critical infrastructure (MSB, 2011, p. 21), and communicate the results to the remainder of the authorities in the RVA system. It would not be efficient for each of the 356 authorities obliged to conduct RVAs to perform this mapping on their own; moreover, through its extensive network, the MSB has access to the expertise needed to ensure the validity of such an analysis. A generic overview of the flow of goods and services between these 11 sectors would enhance individual authorities' understanding of the potential cascading effects of different risk scenarios and enable them to contact the right sets of stakeholders when performing their RVAs.

It should be pointed out that the MSB's predecessor, the Swedish Emergency Management Agency (SEMA), performed a similar mapping shortly before it was dismantled (MSB, 2009). The work resulted in information on the interdependencies between vital societal functions and tools that could be used by individual

organizations when assessing their dependencies on internal and external resources. However, the communication of the outcomes was stalled by the transition of responsibilities when the MSB was created. The diffusion and impact of the results may also have been impeded by the rather complex contents of the associated reports, as well as the absence of training or other kinds of support to facilitate such implementation. Moreover, although the functional areas encompassed by SEMA's assessment were similar to the 11 sectors that the MSB later prioritized within work to ensure societal safety, they were not identical. Additionally, the dynamic development of contemporary societies may mean that some of the interdependencies that were established previously have since become altered. These aspects motivate the contention that the MSB should review, and potentially adjust and supplement, the work that SEMA conducted, as well as simplify its presentation or help the intended target group to use it in other ways (e.g., by providing training).

- **Create multi-hazard scenarios to promote information sharing and trust between actors with disparate functional responsibilities**

Understanding how vital societal functions are interconnected is a necessary, but insufficient, step for identifying which stakeholders one ought to involve when performing RVAs (i.e., the actors who are affected by, or may reduce the likelihood or effects of, a particular scenario). Since different actors are relevant to different scenarios, it is also important to grasp how different hazards may interact—how they may trigger each other or, indeed, amplify or decrease each other's probabilities and consequences (Carpignano et al., 2009; Commission European, 2010, p. 23; Gill & Malamud, 2016). Most risk assessments (including RVAs in Sweden) focus on one hazard type at a time, whereas recent real-world experiences (e.g., the flooding of New Orleans following Hurricane Katrina in 2005; transportation disturbances due to the eruption of Eyjafjallajökull in Iceland in 2011, and the Tohoku earthquake and the subsequent tsunami and nuclear-reactor meltdowns in Japan the same year) show that correlations between natural hazards, technological hazards, anthropogenic activities, and our complex socioeconomic systems are to be expected and must be prepared for. By focusing on one hazard at a time, however, we may underestimate vulnerability levels and even exacerbate them, as a measure to mitigate one type of hazard may increase the risk of another (Budimir, Atkinson, & Lewis, 2014; Kappes, Keiler, & Glade, 2010; Marzocchi, Garcia-Aristizabal, Gasparini, Mastellone, & Di Ruocco, 2012). In addition, an unconnected approach delimits the types of participants involved in the production of RVAs. By constructing multi-hazard scenarios on the basis of sound analyses of how different hazards interact, the scenarios themselves will catalyze the exchange of information and interaction between actors who are likely to have to collaborate during real events with cascading effects.

In line with this, it would be useful if the MSB were to assess the potential interactions between the 24 hazards they have identified as pertinent, from a national perspective (MSB, 2011b), and to use this analysis as a foundation for creating multi-hazard scenarios that all governmental authorities might be obliged to assess in accordance with RVA regulations (MSB, 2016). The hazard interaction matrices and hazard/process flow diagrams developed by (Gill & Malamud, 2014, 2016) could be helpful for this endeavor. By combining the mappings of the interdependencies between vital societal functions (connected to the 11 sectors described above) with the interactions between different hazards (as integrated in multi-hazard scenarios), authorities would be able to make informed choices on the sets of actors that they should try to involve in the production of their RVAs.

Having said this, it is important to point out that it is impossible to identify, lest assess and prepare for, all possible risk scenarios (Commission European, 2010, pp. 21-22; Flage, Amundrud, & Wiencke, 2015; Taleb, 2010). One way to go about this is to identify consequences and needs that are likely to arise in the wake of the most pertinent risks, as selected via the risk evaluation phase (cf. Section 3.2.1), and to develop the required abilities to address them (e.g., systems and routines for issuing alerts; creating situational-awareness; communicating with the public and between authorities). Naturally, hazard-specific consequences exist as well, which prompt the need to develop hazard-specific abilities (e.g., resources and knowledge to deal with CBRN accidents, floods, or earthquakes). Possessing capabilities to address generic and hazard-specific needs will provide flexibility, as these capabilities may be combined in different ways, depending on how a specific event unfolds. In turn, this would reduce the need to identify and prepare for all possible risk scenarios. Yet, this pragmatic way of dealing with an uncertain world may encourage authorities to delimit themselves to single-hazard types of risk scenarios, when both types of risk assessments may be needed.

In line with the reasoning regarding the interplay between analyses and syntheses (cf. Section 5.1.1), one may need to begin by assessing the consequences, needs, and required abilities pertaining to individual hazard types (i.e., the analysis) before comparing these in order to understand which of the consequences, needs, and abilities are common to multiple-hazard types (i.e., the synthesis). Having assessed and developed abilities for such generic functions, organizations may then be ready to start assessing multi-hazard types of risk scenarios in multi-stakeholder settings. Indeed, the European Commission is urging EU member states to consider multi-hazard scenarios as bases for their national risk assessments (Commission European, 2010, p. 29). I believe that the Swedish RVA system is ripe for this.

- **Increase efforts to engage private stakeholders in DRM**

Given that the significant share of vital societal functions are in the hands of private stakeholders, these stakeholders also carry an analogous share of the informational basis necessary to be able to produce high-validity RVAs on extraordinary events. However, the current RVA regulations include public authorities only; there is no formal requirement for private stakeholders to partake in the assessments. The crux of the matter is that dialogue between private and public actors needs to be increased in a way that is perceived to be practical and effective for both types of stakeholders. As usual, changes may be catalyzed by carrots or sticks. A representative from a county administrative board mentioned that they planned to condition municipal allowances for crisis preparedness on the degree to which they had grounded their RVAs on cross-sectorial information exchange and integration of the perceptions of private stakeholders (or, alternatively, to use the allowances to stimulate such collaborations). This is, indeed, in accordance with a formal agreement enacted between the MSB and the Swedish Association of Local Authorities and Regions (MSB, 2013, p. 5). However, such a measure might be precarious to carry out in practice. First of all, it would be difficult to establish a threshold for an "acceptable level" of public-private partnership (is it enough to exchange documents or do representatives have to meet in person? How frequently? To discuss which matters?). Second, it could prove tricky to monitor and determine whether or not municipalities had met the criteria. In addition, public-private partnerships are contingent on mutual interest, so should municipalities be "punished" if private stakeholders neglected or declined invitations?

The LFA workshops also included discussions on the possibility of pressuring private stakeholders by, for example, allow only companies that contribute to public-private partnerships in the realms of DRM to carry out (and make profits on) vital societal functions. However, the same types of difficulties in deciding and monitoring collaborative criteria apply in this case, and it may be more efficient to try to induce a shift in the mindset of private stakeholders from a self-perception of being mere contributors to one in which they see that they may benefit from exchanging information with public actors. Obtaining access to information that may help to safeguard their operations and profits (such as the results from the mapping of interdependencies across hazards and societal sectors as discussed above) should be sufficient incentive, but such gains need, perhaps, to be better communicated by public stakeholders and better understood by private ones. To make meetings and workshops more attractive, interesting guest speakers could also be invited to attend, as suggested by Gramenius and Svensson (2013).

- **Increase trust and public-private partnerships through joint exercises and training, particularly on the management of sensitive information**

Persuading people to meet is one thing; encouraging them to share information is another. To enhance the chance of the latter occurring, it seems that private stakeholders need to increase their trust in authorities' ability and willingness to safeguard sensitive information. Meetings and joint ventures, including training and exercises, are potential ways to generate inter-organizational trust (Garnett & Kouzmin, 2007). To "kill two birds with one stone," joint training on the protection of sensitive and classified information could be conducted, a field which has become more relevant than ever in the wake of the resumed ambition of the Swedish Government to ensure a strong total defense (Försvarsmakten & MSB, 2016; Swedish Defence Commission, 2017).

- **County administrative boards to function as mediators between municipalities and enterprises with region- or nationwide operations**

To address the challenge that private stakeholders with region-wide or nationwide operations cannot partake in every municipal RVA, it is suggested that county administrative boards should act as hosts at regional conferences to which risk managers from all municipalities in a given county would be invited and encouraged to pose questions to pertinent private stakeholders. To rationalize information collection even further here, the county administrative boards could collect questions from the municipalities as a basis for deliberations with private stakeholders at the three collaborative forums that bring together county administrative boards in the southern, middle, and northern parts of Sweden.

- **Avoid naming and shaming, but show "good examples"**

The potential problem of authorities deliberately overestimating their DRM capabilities to avoid being regarded as the "black sheep" among their peers could be offset if the authorities that possess the aggregated picture refrained from exhibiting it to everyone. Increased comparability between different stakeholders' assessments (which may result from some of the recommendations in the following section) should be used, rather, to underscore "best practice" and highlight those stakeholders who seem to be well prepared in relation to certain scenarios. Authorities that do less well know it themselves, and they would be able to receive guidance via the promotion of "good examples" and by knowing who they could turn to in order to enhance their DRM capabilities. In this way, increased comparability could improve opportunities for peer-to-peer learning and, hence, serve not only the authorities tasked with aggregating separate assessments, but also the individual authorities who provide them.

- **Adjust deadlines for submitting RVA reports**

The bottom-up approach envisioned by the Government posits that DRM capabilities should be built from the local to the national level, via the regional level (cf. governmental bills from 2002 and 2006). This is rational, given that the municipalities are the authorities that are closest to, and hence should possess the best knowledge on, the systems in focus of protection. However, if municipal RVAs are to function as input for RVAs conducted by regional county administrative boards (which, in turn, should be bases for RVAs at the national level), it is not practical for these authorities to have the same deadline for submitting their RVA reports.

- **Continue the two-pronged strategy for obtaining information on disaster risk (i.e., through RVA reports *and* workshops)**

As previously argued (Section 5.1.3), internal RVA processes at individual authorities and multi-stakeholder workshops (such as the one MSB conducts to broaden the basis for national risk assessments) have different advantages and drawbacks. However, both are viable means of obtaining information in support of enhancing DRM capabilities, and may produce better results conjointly than alone (an initial multi-stakeholder workshop may, for instance, provide an understanding of the indirect effects of various risk scenarios that may enhance the quality of individual authorities' RVAs). For this reason, authorities at local and regional levels could contemplate whether they might imitate the workshops conducted by the MSB in order to obtain information from regionally or locally pertinent stakeholders. However, being mindful of the potential geographical scope of extraordinary events and seeking to avoid fatigue in terms of participating in risk management workshops, it may be prudent to confine such workshops to regional conferences hosted by county administrative boards (perhaps in conjunction with private stakeholders representing regional or nationwide operations, as suggested above).

5.2.4.2. Synthesizing Collected Information

- **Continue using behavioral means of aggregating expert opinions**

Through the scoping study (paper IV), I became aware of research that differentiated between "behavioral" and "mathematical" methods of aggregating expert opinions (Clemen & Winkler, 2007; Meyer & Booker, 1991, pp. 118-119). The former entails group interaction between experts and methods that facilitate the production of common estimates in relation to the issues at hand. The latter, on the other hand, uses mathematical algorithms to produce single, combined estimates based on the distribution of several experts' individual estimates. Significant approaches of this type include Bayesian inferences (French, 1985; Genest & Zidek, 1986; Jacobs, 1995; Lindley, 1983; Morris, 1977), evidential reasoning based on Dempster-Shafer's rule of combination (Dempster, 1967; Shafer, 1976; Tang et al., 2012), and fuzzy logic (An et al., 2016; Dubois & Prade, 2015; Shang & Hossen, 2013; Zadeh, 1978).

As portrayed already in section 3.2.1., Swedish authorities typically use behavioral means of aggregating expert opinions and there are various reasons why mathematical methodologies may be inappropriate in the present context. For instance, the Bayesian and Dempster-Shafer methods have a strong focus on probabilities, whilst omitting the consequence side of risk (Yang et al., 2015a). They also require quantitative estimates and are best suited, therefore, to assess risk scenarios for which there exist ample empirical evidence and less relevant in relation to scenarios that are very rare or have never occurred (which includes risk scenarios related to extraordinary events).[r] Even where risk that involves ample empirical data is concerned, there is no clear-cut evidence that mathematical methods outperform behavioral aggregation methods. In fact, Clemen and Winkler (2007, pp. 22-23) refer to several studies where behavioral methods have performed as well or better than mathematical methods, even if they also mention cases where the reverse has been true. In addition, mathematical methods often assumes that the experts are independent of each other (Booker & Meyer, 1988; Chhibber & Apostolakis, 1993), whereas the reverse is true, and expected, with regards to the production of RVAs. Joint deliberations amongst experts from many different fields, organizations and departments is here seen as conducive to the identification of interdependencies, gaps and duplications of capacities, and risk reducing measures as well as the creation of trust between stakeholders that may have to collaborate in the management of the risk scenarios if they were to occur (Hallin et al., 2004, p. 24; Hassel, 2010, pp. 92-93; Perry & Lindell, 2003, p. 347). Moreover, mathematical methods of aggregation involve the practical and difficult challenge of having to allocate weights according to the reliability of different experts and the dependencies between them (Babuscia & Cheung, 2014; Chhibber & Apostolakis, 1993; Clemen & Winkler, 2007; Paté-Cornell, 1986). Perhaps of more importance, however, is that many of the mathematical methods (such as those based on Bayesian operations, the Dempster-

Shafer rule of combination, or fuzzy-set theory) are arithmetically complex and require thorough training and experience, if they are to be used effectively.

An important value that has guided this thesis is that the study outputs should be applicable—and hence relevant—to the intended users—i.e., risk managers at Swedish authorities. The Swedish Civil Contingencies Agency (MSB) underscores that a major benefit of the RVA system is that it leads to increased risk awareness and enlarged networks amongst staff within and between Swedish authorities (MSB, 2012, pp. 15-16, 39; SEMA, 2006a, pp. 23-24). Such effects will emerge only if the staff is involved in the production of the RVAs and refrain from outsourcing the work to external consultants. To reduce the appeal of outsourcing, then, one must propose methods or measures that are attractive to the intended users, or which the users can feasibly apply on their own, at least. One way to approach this is to review the methodologies that these managers already use, which likely reflect their needs, resources, and constraints related to the task at hand (e.g., the individuals' levels of knowledge regarding risk assessment methodologies, the time at their disposal, and the characteristics of the risk in question). Whilst scrutinizing more than 120 RVA reports from authorities at all administrative levels in Sweden (paper I), I did not observe any authority using Bayesian operations, the Dempster-Shafer rule of combination, or fuzzy logic. This might be due to ignorance of these methods; it may also be that the methods are unfit to tackle the issues at hand, or are too cumbersome and difficult to understand and apply. In any case, for the reasons given above I believe that Swedish authorities ought to continue using behavioral means of aggregating expert opinions on disaster risk. Nevertheless, as clarified from the remainder of proposals presented here, there are ways to enhance how this is carried out.

- **Continue using scenarios—and, preferably, common ones**

The vast majority of Swedish authorities use scenarios as bases for their RVAs (cf. paper I). As opposed to solely assessing capabilities on the basis of existing resources (equipment as well as personnel), scenarios trigger imagination, which purportedly facilitates the identification of the direct and indirect effects associated with different risk scenarios and the related internal and external dependencies on services and goods. As such, scenarios function as points of reference against which it is possible to assess whether the resources one possesses are sufficient or not (cf. Section 2.2 on the possibility of assessing vulnerability). Scenarios also facilitate aggregation as they function as similar points of reference for receivers of risk information (e.g., a county administrative board), enabling them to understand why different actors (e.g., municipalities) assess their capabilities in the ways that they do. In this way, scenarios enable comparisons between the DRM capabilities of different stakeholders.

Naturally, this requires that: a) the scenarios are well defined and b) the assessments are coupled with transparent motivations.

Aside from the general benefits of using scenarios as bases for RVAs, from the perspective of aggregation, it would be even more beneficial if different actors were to use the *same* (or at least *similar*) scenarios when assessing DRM capabilities. Whilst acknowledging that different organizations are focused on disparate types of risk, depending on their areas of responsibility and/or operations, authorities with a geographical area of responsibility (municipalities, county administrative boards, and the Government, through the MSB) have analogous obligations and the scope of their RVAs, therefore, is similar. Of course, there are differences between their respective administrative areas, where the presence of, for instance, harbors, dams, nuclear power plants, forests, or low lying landmasses in conjunction with waterways may induce variances in the focus and contents of their RVAs. At the same time, a number of hazards pose risks to all municipalities or counties (e.g., storms, floods, power outages, epidemics, financial turmoil, social unrest, antagonistic events, and leakages of hazardous substances). This common ground offers the potential to use the same scenarios and, hence, to increase the possibility of aggregating their risk information. As mentioned earlier, the current RVA regulation (MSB, 2016) grants the MSB the ability to oblige national authorities and county administrative boards to assess certain scenarios. The same rule does not exist with regard to county councils or municipalities. However, provided that the scenarios were relevant to authorities at all administrative levels and suited the interests of the National Board of Health and Welfare, as well as of the county administrative boards (in terms of receiving relevant input for their own assessments), it is possible that an agreement could be made for county councils and municipalities to assess the same kinds of scenarios, too.

- **Create dimensioning scenarios**

Given that the scenarios should be "extraordinary" (i.e. have a disaster potential) and that this is linked to DRM-capabilities, it requires the construction of variations of the same scenario so that it may be recognized as extraordinary for municipalities and county councils which differ in size and resources. To this end, scenarios could be constructed on three different levels to accommodate the conditions within small, medium-sized, and large municipalities or county councils (according to numbers of inhabitants, as these are linked to tax resources, which are a foundational element of institutional and operational DRM capabilities). Such differentiation could be achieved by adjusting the contextual factors that are decisive for the management and consequences of particular scenarios (e.g., by altering the temperature and time periods of power outages, or the wind speed and number of people exposed to a chemical accident).[5] Although the scenarios would vary in intensity, they would still provide useful information for aggregation purposes, as they would give rise to the

same types of consequences and involve the same kinds of stakeholders, and would require the same types of resources to cater for similar needs.

Further, this opens up the possibility of developing "dimensioning scenarios" connected to minimum standards for delivery of basic necessities, which would be useful means for benchmarking the ability of municipalities and private operators of vital societal functions to provide for the needs of citizens, given different scenarios. The so-called "result goals" for crisis preparedness that the MSB has already developed in relation to the provision of potable water, food safety, heat, information and communication, and financial services (MSB, 2015d) would provide a good base here. During the course of my research, I have gotten the impression that there is widespread uncertainty among risk managers at all administrative levels concerning which DRM capabilities they are supposed to have (in terms of level, as well as type). Dimensioning scenarios (expressed as, e.g., "given this magnitude of this type of scenario, we expect you to be able to provide potable water to 60% of your inhabitants within the first 72 hours from the onset of the event") would, I believe, help to clarify expectations and enable individual authorities to visualize targets. In addition, this approach would facilitate comparability across authorities and, thus, the possibility of obtaining cost-efficient allocations of resources to enhance DRM capabilities in functional or geographical areas that supersede the scope of individual authorities' responsibilities and RVAs.

- **Harmonize ways that authorities assess risk**

In addition to common scenarios, it would be beneficial to harmonize the ways that authorities assess risk. As argued in paper I, and strengthened further by the outcomes of the experiments in paper II, an ideal situation for the purpose of aggregating the risk assessments of various stakeholders would be characterized by:

1) a low degree of "uncommon categorization"; i.e., disparities in the ways that different actors interpret common terms and classify risk-related information such as hazard types, consequence dimensions, risk-reducing measures, etc.
2) a high specificity in the ways that likelihood and consequences are expressed (note: this is not the same as high validity; it connotes merely that quantitative expressions are easier to aggregate than qualitative ones)
3) a provision of narrative evidence in support of the assessments (i.e., transparent accounts of factors that have affected perceptions of risk, such as empirical experiences, anecdotal information, logical reasoning, and supporting statistics). Such information helps to counterbalance the difficulty of comparing risk assessments from actors that assess and present the likelihood and consequences of risk scenarios in dissimilar ways.

Whilst recognizing the difficulties with realizing these ideals in the current context (particularly the problems inherent in assessing the risk of extraordinary events via quantitative methodologies), there are opportunities for closing the gaps between the present and the ideal situation.

First of all, the MSB has tried to reduce uncommon categorization by expanding the list of definitions of important terms in the RVA regulations, and establishing common nomenclature is also a frequently proposed solution to communication problems in the DRM field (Bossong & Hegemann, 2016; de Bruijn et al., 2015; Komendantova et al., 2014; Schutz, 2005; Tomas et al., 2015).

Second, regulation may be an efficient way of catalyzing desired changes. As paper I shows, the inclusion of a scale and indicators to assess DRM capabilities in the RVA regulations has had a strong effect of conformity, in terms of the ways that different authorities assess and present capabilities. Similar scales and indicators have not been provided for the assessment of likelihood and consequences. Whilst recognizing the need to using particular methodologies to assess risk within specific functional areas (e.g., technical infrastructure), I believe that authorities with similar mandates, such as county councils or authorities with geographical areas of responsibility (municipalities and county administrative boards) should be able to use the same scales for assessing the risk of extraordinary events. Risk managers from these authorities could also collaborate with risk assessors using specific methodologies in an attempt to try to translate their assessments to fit a more generic scale (as has been proposed, for example, in the context of multi-risk assessment methodologies in support of spatial planning in European countries; see Grieving, 2006: 79). Albeit a somewhat coarse solution, this proposal could provide opportunities for valid indications of levels of risk in different parts of systems that need to be assessed by many different stakeholders. As is often the case with aggregating information, one has to balance the drawback of losing some of the detail with the gain of increased communicability (Abson, Doughill, & Stringer, 2012; Canavan, 2005; Fekete et al., 2015: 1854). In the process at hand, one should consider the needs of the target groups, especially where, for instance, crude-but-swift overviews may be needed to support strategic decision-making on the allocation of resources.

To enhance the possibility of aggregating multiple authorities' RVAs, it is suggested that the MSB and the National Board of Health and Welfare, in conjunction with county councils and authorities with geographical areas of responsibility, should develop common scales and indicators for assessing the likelihood and consequences of extraordinary events, which should then be incorporated into the RVA regulations. Mindful of the difficulties of assessing extraordinary events via quantitative methodologies, it is suggested that semi-quantitative scales, which the majority of the authorities already seem comfortable with using (cf. paper I), should be adopted. In addition, the indicators need to be generic and scalable so that they are applicable to

authorities with differently sized administrative areas (e.g., using percentages rather than fixed numbers for assessing potentially affected areas or parts of populations and systems).

Aside from disparate scales and indicators, there is still no agreement on which dimensions to use as basis for consequence assessments. As mentioned earlier, the MSB has supplemented the RVA regulations (MSB, 2015a, 2015, 2016a) with an appendix that, *inter alia*, includes recommendations on dimensions to consider (i.e., life and health; the functionality of the society; the preservation of rule of law and democracy; the protection of property and the environment). However, the appendix is not binding, and it remains to be seen whether it has the same conforming effects as the scales for capability assessments mentioned previously. Aside from its optional nature, two other factors speak against this. First, some of the dimensions are ambiguous and difficult to quantify, such as the meaning and state of "societal functionality" or "rule of law and democracy", which may discourage authorities from using them. In addition, the MSB has recently issued a fact sheet on the implementation of RVAs (MSB, 2017), which comprises of a set of consequence dimensions that diverges slightly from the ones recommended in the appendix of the RVA regulations (whereas "property" is mentioned in the appendix, "economy" is mentioned in the fact sheet. The latter also includes "human freedom and rights" and "national sovereignty," which do not appear in the appendix). Hence, it is suggested that the MSB establishes which consequence dimensions it would like authorities to use and develops indicators for each dimension to reduce variances in interpretation by the stakeholders who are expected to use them.

- **Increase the use of visual aids, and GIS in particular, to support the assessment and presentation of risk information**

Paper I revealed large discrepancies regarding the ways that different authorities convey the information in RVA reports—for instance, risks, vital societal functions, resources, and suggested risk-reducing measures could be presented as bullet-point lists, in matrices, or as plain running text. Using visual aids such as diagrams, matrices, tables, and colors has been shown to facilitate understanding by reducing the cognitive load and time necessary to comprehend complex and abundant risk information (Assmuth, Hildén, Lyytimäki, Benighaus, & Renn, 2009; Eppler & Aeschimann, 2009; Lipkus & Hollands, 1999). Visual aids may be a general means, therefore, of improving risk communication. To facilitate the aggregation of information from various stakeholders, however, the same visual aids need to be used across the board, as consistency from one report to the next would accelerate understanding of new material and facilitate comparison of the contents of different reports. As such, exploration of the types of visual aid that can support the presentation of the different items required by the RVA regulations is recommended.

A related and promising avenue is the notion of increasing the use of Geographical Information Systems (GIS) for RVA purposes. Due to the ability of these systems to overlay multiple maps according to different themes (e.g., hazardous areas, objects of interest, resources), they could serve to produce overviews of risk and vulnerabilities in individual administrative areas (such as in a municipality), as well as to enable the aggregation of risk information from multiple stakeholders and for various administrative areas (Abson, Dougill, & Stringer, 2012; Ballarin-Denti & Oliveri, 2010; Fekete et al., 2015; Zhao & Liu, 2016). The scoping study undertaken for this thesis returned a number of articles on how GIS is being utilized currently by many European countries to implement the EU flood directive (De Bruijn, Klijn, van de Pas, & Slager, 2015; de Moel et al., 2015) and to underpin the development of multi-hazard risk-management approaches (Carpignano et al., 2009; Gallina et al., 2016; Greiving, 2006). In addition, the general benefits of GIS for DRM purposes are expounded by Altan et al. (2013), Fekete et al. (2015), and Tomaszewski (2015). GIS, which incorporates the general benefits of visual aids (as mentioned above) is seemingly perfect for meeting the demands of, and addressing problems observed in, the Swedish RVA system.

Despite these advantages and the fact that risk information is, to a large extent, spatial in nature (Tomaszewski, 2015), the use of GIS for RVA purposes is still limited in Sweden. The content analysis completed for paper I showed that just 39 of the 127 RVA reports studied (~30%) contained maps, and many of these were restricted to displaying the boundaries of the administrative areas. A plausible explanation for this is that decision-makers and risk managers at public authorities generally have poor knowledge regarding what GIS is and how it can be applied to enhance their work. The participants at the LFA workshops conducted for this thesis also believed that extensive training would be needed if GIS was to be to used support the production of RVAs across the Swedish DRM system. There is untapped potential here, then, to utilize GIS for the production of RVAs and for the presentation and aggregation of their outcomes. Akin to the previous ORSA project (see Section 4.3), it may be fruitful to initiate a pilot project, in which a few interested municipalities could utilize GIS to analyze and present RVA information, before communicating the results to a county administrative board attempting to aggregate the input. If successful, the findings of the pilot could then be included in a best-practice handbook, alongside training material on how to implement GIS in the production of RVA reports.

5.2.4.3. Disseminating Synthesized Information

- **Perform target group analyses and enhance the communication of RVA outputs to stakeholders beyond public authorities**

To obtain the purposes of the RVA system (e.g., increase preparedness of society in general; increase risk awareness among decision-makers and the general public), the outcomes of RVAs ought to be communicated to stakeholders beyond the authorities that are encompassed by the RVA regulations. First, the outlook for increasing the input of external stakeholders, including private enterprises (as envisioned in Section 5.1.4.1), to the RVA process appears to be connected to the extent to which they obtain valuable information in return. This exchange could be arranged through the conduct of the conferences or workshops suggested above, which would be held under the auspice of regional county administrative boards. However, as has been shown previously (Nilsson, 2010, p. 66), stakeholders in the Swedish DRM system are more aware of the actors upon whom they depend, than of the stakeholders who may depend on them. Accordingly, they may not communicate the outputs of their RVAs to the stakeholders that may benefit from them. To increase the usefulness and potential impact of RVAs, it is therefore suggested that the different authorities producing RVAs should conduct analyses of which stakeholders are dependent on their services, as well as identifying suitable channels and formats through which RVA results may be conveyed to them.

Having ensured that no classified information is present in their RVAs, authorities normally post the reports on their respective webpages. However, given that most people have limited time to process information, uploading full RVA reports (which normally span between 30 and 100 pages) on websites may not be the most efficient way of conveying RVA outputs to the general public or other stakeholders. A better option may be to compose popular versions or summaries of the RVA reports in the form of easily digestible leaflets that include visual aids (e.g., matrices and maps) and focus on the main outcomes of the RVAs, such as the major hazards in a given area, their potential direct and indirect effects, what public actors have done to protect citizens, and what citizens can do to protect themselves. This approach has been trialled successfully by the county administrative board in Östergötland and has also been proposed (with examples) as an element of the outcomes of the ORSA project (cf. Blom et al., 2013).

To avoid burdening all the authorities with the task of developing their own templates for "RVA fact sheets," however (which, aside from being time consuming, could also complicate the communication of risks to external stakeholders with region-wide or nationwide operations), it is suggested that a common template could be developed at the forum for crisis preparedness that includes the MSB and representatives of all the county administrative boards in Sweden. When compared with uploading an RVA report to a website, the idea of producing an additional

summary would require a bit more time and effort by the authorities that conduct RVAs; on the other hand, having to review the RVA report and extract just the information that the general public needs to know would reduce the risk of information that may jeopardize societal safety being posted online by mistake. In the end, it would be up to the decision-makers at individual authorities to assess whether or not they should strive to attain the full objectives of the RVA system (e.g., by seeking to ensure that the outputs reach and raise awareness and preparedness among ordinary citizens) or settle for fulfilling the legal requirements (i.e., producing the RVAs and communicate the results to the delimited set of stakeholders stipulated by the RVA regulations).

- **Adjust the possibility of sharing information via the new digital reporting system and increase the benefits for the authorities who are meant to use it**

The impact and usefulness of the digital reporting system for RVAs that the MSB recently developed was discussed during the LFA workshops conducted for this thesis. Apparently, the system allows county administrative boards to obtain information only from municipalities; not from county councils or national authorities. It was suggested that this should be changed and that, akin to the functionality in WIS,[t] users should be allowed to disseminate their own information to whomever they like. This would, *inter alia*, obliterate the need to search each other's homepages or call desk officers to obtain the material sought.

In addition, it was suggested that the instrument could be made more attractive by coupling it with informational resources that may be useful when the individual authorities conduct their RVAs. Such resources could be electronic versions of the so-called "beroendehjulet" (MSB, 2009)—the mapping of interdependencies across vital societal functions and sectors, as discussed above—and a contact list of persons with extensive experience of RVAs and who could be consulted if needed. A final, but important, aspect is to ensure the integrity of the data, i.e. that the encrypting is indeed efficient and precludes unauthorized parties to access the information. If authorities do not trust this to be the case, it is likely that they refrain from using the system.

5.2.4.4. Providing Feedback on Received Material

- **Compose a checklist in support of feedback between receivers and producers of RVA reports**

To increase the amount of constructive feedback from the MSB and county administrative boards to the authorities that communicate RVA reports to them, it is suggested that the MSB should develop an easy-to-use checklist comprised of criteria for what a "good RVA" entails. Aside from submitting RVA reports in accordance with the structure and contents imposed by the regulations, such criteria could enable more tacit aspects (e.g., how participatory the process has been, the level of transparency concerning assessments, and the connections between assessments and proposed risk-reducing measures) to be embraced. The criteria could be derived, for instance, from the RVA handbooks and the feedback reports to governmental authorities that the MSB and SEMA have produced over the years. In addition, there is ample research offering reflections and recommendations on communication in the Swedish RVA system, which could also be used, e.g., Abrahamsson (2009); Eriksson (2010); Hassel (2010); Lin (2018); Nilsson (2010).

Naturally, this checklist should also be communicated to the authorities that are to receive the feedback being given. Aside from clarifying expectations, the checklist could be used, then, as a means of further harmonizing the structure and contents of RVA reports. Given that feedback provides impetus for the steady provision of information and is an instrument for obtaining useful input for the RVA system in general, it could be suggested that this activity should be mandatory—and, hence, part of the RVA regulations. However, it may be prudent to wait before compelling parties to do so as it would be sensible first to assess whether access to a tangible checklist would be sufficient to catalyze a fruitful dialogue between the providers and receivers of RVA reports.

Ch. 6. Discussion

6.1. General Reflections

This chapter reflects on the credibility, generalizability, and implications of the research findings. It also addresses the quality of the research and presents ideas for further research.

How Credible are the Results?

As argued by many scholars (Denzin, 2009, pp. 297-313; Patton, 2002, p. 247; Robson, 2002, p. 371), triangulation is a means of controlling bias, as well as obtaining valid results and propositions. In accordance with the risk-governance paradigm (which emphasizes the involvement of multiple stakeholders in DRM approaches) and the critical-realist view (which emphasizes the subjective nature of perceptions), I have considered it important to obtain perspectives from multiple sources and informants. First, this is of essence to ensure that the research questions are illuminated from a variety of angles. Second, as maintained by (Healy & Perry, 2000), and supported further by Yin (2003, pp. 97-100), convergence of results from various methodologies and sources of evidence also suggests that the findings reflect an objective reality.[u]

As presented in Section 4.4 and displayed schematically in Table 5-1, the results of this thesis draw on a number of different methodologies (e.g., interviews, experiments, content analyses, LFA workshops, and literature reviews). In addition, the informants include representatives of authorities at all administrative levels in Sweden (paper I), representatives of all regional county administrative boards (paper III), and students from different universities with distinct scholarly traditions (paper II).[v] For the scoping study (paper IV), which did not involve any respondents, triangulation was obtained through the use of multiple databases and keywords. The schematic figures in Chapter 5 (Figs 5-2 to 5-6) depict aspects and relationships that, in my understanding, represent the convergence of the results achieved from all the studies that underpin this thesis. The question remains, however: how certain can we be that these findings do, in fact, reflect an "objective reality"?

Unfortunately, this question is impossible to answer, as we all are limited by our subjective frames of reference. As such, we cannot be sure that we perceive the mind-independent reality in an objective way (in fact, we would not even recognize it if we saw it). Nevertheless, as suggested, we may be able to hint at such reality by examining the convergence of the outcomes obtained through different methods and sources. Whilst contemplating this, however, we may also need to distinguish between the strengths of the evidence gathered via each type of methodology, as well as acknowledge the uncertainty associated with the substance of investigation.

As pointed out earlier (Section 4.4.3), well-designed experiments yield a high degree of confidence in the relationships between the variables studied. The experiments conducted for paper II, together with convergent outputs of similar experiments (Lin, Rivera, Abrahamsson, & Tehler, 2016), strongly support the notion that the aggregation of risk assessments from several stakeholders is facilitated if these actors: 1) express risk using the same scales, 2) describe likelihood and consequences with a high degree of specificity (i.e., *simple* quantitative or semi-quantitative scales are better than qualitative descriptions or ordinal scales), and 3) supplement their assessments with background information ("narrative evidence").[w]

Regarding the outputs from the scoping study, the quality of the findings is ensured, to some degree, by the fact that the papers included were subject to peer review enacted by the scientific journals in which they were published. However, it has been my task to assess whether these findings are applicable in the current context, which, of course, is a potential source of error. The strength of the evidence obtained via the material that resulted from the remainder of the qualitative methods employed (interviews, LFA workshops, and content analyses) is contingent upon the convergence of the results emanating from the use of these techniques. Indeed, I believe that the outputs reported in Chapter 5 are representative of, and quite close to the actual functioning of, the Swedish DRM and RVA systems. However, the convergence of evidence does not necessarily equal validity, since a lot of sources may concur on aspects that are intrinsically uncertain. For instance, it is fair to point out that relationships between causes of current challenges to aggregation are probably easier to identify (and, hence, more valid) than estimates of their effects, as the former are already manifest (have already occurred), which is in contrast to most of the indirect effects (as depicted by Fig. 5-6).

Returning to the design science framework, we may also ponder on the validity of normative results; i.e., on the measures or "nudges" that are proposed to facilitate the aggregation of disaster risk information. Aside from paper II, for which the hypotheses were tested through controlled experiments, the anticipated benefits of most of these nudges have been evaluated analytically only, through considerations of findings in scientific literature (notably paper IV) or discussions with DRM professionals (papers I and III) and close colleagues. As argued in paper IV, the

scientific community has been apt in describing challenges to the quest of aggregating risk information, but less elaborate regarding recommendations on how these challenges may be countered. This may be due to the fact that most of the articles stem from social and natural sciences, which strive to explain the world as it *is*, rather than how it *ought to become*. To the extent that the articles contained prescriptive measures, their effect did not seem evaluated and the articles rarely rendered account for the generative mechanisms that were deemed to produce desired results. Adhering to the CIMO-logic proposed by Denyer et al. (2008), there is a need for supplementing proposed interventions (I) with thorough descriptions of the context (C) in which they are supposed to work and the mechanisms (M) that are deemed to generate the intended outcomes (O).

In the terminology of Carlsson et al. (2010), most of the proposals found in literature—including this thesis—have been subject to an alpha (α), but are yet to be exposed to beta (β) and gamma (γ), types of evaluations (this typology was explained in Section 4.1). As such, we may appreciate them as *design propositions* that need to be tested in their intended environments so that their efficiency, in terms of achieving their purpose, can be validated (van Aken & Romme, 2012). Accordingly, there is no certainty as to whether they will produce the projected benefits—and, unfortunately, the effects of some of these proposals will also be difficult to discern. Their ultimate objective—to reduce disaster risk and the occurrence of extraordinary events—entails the difficulty that these events are rare, producing a meager statistical basis for evaluating whether the objective has been met or not. The effects of individual proposals may also be hard to determine due to time lags in their projected effects, as well as difficulties in isolating their effects from the influence of other measures or from factors that may confound the results.

Nonetheless, by conducting various studies, I have explored the *environment* (the needs and limitations of intended users; the frames set by legislation, regulations, and policies; and the requirements connected to organizations and processes) and the *existing knowledge base* (e.g., theories and methodologies) related to the aggregation of disaster risk information in the Swedish DRM system. Information from these two sources of knowledge has also been merged as a basis for identifying proposals that, subsequently, have been explained and motivated through logical reasoning and justificatory knowledge (or, at least, attempts to show how they might serve to address current challenges). These activities are fundamental steps of design processes and according to Gregor and Jones (2007, p. 323), also sufficient as outputs of such. Ideas per se, they maintain, can be influential as catalysts for change and instantiations (e.g. material artifacts) as proof of concepts "could come later" (ibid, p. 324). What we can say here is that implementing some or all of the proposed measures is likely to facilitate the aggregation of disaster risk information from multiple stakeholders and, together with subsequent evaluations, will certainly add to our knowledge of how this can be achieved.

Can the Results be Generalized?

This thesis provides an account of a large number of challenges and proposals related to the possibility of aggregating disaster risk information. Being so rooted in the Swedish DRM system, however, one may wonder whether or not the outcomes are useful and applicable to other DRM systems, as well. Whilst reflecting on this, it may be useful to consider not just the challenges and measures themselves, but also the reasons why they exist in the first place. As pointed out in the introduction, the need for the aggregation of disaster risk information from multiple stakeholders and the challenges associated with this endeavor can be traced to the institutional fragmentation which has underpinned the development of modern welfare states but, simultaneously, has resulted in the dispersion of risk-related knowledge among a large number of interdependent stakeholders. This development has been common in contemporary societies all over the world, as has the ambition to apprehend and manage disaster risk through multi-hazard and multi-stakeholder approaches. Such commonalities provide a basis for suspecting that the findings of this thesis may be informative and useful for reflections on, and development of, DRM in other countries, as well. Many of the challenges identified through this thesis have also been highlighted in scientific papers describing other DRM systems, including the complex interdependencies between vital societal functions (Ansell et al., 2010; Hills, 2005; Olsen et al., 2007), the importance of inter-agency trust and communication (Garnett & Kouzmin, 2007; Haimes, 2001; Kramer, 2005; van Asselt & Renn, 2011), the necessity of concealing sensitive information (Beierle, 2004; Garrick et al., 2004, pp. 165-166), the challenges of integrating risk assessments based on disparate methodologies (Restrepo, 1995; Rosqvist, 2003, p. 9; Tomas et al., 2015), and the problems inherent in synthesizing qualitative expressions (Budescu, Weinberg, & Wallsten, 1988; Coppola, 2011, p. 142; Nakao & Axelrod., 1983). Moreover, there is no reason to suspect that Swedish people would be more vain, irresponsible, distrustful, or prestige-focused than people from other countries or cultures. Challenges related to accountability, competition for resources, and deliberate over- or underestimations of one's capabilities could therefore be expected elsewhere, too.

In essence, I believe that it is easier to identify which challenges and measures are likely to be relevant solely in a Swedish context, than to enumerate the ones that have transfer potential. These exceptions are likely to relate to the effects of particular pieces of legislation and policies (such as deadlines for submitting RVA reports) and specific tools developed by the DRM stakeholders themselves (such as the digital reporting system for RVAs). The remainder (i.e., the vast majority) of the challenges and connected "nudges" are likely, therefore, to be relevant to many other DRM systems, but it is beyond my knowledge and the purposes of this thesis to pinpoint the settings in which this might be the case. My aim here has been to identify and describe challenges and measures in the *Swedish* DRM system in a way that enables others to assess whether these are relevant and applicable in their contexts. Whilst

doing this, however, I contend that one should not forget that it is possible to extract useful information from the lessons learned via different systems (Creswell & Miller, 2000, p. 129). The studies undertaken for this thesis may provide knowledge, therefore, that is useful beyond the context of investigation. Likewise, I believe that research on the aggregation of disaster risk information in other contexts might contain helpful ideas for addressing challenges in the Swedish DRM system.

Having said this, it is fair to point out some characteristics of Swedish society that might be unique to the national context and which have implications for risk governance. One such aspect is the generally high degree of trust that scientists, politicians, and authorities enjoy from the citizenry, which, according to Boholm et al. (2012), may explain the low public interest and involvement in risk governance—including the production of RVAs. If this were not the case, there may be more contestation of the governance of disaster risk and interest in participatory approaches such as public hearings, surveys, and citizens' review panels, as discussed by Fiorino (1990) and Renn (1999). Another aspect that distinguishes the Swedish DRM context from others is the high level of self-autonomy enjoyed by individual authorities, which, together with the DRM principles of proximity, parity, and responsibility, constrain top-down approaches to risk governance. Given its importance for risk management in general and the production and aggregation of RVAs in particular, this matter warrants a few paragraphs of its own.

Top Down, Bottom Up, or a Mix of the Two?

Many challenges to the aggregation of disaster risk information in the Swedish DRM system are linked to the multidimensional purposes of its RVA system. The RVA is seen as a tool for preparedness planning at individual authorities but is also required to function simultaneously as a basis for generating comprehensive pictures of disaster risk in society in general. Many of the respondents to the studies undertaken for this thesis testify that these two purposes are in conflict, as the varied mandates and responsibilities of different authorities require specific risk-assessment methodologies, a situation which renders outcomes that are hard to synthesize. If we use Rasmussen's (1985) and Brehmer's (2007) analytical lenses (see Section 4.1), we may contend that there are discrepancies at the purpose, function, and form levels of the Swedish RVA system, in which aspects of its purposes (to generate a comprehensive overview of risk, vulnerabilities, and disaster-risk-management capabilities at all administrative levels) are hampered by difficulties in performing the required function (the aggregation of disaster risk information from multiple stakeholders), which is due to challenges at the form level. Here disparities in risk-assessment methodologies constitute but one of many barriers.

One of SEMA's guidance booklets on the performance of RVAs contains an encouraging picture of a "ladder of maturity," which seeks to illustrate that the quality of RVAs is a function of experiential knowledge, thus suggesting that initial attempts will become more refined and sophisticated with time (SEMA, 2006a, p. 21). This has probably been the case from the perspectives of individual authorities. Considering that the Swedish RVA system has been operative since 2002, however, the multiple challenges disclosed through the studies in this thesis reveal that the maturity process is quite slow, with regard to meeting the objective of aggregating information. At least, it does not seem as if the challenges can be regarded as "teething problems" that might disappear automatically as the authorities come to understand each other's needs and how to adapt to them. In fact, the difficulties go beyond a lack of awareness to include the possibility and the will of adapting. An interesting question, then, is whether fulfilling the two purposes has to be a zero-sum game; i.e., does advancing the possibility of aggregating information from various stakeholders have to come at the expense of the usefulness of RVAs for their own, internal, purposes? If not, then we might also ponder how the process of enabling the aggregation of information from various authorities might be sped up.

In order to adapt to the needs of individual authorities, the MSB has hitherto refrained from stipulating which methodologies should be used as a basis for RVAs. At the same time, however, it has tried to enhance the possibility of aggregation by regulating the ways in which these authorities present the outputs of their RVAs. The studies conducted for this thesis have shown that the regulations have had strong effects, which suggests that increased top-down governance might be a useful means of furthering the objective of aggregation. In fact, Tehler et al. (2018) suggest that increased standardization may be the answer to facilitating inter-organizational collaboration and communication in the Swedish DRM system. Unfortunately, their conclusions are not clear cut. While standardization may enhance the comparability of information, it might also undermine individual stakeholders' motivations for producing RVAs, which, in turn, could reduce the quality of their RVAs, thus rendering them less, rather than more, useful for DRM purposes.

Notwithstanding this, it is plausible that top-down governance is needed to increase the coherence between the forms, functions, and purposes of the Swedish RVA system. Metaphorically, it is impossible to drive a coach run by four horses without reins, or to build a hotel without drawings and supervisors. In this case, we are confronting the challenge of creating holistic overviews of disaster risk, which requires the communication of uniform and comparable information. To this end, it would be interesting to assess the effects of the recently added appendix to the RVA regulations, which contains guidelines on how to communicate on the different elements that authorities are supposed to report upon.

Moreover, I do not believe that increased alignment in terms of how different authorities assess and describe risk necessarily has to decrease the usefulness of RVAs for the purposes of individual authorities. If, for example, county administrative boards had a better chance of understanding which municipalities were more or less resilient, relatively speaking, with regard to different types of risk scenario, they would also be more able to provide guidance to these municipalities on to whom they should talk in order to increase their resilience. In addition, if municipalities were using the same types of scenarios and assessing them via similar scales, they would also have a better platform for joint discussions and peer-to-peer learning, which would benefit not only themselves, but also society more broadly. Implementing the proposals put forth in this thesis would be likely to increase the chances of such outcomes. However, in order to respect the tradition of consensual governance in Sweden and avoid undermining the sense of ownership and the motivation of individual authorities, it would be important for the MSB to continue to develop directives and regulations together with the authorities that have to abide by them. In this way, a combination of bottom-up and top-down approaches could help to ensure that unified information would retain the quality needed to support the efficient management of disaster risk.

6.2. Quality of the Research

The ways in which I have sought to uphold validity and reliability in relation to the different methodologies and papers presented in this thesis were explained in Section 4.4, and the issue of possible generalizations (sometimes denoted "external validity") has already been addressed in the current chapter. For these reasons, this section focuses on the risks of researcher and respondent bias, which are issues of importance to all researchers, but are particularly relevant when researchers (as in my case) have experience and prior knowledge of the area that they are researching.

6.2.1. Researcher Bias

The risk of researcher bias refers to the potential that preconceptions or interests on part of the researcher will skew the results; i.e., that the researcher might conduct the research in ways that will confirm what he or she wants to find. To reduce this risk to validity, the researcher needs to reflect on his or her experiences, interests, and perspectives, and should seek to minimize their potential effects on the research outcomes (Creswell & Miller, 2000, p. 127; Johnson, 1997).

The fact that I have professional experience within the Swedish RVA system has been advantageous, in the sense that I already had some understanding of the structures and principles of the system, DRM policies and legislation, and the forums in which RVAs are discussed. In addition, I am also personally acquainted with some currently active DRM professionals. This facilitated access to interview respondents, RVA documents, and regional forums such as ÖSAM, Nordsam, and Sydsam. My background has also been helpful for the design of the studies conducted as it enabled me, for example, to select suitable participants for the LFA workshops, as well as to choose a representative sample of respondents and RVA reports to form a basis for the interviews and content analyses.

However, in line with the critical-realist stance explained earlier in the thesis, I am also aware that I held preconceived notions about challenges in my research field. For instance, I knew that there were large discrepancies in how different actors assess and describe risk (which, indeed, was the reason why I became engaged in producing a unified RVA methodology for the municipalities in Stockholm County prior to my PhD endeavor). I did not know the character or extent of these discrepancies, though, or the conforming effects of the RVA regulations (which were studied and elucidated through research for paper I). During my studies, I also employed the LFA methodology partly because it was familiar to me, but mainly because it was instrumental in creating the desired participatory atmosphere, in which people were free to identify, question, and supplement each other's ideas. Given that the workshop deliberations and outputs are well documented (as I believe they have been in the current case), the LFA methodology also corresponds with scientific criteria, in terms of clarifying the rationale behind the cause-effect relationships for different phenomena.

Different measures have also been undertaken to counterbalance the potential biases of my perception of the world. Most important here was the intentional use of a variety of methodologies and empirical sources, an approach which can offset the effects of the potential biases of both the researcher and the informants (Blatter & Haverland, 2012, p. 68; Golafshani, 2003, p. 604). Additionally, I have made extensive use of peer review (Creswell & Miller, 2000, p. 129; Johnson, 1997). Two of the articles (papers I and II) are the results of joint efforts with several people, all of whom contributed to the design and implementation of the studies, as well as to the analysis of the results. Neither papers III or IV were conducted in isolation, as I received advice on their implementation, as well as comments on drafts from supervisors. In addition to undergoing peer review by close colleagues, all the papers have been submitted to scientific journals and subjected to conventional reviews by anonymous researchers.

An important measure to reduce the risk of bias on the part of researchers (and to dispel suspicions about it) is to document and save the empirical material used in a

way that makes reviewing it possible and feasible (Moravcsik, 2014). To this end, the interviews were recorded and transcribed, the problem-and-effect-trees that were elaborated during LFA workshops were photographed, and the RVA reports used for the content analysis, as well as the questionnaires and answers used in the experimental study, have all been saved. Moreover, I have tried to be as transparent as possible, with regard to the description of the methodologies that underpin the different papers.

6.2.2. Respondent Bias

Finally, I would also like to address the potential for respondent bias, which refers to the risk that informants might adapt their answers in line with what they believe the researcher wants to hear, or might withhold information if they perceive the researcher as a threat (Robson, 2002, p. 172). Respondent bias may arise due to the asymmetrical relationship between researchers and their informants, in which the former enjoys a position of power because he or she has designed the study and is in control, therefore, of the structure and content of the interaction (Brinkmann, 2007). In addition, some respondents may be unfamiliar with research and may feel threatened or intimidated by an academic situation.

To reduce the risk of respondent bias, I tried to prepare the respondents by clarifying the purposes of the interactions (the interviews, LFA workshops and experiments) well in advance. During each interaction, I also tried to gain trust and to make the respondents feel at ease by starting with "small talk," through which I also presented myself and repeated the purpose of the activity. Whether my profile as a "pracademic"[18] made informants more open or restricted in their attitudes towards me is beyond my knowledge. However, when talking to the respondents, I tried to refrain from using academic jargon and, in accordance with a semi-structured approach, let informants deviate temporarily from my prepared set of questions, if they so wished. To reduce the sense of being controlled by the researcher, I was also keen to let the participants at LFA workshops be in charge of the brainstorming sessions, and to let them criticize or supplement each other's conceptions of cause-effect relationships and proposals for measures related to the challenges they identified. As I did not see the need to publish the names of the respondents (being interested, rather, in representing the views that were prevalent among risk managers in the Swedish RVA system in general and at different administrative levels in particular), I allowed the informants to be anonymous, which, I believe, may have reduced their potential sense of a need to please the researcher.

[18] As expounded by Posner (2009), a *pracademic* is a person who both is an academic and practitioner with experience from his or her field of research.

6.3. Suggestions for Further Research

Whilst the studies underpinning this thesis have provided insights, answers, and recommendations that are in line with the research objectives, they have also generated ideas and questions that require further research. Some suggestions for future research are listed, therefore, below.

- While the research managed to identify different challenges and measures, it did not weight them, in terms of importance or feasibility. Such an endeavor would constitute a logical continuation of the current research, and may contribute to the creation of a better basis for decisions on which challenges to address and how. Further research could, for instance, involve an electronic survey, in which risk managers across the RVA system are asked to prioritize the challenges and measures proposed here. In addition to providing a basis for prioritization, such an enquiry could also yield interesting insights concerning sentiments regarding top-down approaches amongst authorities at different administrative levels in the Swedish DRM system.

- One challenge while synthesizing several different RVAs is that data from authorities at lower administrative levels is sometimes too detailed and extensive, making it difficult to process. Hence, another area for future research could be to explore the level of detail required by authorities at different administrative levels in relation to the items required by the RVA regulations. Such an investigation could also include the assessment of suitable formats for presenting the substance of RVA reports and might include probing the possibility of using various forms of visual aids.

- The assembled recommendations in Section 5.1.4 also raise other ideas that may benefit from input by researchers (as well as practitioners), such as the development of multi-hazard scenarios and common scales for the assessment of the likelihood and consequences of disaster risk.

- Another suggestion that merits a point of its own is the notion of an investigation of how GIS can be employed to support the production of individual RVAs, as well as the aggregation of multiple RVAs and risk information in general. Whilst building on the outputs of the ORSA project (see Section 4.3), central research objectives here would include: 1) investigating

which spatial datasets are needed to analyze and display the information required by the RVA regulations, and 2) examining whether these datasets need to be produced or whether they exist already—and, if so, how they can be obtained and shared in support of RVA work. The last point would presumably involve the identification of potential barriers and facilitating measures related to the aggregation of geographic information between authorities at different administrative levels (e.g., legislation, software interoperability, knowledge, and costs).

- Aside from advancing the integration of datasets possessed by various stakeholders, it would also be interesting to study how "participatory GIS" (PGIS) may facilitate aggregation. Albeit often employed to promote community empowerment in developing countries, PGIS fosters the interactive participation of stakeholders in generating and assessing spatial information for planning purposes, and is claimed to facilitate discussion, information exchange, analysis, and decision-making (Corbett et al., 2006; Rambaldi, Kwaku Kyem, McCall, & Weiner, 2006). Potentially, it could also provide a useful method for extracting and integrating the views of different stakeholders during RVA workshops, thus being a vehicle for behavioral aggregation. The possibility of overlaying different datasets, as envisaged above, could enable workshops to be held with participants from different functional areas and administrative levels. Participatory observation, interviews, and surveys may offer suitable ways of obtaining knowledge about the usefulness of GIS for the support of RVA work in general and aggregation in particular.

- In general, there is a need of testing and evaluating the effects of proposals to enhance the aggregation of risk information and uncovering the mechanisms through which this is achieved. This, in turn, requires the design of experiments which may isolate the effects of independent variables in space and time (or at least are able to produce results which are indicative thereof). The design of such experiments is yet another challenging, but important, area for future research.

Ch. 7. Conclusions

Using the Swedish disaster risk management (DRM) system as a study case, this thesis has sought to explore the notion of aggregating disaster risk information from multiple stakeholders and the challenges involved when attempting to do so. In addition, it has probed the causes and consequences of these challenges, and has aimed to generate ideas to resolve them or to reduce their negative effects. The conclusions below are structured in accordance with the main research questions presented in the introduction (Section 1.3).

- Aggregating risk information is comprised of two essential processes: the collecting and the synthesis of risk-related information. Synthesis permits the examination of relationships between different pieces of information and may produce knowledge that cannot be obtained by studying these elements separately. The purpose of aggregating risk information is to obtain an overview of risk that, *inter alia*, is conducive to the efficient allocation of resources to reduce risk. A definition for aggregation that captures these intrinsic aspects was proposed:

  > *Aggregating information in the context of disaster risk management systems refers to the processes of collecting and putting together disaster risk information, including complete risk assessments, from different stakeholders, with the aim of producing a more comprehensive picture of risk than would be possible through analysis of the constitutive parts of information in isolation and is undertaken to support the efficient management of disaster risk.*

- Aggregating risk information is also linked to the processes of *disseminating* the synthesized risk picture and *providing feedback* on the material received from external stakeholders and used as a basis for it. Unless the synthesized risk picture is disseminated, the purpose of aggregation will not be achieved. In DRM systems with recurrent risk-assessment cycles, the results of which are produced and communicated among a fixed set of stakeholders, feedback is a means of

enhancing the chances of aggregating information—and, thus, of increasing the possibility of managing disaster risk efficiently.

- Challenges to aggregation are related to all processes mentioned above. The collection of risk information is inhibited by a lack of empirical evidence, a limited awareness of what information one needs and where to find it, the need to conceal sensitive information, competition for resources, inadequate dialogue between public and private stakeholders, and costs (in terms of time, energy, and money). Attempts to synthesize information from multiple stakeholders are constrained by the use of distinct scenarios and heterogeneous ways of analyzing and presenting risk, as well as by disparate terminology, limitations on access to analytical resources, the predominance of qualitative assessments, insufficient motivation, and suboptimal channels, submission dates, and formats for communicating information. The dissemination of assessment results is hampered by, for example, uncertainty about who to inform about what and how, and the importance of protecting sensitive information. In addition, feedback is inadequate due to a lack of prioritization and the absence of criteria for assessing the quality of the information received.

- The causes for the challenges involve both structural and psychological factors, such as the complexities of modern societies, non-existent or conflicting regulations, and limited resources (notably time), as well as motivation, self-confidence, trust, prestige-related matters, and accountability.

- The effects of the challenges of aggregating risk information from multiple stakeholders include frustration and resignation on the part of risk managers who are tasked to do it, as well as sub-optimal bases for decisions about how to reduce disaster risk. This situation leads to the risk of inefficient allocation of resources when preparing for disasters, as well as the risk of unnecessary losses if these disasters do occur; in short, the result is a sub-optimal DRM system. In turn, such set of circumstances can undermine public trust in the authorities responsible for societal safety.

- The difficulties associated with comparing and integrating the outcomes of multiple authorities' risk and vulnerability assessments (RVAs) have also prompted the instigation of workshops at which private and public organizations from all administrative levels meet to jointly assess risk scenarios of national concern. While these workshops are resource intensive, they are also conducive

to aggregation, and they supplement the RVAs as they provide a platform for information exchange across sectorial and administrative borders. As such, these workshops are vehicles for inter-organizational trust and awareness of functional interdependencies.

- In terms of seeking to enhance the possibility of aggregating disaster risk information from multiple stakeholders, experimental studies provide strong normative support for aligning the ways that risk is assessed and described. In addition, experimental results suggest that simple quantitative and semi-quantitative scales are more useful than qualitative ordinal scales or descriptions, when communicating the consequences and likelihood of risk. Transparency regarding the rationale for assessments is also beneficial, as it counterbalances the difficulties associated with comparing and combining assessments that are based on different methodologies and scales. Moreover, it is advantageous if RVAs are based on scenarios in which aspects that are decisive for the management and consequences are well defined. Whereas adherence to these factors is the ideal, where the notion of increasing the possibility of aggregating information is concerned, it may not be feasible due to a lack of empirical data (as a basis for quantitative assessments) and/or the need for tailor-made methodologies to assess certain kinds of risk.

- Aside from the data obtained via experimental outputs, normative ideas have been derived from DRM professionals, literature studies, and my own reflections. Although their effect is yet to be proven, they are grounded in the challenges observed and are deemed as conducive to the possibility of aggregating risk information from multiple stakeholders. The proposals include mapping interdependencies across vital societal functions; using multi-hazard scenarios as catalysts for inter-organizational dialogue and collaboration; developing common and dimensioning scenarios; elaborating uniform dimensions, scales, and indicators for the assessment of consequences and likelihood; promoting exchange between public and private actors through joint exercises and training (notably on the management of sensitive information); composing a checklist to stimulate feedback on inter-organizational risk communication, and exploring the possibility of using visual aids and Geographical Information Systems (GIS) to support the production of individual RVAs, as well as the synthesis of their outputs.

Ch. 8. Final Remarks

As a closure of this thesis it is suitable with a final reflection on the persistence of the need and challenges of aggregating disaster risk information as well as the ease with which proposals in this thesis may be implemented.

With regards to the need, it is likely that the long lasting trend of increasing specialization and interdependencies across vital societal functions will endure. Moreover, whilst functional or geographical areas (e.g. a public health system or a county) can be considered as "indivisible wholes" in an operational or administrative sense, their size and complexity motivates a continued division of labor amongst multiple stakeholders. This, in turn, implicates a persistent situation where the knowledge necessary to understand these systems is dispersed between various actors who each possesses different fragments of the reality (or rather interpretations of it). Hence, the need to aggregate disaster risk information from multiple stakeholders is likely to remain in times to come.

Regarding the identified challenges, some are more difficult to resolve than others. This includes the lack of valid empirical data as basis for quantitative assessments (and adherent need to aggregate disaster risk information through behavioral rather than mathematical methods) as well as the demand to conceal sensitive information and, thereby, certain parts of reality. It also embraces less tangible aspects such as trust, prestige, self-confidence and motivation. Although increased interactions between interdependent stakeholders may be arranged and reduce the influence of some of the negative effects associated with these challenges, there are no quick fixes or permanent solutions linked to these issues. Inter-organizational trust and collaboration may be contingent on the positive relationships between certain individuals which takes time to develop. Such enabling factors are also vulnerable to staff turnovers and might need to be reestablished time and again.

Considering the ease with which the proposed measures in this thesis can be realized, it could be noted that some of these should be fairly quick and easy to implement, such as adjusting deadlines for RVA reports and functionalities in the digital reporting system; conducting joint trainings for private and public stakeholders; composing a checklist for the provision of feedback; and decisions on which consequence dimensions to use. Other measures may need more deliberations and resources, e.g., elaboration of common scales for assessment of likelihood and

consequences; developing templates for popularized summaries of RVA reports or investigating how visual aids and GIS may enhance the production and comprehension of disaster risk information. Naturally, decisions on the realization of measures need to be based on the weighing of their projected costs and benefits. Such an exercise should also consider the costs associated with failures to obtain holistic pictures of risks to societal safety.

To conclude, I believe that implementing measures proposed in this thesis will improve the chance of aggregating fragmented pieces of knowledge to attain comprehensive understandings of indivisible wholes of reality.

Endnotes

[a] This exercise was effected through the Council Conclusions on Further Developing Risk Assessment for Disaster Management within the European Union, 11–12 April 2011 (8068/11).

[b] The Swedish Civil Contingencies Agency (MSB) was established in 2009. It simultaneously replaced and overtook the responsibilities (including overall support for the RVA system) from three other authorities: the Swedish Emergency Management Agency (SEMA), the Swedish Rescue Services Agency (SRSA), and the Swedish National Board of Psychological Defence.

[c] This component of vulnerability can be seen as an antonym to *resilience*. In an attempt to operationalize the notion of resilience, Becker (2014, pp. 149-165) proposes that human-environment systems (such as the DRM system) need to fulfill a set of functions (italicized) and related activities. First, the system needs to be able to *anticipate* what is going to happen (through, e.g., RVAs and forecasts). Then, it also needs the function of *recognition*, in part to detect imminent threats (through monitoring) but also to understand what has happened in the immediate aftermath of a disaster (through impact assessments). The function of *adaptation* entails activities undertaken to accommodate threats or occurred events, and involves the embrace of functional areas that are commonly considered part of the so-called disaster management cycle (Coetzee & Van Niekerk, 2012)—i.e., prevention, mitigation, preparedness, response, and recovery (definitions of these terms are also provided in (Becker, 2014, p. 159). Finally, the system has to be able to *learn* from occurred events (through evaluations). I concur with this framework and, accordingly, view vulnerability as (partly) determined by the (in)capability to accomplish these functions and activities.

[d] There is, in fact, a fourth administrative level of importance, which is comprised of international collaborations and agreements that Sweden is part of or obliged to follow—most notably, Sweden is a member of the EU and also the UN. However, since these systems and arrangements are multilateral, rather than Swedish, they are not in focus here.

[e] The mandates of county administrative boards *vis-à-vis* county councils may need clarification here. County administrative boards are responsible for coordinating the development of the county in line with goals set out in national politics. This includes a vast number of policy areas, including DRM. In each county there is also a county council which is responsible mainly for public health care. In relation to RVAs, the cross-sectorial responsibility of county boards necessitates a much broader analytical scope than that required for county councils, although the latter provide more detail regarding the health sector.

[f] These bullet points are consistent with a content analysis of RVA legislation, official reports, and instructions given to the MSB and other authorities by (Abrahamsson & Tehler, 2013), which was performed to map the officially declared purposes behind conducting RVAs.

[g] The stepwise, linear approach illustrated in Fig. 3-2 might be deceptive, as RVA processes often entail interactions between different steps (e.g., between the assessment of existing capabilities and the identification of risk-reducing measures).

[h] To this end, it may be useful to differentiate between primary (intrinsic) and secondary (extrinsic) values, where the latter (e.g., protection of critical infrastructure and rule of law) are instrumental in relation to the former (e.g., protection of life and health) (Hallin et al., 2004; Nilsson & Becker, 2009).

[i] Given the sparse data supporting assessments of the likelihood and consequences of extraordinary events, these will naturally be associated with significant uncertainty. This uncertainty is also expected and accepted. In fact, the Swedish Emergency Management Agency (the predecessor of MSB) took a rather pragmatic (and deterministic) viewpoint, recommending that authorities placed less focus on assessing probabilities and more focus on the consequences and DRM capabilities (SEMA, 2003a, p. 32; 2006a, pp. 16-17; 2006b, p. 33). Hence, the risk assessment is not conducted primarily to obtain as exact an estimation of risk as possible, but to be able to prioritize which hazards that should be used as basis for the subsequent vulnerability assessment (SEMA, 2006a, pp. 29-31). Accordingly, and in contrast with quantitative analyses of more frequent events, risk assessments for extraordinary events seldom include sensitivity analyses to explore the effects of different assumptions on risk estimates. However, the subsequent vulnerability assessment might incorporate "what-if" reasoning to probe the effects of varied contextual factors (e.g., whether power outages occur during winter or summer; the time of day or the direction and speed of wind during a leakage of a hazardous substance).

[j] Personally, I have not been part of RVAs where authorities have established and used their own criteria for evaluating risks (i.e., what degree of risk they deem acceptable or not). Rather, the evaluations have focused on assessing whether the identified risks could be regarded as extraordinary or not, with the prioritization of risks being conducted subsequently as basis for vulnerability assessments. Such prioritization can also be carried out in conjunction with, or by, the senior decision-makers at the authority (SEMA, 2006a, p. 32), who may take aspects other than risk estimates into account.

[k] Whether to assess consequences before coping capacities is a matter of debate. Some people argue that one cannot assess the ability to respond and recover without knowing the consequences associated with the event, whereas others propose that the consequences to a large part are dependent on the capabilities one possesses (SEMA, 2006b, p. 41). If so, the scenarios cannot contain full-fledged descriptions of consequences as this would make the capability assessment void. Instead, the scenarios should contain enough details on contextual factors that are decisive for the management - and hence consequences - of the scenario. To instigate a discussion on the relationship and effect of different measures on the types and magnitude of potential consequences (which often facilitates the identification of risk reducing proposals), I often favor the latter approach, hence the order of the steps in Fig. 3-2.

[l] Aside from the input and constraints stemming from potential users, the knowledge base, and the socio-political environment, it should be noted that the researcher's own judgment plays a role in the process

of elaborating the purpose, formulating design criteria, and constructing the method. Such an influence is unavoidable—and even required—since it is the researcher (designer) who, ultimately, is responsible for ensuring that the outcomes of the research process fulfill the intended purpose (Abrahamsson, 2009, p. 22; van Aken & Romme, 2012).

[m] It should be noted that the ontological and epistemological positions of critical realism are rooted in arguments presented by earlier thinkers such as Democritus, Galileo, Descartes, and Locke, who advocated for a separation between primary and secondary qualities of physical reality; i.e., a distinction between how we perceive and characterize things in the world, and how they really are (Uzgalis, 2017; Woleński, 2004, p. 20).

[n] The authorities in the 2011 study were selected to obtain differentiation, in terms of size and geography. The study included two counties in southern Sweden, two in the middle of Sweden, and one in the north of the country. Within each county, a large, a medium, and a small municipality was chosen (with >90000; 9000-15000, and <9000 inhabitants, respectively). To obtain functional variation, the five national authorities were all part of different forums for crisis preparedness (cf. Section 3.1). The interviews conducted in 2014 included representatives from all 11 sectors that the MSB has highlighted as essential in the national strategy for the protection of critical infrastructure—i.e., energy supply, financial services, food stuffs, health, medical and care services, information and communication, public-administration management, safety and security, social insurance, technical municipal services, trade and industry, and transport (MSB, 2011).

[o] A flood scenario was selected as it is a common risk at many Swedish municipalities and often spans large areas (and, hence, is likely to involve more than one municipality simultaneously). A recent mapping of flood risk conducted in accordance with the EU Floods Directive 2007/60/EC also added to the credibility of the scenario. Nevertheless, one may ask whether another scenario would lead to different results. However, a study by Lin et al. (2015) has shown that the main reason for differences in the perceived usefulness of risk assessments are derived from the types of risk description involved, rather than from the type of scenario.

[p] In the context of development aid, this normally includes funders, decision-makers, and implementers of projects, as well as people deemed to be affected by it, whether positively or negatively (Örtengren, 2003). In this thesis, it refers to people with thorough experience and knowledge of the problems discussed.

[q] Whether dissemination actually facilitates decision-making also depends on whether the target groups have the time, knowledge, and will to integrate the information into their own assessments and decision-making processes.

[r] Bayesian inferences involve the updating of an estimated probability given that more evidence or information has become available, which often (albeit not always) entail that the assessed situation or event has occurred and been observed.

[s] This reasoning on hazard-specific scenarios may seem contradictory to the earlier suggestion of increasing the use of multi-hazard scenarios. To develop abilities for a set of core needs or functions that

can be combined in response to various multi-hazard scenarios, however, it may be necessary to start by developing abilities for hazard-specific needs or functions based on single-hazard scenarios.

[t] "WIS" stands for Web-based Information System and is a tool that Swedish authorities use primarily to share information with one another during the management of societal perturbations (MSB, 2017).

[u] It is important to point out that this reduction in bias or convergence of opinions does not happen automatically as a result of multi-method, multi-source types of research. Such approaches are, rather, means of extracting different views; all results still need to be reviewed and assessed for validity. Further, it is down to the researchers themselves to construct a new, synthesized (or converged) meaning from the underlying material (Mathison, 1988).

[v] As the supervisor of Master's theses focused on the private-public collaboration within the food supply sector in Sweden (Gramenius & Svensson, 2013) and on challenges to RVA work at local and regional levels (Filipek & Laksman, 2013), I also gained additional insights into the aggregation of risk information from private stakeholders.

[w] As with the varied character of quantitative assessments, it is warranted to acknowledge that narrative evidence may be of different kinds and, therefore, generalized claims about their value should be treated with caution. Naturally, their value is contingent upon their content and its relevance in explaining the assessments conducted.

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This book investigates the possibility of understanding disaster risk. Specifically, it explores challenges and opportunities for collecting and making sense of disaster risk information from multiple actors. The way that this is done is not only decisive for which risks we address and how. It is also decisive for the types and magnitude of losses that future disasters will bring about.

Peter Månsson has conducted his PhD during a leave from the Swedish Civil Contingencies Agency (MSB). Prior to his position at Lund University, he gained more than 10 years' experience from working with disaster risk management at different administrative levels in Sweden and abroad. Through a blend of document analyses, experiments, literature studies and consultation with disaster risk managers, he has tried to gain insights to resolve challenges he experienced during this time. This book contains the collected outputs of these endeavors.

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