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Insights and recommendations from the Swedish system

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Risk communication in multi-stakeholder disaster risk management systems:

Insights and recommendations from the Swedish system

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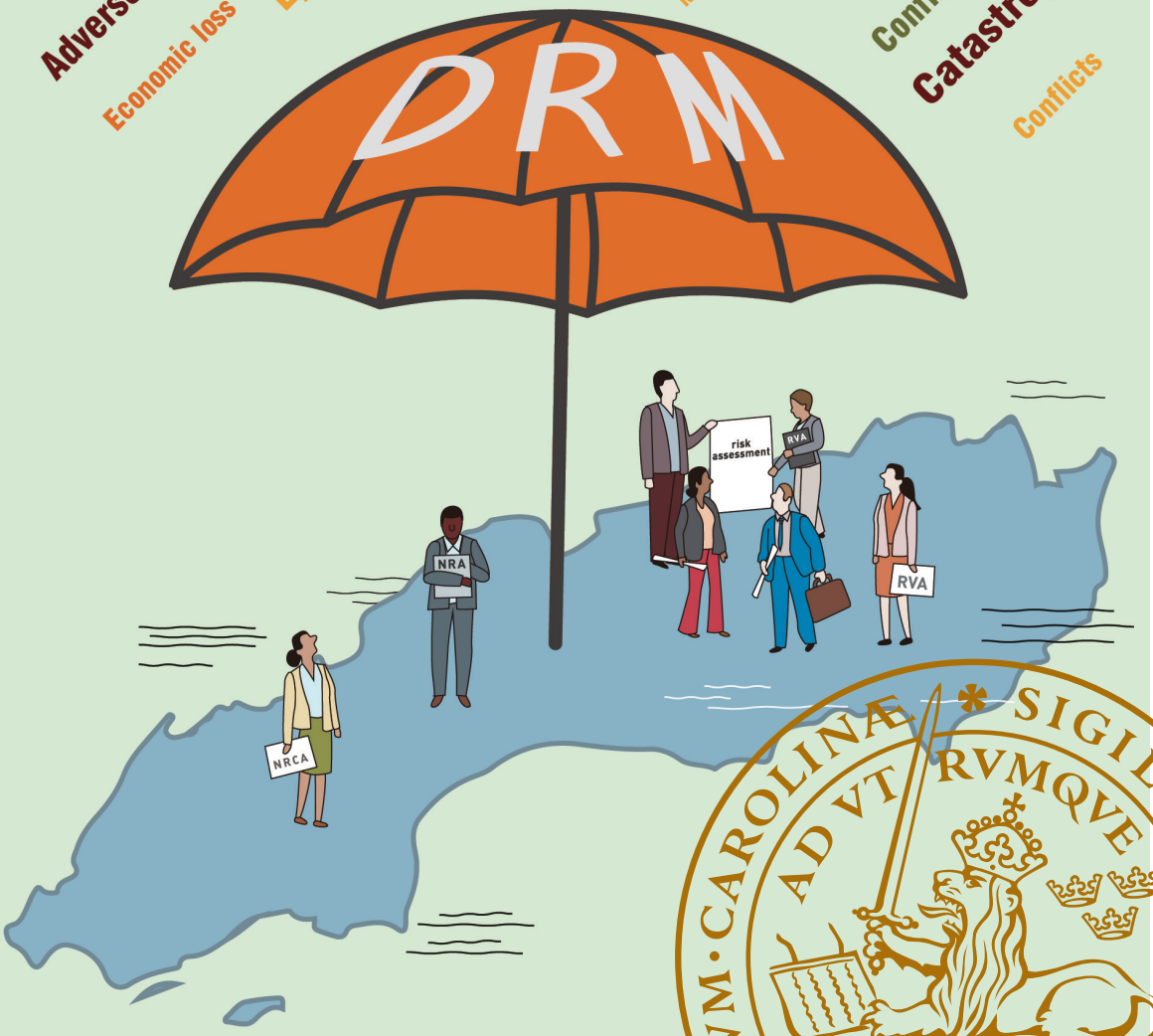

Risk communication in multi-stakeholder disaster risk management systems

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Insights and recommendations from the Swedish system

Lexin Lin

LUND UNIVERSITY

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Abstract

The overall purpose of this thesis is to improve our understanding of how disaster risk management (DRM) systems function. Specifically, it aims to increase our knowledge about effective communication in a multi-stakeholder, multi-level DRM system, with a particular focus on the exchange of risk-related information for risk assessment. The Swedish DRM system is taken as a study case to examine how DRM stakeholders collect and share information while conducting, disseminating and utilizing risk assessments, and the challenges that hinder effective risk communication. The studies included in this thesis highlight how risk assessment work and the associated communication issues influence Swedish DRM practice, both positively and negatively. They also propose countermeasures to overcome these challenges in order to improve the effectiveness of risk communication among stakeholders, increase their collective ability to assess and manage potential disaster risks, and thus enhance the overall performance of the system.

Research methods include, for example, semi-structured interviews, focus group discussions, experiments, and document analysis. Empirical data are collected mainly from the Swedish DRM system (municipal, regional and national levels). However, some experiments involve participants from another DRM context (Nicaragua), and additional policy documents from the European Union are included in the analysis. The results highlight that a lack of standardization in risk assessment work has hampered the communication via risk assessment documentations. DRM stakeholders vary widely in terms of the scale and frequency of the potential risks they assess, making communication less meaningful since they are focusing on different types of events. They are unwilling to disseminate the results of their risk assessments, due to concerns that sensitive risk-related information and managerial shorcomings might be exposed. Finally, there is a lack of constructive feedback regarding the quality of risk assessments, making it unclear how to improve and resulting the risk communication a one-way process.

Two sets of countermeasures are proposed to overcome these risk communication challenges:1) efforts should be made to solve systemic problems. Examples include the provision of constructive feedback that would make risk communication two-way, and the establishment of a clear information disclosure procedure; and 2) risk assessment documentation should be better designed. The inclusion of scenario descriptions, assessments of the likelihood of events and consequences, and background information concerning estimated likelihoods will probably improve the usefulness of the risk assessment for decision-making and communication. Quantitative and semi-quantitative scales seem to be promising ways to communicate risk-related information, especially if they are complemented by narrative evidence.

Key words: risk communication, disaster risk management (DRM), risk assessment, communication challenges, multi-stakeholder multi-level DRM system, Sweden

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Risk communication in multi-stakeholder disaster risk management systems:

Insights and recommendations from the Swedish system

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Dedicated to the loving memory of my uncle, Jianping,
who was always curious about my research.

谨以此书献给我一直怀念的小舅舅建平。

他曾对我的研究充满了好奇。

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Summary

Increasing inter-dependencies, urbanization, and the growing complexity of modern societies mean that disaster risks are a cascading threat to humankind. Although governments worldwide are increasingly aware of, and committed to, reducing their impact, the number of lives lost and assets destroyed continues to grow rapidly. Faced with this evolving landscape, many countries have established disaster risk management (DRM) systems. Key actors at various levels of government work with stakeholders with multi-disciplinary backgrounds and representatives from the private sector and civil society to assess preparedness for extreme events and collectively manage potential disaster risks. A preliminary step is to understand the risks that must be managed – through a risk assessment. In today's interconnected society, no single organization can 'own' a crisis, and no-one possesses all of the relevant information concerning all of the risks. Therefore, in order to develop a comprehensive risk picture, all relevant stakeholders must work together to actively and meaningfully communicate risk-related information, within a multi-stakeholder, multi-level DRM system.

This is not easy to achieve. The process is fraught with challenges that hamper the flow of risk communication, and make it difficult for parties to reach agreement, thus degrading their collective ability to manage disaster risks. Therefore, the research presented here aims to increase our knowledge of effective risk communication in a multi-stakeholder, multi-level DRM system, with a specific focus on the exchange of risk-related information for risk assessment. It takes the Swedish DRM system as a study case, and focuses on how stakeholders collect and share information in order to conduct, disseminate and utilize various risk assessments. Furthermore, it investigates the communication challenges that hinder effective stakeholder communication and collaboration. More importantly, this thesis examines how risk assessment work and the associated communication issues influence Swedish DRM practice, both positively and negatively. The findings are used to propose countermeasures to overcome the challenges and improve the effectiveness of risk communication among DRM stakeholders, in order to increase their collective ability to assess and manage potential disaster risks.

The work employs various research methods for data sampling, collection and analysis. The results indicate that communication challenges exist throughout the Swedish DRM system and can be linked to the following factors: 1) a lack of standardization in the methods, tools and formats that are used to conduct risk assessments makes it very difficult for DRM stakeholders to communicate risk-related information via risk assessment documentation; 2) DRM stakeholders have very different ideas regarding the scale and frequency (day-to-day safety issues or low-probability disastrous events) of the risks they assess, meaning that risk

assessments from different actors are hard to combine; 3) the dissemination of the risk assessment is very limited, due to the lack of an appropriate distribution channel and authorities' unwillingness to disclose sensitive data and managerial shortcomings; 4) constructive feedback regarding the quality of risk assessments is largely missing at all levels, creating significant uncertainty about future risk assessment work and resulting in a one-way communication process; and 5) it is difficult to convince some stakeholders of the need to conduct a risk assessment. High staff turnover leads to a loss of continuity and influences the quality of the assessment.

The examination of both the positive and negative influences of risk assessment work on the Swedish DRM system and the associated communication issues led to the identification of two strategies to overcome challenges. The first takes a systemic perspective. Relevant feedback would improve the quality of the risk assessment and make communication two-way. Furthermore, the results of risk assessments need to be properly disseminated, balancing authorities' duty-to-disclose risk-related information and stakeholders' right-to-know about the potential risks. The second takes a content perspective, and seeks to enhance the usefulness of risk assessment documentation for risk-related decision-making and communication. It is likely that documents could be made more useful by including scenario descriptions, information concerning the estimated likelihood of events and their associated consequences and supporting background information. Moreover, quantitative and semi-quantitative scales appear to be promising ways to communicate information concerning likelihood and consequences, especially if they are complemented by narrative evidence.

It should be noted that although this thesis focuses on the Swedish context, the implications of the findings are not necessarily limited to Sweden. Researchers and practitioners from other DRM contexts are invited to compare this detailed presentation of Swedish practice with their own situation, and judge if the insights and recommendations could be applicable. It is likely that the more similar the two contexts are, in terms of risk communication, the more the conclusions will be valid.

Sammanfattning

Det moderna samhällets utveckling mot urbanisering och ökat beroende mellan samhällets olika delar innebär att kriser och katastrofer riskerar att snabbt spridas både mellan sektorer och över stora geografiska avstånd. Regeringar är medvetna om det ökande hotet från katastrofer, men denna typ av kaskadeffekter innebär att katastrofernas allvarliga konsekvenser har fortsatt att växa. För att hantera denna typ av risker har flera länder etablerat så kallade katastrofriskhanteringssystem där syftet är att involvera aktörer så som privata företag och icke-statliga organisationer i arbetet med att förebygga och förbereda för katastrofer. Denna typ av samarbete är nödvändigt eftersom ingen aktör ”äger” en kris, och ingen har all information som är nödvändig för att bedöma sannolikheten för katastrofala händelser eller vilka konsekvenser de medför. För att skapa sig en uppfattning av de risker samhället står inför är det därför nödvändigt att aktörerna i krishanteringssystemet kommunicerar olika typer av riskrelaterad information för att därigenom kollektivt bygga upp en förståelse av den samlade riskbilden.

En konsekvens av strukturen i dessa krishanteringssystem är att ett effektivt och meningsfullt informationsutbyte blir en förutsättning för att de ska fungera väl samtidigt som strukturen själv, med flera administrativa nivåer och aktörer med olika bakgrund och intressen, blir ett hinder för just ändamålsenlig kommunikation. Målet med forskningen som presenteras i den här avhandlingen är att öka vår kunskap om kommunikation av risk inom katastrofriskhanteringssystem med ett speciellt fokus på kommunikation som syftar till att stödja riskbedömningar. Genom att studera det svenska katastrofriskhanteringssystemet (även kallat krisberedskapssystemet) undersöks hur olika aktörer (ex. kommuner och länsstyrelser) samlar in och delar riskrelaterad information för att identifiera, analysera och hantera olika typer av risk. Vidare fokuserar forskningen som presenteras här på utmaningar som finns när det gäller kommunikation av riskinformation och på hur dessa kan hindra samarbete och, i förlängningen, hanteringen av risk. Med grund i de studier som ingår i avhandlingen presenteras även förslag på hur dessa utmaningar kan hanteras för att förbättra möjligheterna att kommunicera riskinformation och därmed förbättra hanteringen av katastrofrisker.

I avhandlingen identifieras flera utmaningar inom det svenska katastrofrisk-hanteringssystemet som påverkar dess förmåga att hantera risker: 1) det saknas gemensamma metoder, verktyg och sätt att uttrycka risk, vilket gör det svårt att kommunicera riskrelaterad information med hjälp av risk- och sårbarhetsanalyser; 2) de aktörer som är aktiva inom katastrofriskhanteringssystemet skiljer sig mycket åt när det gäller vilka risker de fokuserar på (ex. så kallade vardagsolyckor eller katastrofhändelser) vilket innebär att andra aktörers analyser ibland uppfattas som oanvändbara eller irrelevanta; 3) de analyser som produceras inom systemet får liten

spridning på grund av begränsade rutiner rörande detta och en ovilja att dela information som kan vara hemlig eller sätta organisationen i dåligt ljus; 4) användbar återkoppling rörande risk- och sårbarhetsanalysers kvalité är begränsad på alla nivåer av katastrofriskhanteringssystemet. Detta leder till att kommunikation rörande risker ofta blir envägskommunikation utan återkoppling rörande hur framtida risk- och sårbarhetsanalyser skulle kunna förbättras; 5) det är svårt att övertyga olika aktörer om vikten av att genomföra genomarbetade risk- och sårbarhetsanalyser. Dessutom leder ofta hög personalomsättning till att kvalitén på analyserna blir lidande.

I avhandlingen föreslås två typer av åtgärder för att möta de identifierade utmaningarna. Den första typen av åtgärder handlar om att angripa utmaningarna på systemnivå genom att: 1) utveckla den återkoppling aktörerna får på sina analyser; 2) se till att resultaten från risk- och sårbarhetsanalysarbetet får större spridning; och 3) balansera aktörers ansvar att inte sprida hemlig information med andra aktörers möjligheter att få tillgång till (för dem) viktig information. Den andra typen av åtgärder som diskuteras handlar om risk- och sårbarhetsanalysernas innehåll. Till exempel rekommenderas att man inkluderar scenariobeskrivningar, samt bedömningen av sannolikheten för olika scenarier och deras potentiella konsekvenser. Till detta bör analyserna även innefatta den bakgrundsinformation, inklusive antaganden, som använts för att göra bedömningarna. Av de olika sätt att beskriva risk som finns inom det svenska katastrofriskhanteringssystemet förefaller de som bygger på enkla kvantitativa skalor (ex. antal skadade personer), samt semi-kvantitativa sådana, vara användbara för att kommunicera risk, i synnerhet om de samtidigt kombineras med texter som förklarar och fördjupar resonemang.

Avhandlingen fokuserar på det svenska katastrofriskhanteringssystemet men slutsatserna är inte nödvändigtvis begränsade till det svenska systemet utan kan även vara generaliserbara till andra länder. Då avhandlingen beskriver det svenska systemet i detalj tillåts forskare och professionella i andra länder att avgöra vilka resultat som är överförbara till just deras sammanhang.

Popular science summary

The world is facing ever-greater threats from disaster risks. Between 2005 and 2014 large-scale disasters had huge impacts on societies around the world. They affected millions of people, killed hundreds of thousands, and caused at least 1.5 trillion USD of economic losses. In 2015 alone, the total number of people affected by disasters triggered by nature and/ or technology (excluding wars, conflict-related famines, diseases or epidemics) was 108 million, 32,550 were killed, and economic losses reached 70.285 billion USD. Faced with these severe consequences, many countries have established disaster risk management (DRM) systems. These systems involve key actors from the whole of society and aim to assess preparedness for extreme events, in order to collectively manage potential disaster risks.

In this context, the quality of the work largely depends on how well actors communicate risk-related information: there are many challenges that can make it difficult for involved parties to reach agreement, or even lead to DRM failures. Therefore, my research investigates risk communication in a context where diverse stakeholders must work together to assess societal risks. I examine how stakeholders communicate risk-related information in their efforts to conduct, disseminate and utilize various risk assessments. My work identifies several challenges and suggests some countermeasures to overcome them.

The Swedish DRM system is taken as a study case. The following communication challenges were identified:

1) Different methods and tools are used to assess disaster risks at different levels in the system. The lack of standardization makes the communication of risk-related information via risk assessment documents difficult.

2) DRM stakeholders do not agree on what risks they should assess. Lower administrative levels often focus on day-to-day safety issues, while higher levels are more concerned with low-probability, but disastrous events. Risk communication loses its meaning when the parties are talking about different scales of risks.

3) The results of the risk assessment are not widely disseminated. There is a lack of appropriate distribution channels, and many authorities are unwilling to disclose sensitive data and/ or expose their managerial shortcomings.

4) There is a lack of constructive feedback regarding the quality of the risk assessment and the risk-related information it contains. Consequently, it is unclear how future risk assessments could be improved, and risk communication becomes a one-way process.

5) It is very difficult to convince some stakeholders of the reasons why they should conduct a risk assessment and communicate potential risks. High staff turnover leads to a loss of continuity, which influences the quality of the risk assessment and risk communication.

Two sets of countermeasures, designed to overcome these communication challenges are suggested:

1) More attention should be paid to providing constructive feedback. This would improve the quality of the risk assessment and make risk communication a two-way process. The dissemination of the results of risk assessments should be improved; a disclosure procedure should be established, and the balance between authorities' duty-to-disclose risk-related information and stakeholders' right-to-know about the potential disaster risks should be found.

2) Risk assessment documentation should be more standardized. Specifically, the inclusion of scenario descriptions, background information concerning estimated likelihoods, and assessments of the likelihood of events and their consequences will probably improve the usefulness of risk assessments for decision-making and communication. Quantitative and semi-quantitative scales appear to be promising ways to communicate information about likelihood and consequences of risks, especially if complemented by narrative evidence.

It should be noted that although this thesis focuses on the Swedish context, the implications of the findings are not necessarily limited to Sweden. Researchers and practitioners from other DRM contexts are invited to compare this detailed presentation of Swedish practice with their own, and judge if the insights and recommendations could be applicable. It is likely that the more similar the two contexts are, in terms of risk communication, the more the conclusions will be valid.

Preface

When I was writing this thesis, I came across this quote by Haruki Murakami. "Sometimes fate is like a small sandstorm that keeps changing directions. You change direction but the sandstorm chases you. You turn again, but the storm adjusts." Now, at the end of my PhD journey, when I look back, I often wonder: what was that *something inside me* that led me to this point, spending years doing a PhD on International Risk and Disaster Studies and living in a country called Sweden, which is so far away from my own?

In 2007, when I was working on my first Master's degree in Mass Communication at Fudan University, Shanghai, China, I had an opportunity to visit Taiwan. That was the first time I had stepped out of mainland China. I was an exchange student at the Chinese Culture University in Taipei, and an intern journalist at the Public Television Group of Taiwan. Taiwanese and mainland Chinese speak the same language, and share the same Chinese culture. However, during these two months, despite many similarities, I realized how different our societies were, without knowing exactly why, at the time. What struck me the most was that when I read different newspapers or switched between different news channels on TV, the same piece of information could be interpreted and reported completely differently, depending on the stance that the respective media took. That was beyond my imagination, given how much I knew about the world outside of China at the time.

If it could be said that the trip to Taiwan aroused my curiosity about how the rest of the world works, the time that I spent doing my second Master's degree in Strategic Public Relations at Virginia Commonwealth University, Richmond, USA inspired me to enter my current research field. After finishing my coursework, I did my internship at ChildFund International, which is a non-profit organization dedicated to helping deprived, excluded and vulnerable children who live in extreme poverty. During this internship I came across children who had suffered from human-made and/ or natural disasters worldwide. At the same time, I had heartbreaking memories of the Great Wenchuan earthquake that occurred in southwest China on May 12th 2008, just before I left for the United States. This event, which killed over 69,000 people, injured 374,176, and made at least 4.8 million people homeless stimulated my interest in the disaster risk management field and made me wonder if there was anything I could do to make this world a little bit better.

After I returned to Shanghai in the fall of 2009, the Erasmus Mundus Programme launched a call to encourage scholarly exchange between China and Europe. When I saw that Lund University offered a PhD program on International Risk and Disaster Studies, I applied for it without any hesitation. Very luckily, I was selected, together with seven other Chinese students, to conduct a PhD. This is how my long journey in Sweden started, on August 16th 2010.

With my mass communication and public relations background, as well as my great interest in crisis communication during my graduate studies, it was not unexpected that my PhD research would focus on risk communication in the disaster risk management field. My original PhD proposal aimed to investigate how Swedish authorities use different media tools to approach the general public, and communicate risk-related information to improve societal safety. However, during my initial exploration of the Swedish disaster risk management system, I encountered many practical challenges. These issues eventually led to a shift in my original research plan, which was revised to include the studies that are presented in the current thesis. By investigating how Swedish authorities communicate risk-related information with each other during the process of conducting, disseminating and utilizing various risk assessments, my study examines the challenges they face and suggests countermeasures to improve risk communication.

This research adventure that I threw myself into was very long – and full of ups and downs. I had never experienced so many difficulties and frustrations in my whole life, and had no idea that, on the other hand, conducting research could bring such a great feeling of accomplishment. If I were given a chance to talk to myself as the person who was just about to apply for her PhD position in 2009, I would remind her: it will be a tough journey, but you will learn a lot and grow up so much. When it comes to the point where the journey ends, as Haruki Murakami put it, "once the storm is over you won't remember how you made it through, how you managed to survive. You won't even be sure, in fact, whether the storm is really over. But one thing is certain. When you come out of the storm you won't be the same person who walked in. That's what this storm's all about".

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Adapting to a new culture, and living in a country far away from family and friends is challenging. Thanks to my amazing friends from all over the world who have made my journey full of joy and laughter. To my girls' cooking club members: Clarissa, Nuk, and Jessie. I cannot imagine a PhD journey without your company. Thanks for all the delicious home-made food, the trips we went on together, and all the good laughs we had. The cold dark Swedish winter was more bearable with you all. Cancan (Jessie), we had many adventures together through these years: going to Iceland, dancing Argentina tango, touring in European cities for tangomarathons, and spending a lot of time discussing the confusion in our lives…Thanks for being my best friend in Lund. I want to thank some of my tango friends: Sonny, Cecilia, Johan, Per and Tommy. Dancing tango has brought so much delight to my life in Lund. The tango trips that I made with my tango friends, the tandas we danced together, always recharged me with energy before I went back to my thesis work. To Tuzi (Zeyuan), I found myself very lucky to walk through the final phase of my PhD together with you. The discussions we had are always inspiring and healing. Hopefully the anxieties we shared will be gone quickly when our PhD is done. After all, we both agreed that doing a PhD makes us a better person. I have some other lovely friends that I miss a lot, whom I got to know in Lund but now live in other parts of the world: Jingjing, Andrej, Mingfa, Kasia, Yinzi and Fengyun. I hope it will not be too long before our next reunion. Thanks to Dong and Magnus, I always felt so warmly welcomed when I visited Stockholm. I owe a big thank you to my dear cousin Xinyi, who used her talent to help with the design of my thesis cover.

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我，终于成为林博士啦！

Lund, April 2018

Lexin Lin (Mona)

林乐心

Appended publications

I. Communicational challenges in disaster risk management: Risk information sharing and stakeholder collaboration through risk and vulnerability assessments in Sweden
Lexin Lin, Marcus Abrahamsson. 2015.
Risk Management 17 (3), 165–178. doi: 10.1057/rm.2015.11

II. On the perceived usefulness of risk descriptions for decision-making in disaster risk management
Lexin Lin, Anders Nilsson, Johan Sjölin, Marcus Abrahamsson, Henrik Tehler. 2015.
Reliability Engineering and System Safety 142, 48–55.
http://dx.doi.org/10.1016/j.ress.2015.04.012

III. Communicating risk in disaster risk management systems – experimental evidence of the perceived usefulness of risk descriptions
Lexin Lin, Claudia Rivera, Marcus Abrahamsson, Henrik Tehler. 2017.
Journal of Risk Research 20 (12), 1534–1553.
doi:10.1080/13669877.2016.1179212

IV. Exploring the development and use of municipal risk and vulnerability assessments in Sweden-Challenges and opportunities
Lexin Lin, Kerstin Eriksson. 2016.
Proceedings of the 13th International Conference on Probabilistic Safety Assessment and Management (PSAM 13), 2–7 October, 2016, Seoul, South Korea. (Nominee for George Apostolakis Fellowship)

V. Integrating a national risk assessment into a disaster risk management system: Process and practice
Lexin Lin. 2018.
International Journal of Disaster Risk Reduction 27, 625-631.
http://dx.doi.org/10.1016/j.ijdrr.2017.08.004

Related publications

I. Communicating risk in a disaster risk management system – A study based on developing and utilizing the national risk and vulnerability assessments in Sweden
Lexin Lin
Top Student Paper Award & Student Merit Award winner at the risk communication special group at Society for Risk Analysis Annual Meeting, Arlington, USA, December, 2015.

II. Mapping the municipal risk information flow-A study based on the practice of risk and vulnerability analysis in Lund, Sweden
Lexin Lin
Society for Risk Analysis Annual Meeting, Baltimore, USA, December, 2013.

III. Evaluating municipal risk and vulnerability analyses: how risk is communicated between the municipal and regional level in Sweden
Lexin Lin
Society for Risk Analysis-Europe (SRA-E) Conference, Trondheim, Norway, June, 2013.

Chapter 1.

Introduction

1.1 Background and rationale

Risks, whether natural or human-made, small or large-scale, frequent or infrequent, sudden or slow-onset, pose alarming threats to humankind worldwide. This is due to the inter-dependencies, urbanization, and growing complexity of modern societies (CaDRI, 2011; OECD, 2003, 2011; UNISDR, 2017). Although governments are increasingly aware of, and committed to reducing the impact of disaster risks, the number of lives lost and assets destroyed, directly or indirectly, continues to grow rapidly (UNISDR, 2017). The World Disasters Report (2016) states that the total number of people affected by disasters triggered by nature and/ or technology (excluding wars, conflict-related famines, diseases or epidemics), was 108 million in 2015, while 32,550 were killed, and economic losses reached 70.285 billion USD (IFRC, 2016). At the same time, annual average economic losses from all disasters have been calculated as around 250 to 300 billion USD (UNISDR, 2015a). Faced with this evolving risk landscape, the severe impacts of disaster risks have gone beyond a wake-up call. More importantly, they prompt us to reassess our preparedness for extreme events, and underline the urgent need to more effectively prevent and reduce disaster risks across the globe (World Economic Forum, 2017).

Internationally, the Hyogo Framework for Action 2005–2015 (UNISDR, 2005) provided governments with an unique opportunity to commit to taking actions against disaster risks, by emphasizing a shift from reactive emergency management to proactive, pre-disaster risk reduction (FAO, 2008). The framework has proven to be a key driver for implementing disaster risk management (DRM), understood as, "the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster" (UNISDR, 2009). DRM has gained widespread support (FAO, 2008), and many countries have started to build so-called DRM systems. These systems include stakeholders[1], technical systems, mechanisms, etc. that implement DRM activities (Lin, 2018; Lin & Abrahamsson, 2015; Lin & Eriksson, 2016; Rivera, Tehler, & Wamsler, 2016).

[1] Stakeholders, actors, and parties are used as synonyms in this thesis. They represent authorities, private companies, professional organizations and interest groups etc. that work in the domain of disaster risk reduction and are responsible for sustaining societal safety.

Along with the shift from a reactive to a proactive approach to risks, their nature and the context they exist in have also witnessed change. First of all, risks are becoming increasingly complex (OECD, 2003), and are associated with uncertainty and/ or ambiguity (Klinke & Renn, 2002; Renn, 2008; van Asselt & Renn, 2011), meaning that it is becoming increasingly difficult to identify them. Secondly, the risk context is becoming more interdependent and interconnected (OECD, 2011), meaning that risks are more transboundary, while even a small, local disruption can spread rapidly and escalate to a global crisis. At the same time, institutional fragmentation is increasing (Almklov & Antonsen, 2010; De Bruijne & van Eeten, 2007), meaning that the authorities, resources and expertise that can be used to manage risks are distributed among many different stakeholders. These changes pose a challenge for DRM. Specifically, they have triggered calls for a move from the traditional, single organization focus (ISO, 2009) to a model in which several organizations work together to manage risks jointly (OECD, 2010).

The Sendai Framework for Disaster Risk Reduction 2015–2030 (UNISDR, 2015b), which is the successor of the Hyogo Framework for Action, was agreed by 187 governments at the Third United Nations World Conference on Disaster Risk Reduction. Among other significant issues, it states that "Each State has the primary responsibility to prevent and reduce disaster risk, including through international, regional, sub regional, transboundary and bilateral cooperation" (UNISDR, 2015b). This can be understood to mean that states have overall responsibility for public safety, including an awareness of potential risks, as well as the prevention and reduction of disaster risks. However, achieving these goals relies upon governments and other relevant stakeholders sharing responsibility, rather than governments acting alone. To be more precise, cross-cutting and complex issues, such as DRM, require a "whole of government" and "all of society" engagement (Caudle & de Spiegeleire, 2010; European Commission, 2010; IFRC, 2016; UNISDR, 2017; Wyman, 2009). The consequence of this multi-stakeholder partnership, mirrored within a country's DRM system, is that key actors at various levels of government (stakeholders with multi-disciplinary backgrounds, representatives from the private sector and civil society) should all be encouraged to manage potential disaster risks together.

An important aspect of managing risk is assessment. A precondition to taking effective action to mitigate disaster risks and their adverse impacts is to understand the risks to be managed, e.g., the hazards and threats that societies are exposed to, the vulnerabilities of human beings, as well as societies' ability to handle these hazards and threats (OECD, 2015). Consequently, conducting a comprehensive risk assessment, which contains such information and can form the basis for prevention policies or strategic mitigation programs, is a priority for stakeholders in the DRM system. The value of risk assessment has been widely recognized, both in DRM practice (European Commission, 2010; G20 & OECD, 2012; IFRC, 1999; OECD,

2015; UNISDR, 2007, 2015b; UNISDR & UNOCHA, 2008), and by researchers (Alexander, 2005; Perry & Lindell, 2003; Quarantelli, 1998). It has been claimed that it helps to create a solid foundation for risk-related decision-making (Aven & Renn, 2009b; Paté-Cornell & Dillon, 2006); similarly, it is used to inform decision-making regarding disaster risk reduction measures (Apostolakis, 2004; Aven & Kørte, 2003). In addition, the process of conducting a risk assessment is acknowledged to be beneficial for DRM work, in terms of increasing risk awareness, stimulating reflection, improving networking among stakeholders, enhancing disaster planning, as well as directing relevant risk behaviors (Busby & Hughes, 2006; Eriksson, 2009; Lin & Eriksson, 2016; Pelling, 2007; Perry & Lindell, 2003). It appears that risk assessment plays a distinct, essential role in DRM. Similarly, the quality of the process that generates the risk assessment seems to have profound impacts in a DRM system.

In the past, the focus was on risk management within a single organization. For example, ISO 31000 defines risk management as "coordinated activities to direct and control an organization with regard to risk" (ISO, 2009). However, researchers now argue that no specific organization can 'own' a crisis (Boin, 2009), and that no-one possesses all of the relevant information concerning all risks. Therefore, if a risk assessment is to present a full risk picture in today's multi-stakeholder DRM system, all relevant stakeholders must work together to actively and meaningfully communicate risk-related information. It is often the case that the greater number of stakeholders engaged in the process, the greater the need for communication and information sharing (Lin, Nilsson, Sjölin, Abrahamsson, & Tehler, 2015). Consequently, the quality of the risk assessment depends on the quality of risk communication among DRM stakeholders.

Effective risk communication is not easy to achieve, although its importance in the context of DRM has been repeatedly stressed (Hermans, Fox, & van Asselt, 2012; van Asselt & Renn, 2011; Veland & Aven, 2013), and has been argued to be particularly key when risk is managed by many actors (IRGC, 2009; Renn, 2014; van Asselt & Renn, 2011). Veland and Aven, for instance, have pointed out that DRM stakeholders have different risk perspectives, which can influence risk communication, and lead to serious problems and barriers in sharing risk-related information (Veland & Aven, 2013). Kramer's study, which examines communication among various governmental authorities before 9/11, demonstrates that in complex bureaucracies, communication and information sharing are associated with multi-faceted barriers: psychological, social, institutional, etc. (Kramer, 2005). Not only do these barriers hamper the flow of risk communication, they also make it difficult for parties to reach agreement and fail to "connect all the dots" (Kramer, 2005), thereby degrading their collective ability to manage disaster risks. It seems that risk communication in a multi-stakeholder context is destined to be associated with many challenges.

The challenges of risk communication, either similar to those identified above, or others that remains hidden could, of course, manifest any time a joint effort is required to generate a risk assessment, in any DRM system. They can seriously limit relevant stakeholders' collective ability to assess risk, and/ or lead to other failures in the DRM system. As indicated above, the consequences can be particularly serious in our complex and interconnected world. Thus, there is a need to investigate the role of risk communication in DRM systems and examine its possible effect on stakeholders' collective ability to manage disaster risks. For example, how is the risk assessment influenced by the status of risk communication among DRM stakeholders? Does this then affect other DRM activities that build upon the risk assessment, or even the overall performance of the DRM system? More importantly, attention should be given to identifying countermeasures that can be taken to improve the effectiveness of risk communication among DRM stakeholders. Ultimately, the aim is to improve the quality of the risk assessment, the ability of stakeholders to work together, and the overall performance of the DRM system.

Past studies of risk communication in a multi-stakeholder context have, to a great extent, focused on communication between authorities and the public (Fischhoff, 1995; Renn, 2014). Very few have studied risk communication between experts, e.g., authorities, private companies, or other professional organizations working in the domain of disaster risk reduction (Bier, 2001; Comfort, 2007; Garnett & Kouzmin, 2007; Kramer, 2005; Thompson & Bloom, 2000; Veland & Aven, 2013). Even fewer have focused on how DRM stakeholders communicate risk-related information for risk assessment purposes (Veland & Aven, 2013), and hardly any have examined a possible domino effect due to poor communication. Given the potentially very important role that the communication of risk-related information can play in a DRM system, there is a need to develop our understanding of the role it plays in the risk assessment process. This process involves several stages: collecting risk-related information and conducting the assessment; then disseminating and utilizing this information. A further aspect is to examine how the risk assessment, both as the result of risk communication and as an essential component of many DRM activities, influences the DRM system.

1.2 Research purpose

The overall purpose of the present thesis is to improve our understanding of how DRM systems function. More precisely, it aims to increase our knowledge of effective risk communication in a multi-stakeholder, multi-level DRM system, with a specific focus on the exchange of risk-related information for risk assessment.

By focusing on the process of how DRM stakeholders collect and share risk-related information to conduct risk assessments, and how assessments are subsequently disseminated and utilized, this thesis investigates the communication challenges that hinder effective stakeholder communication and collaboration. These challenges may influence the quality of risk assessments and the overall performance of the DRM system.

The thesis proposes a new direction for the examination and enhancement of risk communication in a well-established DRM system. Specifically, it adopts various perspectives, and examines approaches to overcoming the barriers that hamper the flow of effective risk communication in a multi-stakeholder context. For example, it enhances our understanding of how to construct a risk assessment that can improve communication; it also addresses systemic problems that can make effective risk communication difficult, and which are embedded before, during and after the risk assessment process.

1.3 Research questions

Given the aim of this study, which was described in the previous section, the overall research question that is addressed in this thesis is formulated as:

How does risk communication, through the process of conducting, disseminating, and utilizing risk assessments, influence multi-stakeholder multi-level DRM systems, and what can be done to improve the effectiveness of such risk communication in order to improve the functioning of DRM systems?

The Swedish DRM system has been chosen as the study case for this thesis (see the next section for further details of the reasons for this decision).

The following three sub-research questions, each dedicated to the examination of communication issues related to risk assessment in the Swedish DRM system have been developed:

1. What are the communication challenges in the multi-stakeholder multi-level Swedish DRM system, relating to the conduct, dissemination, and utilization of various risk assessments?

2. How does risk assessment work and the communication issues that are linked to this activity influence Swedish DRM work in practice?

3. What should be done to improve the effectiveness of risk communication, based on risk assessment work, in order to improve the ability of DRM stakeholders to work together, and the overall performance of the DRM system?

Each of these three questions has a specific focus, and a summary of the results from the appended publications are outlined in this thesis. It should be noted that the sub-research questions given here are not the same as the research questions given in the appended papers. The former is both broader, and more holistic. However, taken together, they represent all of the studies that make up this thesis and, more importantly, they contribute to addressing the overall research question. Chapter 4 addresses each question explicitly.

1.4 Geographical focus

The purpose of this section is to introduce the multi-stakeholder, multi-level DRM system in Sweden and explain why Sweden was chosen as a study case for this thesis.

1.4.1 The Swedish DRM system

The Swedish DRM system consists of three administrative levels of governance: local (municipalities), regional (county administrative boards and county councils), and national (government departments and agencies). The system is guided by three fundamental principles: responsibility, parity, and proximity. Respectively, these principles translate into: 1) whoever is responsible for an activity under normal conditions is also responsible for it during an emergency; 2) how authorities and public services function during a crisis should, as far as possible, be the same as under normal circumstances; and 3) a crisis should be dealt with at the lowest administrative level, and by those who are closest to it (Prop, 2005/06:133).

At a national level, the Swedish DRM system is coordinated by the Swedish Civil Contingencies Agency (MSB), which is responsible for issues concerning civil protection, public safety, emergency management and civil defense in the country. The Swedish government specifies the MSB's responsibilities, objectives and reporting requirements, and allocates its resources. One of the MSB's principle tasks is to enhance Swedish society's DRM capacity, by providing support and guidance to relevant stakeholders' DRM activities.

More generally, it should be noted that a holistic, all-hazards approach is mandatory. Swedish legislation (SFS, 2006:942, 2015:1052)[2] states that government-level planning must be coordinated. In order to strengthen society's crisis response, governmental authorities (national agencies and regional county administrative boards) and other actors (municipalities, county councils, and armed forces) are required to cooperate in six central areas. These are: 1) economic security; 2) dangerous substances; 3) geographic area of responsibility; 4) protection, rescue and care; 5) technical infrastructure; and 6) transportation (Lin, 2018). Each area concerns five to ten governmental authorities or bodies. The exception is geographic area of responsibility, which comprises one national authority (the MSB), and the 21 county administrative boards covering the whole of Sweden. Although the stakeholders involved in these six areas have different responsibilities, they are required to agree and synchronize their DRM planning. In particular, they must reduce society's vulnerability in the six areas and ensure that a crisis is handled as well as possible.

1.4.2 The risk and vulnerability assessment

One of the most important components of Sweden's multi-stakeholder, multi-level DRM system is the risk and vulnerability assessment (RVA). Mandatory under Swedish law (SFS, 2002:472, 2002:833, 2006:544, 2006:637, 2006:942, 2015:1052), national agencies, regional authorities and municipalities began to conduct RVAs on a regular basis, at different levels of society, in the early 2000s. Other critical infrastructure operators, such as electric power supply companies, telecommunication groups and potable water suppliers, etc., also carry out their own RVAs (either required by legislation, or voluntary, depending on the functional sector they belong to).

The RVA normally includes an assessment of the potential risks faced by an authority, together with any other specific risk scenarios chosen by the MSB, and information about the authority's capability to deal with these adverse events. The primary purpose of conducting the RVA is to raise the awareness and increase the knowledge of those responsible for making decisions concerning risks and vulnerabilities, and to provide a basis for planning and the implementation of measures that reduce risks and vulnerabilities (SOU, 2004:134). More precisely, RVAs are expected to form the basis for many DRM activities, for example, proactive risk reduction planning, crisis response preparations, DRM-related exercises, and staff training (SFS, 2006:544, 2006:942, 2015:1052).

[2] SFS 2006:942 has been replaced by SFS 2015:1052.

Within the Swedish DRM system, the underlying logic for RVA work is that RVAs conducted by a lower administrative level should serve as the basis for a higher-level assessment (Abrahamsson & Tehler, 2013; SOU, 2004:134). For instance, the regional-level RVA should be based on input from the municipal RVA, as municipalities and their respective regional county administrative board share the same geographical area. Similarly, national-level RVAs should be based on the results of regional RVAs. The system is designed to rely upon joint efforts by stakeholders at various societal levels, based on the belief that stakeholder collaboration generates a comprehensive overview of the risks and vulnerabilities faced by the whole of society.

1.4.3 Previously-identified weaknesses and new challenges

Historically, the MSB, and its predecessor, the Swedish Emergency Management Agency, carried out the overall assessment of Sweden's emergency management capability, based on the RVAs that were conducted by authorities at local, regional and national levels (Abrahamsson & Tehler, 2013). However, aggregating and merging these assessments has proved to be a huge challenge. This is because, among other reasons, lower-level RVAs that are designed to facilitate disaster risk preparedness at the local/ regional level are unlikely to be useful from a national perspective (Eriksson & Borell, Forthcoming). Moreover, municipal and regional-level RVAs focus on the geographical area of responsibility, while national authorities are responsible for a function, e.g., transportation, telecommunications, customs, police. As national authorities have a functional area of responsibility, rather than being geographically delimited, they have found it difficult to use the regional/ municipal RVAs based on a geographical area. In addition, different authorities select very different methods to analyze and evaluate potential disaster risks and their consequences, making aggregation and merging even more difficult. There is, therefore, an obvious need to improve the coherence of all RVAs as the weaknesses of this bottom-up system have become clear. In 2010, the MSB issued regulations (MSBFS, 2010:6, 2010:7) that aimed to enhance the comparability and transparency of RVAs. These regulations were subsequently replaced (MSBFS, 2015:4, 2015:5, 2016:7) after a few years of practice. However, it appears that RVA work continues to lack a systematic method (Eriksson, 2016). The problem has become more apparent, and the desire to address it has also grown more urgent, following the country's decision to respond to the European Union's (EU) call to conduct a national risk assessment (NRA).

Under EU regulations, Sweden is required to conduct an NRA (Council of the European Union, 2011). The Swedish government has given the MSB responsibility for carrying out this task (Fö2011/947/SSK, 2011). Although it was the case that RVAs at all levels provided the basic foundation to identify potential disaster risks,

the lack of a systematic method, together with the challenges mentioned above relating to the design of the system, have proved to be major obstacles for the MSB (MSB, 2016).

An earlier study that focused on the Swedish DRM system pointed out that the expected bottom-up, aggregation and merging of RVAs is not happening in practice (Abrahamsson & Tehler, 2013), and this could be because of a lack of stakeholder communication. It therefore appears useful to investigate the issue in detail from a risk communication perspective.

The Swedish DRM system is a natural candidate for a study case, in the sense that it provides a multi-faceted, empirically-sound basis for examination. The system mandates all stakeholders to conduct a regular risk assessment (the RVA). It has established a thorough, risk-related information reporting channel that is based on RVAs and involves stakeholders from the whole of government and all levels of society. Despite the weaknesses that have been discovered, rather than limiting the role of RVAs in DRM work, Sweden has actively tried to find solutions that bridge the gaps, and continues to use RVAs in NRA work, following the international trend. The situation in Sweden is representative of the situation worldwide: many countries have established DRM systems that involve stakeholders in various functional sectors and within geographical boundaries, with the aim of anticipating, preparing for, and responding to disaster risks. The problems found in the Swedish DRM system, and the experience that has been gained, may therefore shed light on the design of other DRM systems, and improve practices.

1.5 Thesis outline

This thesis is composed of six chapters and five appended scientific publications. It outlines how the overall theory and methodology have been developed and provides a comprehensive summary of the research outcomes.

Chapter 1: Presents the background and rationale, research purpose, research questions, and the geographical focus of the study case.

Chapter 2: Outlines the theoretical and conceptual foundations for the research.

Chapter 3: Describes the philosophical positioning of the thesis, the strategy for the overall research design, the research process, and the methods that were adopted for data sampling, collection, and analysis.

Chapter 4: Summarizes the combined findings from the appended publications.

Chapter 5: Discusses the results, reflects upon the quality of the research, and offers some ideas for future research according to the limitations of this thesis.

Chapter 6: Draws some conclusions based on the work presented in the thesis.

Chapter 2.

Conceptual framework

This chapter outlines the principle theories and concepts that provide the framework for the studies presented in this thesis.

2.1 Risk governance and DRM

A risk governance perspective has been adopted throughout this thesis. Risk governance addresses the process within which multiple actors (individuals and institutions, public and private) work together to collectively manage risks characterized by uncertainty, complexity, and/ or ambiguity (van Asselt & Renn, 2011). It is a perspective that is very relevant to the studies presented here, especially when seen as "the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analyzed, and communicated, and how regulatory decisions are taken" (IRGC, 2009; van Asselt & Renn, 2011). It should be noted that risk governance concerns more than just minimizing risks: it also aims to reduce vulnerability and increase resilience, so that the society can better withstand, or even tolerate, hazards and threats (van Asselt & Renn, 2011).

DRM is commonly seen as an ongoing process that aims to lessen the disaster risks that threaten human beings, reduce the impact of potential adverse events, and strengthen the resilience of societies (UN General Assembly, 2016; UNISDR, 2009). DRM can be found at various levels of society, and often involves stakeholders from different backgrounds who jointly seek to create a safer environment. The organizations, technical systems, mechanisms, etc. that are engaged in the DRM process constitute a DRM system (Lin, 2018; Lin & Abrahamsson, 2015; Lin, Rivera, Abrahamsson, & Tehler, 2017; Rivera et al., 2016). Given that both risk governance and DRM invite different parties to work together towards the overall goal of reducing risks and their negative impacts, and enhancing the resilience of the society, it is reasonable to see a DRM system as a practical example of risk governance. Using this argument as a point of departure to examine the DRM system may reveal risk governance deficits (IRGC, 2009). Similarly, risk governance principles (van Asselt & Renn, 2011) can be applied to DRM process.

Risk governance deficits are the "deficiencies or failures in the identification, assessment, management or communication of risks, which constrain the overall effectiveness of the risk governance process" (IRGC, 2009). The International Risk Governance Council's report (2009) groups risk governance deficits into two categories relating to: 1) the risk assessment; and 2) risk management. Risk assessment relates to collecting and developing knowledge about risks, in order to further understand and evaluate them, while risk management emphasizes taking actions to reduce, mitigate or prevent the identified risks (Florin, 2013). Risk communication is an integral part of both. Therefore, deficits, either in risk assessment or risk management, can be related to, or triggered by, failures in risk communication (IRGC, 2009). Due to the scope of this thesis, studies reported here focus on risk assessment and the associated risk communication among stakeholders.

Understanding the causes of risk governance deficits and minimizing the chances of their recurrence is a good strategy for improvement (Florin, 2013), as they can easily occur in a DRM system and hinder its functioning. Given that the purpose of this thesis is to draw upon knowledge that is gathered from risk assessment and risk communication perspectives to enhance the functioning of DRM systems, tracing the deficits in the DRM system can be a useful starting point, prior to action being taken to overcome them. Aven argues that some of the deficits in risk governance that have already been identified (IRGC, 2009) need to be rewritten and reinterpreted (Aven, 2011). Therefore, instead of looking again for the same deficits in the DRM system, it is more helpful to be aware of the fact that deficits may exist throughout the whole DRM system, while, at the same time, seeking to understand at which stages of the risk assessment process, and how, these deficits are most likely to be found.

In addition to identifying and overcoming deficiencies in the DRM system, it is also important to develop guidelines, or general rules, regarding the key issues to be taken into consideration during the DRM process, in order to enable the system to function properly, if not even better. These risk governance principles, as van Asselt and Renn point out, represent a synthesis of wise approaches to risk governance (van Asselt & Renn, 2011). In the present thesis, the author presents some of the risk governance principles that are most relevant to the research that is conducted and interprets them in the context of a multi-stakeholder, multi-level DRM system.

The first is the principle of communication. Effective communication, in a DRM context, should be two-way (van Asselt & Renn, 2011). The aim is to bring stakeholders together, enable them to actively and meaningfully interact, share risk-related information, and come up with possible solutions (van Asselt & Renn, 2011). However, it goes far beyond just bringing stakeholders together and initiating a conversation, as their values, perspectives and goals may vary greatly (Rasmussen,

1997) and the dialog could become meaningless (Kramer, 2005). Therefore, social learning must form part of the process: the aim is that stakeholders gradually learn what kind of information should be communicated with whom, when, and how (van Asselt & Renn, 2011). Communication should provide a solid foundation for stakeholders to effectively and continuously share risk-related information and improve the DRM system. As van Asselt and Renn argue, effective, mutual risk communication is very challenging, and its success or failure can lead to the success or failure of the DRM system (van Asselt & Renn, 2011).

The second is the principle of inclusion. A DRM system is a multi-actor partnership, and the process requires a collective effort from multiple actors. The principle suggests that it is not the number of actors that matters. Instead, all parties play an essential role in assessing and framing the risks (van Asselt & Renn, 2011). Meanwhile, openness (about whom/ what to include), and flexibility (regarding the way stakeholders could work together) are needed. It is important to bear in mind that more inclusion does not equal a better DRM result (van Asselt & Renn, 2011). Even though a joint effort is preferred, it requires careful thought about who should be invited to participate. Ideally, it will include stakeholders with complementary roles and diverging interests, in order to cover the full diversity of potential risks (van Asselt & Renn, 2011).

The third is the principle of integration. Integration refers to, "the need to collect and synthesize all relevant knowledge and experiences from various disciplines and various sources including uncertainty information and articulations of risk receptions and values" (van Asselt & Renn, 2011). In the DRM context, there are two aspects (Lin, 2018; van Asselt & Renn, 2011). The first relates to the content of the end product. Risk assessment documentation can take various forms, such as RVAs, the NRA, capability assessments, and so on. These documents must present the evaluation of potential risks from a multi-dimensional perspective. The second aspect refers to the DRM process; in other words, the interlinked activities of risk assessment, risk management and risk communication. It is very important to view these different DRM activities as connected rather than isolated, and stakeholder interaction during the process must be active and meaningful.

The final principle refers to reflection. DRM cannot be simply routinized and repeated. The risks that need to be managed change, as does the context in which they exist, and the stakeholders who are involved. Therefore, DRM activities should be reviewed and adjusted continuously. The stakeholders involved in the DRM system should repeatedly and actively reflect upon what they have been doing, and what else they could do. Similarly, they should examine the pros and cons of the actions that have been taken, and any ongoing issues, throughout the whole DRM process (van Asselt & Renn, 2011).

2.2 Risk and risk assessment

Risk is one of the fundamental concepts in the present study. Although the research presented here does not study the concept of risk *per se*, it is based on risk assessments and the inherent use of risk communication. Naturally, this draws upon the concept of risk and its measurement. Risk has been defined in many different ways, and there is no shared understanding (Aven & Renn, 2009a; Aven, Renn, & Rosa, 2011; Haimes, 2009; Kaplan, 1991). Aven, Renn and Rosa (2011) divide current risk concepts into three categories, based on the ontological status of the risk. They are: (a) risk as a concept based on events, consequences and uncertainties; (b) risk as a modeled, quantitative concept (reflecting aleatory uncertainties); and (c) risk measurements (risk descriptions) (Aven, Renn, & Rosa, 2011).

Compared to the often narrower, technical definitions of categories (b) and (c), category (a) is broader and more applicable in the context of the current study. For example, uncertainty, as understood in category (a) is not equal to the probabilities or frequencies that are used to describe uncertainty in categories (b) and (c) (Ale, 2002; Willis, 2007). In this thesis, Aven and Renn's definition "Risk refers to uncertainty about and severity of the events and consequences (or outcomes) of an activity with respect to something that humans value" (Aven & Renn, 2009a), which is representative of category (a), has been adopted. This definition is also consistent with Aven's argument that events/ scenarios (A), consequences (C), and uncertainties (U) constitute the three vital building blocks of the concept of risk (Aven, 2010). That is to say, risk = (A, C, U) (Aven, 2010).

On the other hand, Aven proposes that the concept of risk should be differentiated from its description (e.g., the results of risk assessments) (Aven, 2012). The distinction is highly relevant to this thesis, as it investigates how stakeholders communicate risk-related information, in order to conduct, disseminate and utilize risk assessments in the DRM system. More specifically, it can be said that the risk assessment process is based on risk communication among stakeholders, and it facilitates the exchange of risk-related information. The final risk assessment documentation, therefore, contains such risk-related information. Either the risk-related information communicated by DRM stakeholders, or the final risk assessment documentation, contains the description of the risk, rather than the risk concept *per se*.

It should be noted that Aven states that the risk description = (C', Q, K), where C' is a description of specific consequences, Q stands for the measure of uncertainty, and K is the background knowledge that Q is based on (Aven, 2012). This statement provides a theoretical foundation for investigating the constitution of risk-related information and/ or risk assessment documentation, especially when efforts are

made to examine how the description of risk influences risk communication among DRM stakeholders.

2.3 Risk communication

Risk communication has been defined as, "the exchange of information among interested parties about the nature, magnitude, significance, or control of a risk" (Covello, 2012). It is a multi-dimensional, interactive process where relevant stakeholders and decision-makers share risk-related information and/ or the results of risk assessments, in order to facilitate risk-related decision-making throughout the DRM process (MacDiarmid & Pharo, 2003; Reynolds & Seeger, 2005). Effective risk communication reflects the mutual exchange of information between stakeholders (Covello & Sandman, 2001; Renn, 1992; Smith & McCloskey, 1998; van Asselt & Renn, 2011), indicating that appropriate feedback is one of its key aspects. In DRM systems, effective risk communication brings together stakeholders with different expertise and from various backgrounds and enables them to actively and meaningfully interact. It implies the internal and external exchange of risk-related information among involved parties, and provides them with a foundation to responsibly and collectively manage disaster risks (van Asselt & Renn, 2011).

Risk communication has always been fraught with challenges (Kramer, 2005). Dransch, Rotzoll and Poser (2010) argue that they relate to several aspects, including the risk communication process, the presentation of risk-related information, and people's risk perception. The risk communication process must have a defined intention and designated media/ communication channel, in order to target its primary audience. The presentation of risk-related information refers to the content of the message being communicated. People's assessment of risk, and their reaction to risk-related information, reveal their risk perception (Dransch, Rotzoll, & Poser, 2010). In the context of this thesis, risk communication challenges could arise: 1) when stakeholders exchange risk-related information to conduct, disseminate and utilize risk assessments; 2) when risk-related information is constructed and presented in different ways; or 3) when stakeholders hold different opinions of risks. As van Asselt and Renn point out, given that risk communication lies at the core of any successful risk governance activity, these challenges can lead to less effective risk governance and even lead the DRM process to fail (van Asselt & Renn, 2011). It is therefore necessary to identify the potential challenges to risk communication and generate countermeasures to overcome them.

Traditionally, risk communication studies have focused on how experts communicate the results of their risk assessments to the public, convince the layperson of their credibility, and inform them of any countermeasures that are taken (Fischhoff, 1995; Renn, 2014). For a long time, risk communication has largely been considered as a one-way process, with the aim of disseminating appropriate messages and educating the public. However, considerable progress has been made, and current risk communication is understood as a complex, two-way activity (Bradley, McFarland, & Clarke, 2014; Gurabardhi, Gutteling, & Kuttschreuter, 2004, 2005). In the DRM context, it is seen as an imperative, as multiple stakeholders are involved, and risks are characterized by high levels of ambiguity, complexity, and uncertainty (Hermans et al., 2012; van Asselt & Renn, 2011). It should be noted that the majority of research into risk communication concentrates on the relationship between experts and the general public, while considerably less attention has been paid to how experts, for example DRM professionals, communicate risk-related information among themselves, namely, via risk assessment documentation (Bier, 2001; Thompson & Bloom, 2000).

Several investigations have looked at the causes of risk communication barriers between experts from different sectors, notably following major disasters such as the 9/11 attacks in 2001 (Kramer, 2005) and hurricane Katrina in 2005 (Comfort, 2007; Garnett & Kouzmin, 2007) in the United States. However, little attention has been paid to communication challenges (and countermeasures) that are encountered when DRM experts exchange risk-related information with each other based on their risk assessment activities—the work of Bier, Thompson and Bloom (Bier, 2001; Thompson & Bloom, 2000) being a notable exception. Consequently, this thesis intends to contribute to knowledge in this field.

Chapter 3.

Research design and methodology

This chapter is divided into three sections. First, the philosophical positioning is described. This presentation provides the foundations for the problem addressed by this research, how the questions are formulated, how the process is designed, and how answers are sought. The research design and process are presented in detail in the following sections, which address, respectively, the overall strategy that was adopted, and the research path that was taken to achieve the proposed objective. Finally, the research methods are described; these are divided into data sampling methods, data collection methods, and data analysis methods.

3.1 Philosophical positioning

The philosophical assumptions of the author, his/ her worldview, paradigms and values all contribute to shape the research that they conduct (Creswell, 2007). Good research requires an explicit statement of these assumptions, paradigms or worldviews, as well as any theoretical frameworks. If authors do not report this, they should, at least, be aware that they influence how the inquiry unfolds (Creswell, 2007). This section, therefore, briefly discusses the philosophical assumptions and paradigms that this thesis is based on.

The researcher's philosophical assumptions have various practical implications for the design and conduct of their research. For instance, the ontological assumption refers to the nature of reality (Creswell, 2003), and is concerned with what constitutes reality (Scotland, 2012). This thesis takes the stance that reality is independent and exists whether it can be observed or not. The epistemological assumption addresses the question of how the researcher knows what he or she knows (Creswell, 2007; Crotty, 1998). It is concerned with how knowledge can be created, acquired and communicated (Scotland, 2012). As reality is independent, empirical investigation rests on the researcher's efforts to interact with the subjects being studied—thus there is no truly objective research (Kuhn, 1970)—and researchers obtain knowledge by minimizing the distance between themselves and the subjects being studied (Creswell, 2007). The axiological assumption states that researchers bring their values to their study, and that it is impossible to be value-neutral (Creswell, 2007). Consequently, they must acknowledge the presence of any biases in their studies.

While philosophical assumptions reflect the author's stance when conducting studies, research is also shaped by their paradigms or worldviews, defined as "a basic set of beliefs that guide action" (Guba, 1990). Different paradigms lead to different stances on reality and knowledge (Scotland, 2012). In this thesis, critical realism best presents the ontological, epistemological and axiological issues that are investigated. Bhaskar argues that the real, the actual and the empirical comprise three domains of reality (Bhaskar, 2008). The real domain exists independently, and is based on the actual patterns of events; the actual domain represents events that are independent of experience, and which can either be observed or not; finally, the empirical domain refers to events that are observed through experience (Alvesson & Sköldberg, 2017; Bhaskar, 2008). The critical realism ontology assumes that there is an external reality that is independent of observers (Easton, 2010). It also argues that our knowledge of the world is fallible and theory-laden (Easton, 2010; Sayer, 2000). In order to be able to explain and understand social phenomena, researchers must evaluate them critically, which means that social science must be critical (Easton, 2010; Sayer, 2000). Within this framework, critical realism allows the researcher to adopt a wide range of research methods, according to the nature of the object of the study, and the knowledge the researcher is seeking (Sayer, 2000).

This thesis explores issues related to effective risk communication in the context of the various risk assessments that exist in the Swedish DRM system. The author acknowledges that the DRM system, and the context in which it exists are independent. The system itself, and the events that occur within it, are independent of the researcher's experience. They can either be observed or not. However, the so-called 'empirical' domain of the DRM system can be observed by the researcher and can provide answers to the research questions if interpreted based on the author's experience. Given that knowledge can be fallible, the researcher must remain critical about what has been learnt, and what might be said to be reality.

3.2 Research design and process

3.2.1 Overall research design

A research design explains the logic that connects the data to be collected and the conclusions to be drawn from the initial questions of a study (Yin, 2009). Case study research, which explores an issue through one or more cases within a bounded system (Creswell, 2007), can be a choice of what is to be studied (Stake, 2005), or a strategy of inquiry, a methodology, or even a comprehensive research strategy (Creswell, 2007). This thesis adopts the case study as a strategy to guide its overall research design.

Case study research allows the researcher to study one or multiple bounded system(s) over time, through detailed, in-depth data collection, involving various sources of information, e.g., interviews, documents and reports (Creswell, 2007). Different methods thus can be employed, as long as the situation permits (Yin, 2009). In other words, the method is all-encompassing, covering the logic of the research design, data collection techniques, and specific approaches to analyze the obtained data (Yin, 2009). Researchers can then look for similarities and differences among the results, and develop generalizations (Creswell, 2007). Case studies can adopt either a single or multiple case design, and be either holistic (a single unit of analysis) or embedded (multiple units of analysis) (Creswell, 2007; Yin, 2009). The single case is best-suited to a critical case, an extreme or unique case, or a revelatory case, while an embedded design examines a collection of subunits, and allows the research questions to shift among these subunits, as long as they remain within the scope of the overall study (Creswell, 2007; Yin, 2009).

The current thesis presents a single case study based on an embedded design. In order to generate knowledge that is designed to enhance the functioning of a multi-stakeholder, multi-level DRM system, it investigates the problem from the angle of improving the effectiveness of risk communication when exchanging risk-related information for risk assessments. The Swedish DRM system is taken as the basis for the analysis. Multiple units of analysis (the studies that are reported in the appended publications) address different research questions, but all contribute to the overall objective. A wide range of methods are used to collect data and analyze the results. The overall aim is to carry out an in-depth, empirical investigation of a contemporary phenomenon (effective risk communication while conducting, disseminating and utilizing the risk assessments) in a real-life context (multi-stakeholder multi-level Swedish DRM system) (Yin, 2009).

3.2.2 Research process

In order to answer the research questions, five studies were carried out over the author's PhD journey; these are reported in detail in the five appended publications. Although each study is independent, they inspire each other and are closely related. Taken together, they present a holistic picture of the risk communication issues that are relevant to the conduct, dissemination and utilization of various risk assessments in the Swedish DRM system and suggest some ways to improve the system. This thesis presents the five papers in the order they were initiated, which does not follow the chronological order of writing or publication. The author believes that the rationale behind each paper is best understood in the light of the whole research process. Likewise, the overall research process and how it addresses the research questions is more convincing when divided into small, robust steps. The current

section illustrates the stepping stones presented in this thesis, the logic that connects them, and the holistic research process that they lead to.

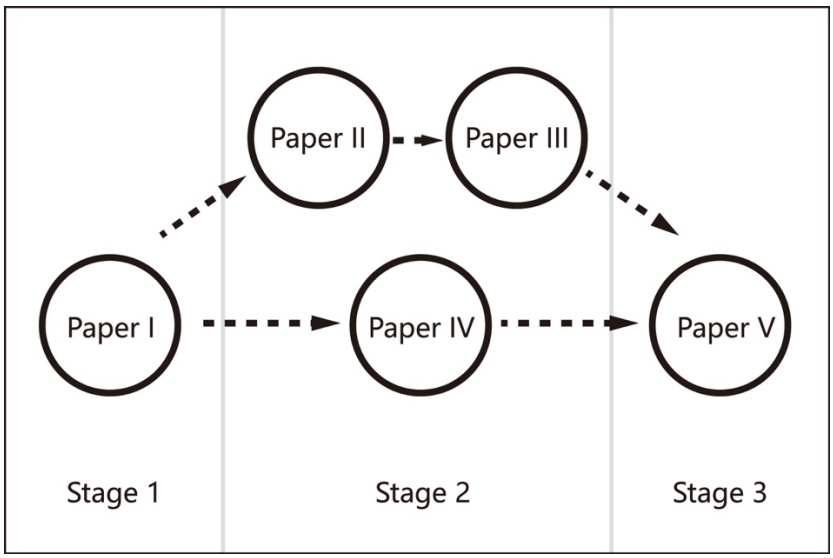

Figure 1: Schematic outline of the chronology of the research process

3.2.2.1 Stage 1

Paper I is the result of the first research activity, which aimed to identify the general risk communication challenges associated with the conduct of risk assessments in the Swedish DRM system. It was prepared in the very first stage of the author's PhD study. Risk information sharing and stakeholder collaboration via RVA work were the focus of this study. Issues concerning risk communication challenges among DRM stakeholders were investigated from a very broad and exploratory perspective. Aspects included: how DRM stakeholders communicated risk-related information, how stakeholders used RVA documentation as a formal channel to share risk-related information, how the RVA system works at different administrative levels, and between levels, and how DRM stakeholders collaborate in order to conduct, disseminate, and utilize RVAs.

Paper I involved stakeholders from all levels (national, regional and municipal) in the Swedish DRM system. Attention was given to both public authorities and relevant critical infrastructure operators. The findings addressed frequently-perceived risk communication challenges that were encountered while developing and using RVAs in all areas of the DRM system. The principal challenges were: 1) difficulties in using other stakeholders' RVAs; and 2) very limited constructive feedback from higher administrative levels, which resulted in risk communication being mostly one-way.

The major findings and knowledge gained via Paper I gave rise to two research paths, both of which aimed to improve the effectiveness of risk communication associated with the risk assessment work in the DRM system. The first aimed to enhance the usefulness of risk assessment documentation from the content perspective. It assumed that effectiveness could be improved if the quality of this documentation was enhanced (this relates to communication challenge 1, stated above). The second path examined the design of the RVA system in Sweden and sought to identify the underlying reasons for communication challenges.

Paper II and III formed the first research path, while Paper IV contributed to the second. They were all developed at the second stage of the author's PhD study, and aimed to generate countermeasures that may help to overcome the risk communication challenges found in the Swedish DRM system.

3.2.2.2 Stage 2

Paper I identified that DRM stakeholders from higher administrative levels found it very difficult to draw useful information from the lower-level's RVAs in order to generate their own, higher-level, RVA, as prescribed by Swedish legislation. It showed that the effectiveness of risk communication based on the exchange of RVAs was hindered in the Swedish DRM system. Papers II and III were intended to improve the perceived usefulness of RVAs for risk communication and risk-related decision-making. The aim was that by making the RVAs more useful, barriers to risk communication based on the exchange of risk assessment documentation (RVAs in the Swedish context) could be reduced, thus enhancing the effectiveness of communication.

Paper II examined how the way in which risk is described influences the overall usefulness of the assessment. It was based on an analysis of RVAs taken from the Swedish DRM system and focus group discussions with professionals responsible for producing a RVA and other DRM activities. The study shows that the perceived usefulness of the RVA is different, depending on how certain aspects of risk information are described. Specifically, the findings suggest that risk assessments that include scenario descriptions, background information concerning estimated likelihoods, and information with regard to the likelihood of events and their consequences are perceived as more useful.

This analysis of real RVA documents, and discussions with professionals who actually use these RVAs in their work are notable strengths of this paper, as they give the study a high degree of relevance. Based on the results of Paper II, a follow-up, experimental study was designed, which enabled the author to test the findings from Paper II and complement it with better control over the materials used and involving more participants with different backgrounds. This experiment was initially carried out in Sweden with Swedish participants who had formal training

and work experience in DRM. It was subsequently run in a completely different context with participants from Nicaragua who had an urban planning background and experience of producing risk assessments and dealing with hazards (access to this group was made possible by one of the co-authors, who is from Nicaragua). Paper III reports the results of this study.

Paper III also investigated how the presentation of the risk assessment affected its perceived usefulness in the DRM context and asked if there was a certain format that was perceived to be most useful. The findings indicated that the presentation of likelihood and consequences was a key influence: quantitative and semi-quantitative scales were perceived as more useful than a qualitative scale, a qualitative description, or no description. Furthermore, as not all of the participants in the experiment were DRM professionals, the results showed that the extent of participants' risk assessment knowledge was not a determining factor in deciding the usefulness of the assessment. However, those with more DRM experience seemed to be more sensitive to differences in how the risk assessment was formatted. The overall conclusion was that quantitative and semi-quantitative scales are good ways to communicate risk-related information in risk assessments, especially when complemented by narrative evidence. This is valid even for people with little formal risk assessment training. It should be noted that Paper III confirmed the results of Paper II.

The second research path in stage 2 examined aspects of the design of the RVA system that may cause the communication challenges for DRM stakeholders. This work is described in Paper IV, which identified systemic challenges that hinder the effectiveness of risk communication. Paper I showed that in addition to the content-focused communication challenges (that Papers II and III aimed to improve), there are other challenges that need to be addressed from a system design perspective.

The findings from Paper I were used as the point of departure. The bottom-up mechanism implemented in the Swedish system means that RVAs are supposed to fulfill a dual purpose: the first is to guide DRM activities at the administrative level where they are produced; the second, as provided for under Swedish legislation, is to provide important input to the next hierarchical level in order to generate the higher-level RVA. It has been found, however, that these two purposes are very challenging to achieve in practice, and the reason for this has been attributed to communication challenges inherent in the process (Abrahamsson & Tehler, 2013; Lin & Abrahamsson, 2015). Therefore, Paper IV investigated this specific issue. It examined the reasons for the problem, and what can be done (from a risk communication perspective) to improve the situation.

The study involved both municipalities and their respective regional county administrative boards. It examined the perceived challenges and opportunities that were encountered during the development and use of municipal RVAs, given that

they must both fulfill local DRM needs, and contribute to higher-level RVAs. The findings were categorized into themes, which represented the systemic challenges found to be due to the design of the RVA system that hindered the flow of risk information between stakeholders. At the same time, although there are clearly significant challenges regarding RVAs, the study also sought to identify their positive impacts on DRM work.

Examples of the systemic challenges that were found include: the unclear focus of municipal RVAs; inconsistent, intermittent RVA work; the very limited dissemination of RVAs; and the lack of constructive feedback from higher administrative levels regarding the quality of municipal RVAs. These challenges meant that both those who developed the RVAs, and others who were supposed to use them, considered them to be of little use. Consequently, this impaired stakeholders' collective ability to assess and manage disaster risks.

On the other hand, despite the reported challenges, Paper IV also identifies some of the benefits that RVAs bring to DRM work. More importantly, the results from Paper IV suggest that it is not just the RVA document, as such, that is important. Another essential aspect is the process. Stakeholders have to communicate and exchange risk-related information in order to conduct, disseminate and utilize the RVAs, which is essential both for DRM work, and the overall functioning of the system.

The results from Papers II, III, and IV not only identified the communication challenges associated with the conduct, dissemination and utilization of risk assessments, but also suggested ways to overcome them, with the aim of enhancing the overall performance of the DRM system.

3.2.2.3 Stage 3

Increasing globalization means that DRM is no longer restricted to one country. International collaboration is widely promoted and practiced. Given this global background, the new trend is for countries to conduct NRAs, which are considered as the precondition for international DRM collaboration, and a way to address DRM issues that may extend across national borders. How can a country with an established, comprehensive risk assessment system contribute to the new, international requirement to conduct a NRA? Are the existing risk communication challenges associated with domestic risk assessments a barrier to the preparation of the NRA? On the other hand, how does an established, domestic DRM system interact with, or be influenced by, the comparatively new, internationalized NRA work? What opportunities or threats does the latter potentially pose to the effectiveness of risk communication among DRM stakeholders, and the performance of the DRM system? These questions motivated the third stage of the author's research.

Paper V builds upon the research interests and questions given above. The aim was to investigate the collation of risk-related information from various DRM stakeholders into the NRA in Sweden and examine how Swedish NRA work interacts with existing DRM activities, in terms of involving stakeholders from the whole of society and generating credible DRM information from various sources. This paper represents the final stage of the author's PhD journey.

The study involved stakeholders from central government. The analysis followed the ISO 31000 risk management process, and the aim was to examine the NRA process, and its integration with existing DRM activities, in detail. The results revealed that risk scenarios that are chosen from the RVAs provide the foundation for the NRA. Given previous experience of risk communication associated with the RVA process, the NRA process has adopted an approach based on workshops, which encourages both vertical and horizontal risk communication among stakeholders. Although there is still room for improvement (risk communication is still not fully two-way) the need and the intention to improve the situation have been addressed.

The studies carried out during these three stages not only recognize the important role that communication plays in the risk assessment process, but also identify the challenges that hinder effective risk communication, and suggest ways to overcome them. Moreover, by linking domestic risk assessment work to the NRA process, this thesis adopts a broader, international perspective. The DRM system, and risk communication issues, are observed in a borderless context. This positioning offers a wider view of how to solve the communication problems found in the Swedish DRM system and suggests ways to further improve its overall performance.

3.3 Research methods

This thesis employed various research methods for data sampling, data collection and data analysis.

Table 1 presents a summary of the research methods that were adopted in each of the appended publications, the respective empirical datasets that were collected and analyzed, and their geographical and administrative focus.

A detailed description of all of the applied methods is also given, divided into three categories, namely: data sampling methods, data collection methods, and data analysis methods.

Table 1.
Research methods and empirical data

Paper	Research Methods	Empirical Data	Geographical Area and Administrative Level
Paper I	Snowball sampling Semi-structured interview Content analysis	36 semi-structured interviews (5 national authorities, 5 county administrative boards, 16 municipalities)	Sweden Municipal, regional, and national
Paper II	Purposive sampling Focus group discussion Content analysis Statistical hypothesis testing Correlation analysis	33 municipal RVA documents (Scania region, 2012) 3 focus groups (6 representatives from the Scania county administrative board, and 10 Master's students from Lund University)	Sweden Municipal, and regional
Paper III	Purposive sampling Experiment Statistical hypothesis testing Wilcoxon signed-rank test	Experiment 1: 28 participants Experiment 2: 114 participants	Sweden and Nicaragua
Paper IV	Snowball sampling Semi-structured interview Content analysis Document analysis	42 semi-structured interviews (6 county administrative boards, 15 municipalities) Official reports related to DRM work (6 county administrative boards, 18 municipalities)	Sweden Municipal, and regional
Paper V	Snowball sampling Semi-structured interview Content analysis Document analysis	21 semi-structured interviews (13 national authorities) Official documents related to NRA from Sweden and the EU	Sweden and EU National, and international

3.3.1 Data sampling methods

3.3.1.1 Snowball sampling

Snowball sampling is "a nonprobability sampling method, often employed in field research, whereby each person interviewed may be asked to suggest additional people for interviewing" (Babbie, 2015). When the researcher begins to explore a new field, it can be difficult for him/ her to identify all of the relevant members of a target group immediately. Adopting the snowball sampling method means that the researcher starts data collection with a few members of the target group that he/ she can identify, then asks these individuals to provide information about other members they are aware of, and who may be helpful in the ongoing research. As the word "snowball" indicates, this sampling method adopts an accumulation approach to contact potential participants (Babbie, 2015).

In Papers I, IV, and V, the snowball sampling method was adopted to identify potential interviewees in the Swedish DRM system. In Paper I, for example, before the author drew up a comprehensive list of people to contact regarding the municipal

RVA, it was helpful to begin by interviewing the person responsible for the RVA at the central municipal level, then following his/ her suggestions regarding other interviewees in other departments of the municipality who contributed to the RVA. These people, in turn, provided additional, useful external contacts, such as private stakeholders, non-profit organizations, and so on. A similar approach was used in the regional and national-level studies to identify potential participants in Papers IV and V.

It has been suggested that the snowball method is more than just a simple technique to identify appropriate participants. It can also reveal social statuses in the networked population of interest (Babbie, 2015). For example: Does the participant know other people who work in similar positions? Can they identify who else could be of help in the research? Do they communicate with each other on a regular basis? What is the nature of their relationship? Do they collaborate with each other? Such hidden information was also helpful in the investigation of the communication and collaboration status of DRM stakeholders in the Swedish system.

Moreover, in addition to enrolling participants for interviews, the method was applied to collect relevant documentation. For instance, the reference list contained in documents often provides important information on citations that are within the scope of the ongoing study. In this way, more documents can be collected and reviewed.

3.3.1.2 Purposive sampling

Purposive sampling, also called judgmental sampling, is "a type of nonprobability sampling in which the units to be observed are selected on the basis of the researcher's judgement about which ones will be the most useful or representative" (Babbie, 2015). This sampling method is based on the researcher's knowledge of the research problem and the population, units or cases to be studied. Rather than taking a random sample, the researcher decides whom or what should be sampled, what form the sampling should take, and how big the sample should be (Creswell, 2007; Teddlie & Yu, 2007).

Purposive sampling was employed in Papers II and III. This was because the author was aware that there was a target group that could provide the most valuable information on the topics being investigated. Hence, the author designed the best form of sampling, and decided who and how many people should be included. For instance, when investigating the usefulness of municipal RVAs in Paper II, the author invited representatives working in the relevant regions, whose responsibilities included reviewing and compiling the municipal RVA. When exploring more general perceptions of the usefulness of RVAs in Paper III, the author purposefully recruited subjects with professional training in the preparation of RVAs and experience of working in the DRM field. A more detailed description

of how the purposive sampling method was applied in the studies can be found in Papers II and III, in Appendix 2.

3.3.2 Data collection methods

3.3.2.1 Semi-structured interview

The semi-structured interview is a data collection method that obtains information through a dialog between the researcher and the interviewee. Compared to unstructured interviews, which are unlimited by time or location, the semi-structured interview is a scheduled activity that requires a certain amount of preparation. Although the questions are open-ended, it usually follows a guide, which lists the questions and topics that need to be covered in a certain order (Bernard, 2006). The semi-structured interview allows the researcher (or the interviewer in this case) to have full control over the data that is collected, while also allowing the interviewer or the interviewee to initiate new topics that are not included in the script. It allows the interviewer to prepare for, but not take excessive control of the process (Bernard, 2006). It can be held in person, on the telephone, or via other means such as a smartphone or computer. Both the number of interviewees (one person or a focus group) and the number of interviewers (one or a few that work closely together) can vary.

Semi-structured interviews were used in Papers I, IV, and V, as they are well suited to the exploration of the perceptions and opinions of interviewees regarding the communication issues they encountered when conducting, disseminating and utilizing risk assessments. The interview guides were drafted according to the research question for each study, and the questions were designed to answer the overall research question. As the interviewees sometimes provided information that was complex or sensitive, and often required further explanation and clarification, the format enabled the researcher to probe for more information. Moreover, the interviewee sometimes highlighted new topics that were highly relevant to the research project but were missing in the interview guide. Hence, these interviews proved to be a good way to gather information that was not anticipated by the researcher.

In this thesis, semi-structured interviews were held both in person and via telephone. This flexibility regarding how and where to conduct the interview fitted well with both the interviewees' busy schedules and the researcher's limited travel grant. All interviews were recorded and most of them were transcribed in full. This ensured that the contents of each interview could always be accessed, and facilitated the following data analysis (Louise Barriball & While, 1994).

It should be noted that semi-structured interviews have limitations (Bernard, 2006). It is important for the interviewer to avoid misunderstandings, biases, and encouraging interviewees to provide a seemingly 'correct' answer. It is a learning process for the researcher, who must become more effective in probing and avoid injecting too much of himself/ herself into the interaction. The author's experience showed that asking simple and neutral questions helped to encourage a good flow of conversation. It was important to avoid commenting on the interviewee's responses, in order to avoid leading the conversation in the direction chosen by the interviewer. Keeping control of the length of the interview also helped to maintain the focus of the study, and avoid the conversation becoming too casual.

3.3.2.2 Focus group discussion

A focus group is usually recruited to discuss a specific topic (Bernard, 2006). Normally, it consists of 6–12 members, plus a moderator who is able to encourage people to open up, and keep the discussion going (Bernard, 2006). Focus group discussions were held during the three workshops described in Paper II. They were all organized with a specific purpose: to rank the overall usefulness of municipal RVAs and understand what professionals think the elements of a useful RVA are. The literature suggests that participants in a focus group should be more-or-less homogeneous (Bernard, 2006). In the context of Paper II, this means that participants either held a similar professional position, or had similar, relevant professional training.

Previous work suggests that it is better if focus group participants do not know each other. This is because it is easier for them to open up and offer real thoughts on sensitive questions (Bernard, 2006). However, the members of the focus groups that were the subject of Paper II knew each other (either from work or university). Nevertheless, the author's observation of the workshops suggested the fact that participants knew each other, or worked together, actually helped to encourage the discussion and improve its quality in this study. At the same time, it should be noted that the topics discussed in Paper II were not sensitive. These discussions resulted in an overall ranking of the RVAs, as planned. Moreover, the author also learnt the reasons why the selected ranking was chosen.

3.3.2.3 Experiment

"An experiment is a mode of observation that enables researchers to probe causal relationships" (Babbie, 2015). It is an effective way to develop a general understanding of the world around us. It is particularly suited to hypothesis testing, and more appropriate for explanatory than descriptive analyses (Babbie, 2015). Experiments in social science research can be carried out either in laboratories under controlled conditions or by, for example, using the Internet as a vehicle (Babbie, 2015). The latter has become increasingly popular and was employed in this thesis.

Francis Bacon and Karl Popper inspired the two major approaches to experimental methods. The Baconian method suggests that the experiment, or data collection, should be exploratory, and precede theorizing. The Popperian method rejects the Baconian approach, and proposes that the experiment should be carried out after the construction of theory (Franklin, 2005). The experiments applied in Paper III are based on the Baconian method. Therefore, they were designed to explore: the influence of the risk scenario description on the perceived usefulness of risk assessments; how the presentation of the risk assessment influenced its perceived usefulness in the DRM system; and whether it was possible to draw some conclusions regarding the best presentation format for the risk assessment. The results of this experimental study were expected to help to improve the design of risk assessments and enhance communication in a multi-stakeholder DRM system.

3.3.3 Data analysis methods

3.3.3.1 Content analysis

Content analysis is the process of organizing information into categories related to the central research question (Bowen, 2009). The main idea is to classify a text that contains many words into a few categories that consist of one, several or many words (Weber, 1990). The content that is grouped into each category is assumed to have a similar meaning (Weber, 1990). A coding strategy is then applied that reduces a huge amount of data into a comparatively manageable corpus, which helps researchers to manage and analyze their datasets.

Content analysis was adopted in four of the studies presented in this thesis (Papers I, II, IV and V). In Papers I, IV, and V, it was used to categorize the transcripts of the semi-structured interviews into topics. The coding scheme was based on the interview guide, supplemented by any new aspects that emerged during the interviews. Similar content was grouped into a category, and inferences were drawn that addressed the study's research questions. In addition, original quotes from the interviewees are noted in each of these papers, in order to explicitly present the participant's opinion. In Paper II, content analysis was used to code 33 municipal RVAs. The aim was to identify texts that described various aspects of the risk assessment deemed to be important for its perceived usefulness. Two coders used a coding scheme to guide their analysis. The results of these analyses were used to analyze correlations with the overall, perceived usefulness of the RVA.

Krippendorff (Krippendorff, 1980; Weber, 1990) states that there are three types of reliability applicable to content analysis: stability, reproducibility and accuracy. Stability refers to the extent to which the results of content classification remain unchanged, specifically where the same coder classifies the same content more than once (Weber, 1990). It has been found that stability is weakest when only one person

is responsible for coding (Weber, 1990). In this thesis, stability was tested by the author conducting the analysis more than once, and actively involving co-authors during the data analysis process. Reproducibility, also called inter-coder reliability, describes the extent to which more than one coder produces the same results when classifying the same text (Weber, 1990). Two methods were used in Paper II to check inter-coder reliability: the percentage agreement and Krippendorff's alpha (α) coefficient (Krippendorff, 1980). For more details, see Paper II. Accuracy refers to the extent to which the classification of a text corresponds to a standard or norm (Weber, 1990). In Paper II, the classification scheme used has been developed and tested in previous studies (Abrahamsson & Tehler, 2013).

3.3.3.2 Statistical hypothesis testing

Statistical hypothesis testing was used in Papers II and III. Before testing the hypothesis, the author needs to specify variables that are thought to be causally related, and how they will be examined (Babbie, 2015). Naturally, in this scenario, studies tend to be based on confirmatory rather than exploratory questions (Bernard, 2006). After hypothesizing the relationship between variables, the author needs to test the strength of the proposed relationship, represented by the statistical significance. This translates into the probability that a given relationship is due to chance, resulting from the selection of subjects (Babbie, 2015). Testing the statistical significance of the hypothesis is often described as mechanical (Bernard, 2006), as the figures listed in a table can tell a researcher whether the obtained result is statistically significant or not. However, the interpretation of the substantive and theoretical importance of statistical significance requires a lot of thought (Bernard, 2006). Thus, it requires significant effort by the author, from the moment the results are calculated and compared, until the time when the final conclusions are drawn.

The Wilcoxon signed-rank nonparametric statistical hypothesis test was used in Paper III. This test is frequently applied to the comparison of two related samples, matched samples, or repeated measurements on a single sample to assess whether their population mean ranks differ (Lowry, 2014). Like many nonparametric tests, this distribution-free test is based on ranks (Rey & Neuhäuser, 2011). In Paper III, the test was adopted to investigate differences between rankings of the usefulness of risk assessments in detail.

3.3.3.3 Correlation analysis

Correlation analysis is a statistical method that is used to investigate the strength of a relationship between two variables. It is useful when the researcher wants to study if there are any connections between variables. It is adopted in Paper II, in order to identify variables that are important for the usefulness of the risk assessment. Specifically, it was used to investigate the association between the overall, ranked usefulness of risk assessments, and six variables that represented different aspects

of these assessments. Spearman's nonparametric rank correlation coefficient was used to measure the strength of these relationships via the IBM SPSS program (Hauke & Kossowski, 2011). The coefficient is said to be a useful tool for exploratory data analysis, and has vast potential applications (Gautheir, 2001). It is applied to ranked data, and can be used for ordinal variables, including small samples (Gautheir, 2001; Hauke & Kossowski, 2011). An interesting feature of the coefficient is that it can be used not only on numerical data, but also on any data that can be ranked (Merkle, 2011), which suited the data analysis reported in Paper II.

3.3.3.4 Document analysis

Document analysis is a systematic procedure that is designed to review or evaluate documents (Bowen, 2009). The documents to be analyzed can take various forms, and the analysis aims to elicit meaning, gain understanding and develop empirical knowledge as the documents are skimmed (superficially examined), read (thoroughly examined), and interpreted (Bowen, 2009). Document analysis is often used in combination with other research methods, when the researcher is seeking convergence and corroboration based on the use of different datasets and methods (Bowen, 2009). In this thesis, empirical data collected from document analysis was as an important add-on to the datasets obtained from semi-structured interviews.

Document analysis was used in Papers IV and V to review relevant policy documents and regulations regarding all kinds of risk assessment work, as well as risk assessment documentation prepared by different administrative levels in Sweden and the EU. This corpus provided extra information about the context within which the studies took place, how the interviewees' organizations were expected to operate, expected results from the legal perspective, and so on. The datasets obtained from the document analysis and semi-structured interviews complemented each other and helped to expand the author's thoughts regarding the ongoing research. More specifically, the reviewed documents contributed to the analysis of additional data that could have influenced the researcher's area of interest, interviewees' daily practice (Mills, Bonner, & Francis, 2006), and stimulated other ideas about the problems being investigated.

Moreover, the examination of datasets collected through different research methods helped to reduce the impact of potential biases that could exist in a study based on a single research method (Bowen, 2009).

It should be noted that document analysis and content analysis (section 3.3.3.1) are different. Document analysis combines elements extracted from both content analysis and thematic analysis in an iterative process of skimming, reading and interpretation of documents (Bowen, 2009). By adopting elements of content analysis, the researcher categorizes information from the studied documents into

categories that are related to the research questions. This filtering process identifies meaningful and relevant documents, which are saved for further examination and interpretation. On the other hand, thematic analysis requires a careful, more focused re-reading and review of the data (Bowen, 2009). It aims to look for certain patterns within the data being examined. Therefore, document analysis is not the same as the content analysis, although they share some similarities.

Chapter 4.

Results and analysis

This chapter highlights the main findings of the thesis, by presenting a synthesis of the results given in Papers I–V. The chapter is organized into three sections that individually provide answers to each sub-question (see Chapter 1, Section 1.3), and collectively answer the overall research question.

4.1 Communication challenges in the Swedish DRM system relating to the conduct, dissemination, and utilization of risk assessments

4.1.1 Difficulties in using other stakeholders' risk assessments

As described in Chapter 1, Section 1.4, the RVA in the Swedish DRM system is intended to work from the bottom up: lower-level RVAs feed into higher-level RVAs. However, the studies presented in this thesis show that in practice, higher-level stakeholders find it difficult to use lower-level RVAs. Some specific problems were identified, and categorized into four themes outlined below.

Firstly, the findings from Papers I and IV highlight the lack of standardization in both methods and tools, and the formats of RVAs. Authorities at all administrative levels have a high degree of freedom to structure the RVA process and prepare the RVA document. Consequently, it is difficult for higher administrative levels to use RVAs from lower-level authorities, given the former's obligation to produce a consolidated description of risks and vulnerabilities.

However, Papers I and IV point out that although upper-level authorities would prefer the lower-level RVAs to be more consistent, the principal objective of the RVA exercise is that it should provide input to risk-related decision-making at the level where it is produced. Therefore, a unified process and/ or reporting format might not be appropriate.

Secondly, both Paper I and Paper V note that local municipalities and regional county administrative boards are responsible for producing RVAs focused on their respective geographical area of responsibility. However, national authorities are organized according to their function (e.g., the Coast Guard, the Transport Administration, the Food and Drinking Water Board), which makes it difficult for

them to use RVAs produced by authorities with a geographical responsibility, due to the very different scope and focus (and vice versa).

Thirdly, the findings from Paper I highlight that RVAs from regional and national-level authorities must be sent to the MSB on the same day. This is very problematic, as it makes it impossible for these authorities to use each other's latest reports as input.

A fourth issue was raised in Paper I by external stakeholders (e.g., critical infrastructure operators) at the municipal level. Some of these external stakeholders are owned jointly by several neighboring municipalities (potable water suppliers, rescue services, etc.), a situation that is very common in Sweden. These stakeholders highlighted the problem of providing risk-related information to multiple authorities who used completely different methods and reporting formats. One informant said, "Today we might have to use four different methods, or 10 if we have more owners in the future […] which would be impossible for us. I think we should find a routine, so that things can be done in a similar way".

4.1.2 Very different perspectives on the focus of the RVA

The above-mentioned problems create barriers that prevent stakeholders sharing risk-related information via RVAs. Papers IV and V revealed that various DRM stakeholders hold very different opinions about what RVAs should focus on, given the lack of standardization. These DRM stakeholders are found either at the same administrative level, or at different levels. For example, Paper IV outlined confusion about the focus of municipal RVAs. Should they focus on day-to-day safety issues? Or low-probability, but disastrous events? Or both? Stakeholders from lower administrative levels tended to argue that the focus should be on day-to-day safety, rather than very unlikely disastrous events. They suggested that by taking care of mundane issues, the municipality would become better able to handle extraordinary events. "We should not adapt to something that […] probably will never come. Instead, we do what we can to make sure it does not happen." In other words, if everyday problems are well-handled, the municipality will also be able to deal with major crises. Another perspective, from the municipal level, is that extraordinary events are very unlikely to happen, and it is very hard to analyze them. The argument is that as municipalities have very limited resources, they should focus less on extraordinary events that almost never occur.

Paper IV also included another perspective on the focus of RVAs, provided by representatives from the regional level. These participants said that municipalities should not only focus on day-to-day safety issues, but should also identify and analyze unlikely, extraordinary events. However, here, the problem is that none of

the interviewees from the regional or municipal level were sure how extreme or improbable a risk scenario should be, or how much detail to provide in the RVA.

On the other hand, at central government level, Paper V reported that the national perspective on the RVA (or NRA) is that it should focus on low-probability, but disastrous events, which can easily spread across the nation or even across the national border, with hazardous impacts for the whole of society. Most of the RVAs conducted at lower levels do not consider this national perspective and are seen as unhelpful in compiling the national-level RVA or the Swedish NRA.

4.1.3 The limited dissemination of RVAs and the disclosure of information

4.1.3.1 Limited dissemination

Papers I, IV and V show that, in general, far more attention has been given to the assessment and preparation of the RVA than to its dissemination and utilization. Official documents (e.g., from the MSB) do not focus on such aspects, and authorities from all levels seem to lack appropriate follow-up procedures once the RVA document is produced. The standard response to the question of how RVAs were disseminated was "it's available on our website/ intranet". In some cases, the RVA had been presented at meetings or workshops. In other cases, participants felt that the RVA was not within their area of responsibility, because it had been developed entirely by the safety coordinator; as the distribution was very limited, it remained relatively unknown.

4.1.3.2 Disclosure of weaknesses and sensitive data

Papers I and IV highlighted disclosure as a barrier to risk-related information-sharing. This is another reason why authorities are reluctant to disseminate their RVAs. Explicit information about vulnerabilities (technical systems, groups in society, etc.) is a key aspect of a RVA. Authorities do not want to broadcast such information, as it demonstrates their vulnerabilities and exposes managerial shortcomings. Although such information is crucial in order to direct disaster risk reduction efforts, it can be harmful if it falls into the wrong hands. "The RVA contains confidential information. The more people who know this information, the greater the risk will be." "we don't want to tell potential terrorists anything […]." It was also pointed out that information regarding the vulnerabilities of a private sector actor could be very sensitive and difficult to obtain, due to concerns about the potential effects on their business, even if such information might be extremely important for public authorities to manage potential disaster risks. Some even thought that the results of public authorities' RVAs should remain confidential; consequently, in some cases the document is classified.

4.1.4 Lack of constructive feedback

The lack of constructive feedback on the RVA from all levels was identified as a problem throughout the Swedish DRM system. Paper I reported that—from external actors who supplied information for the municipal RVA—to national-level bodies responsible for generating the national RVAs based on regional RVAs, feedback from higher administrative levels was too general to be of any use. In some cases, oral feedback such as, 'OK, it's good enough' was provided. In other cases, it took the form of summaries such as, 'two-thirds of the regions have demonstrated good involvement by all relevant organizations in their RVA activities', while no specific feedback was provided to individual stakeholders. Paper IV investigated some of the reasons why regional-level stakeholders found it difficult to provide constructive feedback ("It is difficult to know what to assess. It's hard to give feedback"). One reason was that providing feedback took a lot of time, and it was difficult to keep up. Informants at regional level said that they would have welcomed feedback from the MSB as input to the development of their RVA. However, the feedback they received simply focused on whether reports had the correct headings; consequently, regional boards give the same type of unhelpful feedback to their municipalities. Although most comments concerning the issue of feedback came from lower administrative levels, Papers I, IV, and V revealed that informants at higher levels failed to provide adequate feedback to lower levels due to limited human resources, time and budgets. Although a solution remains to be found, the issue of the lack of constructive feedback has, at least, been identified.

The studies presented in this thesis also investigated why the lack of constructive feedback from higher administrative levels is problematic in the DRM system. Paper I found that without constructive feedback, there is nothing to base future improvements on. In particular, the lack of detailed feedback on the strengths and weaknesses of the RVAs resulted in greater uncertainty in future RVA work. Another issue is that effective risk communication relies on two-way communication. Paper V found that without proper, timely feedback, stakeholders were unsure whether the information they had provided was useful or not, or whether it was sufficient. Consequently, this has decreased some stakeholders' motivation to improve their analysis, given that they have no idea about how their previous input has been evaluated.

4.1.5 Communication challenges related to DRM practitioners

Many of the above-mentioned communication challenges are related to the lack of a standardized RVA process and are due to the design of the system. Other challenges relate to practitioners. Paper I pointed out that at both municipal and regional level, respondents from the central risk/ crisis management office stated

that their greatest challenge was "to make the various departments understand why they should be doing it (RVA) in the first place". Furthermore, high staff turnover led to a loss of continuity in immature RVA work. Paper I noted that, especially at municipal level, several informants had only recently started working on the RVA and were not yet familiar with the organization's risk-related activities. Respondents at the upper administrative levels pointed out that high turnover meant that staff responsible for lower-level RVAs did not really understand what was required, which had an impact on the quality of the RVA.

4.2 Risk assessment and communication issues influencing Swedish DRM

4.2.1 Negative influences

4.2.1.1 RVA information is not aggregated

The findings of Papers I, IV, and V highlighted that the simple aggregation of RVA information from different levels into a holistic risk picture is not happening. Priority is given to benefitting the level where the report is produced, rather than serving as input for the higher-level RVA. Many examples were found of lower-levels RVAs being unhelpful in upper-level RVA work. For instance, in Paper IV, regional representatives noted that the purpose of RVA work was to benefit municipalities. However, some municipal representatives complained that they saw no benefits for themselves; the purpose of the RVA was simply to comply with the request from the county administrative board. In some authorities, where RVA work simply consisted in preparing the RVA document, it was considered to be an isolated and obscure task.

On the other hand, Swedish regulations (MSBFS, 2010:6) state that municipal RVAs should provide input to the regional overview of risks and vulnerabilities, and form part of the regional RVA document. In Paper IV, regional informants found it very difficult to use municipal RVAs to create regional RVAs, as differences in scales and methods made them impossible to aggregate. None of the regional boards used municipal RVAs as the only source of information to generate their RVA. The same happened when national-level authorities tried to use regional-level RVAs to compile national-level RVAs or the NRA, as Paper V indicates. Informants argued that the lower-level RVAs would be better used as an input to the higher-level RVA process, or other DRM activities.

4.2.1.2 Implementing tasks listed in the RVAs

According to the MSB (MSBFS, 2010:6), municipalities should report the "planned and implemented measures and an assessment of the need for further action on the risk and vulnerability assessment results" in Section 8 of the RVA document. The results presented in Paper IV show that many municipalities were unsure what this meant. One example of how to deal with this requirement is, "In the RVA, the municipality must be able to point out things that need to be done, but without promising to implement them."

4.2.1.3 The private sector is largely excluded

The studies included in this thesis show that the private sector is largely excluded from Swedish DRM work, notably in the conduct of the RVAs. There are many reasons for this, ranging from practical to legislative issues. Paper IV shows that most municipal RVA work is seen as only relating to the municipality's own operations, rather than the whole geographic area. This study suggests that this is not because authorities see collaboration with other private sector actors as unimportant, but rather because it is very hard to achieve. During the first few years of working with RVAs, municipalities focused primarily on their own operations. Consequently, private sector stakeholders were excluded from the very beginning. Municipalities emphasized that they trusted private sector stakeholders to be able to take care of their own responsibilities and did not want to interfere or take over their DRM responsibilities. At the same time, data protection was reported to be a key challenge in involving them. The information contained in public authorities' RVAs is made public, but for many private sector actors this information is highly confidential.

Paper I lists some other reasons why private sector actors are absent in RVA work. It was claimed that they had their own priorities regarding risk assessments and considered that contributing to official RVAs took up too much time and cost too much money. However, in practice, external actors appeared to be more involved at regional than municipal level, and they described their participation as an important learning process. It appears that private sector stakeholders are willing to collaborate more with authorities, on the condition that the exchange of risk-related information is mutual, rather than private sector stakeholders providing one-way information to authorities.

Paper V suggests another reason: private sector stakeholders are largely excluded from the NRA process and other relevant DRM activities because they are not legally required to participate. However, many of the studies presented in this thesis report that authorities at all administrative levels are keen for private sector stakeholders to be encouraged to be more actively involved in the country's DRM

activities. Furthermore, the need to invite researchers and research institutes to contribute their perspectives was noted.

4.2.1.4 Risk-related information can be biased and information sharing tends to be vertical

Papers I and V found that some authorities organize workshops to collect risk-related information for RVAs and the NRA. It was pointed out that using workshops to collect this information could result in the views of some participants being overrepresented, depending on how active they are, eventually biasing the DRM process. Some authorities had noted this problem and had taken countermeasures. Paper V found that collecting risk-related information via workshops to generate the NRA had been proven to be very useful, despite the possibility that discussions could be dominated by a few, very active, representatives from certain organizations, while others were more silent. This was compensated for later, by approaching less-active participants, in order to ensure that the views of all parties were represented. Another approach, implemented at central government level, was to forward the finished risk assessment to all workshop participants, and ask for further comments. Whether the same approach has been adopted at lower administrative levels is unknown.

Another potential bias in risk-related information was the observation that risk information sharing and stakeholder collaboration tended to be vertical, and mostly upon demand. Horizontal dialog (i.e. between stakeholders at the same administrative level, but with different responsibilities) was less apparent. Linked to this, a desire for more open dialog between stakeholders on the same administrative level was frequently expressed. Informants stated that this would help them understand their mutual dependencies, develop a shared understanding of vulnerabilities and potential risks, and explore how to deal with possible risks or crises together.

4.2.2 Positive influences

The risk assessment process is designed to involve all levels of society and highlight vulnerabilities and deficiencies that must be addressed. Although there are areas that need further improvement, risk assessment work has also had positive influences on the Swedish DRM system, notably through the conduct of RVAs and the NRA.

4.2.2.1 Benefits from RVAs

Paper IV showed that since RVA work has been on the agenda of the Swedish DRM activities, it has increased interest and changed attitudes regarding how people think about and see things from a safety perspective. The RVA process, and the final

documentation have heightened the awareness of decision-makers. Authorities have started to tackle issues that have been highlighted in their RVAs, and the direct or indirect results have been used as input for decision-making. Some authorities have used RVAs to develop emergency planning to deal with potential, extraordinary events; they have also been used to develop vulnerability scenarios and carry out crisis management exercises.

RVAs are also used in other, less obvious ways. For example, they have been used to identify the principal potential risks for authorities and prioritize important issues. Some details of authorities' ongoing work were provided, in addition to the issues discussed during the RVA process. Some informants mentioned that the RVA process had led to work connected to societal sustainability. In other cases, RVAs have been used in authorities' overall planning. For example, they are used in urban and social planning as a way to identify 'municipal protection values' in major construction projects; other municipalities have begun to develop a climate change adaptation plan, which, according to safety coordinators, can be partially merged with RVA work.

The Ordinance on Emergency Preparedness and Heightened Alert (SFS, 2006:942) states that regional governments must "work to ensure that […] the regional risk and vulnerability assessments are compiled"; accordingly, all municipal RVAs are expected to be structured using the same headings, so that the county administrative board can compile them into a regional RVA (MSBFS, 2010:6). However, some regional representatives highlighted that RVA work is not simply drawing up an RVA document. Instead, it is a very important process that should be motivated by local self-interest, rather than the requirement to contribute to the regional/ national risk assessment. Informants argued that it is more important that the authorities have an established risk assessment process, than that they produce a compliant final document. The identification of local risks and vulnerabilities should be supplemented by a capability assessment regarding essential services and implemented measures. The purpose is for society to collaborate and manage extraordinary events, based on potential risks and vulnerabilities.

Finally, Paper V reported that RVAs from different levels have contributed risk scenarios that are included in the NRA.

4.2.2.2 Benefits of the NRA

RVA risk scenarios are often very different, in terms of the fields and sectors they relate to. Thus, during the preparation of the NRA, the MSB selects stakeholders who are most likely to be affected by a scenario (e.g., representatives from municipalities, county administrative boards, county councils, national agencies, volunteer groups, NGOs) and invites them to workshops to develop it in more detail. Participants are drawn from "pretty much the whole of society", and the scenarios

that are identified and described are the result of their joint efforts. The workshops are considered to be the main channel to bring together relevant stakeholders, collect risk-related information, and carry out an assessment. They provide a platform for DRM stakeholders to become familiar with each other's responsibilities, interact, and understand their dependencies when facing a crisis. In turn, stakeholders understand the usefulness of a wider range of input from different perspectives, and are encouraged to collaborate more.

Another positive aspect of NRA work (Paper V) is that some authorities referred to it in their RVA and used it to draw lessons about their own situation. Moreover, some participants in the NRA workshops continued to work on their risk scenarios even when the workshop had ended and had developed plans regarding how to deal with these scenarios within their organizations. In addition, the MSB uses the NRA as a primary source to develop the Swedish national risk and capability assessment (NRCA) that guides the country's overall DRM work.

The studies forming this thesis note that governmental authorities have realized that they are highly dependent on each other in their risk assessment work. Authorities acknowledge that it is unwise for agencies to conduct their own risk assessment without knowing the roles, responsibilities, and potential risks of others. The NRA workshops and regular DRM-related meetings offer stakeholders opportunities to meet and understand each other's work. Nevertheless, even more communication and collaboration have been called for. Stakeholders suggested that more information exchange and communication should be included in the risk assessment process, even in the case where an authority simply conducts its own RVA.

4.3 Improving the effectiveness of risk communication via risk assessments

Papers I and IV report that Swedish authorities from all three administrative levels have a lot of freedom in how the RVA is conducted. For instance, Paper IV describes DRM stakeholders' discussions regarding whether a standardized RVA template and evaluation criteria should be created. This found that while some appreciated the lack of detail in the legislation, as it enabled them to conduct the RVA in the way that suited them best, others were keen to see more explicit guidance specifying "what the RVA should look like". As Paper IV notes, stakeholders at regional level pointed out that the regulations simply state that the RVA should be conducted and that it should support risk-related decision-making. However, they observed that the available guidance is overly general and "very fuzzy". Thus, the nature of the RVA process remains unclear for many of the stakeholders who have to manage it.

It appears impossible to provide specific methods and a standardized RVA template to all DRM stakeholders. However, some informants noted (Paper IV) that certain aspects of the RVAs were 'universal' and should be determined centrally, or at least the supervisory authority should be able to describe what they wanted, and what the RVA should look like. Although county administrative boards are required by law (SFS, 2007:825, 2017:870)[3] to evaluate the quality of municipal RVAs, some municipalities stated that the evaluation is subjective, and that there are no clear rules.

Papers II and III explored whether certain rules are applied by supervisory authorities when assessing lower-levels' RVAs, and whether these lower levels should strive to make their RVAs 'useful'. These two studies were designed to increase understanding of how the risk assessment should be constructed to improve communication, and they are outlined below.

The findings from Paper II suggest that risk assessments that include scenario descriptions are perceived as more useful than those that do not. Similarly, those that include background information concerning estimated likelihood are perceived as more useful than those that do not. Finally, those that include information concerning the likelihood of events and their associated consequences, in quantitative terms (equality, greater or lesser, intervals, differences, or ratios), are perceived as more useful than those that do not. There was no evidence to suggest that risk assessments are perceived as more useful if they include background information concerning how scenarios were selected or how consequences were assessed.

Paper III took an experimental approach. The results indicated that the type of risk scenario (e.g., flood or fire) does not influence the perceived usefulness of the risk assessment. On the other hand, it supported the results of Paper II by confirming that the presentation of likelihood and consequences did influence perceived usefulness. Specifically, quantitative and semi-quantitative scales were perceived as more useful than others (qualitative ranking, qualitative description, and no description). This study involved participants from different fields and countries and demonstrated that their risk assessment knowledge was not a determining factor in the ranking. However, those with more experience seemed to be more sensitive to differences in format. Last but not least, Paper III suggested that quantitative and semi-quantitative scales were promising ways to communicate risk-related information, especially when these two formats were complemented by narrative evidence. This was valid even for people with little formal risk assessment training, but who work in the DRM domain. This situation is common in the Swedish DRM

[3] SFS 2007:825 has been replaced by SFS 2017:870.

system, especially in lower administrative levels, or in authorities that do not value DRM work.

Papers II and III suggest ways to improve the effectiveness of risk communication, through improving the construction of risk assessment documentation. However, this thesis's contribution to more effective risk communication in the DRM system is more than just these two, effect-focused studies. The findings of Papers I, IV and V provide important empirical evidence regarding how risk assessment work and its associated communication issues influence Swedish DRM. These findings can guide improvements in risk communication, notably the conduct, dissemination, and utilization of risk assessments. Based on the principal theories and concepts outlined in Chapter 2, the next chapter discusses the countermeasures that can be taken to combat the communication challenges found in the Swedish DRM system. In doing so, the study paves way for future research and practice and provides insights that can be used to enhance the effectiveness of risk communication in other similar, multi-stakeholder DRM context.

Chapter 5.

Discussion

This chapter discusses both the contributions and the limitations of this thesis. It starts by reflecting upon the risk communication challenges that are encountered in the Swedish DRM system, then suggests potential countermeasures by referring to the theoretical framework described in Chapter 2. It continues with a discussion of the quality of the research and its limitations, then ends by proposing some ideas for future studies.

5.1 Communication challenges and potential countermeasures

Communication has been claimed to be at the core of any successful risk governance activity (van Asselt & Renn, 2011). Similarly, effective communication is essential in any DRM system. This thesis explored the communication challenges in the multi-stakeholder, multi-level Swedish DRM system, relating to the conduct, dissemination, and utilization of various risk assessments. The purpose is to improve the effectiveness of risk communication, and consequently to enhance the overall functioning of the DRM system. As Chapter 4 shows, various communication challenges and their influences on the DRM system have been identified in the studies that make up this thesis (Sections 4.1 and 4.2), and some countermeasures that may improve the structure of risk assessment documentation have been proposed (Section 4.3). The current section focuses on these communication challenges and reflects on some potential countermeasures that were not discussed in the previous chapter.

5.1.1 Lack of constructive feedback

A lack of constructive feedback regarding risk assessments is a common problem throughout the Swedish DRM system. The feedback that is provided is often too general and does not highlight the strengths and weaknesses of current risk assessments. Without knowing the strengths to build upon, and the weaknesses that need to be corrected, it becomes difficult to introduce improvements. Past studies in the area of DRM have addressed effective, two-way risk communication (Covello & Sandman, 2001; Renn, 1992; Smith & McCloskey, 1998), which happens when the recipient of the information interprets the sender's information as intended

(Eriksson & Borell, Forthcoming). Apart from identifying the strengths and the weaknesses of the received message, appropriate feedback also confirms that the intended message has been received, and whether it has been understood properly. Thus, providing constructive feedback not only assists future risk assessments, but also ensures two-way information exchange.

Previous studies have showed how feedback, both positive and negative, affects individual motivation (Finkelstein & Fishbach, 2012; Koo & Fishbach, 2014). Interpreted in the context of conducting risk assessments, positive feedback points out areas the authorities have been successful, and gives them the green light to continue, while detailed negative feedback indicates areas that require more effort. However, not only does the limited feedback provided in the Swedish DRM system lack insight, it is far from constructive and helpful.

It should be noted that, in the context of risk assessment work in the DRM system, the establishment of a successful feedback mechanism should be based on agreed goals, e.g., why it is needed. For instance, stakeholders should understand the conduct of the risk assessment goes beyond just complying with a legal requirement. In some cases, contributors consider that as long as the documents have been prepared and sent to the supervisory authority, their mission has been accomplished, and no further thought is given to ongoing improvements. As pointed out in the results (Chapter 4) presented here, one of the major challenges in producing lower-level risk assessments is to make stakeholders understand why they are doing it. The reasons for this lack of understanding, together with the lack of feedback, are not as simple as they may appear. One cause may be systemic: practitioners lack a common understanding of why the risk assessments should be conducted, disseminated, and utilized. More precisely, one reason why upper-level stakeholders fail to provide constructive feedback to lower levels might be because they consider the preparation of their own (legally-required) risk assessment to be the ultimate goal. Consequently, they do not invest time and energy to improve future work. Of course, other reasons included the very limited resources that are available to authorities. Nevertheless, it is very likely that, beyond these practical causes, the value of risk assessment work and the provision of constructive feedback have been underestimated in the DRM system as a whole.

The multi-stakeholder, multi-level Swedish DRM system studied in this thesis is a bottom-up structure. The author believes that the implementation of an appropriate feedback mechanism requires an initiative from the highest administrative level. The question of limited time and resources must also be addressed, as authorities often attributed their lack of feedback to this issue. However, the more important point is to establish a common understanding of the meaning of risk assessment work, and how it can be improved through a healthy feedback mechanism.

5.1.2 Perspectives of risk assessments

People manage disaster risks. The successful management of any societal risk depends on how well they communicate. Many factors can contribute to failure, including different risk perspectives among DRM stakeholders (Veland & Aven, 2013). The findings presented in this thesis show that when the legislation does not give detailed and specific guidance on how to carry out a risk assessment, stakeholders may adopt their own risk perspective, which varies from one authority to another, and differs from one administrative level to another. For instance, there is no agreed focus for the risk assessment among levels, and it is very unclear how the risk assessments should be conducted and evaluated. Meaningful risk communication relies on solid scientific foundations (Veland & Aven, 2013). This also applies to the risk communication that is associated with the various risk assessments. The studies in this thesis report that there are still many gray areas in risk assessment work in the Swedish DRM system, and there is clearly room for improvement. As Veland and Aven put it, "if a concept is introduced, it must be given a meaningful definition and interpretation" (Veland & Aven, 2013). Unfortunately, this is not the case in many situations, including the risk assessment work in the DRM system studied in this thesis. Sound scientific principles and methods would clarify the current confusion and improve the level of professionalism. In the meantime, rather than pursuing a standardized risk assessment procedure that would make the RVA easier for higher levels to aggregate, priority should be given to meeting fundamental needs at the level where it is produced.

5.1.3 Dissemination of risk assessments

The thesis has pointed out communication challenges related to the dissemination of risk assessments that contain sensitive or confidential information. Risk assessment work goes beyond gathering and disseminating vital, risk-related information; it should also guarantee the integrity and security of that information. At the same time, it cannot be denied that it is better for sensitive information concerning societal risks and vulnerabilities not to be disclosed to potential enemies. On the other hand, DRM work is a balancing art: the more people are aware of societal risks and vulnerabilities, the more prepared society is for potential adverse events, and the less likely it is that people will be taken by surprise by hazards. The danger of being over-protective with regard to risk-related information is that secrecy can lead to a false illusion of safety, which can be disastrous while facing a sudden attack. Moreover, if the results of risk assessments are not communicated, there will be no learning process, which is in itself an important part of the DRM process. Therefore, a balance needs to be found between those who are potentially

affected by disaster risks, and who have a right to know, and authorities' duty to disclose risk-related information.

5.1.4 The involvement of the private sector

The establishment of a multi-stakeholder, multi-level DRM system is closely related to the fact that risks no longer have a specific owner (Boin, 2009), who is able to identify the full risk landscape and deal with various risks, without drawing upon input from others (Rasmussen, 1997). Therefore, it is natural that the risk assessment process involves stakeholders from various disciplines and different administrative levels, and efforts from both governmental bodies and non-governmental stakeholders are integrated to ensure that the DRM system functions effectively (Kapucu, Arslan, & Demiroz, 2010).

The results of this thesis indicate that improvements could be made in the Swedish DRM system if more private sector stakeholders were involved. The need is clear, and changes are already ongoing although still not sufficient (e.g., the NRA process described in Paper V has highlighted the positive inclusion of stakeholders from the whole of society). However, more thought needs to be given to the inclusion of non-governmental stakeholders, who are not legally obliged to participate in DRM activities. For instance, private sector stakeholders, who are responsible for the operation of critical infrastructure and could contribute to authorities' risk assessment work, are currently excluded from the country's DRM work. Open and adaptive participation will help to improve social learning among stakeholders and encourage them to better understand each other's complementary roles. It may also increase stakeholders' willingness to participate in collective DRM activities, rather than simply being involved because they have to. A well-connected, effective stakeholder network can be established in the DRM system by starting to share risk-related information and understanding each other's complementary roles. After all, the inclusion of stakeholders from various areas of society is not a simple add-on. To make collaboration necessary and meaningful, it is essential for all of the involved parties to realize the importance of their DRM activities, and the first step can be initiated through joint risk assessment work.

5.1.5 The vertical dimension of risk-related information sharing

The results presented in this thesis indicate that sharing risk-related information in the Swedish DRM system tends to be vertical (across hierarchical levels), while in the horizontal dimension (stakeholders from other functional sectors with different expertise, or counterparts located in other geographical areas) it seems to be sorely lacking. The different organizational responsibilities of DRM stakeholders result in different forms of knowledge and expertise. The less they have in common, in terms

of organizational roles, the less they are interested in sharing information and dialog. Kramer's study suggests that people are more likely to share knowledge when they already have some knowledge in common (Kramer, 2005). Although this thesis suggests that horizontal communication is currently limited, the results reveal that DRM stakeholders become more interested in the work of their peers when there are opportunities to share risk-related information (such as during the workshops organized for the NRA). Once the stock of common knowledge increases, interest grows in future communication and collaboration.

The NRA process brings together many stakeholders and provides them with a platform to communicate with each other. It offers them an opportunity to continuously and interactively share and exchange DRM information, both during and after the NRA workshops. Although it is unclear whether the stakeholder communication resulting from the NRA process is effective, the findings suggest that involving stakeholders in these workshops does improve communication and the sharing of risk-related information, in the sense that communication is no longer restricted to the vertical dimension. However, the quality of communication at these workshops may be affected by the potential for some, more active, participants to dominate others. However, at a minimum, it provides an opportunity to expand vertical communication to the horizontal dimension.

Although stakeholder communication in a DRM system should not be limited to one dimension, it takes time for stakeholders to learn who to communicate with, about what, and when. The creation of a common body of knowledge could be the first step in a dialog leading to increased information sharing and risk communication between DRM stakeholders, especially those from different functional sectors. Furthermore, risk assessment work is often considered as the first step in many DRM activities. If effective risk communication can be established at this early stage, it will clearly lead to greater efficiency in the later stages. As van Asselt and Renn state, "risk communication and trust are delicately interconnected processes" (van Asselt & Renn, 2011). Although trust is not the focus of this thesis, a breakdown in risk communication is highly likely to decrease trust among DRM stakeholders, which may result in the failure of DRM activities.

5.2 Reflecting upon the quality of the research

Silverman states that there is little point in aiming to submit a research dissertation, unless the researcher can demonstrate that the procedures that are applied ensure that the methods used are reliable, and that the conclusions that are drawn are valid (Silverman, 2013). All research designs and methods are exposed to factors that may undermine their credibility and integrity. This section, therefore, addresses the quality of the research conducted in this thesis.

5.2.1 Validity

Validity refers to "the correctness or credibility of a description, conclusion, explanation, interpretation, or other sort of account" (Maxwell, 2012). As this thesis employs the case study as the overall research strategy, the discussion of validity is based on Yin's work: construct validity, internal validity and external validity (Yin, 2009).

Construct validity refers to the identification of operational measures that are appropriate to the concepts being studied (Yin, 2009). Three strategies were adopted to improve construct validity during the different phases of the research: the first was to use multiple sources of evidence during the data collection phase; the second was to establish the chain of evidence during the data collection phase; and the third was to have key informants review the draft report during the composition phase (Yin, 2009). These three tactics are addressed in turn below.

First, multiple sources of evidence were used when collecting datasets (see Table 1). Different types of empirical data were identified and collected: legislation, regulations, RVAs, NRAs, policy documents, emergency plans, business continuity plans, scientific reports, interviews, experiments, etc.

Second, studies are linked to each other by evidence relating to risk communication issues that appear during the process of conducting, disseminating, and utilizing of various risk assessments at all levels of the Swedish DRM system. For example, Paper I addresses the overall picture of risk communication issues. This led to more detailed investigations of different aspects of communication issues at different administrative levels: Paper IV (between regional and municipal levels), and Paper V (national level). In addition, Papers II and III focused on effects, seeking to address some of the major problems identified in Papers I and IV.

Third, informants who participated in the semi-structured interviews were all asked, after the recorded interview, if they would like to clarify any unclear statements during the data analysis and writing up process. Some key informants were

contacted after the research papers were written and asked to double check quotes and other relevant, empirical data.

Internal validity seeks to "establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships" (Yin, 2009). In this thesis, close attention was paid to testing internal validity, for example in Papers II and III. Internal validity is threatened when anything other than the experimental stimulus can affect the dependent variables (Babbie, 2015). With respect to the studies reported in Papers II and III, the threat to internal validity is greater in Paper II than in Paper III. This is due to the experimental setup and the materials used (see Discussion in appended Paper II). In Paper III several measures were taken to limit threats to internal validity, for example randomization of the order in which participants were exposed to the various risk descriptions. More in-depth discussion about issues that could influence internal validity, including the choices involved in designing the experiments can be found in Paper II and Paper III.

Researcher bias is another threat to validity (Maxwell, 2012). This was addressed in the respective studies, depending on the specific methods that were used. For instance, in Papers I, IV and V, direct quotes from informants, or opinions representing informants' perspectives were clarified and distinguished from the author's thoughts. All references were identified, where needed, in each paper. Most of the policy documents, legislation, RVAs, and other documents that were analyzed have been made public, and can be downloaded from the Internet, ensuring traceability.

External validity refers to the extent to which the findings of a study can be generalized (Yin, 2009). It has been considered as one of the major barriers in case study research, as critics argue that single case studies do not offer a sound basis for generalizing (Yin, 2009). Yin argues that such criticism implicitly contrasts the situation where the research was carried out based on surveys, which use a sample to generalize to a larger universe (Yin, 2009). On the other hand, Flyvbjerg says, "[a] case study without any attempt to generalize can certainly be of value in this process and has often helped cut a path toward scientific innovation" (Flyvbjerg, 2006). The thesis presented here does not make generalized claims about risk communication issues related to risk assessment work in any DRM system. Instead, it provides an in-depth analysis of the communication challenges that might be encountered when stakeholders must communicate risk-related information in order to conduct, disseminate, and utilize various risk assessments in a multi-stakeholder, multi-level bottom-up DRM context. It also suggests directions for future efforts designed to overcome these communication challenges.

This thesis focuses on the Swedish DRM system. However, the results are not necessarily limited to Sweden. Similar findings might be observed in other DRM

systems with a similar setting. It should be noted that the study presented in Paper III involved two, non-Swedish groups, with a different professional background (which, moreover, addresses the issue of external validity). Nevertheless, although it may be unwise to generalize the findings of the experimental study (Paper III) to all professionals working in the field of DRM or other fields (and this was not the intention), the results provide some potential avenues to advance future research.

5.2.2 Reliability

The goal of reliability is to minimize errors and biases. The study should be repeatable, and the same results obtained (Yin, 2009). A prerequisite for this is the explicit documentation of exactly how the research was carried out (Yin, 2009). Without such documentation, it becomes difficult for even the original author to repeat his/ her own studies. All of the studies that make up this thesis have been documented in detail in the appended five publications, providing a firm foundation for assessing the reliability of the work.

In Papers I, II, IV and V reliability was checked in several ways. In Papers I, IV, and V content analysis was used to analyze the transcripts of semi-structured interviews. Coding stability (whether the results remain unchanged over time) was checked by conducting the analysis more than once, and actively involving co-authors during the data analysis process. The results showed good agreement in all three papers. In Paper II, two coders analyzed RVA documents. Inter-coder reliability (whether the same results are obtained when more than one coder classifies the same text) was checked using two methods: percentage agreement and Krippendorff's alpha (α). As Paper II shows, both the percentage agreement (89%) and Krippendorff's alpha (α) (78–99%) indicate very good agreement.

In addition, establishing collaboration with other researchers is helpful to strengthen reliability, as the thorough documentation and explicit description of the research process provide a basis for any discussion. The studies conducted in this thesis demonstrate the author's extensive collaboration with different researchers. The involvement of co-authors helped to establish an ongoing dialog regarding the research process and develop a more reliable interpretation of the empirical data.

5.3 Limitations and future research

The studies presented in this thesis investigate the communication challenges associated with risk assessment work that threaten the overall functioning of a DRM system. This research is based on the Swedish context. It suggests countermeasures to overcome risk communication challenges and proposes ways to improve risk assessment work. The aim is to enhance DRM practice and advance risk communication research based on experience from the Swedish DRM system.

However, the limited time and resources available to the author meant that other issues were neglected. For instance, Papers II and III began to explore how the format of information influences the perceived usefulness of risk assessment documents. The findings suggest ways to construct a more useful risk assessment. However, in practice, risk assessment documents are far more complex and contain many other elements that influence the usefulness of the whole document. Secondly, in a DRM system, stakeholders are not limited to administrative authorities. For practical reasons, the studies in this thesis mostly involved governmental authorities from all levels of the Swedish system, while the views of private sector or other non-governmental stakeholders are not fully represented. Moreover, although Paper III involved subjects from Nicaragua, this thesis is focused on Sweden. Previous studies of the Norwegian DRM system (Vastveit, Eriksson, & Njå, 2014) have shown that the Swedish and Norwegian systems have many similarities, and it would be interesting to be able to collect empirical data from parts of the world beyond Scandinavia. This would enable a comparison of experience from very different social contexts.

These reflections regarding the limitations of the current research gave rise to additional research questions, some of which are listed below:

- The findings reveal that the lack of standardization in the risk assessment process throughout the Swedish DRM system has created many barriers that prevent stakeholders exchanging information based on each other's documentation. Although a strict standard regarding the conduct of the risk assessment, and how documents should be formatted is neither possible nor recommended, further research could build upon the first path presented in this thesis. For instance, following Papers II and III, it would be interesting to investigate other aspects of the risk assessment document (background information describing the scenario, the uncertainty of adverse events, etc.), and suggest how they could be presented in order to make the document more informative (for communication) and more useful (for decision-making).
- While a lack of constructive feedback was listed as one of the most problematic communication challenges in the Swedish DRM system, efforts could be directed to investigating how this could change in the future. Questions include:

What kind of feedback is most needed? Is there an optimal, cost-effective way to give appropriate feedback? How can DRM stakeholders be included in a truly two-way communication process?

- The purpose of the risk assessment is not just to identify potential risks and vulnerabilities. Follow-up activities should be implemented in order to improve society's resilience. The findings presented in this thesis indicate that more attention should be devoted to communicating the results of the risk assessment, and efforts should be made to implement DRM practices that protect against potential challenges. Future studies could examine the link between the results of the risk assessment and the measures taken to address problems. These studies could look at how the findings from risk assessments are disseminated and integrated into DRM practice. This might give an insight into the communication of the results and their use in the DRM system.

Chapter 6.
Conclusions

The purpose of this thesis was to increase knowledge about effective risk communication in multi-stakeholder, multi-level DRM systems, in which the exchange of risk-related information relies upon the conduct, dissemination, and utilization of various risk assessments. It took the Swedish DRM system as a study case and investigated the topics of communication challenges and how these challenges and risk assessment work influence DRM. It offers some suggestions regarding how to overcome these communication challenges and improve the overall performance of the system.

The main conclusions are summarized below:

- Communication challenges are found throughout the Swedish DRM system, notably relating to the conduct, dissemination, and utilization of risk assessments:
    - A lack of standardization in the methods and tools used to conduct risk assessments at all levels of the Swedish DRM system has made it difficult to communicate risk-related information via risk assessment documentation.
    - Different DRM stakeholders have very different views on what the risk assessment should focus on (day-to-day safety issues, or low-probability, but disastrous events), meaning that assessments conducted at lower administrative levels (which often focus on daily safety issues) are not seen as useful for compiling higher-level assessments, which focus more on large-scale disasters.
    - The very limited dissemination of the risk assessment is due to the lack of appropriate distribution channels and authorities' unwillingness to disclose sensitive data and managerial shortcomings.
    - A lack of constructive feedback has created great uncertainty about future risk assessment work. It has decreased DRM stakeholders' motivation to improve their analysis and turned risk communication into a one-way process.
    - Convincing DRM stakeholders of the need to conduct risk assessments is very challenging. High staff turnover has led to a loss of continuity and influenced the quality of the assessment.

- Risk assessment work, and its associated communication challenges, have both positive and negative influences on the Swedish DRM system:
    - The system seems to fail in many ways: risk-related information from various levels cannot be aggregated into a holistic picture; planned DRM activities are not implemented in practice; private sector participation is lacking; and risk communication remains vertical and one-way.
    - Nevertheless, there are benefits. The risk assessment process has increased interest and changed people's attitudes regarding how they think about and see things from a safety perspective. The direct or indirect results of assessments have contributed to authorities' decision-making, emergency planning and other crisis management exercises. The process provides DRM stakeholders with an opportunity to get to know each other and forms the basis for future collaboration. Calls have been made for increased communication and stakeholder collaboration within the DRM system; this is due to stakeholders seeing the benefits of their joint risk assessment work.
- The following countermeasures could mitigate risk communication challenges, and improve the usefulness of risk assessment documents:
    - The empirical evidence gathered during the preparation of this thesis provides a solid foundation for efforts to mitigate some of the systemic problems that hamper effective risk communication in the Swedish DRM system. For instance, efforts should be made to provide constructive feedback that could improve the quality of the risk assessment, and make risk communication a two-way process. The dissemination of the results of the assessment could be improved; this requires establishing the balance between authorities' duty-to-disclose risk-related information and other stakeholders' right-to-know about potential disaster risks.
    - The findings presented here suggest ways to improve risk assessments in order to make them more relevant for decision-making and risk communication. Specifically, including scenario descriptions, assessments of the likelihood of events and consequences, as well as background information concerning the estimated likelihoods seems to be a promising way to improve the usefulness of risk assessments. Furthermore, quantitative and semi-quantitative scales seem to be perceived as more useful than alternative ways (e.g., qualitative rankings, qualitative descriptions, and no description) to present likelihood and consequences, especially if they are complemented by narrative evidence.

This thesis focuses on the Swedish context. However, its findings are not necessarily limited to Sweden. Although the studies presented here provide insights and

recommendations for enhancing the functioning of the Swedish DRM system, they are likely to be applicable to other DRM systems. In particular, the more similarities there are with the Swedish system, in terms of risk communication, the more likely it is that the conclusions will be valid.

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Appendix 1:

Author contributions to the appended publications

Paper I: First author. I had overall responsibility for designing and conducting the study. I played a major role in data analysis and writing the paper.

Paper II: First author. I had overall responsibility for designing and conducting the study. I played a major role in data analysis and the writing the paper.

Paper III: First author. I had overall responsibility for designing the study, analyzing the data and writing the paper. Data collection was a joint effort by the listed authors.

Paper IV: First author. I had overall responsibility for designing the study and writing the paper. The second author was mainly responsible for data collection. Both authors contributed to the data analysis and structuring the text.

Paper V: Single author.

Appendix 2:

Appended publications

Paper I

Original Article

Communicational challenges in disaster risk management: Risk information sharing and stakeholder collaboration through risk and vulnerability assessments in Sweden

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Abstract Many countries have established disaster risk management systems. These systems involve various parties and aim to maximize resources and use their diverse expertise to manage disaster risks. In such systems, sharing risk and vulnerability assessments (RVAs) between stakeholders is the most common way to communicate risk-related information. This study investigates communication challenges linked to the preparation and use of RVAs in Sweden. The practices of five national authorities, five country administrative boards and 16 municipalities were studied in 36 semi-structured interviews. Questions concerned the sharing of risk-related information and stakeholder collaboration. An analysis of the perceived communication challenges showed that the major problems were the lack of a constructive vertical feedback mechanism (which resulted in one-way communication), and limited stakeholder partnerships and collaboration in the horizontal dimension.
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Keywords: disaster risk management (DRM); risk and vulnerability assessment (RVA); communicational challenge; stakeholders; risk information sharing; collaboration

Introduction

The risks faced by societies are becoming increasingly complex (OECD, 2003), systemic rather than linear (OECD, 2003; Van Asselt and Renn, 2011), and associated with uncertainty and/or ambiguity (Klinke and Renn, 2002; Renn, 2008; Van Asselt and Renn, 2011). At the same time, societies are becoming increasingly interdependent (OECD, 2011), and disruptive events that begin locally can spread rapidly, leading to global effects. The current trend in responding to such challenges is to employ a 'whole of government' or 'whole of society' approach (Caudle and de Spiegeleire, 2010, p. 1). This implies the need for a coordinated effort from various stakeholders across functional sectors and geographical boundaries in order to anticipate, prepare for and respond to risks (Van Asselt and Renn, 2011). Inclusive risk governance is based on a normative belief that contributions from all of the actors involved can be integrated. Its premise is that risk-related decision making can best be accomplished by gathering collective knowledge based on the values of various stakeholders (Renn and Schweizer, 2009). Communication is key in such a multi-stakeholder context (Kramer, 2005; Van Asselt and Renn, 2011; Hermans *et al*, 2012).

The communication of information is important for risk management in any multi-stakeholder context. Here we focus on risk communication in a formal disaster risk management (DRM) system. DRM is defined as, 'the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster' (UNISDR, 2009, p. 10). DRM is a process that is found at the level of the city, region or nation; therefore the actual organizations, technical systems, mechanisms and so on, that employ the process are referred to as a DRM system (Rivera *et al*, forthcoming). A DRM system can be seen as the application (or practice) of inclusive risk governance, based on the fact that all parties are involved in addressing the disaster risks faced by their society. Many countries have implemented multi-stakeholder DRM systems, and the aim is to maximize existing resources and use the diverse expertise available. A global driver has been the Hyogo Framework for Action (UNISDR, 2005), which has been signed by over 168 nations worldwide (UNISDR, 2007).

A common way to communicate risk information in a DRM system is through a risk and vulnerability assessment (RVA). Many scholars have contributed to the field of risk assessment and decision making, both normative

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(Von Neumann and Morgenstern, 1947; Savage, 1954; Cox, 2012; Karvetski and Lambert, 2012; Aven, 2013), and descriptive (Hassel, 2012; Abrahamsson and Tehler, 2013; Lin *et al*, 2015). However, few studies have investigated the challenges related to communication between stakeholders when conducting RVAs and sharing RVA documents in a DRM system.

This article describes an exploratory study of perceptions of communication-related challenges in developing and using RVAs in a national DRM system. While traditionally risk communication studies have focused on interactions between organizations and the general public (Fischhoff, 1995; Renn, 2014), only a few have explored the issue from the perspective of information sharing and communication between public and private stakeholders (Thompson and Bloom, 2000; Bier, 2001; Kramer, 2005; Olsson, 2014). We chose the multi-level/multi-stakeholder Swedish system as a representative example of a national DRM system in which RVAs are the main formal communication channel. The Swedish RVA system takes a bottom-up approach; assessments performed at lower administrative levels form the basis for the overall picture of risks and vulnerabilities at higher levels. One of the system's purposes is to generate a comprehensive overview of risks, vulnerabilities and emergency management capabilities at all levels: local, regional and national (Abrahamsson and Tehler, 2013). However, it has been argued that this is not, in fact, happening (Abrahamsson and Tehler, 2013), and that this could be because of poor communication between stakeholders in the system. This leads to our main research question: What do stakeholders in the Swedish DRM system see as the main challenges in the development and use of RVAs, in terms of information sharing and collaboration?

This article is structured as follows. First, the background outlines the principal theoretical concepts, followed by a description of the methods used. Next, we present the empirical findings and analysis. This is followed by a discussion and suggestions for improvements to the DRM system from a risk communication perspective. Finally, the conclusions are presented.

Background – Conceptual Framework

This exploratory study investigates perceived challenges in the Swedish DRM system concerning risk communication among stakeholders. It takes a risk governance perspective, which focuses on 'the various ways in which many actors, individuals, and institutions, public and private, deal with risks surrounded by uncertainty, complexity and ambiguity' (Van Asselt and Renn, 2011, p. 432). The importance of communication in a multi-stakeholder context is well-established (Kramer, 2005; Van Asselt and Renn, 2011; Hermans *et al*, 2012), and it is clear that effective communication should be at the center of risk governance. This, however, is not an easy task.

For instance, Kramer argues that in complex bureaucracies, communication and information sharing are associated with barriers, and it is difficult for parties to reach agreement. Unless appropriate measures are taken, these barriers may seriously affect the ability to manage risks (Kramer, 2005).

Risk communication has been defined as, 'the exchange of information among interested parties about the nature, magnitude, significance, or control of a risk' (Covello, 2012, p. 359). Others have stressed that risk communication is a multi-dimensional and interactive process involving all stakeholders and decision makers. It involves sharing the results of risk assessments and other risk-related information, throughout the process, and ideally from the very beginning (MacDiarmid and Pharo, 2003; Reynolds and Seeger, 2005). That said, risk communication can serve many purposes, ranging from information sharing to triggering a particular change in behavior by the recipient.

A key issue in effective risk communication is that it should involve mutual information exchange (Renn, 1992; Smith and McCloskey, 1998; Covello and Sandman, 2001; Van Asselt and Renn, 2011). Appropriate feedback is needed in all forms of effective communication. Tailored feedback enables the provider of the information to adjust and regulate their message. For instance, both positive feedback (about strengths and accomplishments) and negative feedback (about weaknesses and lack of accomplishment) should help the recipient to correct their actions (Finkelstein and Fishbach, 2012). Research has shown that positive feedback on accomplishments is essential in achieving goals, as it reinforces the fact that a particular organization is doing the right thing (Finkelstein and Fishbach, 2012). On the other hand, negative feedback encourages the information provider to change their approach, or work harder towards the goal (Finkelstein and Fishbach, 2012). Organizations often pay insufficient attention to feedback (Fortune and Peters, 1995), which reduces the effectiveness of communication (Smith and McCloskey, 1998).

It has been said that if someone is not being heard, they cannot be expected to listen (Covello and Sandman, 2001). In a multi-level/multi-stakeholder DRM system, it is very important to allow all stakeholders to express their opinions, and to be heard. Communication involves how people understand each other and how information is transferred within and between organizations. Therefore the analysis of communication must focus on to the boundaries in an organization that prevent information sharing and integration.

A DRM system includes stakeholders from various administrative levels and functional sectors. Consequently there is a need for cross-boundary sharing and integration of information not only between different levels of government (the vertical dimension), but also between governmental and non-governmental agencies (the horizontal dimension) (Yang *et al*, 2012). This becomes complex when the different parties involved lie at different administrative levels, and have their own functions, goals, values and cultures (Kapucu *et al*, 2010; Yang and Maxwell, 2011).

The collaborative organizational structure inherent in a DRM system normally includes both vertical and horizontal dimensions. Past studies have identified obstacles in both dimensions. In the vertical dimension (the hierarchical structure), barriers to information sharing and communication may be encountered between different levels in the hierarchy, while in the horizontal dimension, departments have different expertise and functions (Yang *et al*, 2012). It has been argued that communication boundaries in the vertical dimension are less complex than those in the horizontal dimension (Layne and Lee, 2001; Chan *et al*, 2008; Klievink and Janssen, 2009; Yang *et al*, 2012), while others claim that barriers are equally important in both dimensions, and can exist simultaneously (Zheng *et al,* 2009; Yang *et al,* 2012). In a DRM system where both vertical and horizontal dimensions are involved (such as in Sweden), it is necessary to explicitly address and overcome these obstacles.

Although the emerging field of risk governance aims to become normative, there is little advice on how to communicate risk information in DRM systems. This exploratory study of experience in the field intends to provide insights that will be useful in future work on improving the system.

Methodology

We examine risk communication in a multi-stakeholder DRM system in Sweden, specifically, RVAs. The RVA is the main formal channel for communicating information about risks and vulnerabilities in the Swedish DRM system. Under Swedish law, annual RVAs must be prepared by authorities at municipal (local), county (regional) and national level. The reporting structure takes a bottom-up approach. At local level, the 290 Swedish municipalities send their reports to their respective regional county administrative board (of which there are 21), where they are used as input to regional RVAs. The county administrative boards then send their reports to the Swedish Civil Contingencies Agency (MSB), which is tasked with producing a national overview of risks and vulnerabilities based on input from all administrative levels. At national level, there are a further 23 government authorities (in addition to the MSB) that also produce RVAs and submit them to MSB as input for the national RVA. Inherent in the system is the idea that information (for example feedback on the RVAs) should flow both vertically and horizontally.

Qualitative research methods were employed in this study. Empirical data were collected through a total of 36 semi-structured interviews carried out in 2011 and 2013. These interviews involved five (of the 24) national authorities, five (of the 21) county administrative boards and 16 (of the 290) municipalities.

The first round of interviews was performed in the autumn of 2011, and included respondents from five national authorities, five county administrative boards and 15 municipalities. The five national authorities represented different

coordination areas (SFS, 2006:942). The five counties represented various geographical locations, and the municipalities (three from each of the five counties) reflected different sizes of population, that is small (<15 000 inhabitants), medium (15 000–75 000 inhabitants) and large (>75 000 inhabitants). All respondents participated in the preparation of the RVA for their respective authority. Twenty-five interviews were conducted (23 face-to-face, two by telephone) all lasting approximately 1 hour. Themes concerned the organization of the RVA, stakeholders (internal and external), forms of collaboration and communication, and how they used information from other actors' RVA documents to generate their own.

The second round of interviews was conducted in the autumn of 2013, and concentrated on the RVA of one Swedish municipality. The purpose was to study information-sharing and collaboration between the municipality's departments, and its external stakeholders. The first interview was conducted with the safety coordinator, who provided information on other employees whose work was related to the RVA. A snowball sampling method (Silverman, 2000) identified a further 10 respondents who represented either the municipality's internal departments (for example building and planning, social services, transportation), or external stakeholders (for example drinking water suppliers, rescue services, social services, the police). Interviews lasted approximately 1 hour and addressed the flow of risk-related information and risk communication between both internal and external stakeholders during the preparation of the RVA.

The combination of the results of the two rounds of interviews made it possible to investigate how risk-related information is communicated between internal and external stakeholders in the Swedish DRM system. The broad issues guiding the analysis were: the collection and use of information on possible risks; giving and receiving feedback on information about risks; channels of communication and problems encountered when communicating information about risks; interaction with partners on the same/higher/lower administrative level; and use of the RVA.

Interviews were transcribed and then analyzed by identifying and coding important statements and details that shed light on the research question. The analysis also identified recurring patterns of information found in different interviews (Yin, 2014).

Results and Analysis

The main results are presented below.

Limited constructive feedback from higher administrative levels

The most common problem concerned a lack of feedback. Most informants stated that feedback from higher administrative levels was too general to be of

any use in improving the RVA. This problem was identified at all levels, from external actors supplying information for the municipal RVA, to the national level. Although most comments came from lower administrative levels, some informants at higher levels referred to the lack of feedback they provided to lower levels in the system. For example, feedback from the national to the county level is aggregated and takes the form of statements such as, 'two-thirds of the regions have demonstrated good involvement by all relevant organizations in their RVA activities', while no specific feedback is provided to individual counties. Other examples include overly general oral feedback such as, 'OK, it's good enough'.

Many informants perceived the lack of constructive feedback from higher administrative levels to be problematic for several reasons. Many found it very difficult to use as a basis for improvement. Some even stated that the lack of specific feedback on the strengths and weaknesses of their RVAs led to greater uncertainty in future work.

Difficulties in using other stakeholders' RVAs

Many informants identified problems related to the use of other stakeholders' RVAs as input for their own. These problems can be represented by four themes.

First, neither the method and tools used to produce RVAs, nor their format is standardized. Therefore, authorities at all administrative levels have a high degree of freedom to structure the process. Consequently, RVAs submitted to higher administrative levels from lower-level authorities differ in both method and format. This was perceived as very problematic at higher administrative levels, given their obligation to produce a consolidated description of risks and vulnerabilities. However, many informants pointed out that while upper-level authorities would like the lower-level RVAs to be more consistent, another important objective of the exercise is that they provide input to risk-related decision making at the level where they are produced. Several informants highlighted potential problems arising from the fact that RVAs have these different objectives. One informant said, 'If municipalities must provide information to higher levels, as they are required to, it should be beneficial for everyone, which is not always seen to be the case'. For example, one county administrative board wanted their municipalities to use standardized software to prepare the RVA. However, some municipal representatives argued that although it could be useful for the regional authority, it would not necessarily be useful for them. Similar opinions were expressed between regional and national levels. While representatives from the higher level found it difficult to use RVAs from the lower level to generate their own, informants at the regional level expressed their concern that a unified process and/or reporting format may not be appropriate for their own risk-related activities.

Second, while (local) municipalities and (regional) country administrative boards are responsible for producing RVAs focused on their respective geographical area of responsibility, national authorities are organized according to their function (for example the coast guard, transport administration, the national food and drinking water board). Several informants pointed out that it was difficult for authorities with geographical responsibility (that is municipalities and county administrative boards) to use national-level information because of its very different scope and focus, and *vice versa*.

Third, some informants from regional and national-level authorities identified the submission date for RVAs as problematic. They pointed out that both regional- and national-level RVAs had to be submitted on the same day, making it impossible for authorities to use each other's latest reports as input.

A fourth issue was raised by external stakeholders at the municipal level, that is stakeholders outside the municipal bureaucratic system, but who are involved in the RVA process. Some of these external stakeholders are owned by several neighboring municipalities (drinking water suppliers, rescue services and so on). These stakeholders highlighted the problem of providing risk-related information to multiple authorities who used different methods and reporting formats. One informant said, 'Today we might have to use four different methods, or 10 if we have more owners in the future [...] which would be impossible for us. I think we should find a routine, so that things can be done in a similar way'.

The issue of disclosure of information

Several informants highlighted disclosure as a barrier to information sharing. Explicit information about vulnerability (technical systems, groups in society and so on) is a key aspect of an RVA. However, many described this as problematic. On the one hand, such information is crucial in order to direct disaster risk reduction efforts. On the other, such information may be harmful if it falls into the wrong hands. 'The RVA contains confidential information. The more people who know this information, the greater the risk will be'. Finally, some respondents pointed out that information regarding the vulnerabilities of a private actor could be very sensitive and difficult to obtain, because of concerns about the potential effects on business.

Involvement of internal and external stakeholders

Internal stakeholders

The term 'internal stakeholders' refers to governmental agencies found at different levels in the Swedish DRM system. Both at municipal and county level, respondents from the central risk/crisis management office stated that their greatest challenge was 'to make the various departments understand why they should be doing it in the first place'. Furthermore, high staff turnover led to a loss of continuity. Several informants stated that they had only recently

started working on RVA, and were not yet familiar with the organization's risk-related activities. Respondents at the upper administrative levels pointed out that because of high turnover, staff responsible for lower-level RVAs did not really understand what was required, which had an impact on quality.

As each department has a very different role in terms of fulfilling the organization's objectives, and the whole process is based on demand, we found that information sharing and collaboration tended to be vertical. Horizontal dialog (that is between stakeholders at the same administrative level, but with different responsibilities) was less apparent. Linked to this, a common theme that emerged from the interviews was a desire for more open dialog between stakeholders on the same administrative level. This would help to develop a shared understanding of the vulnerabilities and potential risks, and how to deal with possible risks or crises.

External stakeholders

The term 'external stakeholders' refers to non-municipal actors at local level, or private actors on the regional and the national level. In general, external stakeholders do not seem to participate much in the preparation of the RVA. Several potential reasons for this were expressed in interviews with internal actors; private sector actors were said to have their own priorities regarding risk assessments, and considered that contributing to official RVAs took time and cost money. External actors appeared to be more involved at regional, rather than municipal or national level. A safety coordinator in the municipal Emergency Management Office commented, 'It's difficult to involve private actors at local level, because it's almost impossible for them to attend all the workshops organized by all the local municipalities in their area. But we do meet them in regional workshops, where we meet people from other municipalities and the private sector'.

External stakeholders described their participation in the RVA process as follows, 'We attend their workshops, but more as a guest'. Both external and internal stakeholders are very clear about their own responsibilities, and one external actor commented, 'If something happens, we take care of our own responsibilities. We can help the authorities, but it's not our responsibility'. However, the majority of private stakeholders we interviewed expressed their willingness to enhance collaboration with authorities. This was thought to improve understanding of the potential risks and vulnerabilities, and how authorities would respond in various crisis situations. Some external actors described participation in the RVA process as an important learning process.

Internal stakeholders at all levels also stated the need for improved collaboration with external, mainly private actors. In fact, some are reorganizing their RVA activities to increase the involvement of the private sector.

In terms of sharing risk-related information, like internal stakeholders, external actors provide information when required to do so. However, this

communication tends to be one-way (that is external actors provide information as input to the RVA). Several respondents highlighted that external actors seldom receive any constructive feedback regarding their input, or receive a copy of the RVA they contributed to.

Discussion

Communication is considered to be 'at the core of any successful risk governance activity' (Van Asselt and Renn, 2011, p. 439). Good communication is thus essential in any DRM system. This study explored the communication challenges in a DRM system related to sharing information about potential risks and stakeholder collaboration in the RVA process. The purpose is to suggest way to improve the design and implementation of such a system.

Overall, we found a lack of constructive feedback on whether the RVAs submitted by lower-level authorities are sufficient to compile the higher-level RVA. There is no scope for highlighting strengths and weaknesses in order to improve the quality of future RVAs. Many studies in the area of DRM have focused on effective, two-way risk communication (Renn, 1992; Smith and McCloskey, 1998; Covello and Sandman, 2001). Effective two-way communication takes place when the recipient of the information interprets the sender's information as intended (Eriksson and Borell, Forthcoming). Appropriate feedback confirms whether or not the intended message has been received and properly interpreted. However, we found that insufficient attention was given to feedback between the stakeholders. Constructive feedback that identifies the strengths and the weaknesses of the received message not only completes the communication loop, ensuring two-way information exchange, but also aids future RVAs.

Earlier research has demonstrated how an individual's motivation is affected by both positive and negative feedback (Finkelstein and Fishbach, 2012; Koo and Fishbach, 2014). Regarding RVAs, positive feedback highlights areas in which the sender has been successful, and encourages continued good work, while detailed negative feedback identifies areas where greater effort is required. Current feedback is considered to be too general to be constructive and insightful.

However, in order to establish a successful feedback mechanism in the DRM system, stakeholders must agree upon the intention of the communication of risk information. They must understand that it goes beyond the fact that they are obliged by law to carry out an RVA. If their intention is simply to fulfill legal requirements, they will believe that as long as the RVA is sent to the relevant authority, the goal has been achieved. As we have highlighted (see Results and analysis section), one of the major challenges in producing RVAs is to make the parties involved in the exercise understand why they are doing it.

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The issue may be systemic. One reason why upper-level stakeholders do not give constructive feedback to lower levels may be that they consider the preparation of their own RVA to be the ultimate goal. As a result, they are unlikely to devote time to giving constructive feedback in order to improve future work.

Regarding the difficulties that were identified in using other stakeholders' RVAs, such problems could be alleviated by giving appropriate and timely feedback regarding, for example, disparities between the expectations of higher-level authorities and the documents submitted by the lower level. We found that the lack of an established feedback mechanism limited risk communication to the submission of RVA documents. This resulted in one-way communication, evidenced by repeated calls from informants for more constructive feedback, at both lower and higher administrative levels.

The DRM system we studied is a bottom-up structure, and we believe that the implementation of an appropriate feedback mechanism requires an initiative from the highest administrative level. The issue of time and resources must also be addressed, as authorities often attributed their lack of feedback to limited resources. With regard to the problem of using other stakeholders' RVAs (see section 'Difficulties in using other stakeholders' RVAs'), if it is found to be a widespread challenge, lower-level authorities should take the initiative and make themselves heard by the hierarchy, if the majority calls for structural change.

In terms of communication challenges in the vertical dimension (hierarchical levels), information tends to only move in one direction. One reason for this is the lack of a feedback mechanism, and the other is the fact that information is submitted on-demand. In the horizontal dimension (stakeholders from other functional sectors with different expertise, or counterparts located in other geographical areas), communication and collaboration seem to be sorely lacking. As our results show, the different organizational responsibilities of these stakeholders result in different forms of knowledge and expertise. The less they have in common, in terms of organizational roles, the less they are interested in sharing information and dialog. Previous research indicates that people are more likely to share knowledge when they already have some knowledge in common (Kramer, 2005). Despite the fact that horizontal communication is currently limited, some of those interviewed pointed out that once they had shared some risk-related information, the stock of common knowledge would increase, as would interest in future communication and collaboration.

Stakeholder participation is a vital element in a DRM system (Renn and Schweizer, 2009). Collaboration should not be limited to one dimension, but should include all sectors and all levels. The creation of a common body of knowledge could be the first step in a dialog leading to increased information sharing and risk communication between stakeholders, especially those from different functional sectors. Furthermore, the RVA is often seen as the

first step in DRM. The establishment of stakeholder partnerships and an effective communication mechanism at this early stage may enhance collaboration, leading to greater efficiency in the later stages of DRM.

It should be noted that the efforts of both governmental bodies and non-governmental stakeholders must be integrated for a DRM system to be successful (Kapucu *et al*, 2010). Improvements could be achieved in the Swedish DRM system by involving more stakeholders from the private sector (where change is already happening). More importantly, all stakeholders should show mutual respect, regardless of the hierarchical structure (Kapucu *et al*, 2010). A well-connected, effective stakeholder network can be established in the DRM system by sharing risk-related information and enhancing collaboration through the distribution of RVAs.

Although this study of the Swedish DRM system is representative of multi-stakeholder systems, the challenges are unlikely to be unique to Sweden. Similar issues may be found in DRM systems and RVA-related work in other countries. We therefore argue that the communicational challenges identified are significant and can be generalized.

Conclusions

We investigated the development and use of RVAs in the Swedish DRM system, focusing on information sharing and collaboration between stakeholders. The main challenge was the lack of a constructive feedback mechanism, which resulted in one-way communication based on the preparation of RVAs. Other challenges, such as the problem of using RVAs prepared by other bodies, and limited stakeholder collaboration in the horizontal dimension, were highlighted. Our understanding of the challenges perceived by practitioners in the Swedish DRM system could help to improve risk communication in similar, multi-stakeholder systems.

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Paper II

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On the perceived usefulness of risk descriptions for decision-making in disaster risk management

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ABSTRACT

Managing risk using an "all-hazards" and "whole of society"-approach involves extensive communication of risk descriptions among many stakeholders. In the present study we investigate how professionals working with disaster risk management in such contexts perceive the usefulness of different descriptions of risk. Empirical data from the Swedish disaster risk management system were used in an attempt to investigate the aspects of a risk description that affect its usefulness (as perceived by professionals). Thirty-three local municipal risk and vulnerability assessments (RVA documents) produced in the region of Scania in 2012 were analyzed in terms of six variables. The documents were then ranked by professionals based on their perceived usefulness for decision-making. Statistical analysis was conducted to identify any possible correlations between the overall ranking of the usefulness of the municipal RVA:s and each of the variables. We conclude that the way the likelihood and consequences of scenarios are described influence the perceived usefulness of a risk description. Furthermore, whether descriptions of scenarios are included in a risk description or not, and whether background information concerning the likelihood of scenarios are included also influence perceived usefulness of risk descriptions.

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1. Introduction

Major crises and disasters pose a serious threat to societies around the world. In the past 30 years, the impact of disasters has increased significantly [1], while new risks are constantly being identified [2]. Moreover, "it is not just the nature of major risks that seems to be changing, but also the context within which they appear…" [1]. In particular, systemic risks, i.e. "…those risks that affect the systems on which society depends – health, transport, environment, telecommunications, etc." [1], are becoming more difficult to manage due, for example, to institutional fragmentation [3,4] and increased interdependencies and interconnections [5]. In response to these challenges many countries have introduced "all-hazards approaches" employing a broadened perspective to risk with the emphasis on identifying connections between a multitude of hazards and risks, rather than considering them in isolation [6,7]. Moreover, the trend is also to employ a "whole of government" or "whole of society" approach [8] in addressing these challenges, which means that a wide variety of stakeholders are involved in the efforts to manage risks. Such approaches have great potential since they can mobilize considerable resources and a diversity of expertise to collectively address the management of risk. However, they are also associated with significant challenges that must be dealt with. For example, the more stakeholders that are engaged in the effort of managing risk, the greater the need for communication and information sharing. Sharing information in complex bureaucracies is always associated with barriers [9], and unless measures are taken to reduce them, they could seriously affect the ability to manage risk.

The present paper addresses the issue of communication and information sharing in multi-stakeholder systems for disaster risk management. UNISDR defines disaster risk management as "The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster." [10]. A key driver for the implementation of disaster risk management is the Hyogo framework for action [11] which has been signed by 168 nations. By signing this document they have committed themselves to, among other things, developing the capacity to identify, assess and monitor disaster risk. One important form of information sharing in this context is the communication of risk descriptions, e.g. the results of risk assessments, to support decision-making

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concerning how to lessen the long-term consequences of disasters. Although supporting decision-making is an important purpose of risk descriptions [12,13], they may also serve other purposes. For example, they could be used to identify alternative decisions [14] or serve as a means of fostering shared understanding between various stakeholders [15]. Nevertheless, the focus in the present study is on the extent to which they support the decision-making of professionals working with disaster risk reduction.

Many scholars have contributed to the area of risk assessment and decision-making. Several of the contributions have been normative, e.g. focusing on suggesting methods for how one *should* make decisions in uncertain situations. For example, classic decision theory [16,17] deals with how to make decisions in uncertain situations. More recently, several authors have made suggestions on how to manage risk in situations involving great uncertainty [18–20]. In the present paper, however, we have chosen a descriptive rather than a normative perspective. Thus, we are interested in how people *actually* make decisions, rather than how they *should* make decisions. However, the present study does not focus on the decision per se, but instead on the effect that different types of risk descriptions might have on decision-making. More precisely, we have investigated how the way in which the risk is described, i.e., how it is presented, influences the usefulness of the description for decision-making as perceived by professionals, i.e. those working with the management of risk and who will use the descriptions. The empirical data used in this study were taken from the Swedish disaster risk management system[1].

The paper is structured as follows. First, we provide a brief overview of previous relevant research in the area of communicating risk descriptions. Secondly, we provide a short description of the Swedish system for risk and vulnerability assessment (RVA), with particular emphasis on the communication of risk-related information by the RVA documents between the local, municipal level and the regional level. Thirdly, we introduce the theoretical concepts that are used in the paper. Fourthly, we present the research methods that were used. We then present the results, and the findings and limitations of this study are also discussed, together with some suggestions for future studies that would be interesting in light of our findings. Finally, the conclusions are presented.

2. Risk communication between professionals

Successful communication is one of the key aspects for managing disaster risk in context characterized by multiple stakeholders, high level of ambiguity, complexity and uncertainty [21,22]. Risk communication research has to a great extent been focused on communication between professionals and the public, and less attention has been paid to communication between professionals [23,24]. However, in order to understand how disaster risk management systems work, and how one can design them so as to avoid blocking the “informational arteries” [9,25] we also need to investigate risk communication among professionals.

Important contributions to our understanding of risk communication between professionals have been made by Kramer [9] who studied communication among various governmental authorities prior to the terrorist attacks of 9/11. He finds several factors, psychological, social and institutional, that contributed to hampering the flow of risk information prior to the attacks and thereby led to a failure of those involved to “connect all the dots” [9]. Moreover, Bier [23] presents a review of state of the art concerning risk communication to decision-makers. Included is a section focusing on the format of risk communication, which is highly relevant to the present study since we investigate the effect of different forms of written communication. In a comprehensive interview study Thompson & Bloom [24] investigate risk communication between risk assessors and risk managers. Thompson and Bloom’s study stands out among previous contributions since it is based on a relatively large number of interviews (41 persons) and it directly investigates risk management professional's opinions and perceptions concerning different forms of risk communication. They conclude that, for example, when communicating risk to support decision-making it is good to include a presentation of the broader context of the decision, descriptions of how uncertainties might influence the effectiveness of different risk management options as well as stakeholder perceptions of the risks.

Other important contributions that do not directly deal with the form of risk descriptions but focus on other aspects relevant in professional communication of risk include Veland & Aven [12], who investigate how different risk perspectives might influence risk communication, and Johansen & Rausand [26], who focus on the importance of risk metrics in communication.

In our opinion, what seem to be lacking in the scientific literature on risk communication between professionals is empirical studies where the effect of different forms of risk communication is investigated. More precisely, how professionals working with disaster risk management perceive the usefulness of risk descriptions for decision-making. The present paper presents such a study. However, before describing the study in detail it is necessary to provide a brief description of the context in which the study was carried out.

3. The Swedish RVA system

The Swedish RVA system is one of the most important components of the Swedish disaster risk management system. It consists of three administrative levels: national (state departments and agencies), regional (county administrative boards and county councils) and local (municipalities). Authorities at all levels are obliged by Swedish law to conduct RVA:s [27,28]. According to a Swedish Government Official Report [29], the primary purpose of RVA:s is to increase the consciousness and knowledge of those responsible for making decisions concerning risks and vulnerabilities, and to constitute the basis for the planning and implementation of measures that reduce risks and vulnerabilities. Thus, one important purpose of the documents is that they should be useful for decision-making in terms of providing support in choosing effective disaster risk reducing efforts. For example, the RVA system is supposed to generate comprehensive overviews of risks and vulnerabilities at all levels in society: local, regional and national [30]. The overviews should guide the nation's disaster risk management activities within the geographical area of interest in terms of prevention and mitigation, preparedness, training, supervision, follow-up and research.

Moreover, the system is based on the general idea that an analysis conducted at a lower administrative level should serve as a basis for the analysis carried out by the level above. For example, the RVA:s produced by local municipalities should serve as the basis for the analysis conducted by the regional county administrative board. Similarly, the RVA:s presented by the regional authorities are used as input in the national RVA. The Swedish system is thus highly dependent on the ability of various authorities to communicate descriptions of risk through RVA:s.

In the present study we used municipal RVA:s, i.e., the RVA:s performed at the lowest level of the Swedish RVA system. All

[1] Although the system is called the crisis management system (“krishanteringssystemet” in Swedish) we focus only on the part of it that deals with risk management.

RVA:s from the local municipals of Scania (thirty-three documents) produced in 2012 were included in the study.

4. Theoretical concepts

The issue addressed in this paper is how different ways of communicating descriptions of risk influence the usefulness of the description. As described in the introduction, there may be many objectives of communicating such descriptions. Here, however, we focus on the *perceived usefulness* for *decision-making* as expressed by professionals working with risk management. We define perceived usefulness as *the degree to which a person believes that a specific risk description would enhance the basis for decision-making*. Our definition is a modification of Davis' [31] to suit the present context better. Thus, the perceived usefulness is not directly related to the decision per se, but rather to the process of constructing the basis for a decision. Although making decisions and constructing the basis for decisions are two different activities, there are, of course, many similarities.

In investigating the usefulness of risk descriptions we have employed a design perspective (see, for example, [30,32–35]). Thus, we consider the descriptions of risk to be artifacts, i.e., they are created by humans with a purpose in mind (as opposed to being the result of natural processes), and they must therefore be studied in relation to that purpose when analyzing their usefulness. In the present study we assume that the descriptions of risk contribute to the overall purpose of managing disaster risk in a specific system by supplying one or more stakeholders with information that supports decision-making. This purpose seems reasonable, given that one important purpose of introducing "all-hazards/whole of society" approaches is to increase the ability to prioritize scarce resources for risk reduction [7]. In a multi-stakeholder system for disaster risk management, many professionals on various administrative levels are involved in developing descriptions of risk. These descriptions are shared between the stakeholders, sometimes with many others, and sometimes with only a few. Regardless of the numbers involved, the reason for sharing the descriptions, and sometimes the data on which the descriptions are based, is that no single stakeholder possesses the knowledge required to produce assessments of risk covering all the relevant areas and all relevant aspects of risk. The relevant areas can be expressed in terms of geographical area and in terms of functional area, i.e., power distribution, transportation, healthcare, etc., and the relevant aspects are related to what is being protected.

Risk is a fundamental concept in the present study. Although we do not study the concept per se, we investigate various stakeholders' *descriptions* of risk, which usually involve the use of some kind of risk measure. The concept of risk has been defined in many different ways (for an overview, see for example, [36–38]). Aven et al. [36] found that regarding the ontological status of risk, the suggested definitions can be divided into three categories:

(a) Risk as a concept based on events, consequences and uncertainties.
(b) Risk as a modeled, quantitative concept (reflecting the aleatory uncertainties).
(c) Risk measurements (risk descriptions).

For reasons similar to those presented by Abrahamsson and Tehler [30], we have chosen to use a definition from category (*a*) since these definitions are usually broader than the, often technical, definitions in categories (*b*) and (*c*). Many of the definitions from categories (*b*) and (c) assume, for example, that probabilities or frequencies are the only way of describing uncertainty (see, for example, [39,40]). The definition used in the present paper is Aven's definition of risk, as described below [41].

Using this definition of risk allows us to describe the important concepts (in addition to the risk concept) that are used in the present paper. More precisely, according to this definition of risk the important building blocks of the concept are events/scenarios (A), consequences (C) and uncertainties (U). Since we are studying different stakeholders' assessments of risk, it is also important to separate the *concept of risk* from the *description of risk*. What we can investigate in the documents studied here are descriptions of risk. The notation used for a risk description is C', Q, K, where C' is a description of consequences, Q a measure of uncertainty, and K is the background knowledge on which Q is based [42].

The variables used in the present study can be described based on Aven's framework, referred to above. Six variables are used to describe how a description of risk is communicated in an RVA document. The first variable is called *description of scenarios* and we denote it by the term $A_{Scenario}$, which is the term used by Aven [41] for events or scenarios, with the addition of the subscript "*Scenario*". $A_{Scenario}$ is a dichotomous variable that can assume one of the two states "yes" or "no". Thus, a particular risk description in a specific document either includes descriptions of scenarios or not. Not including a description means that the names of scenarios, i.e. "flood", "earthquake", etc., are the only aspect mentioned in a specific risk description. If descriptions of the scenarios are included, then there will be explanations of what "flood", for example, means in a specific case. The reason why we believe that descriptions of scenarios will influence people's perception of the usefulness of the risk description is that it helps them relate the information in the risk descriptions to aspects they are already familiar with. As Fisher points out, "Humans are essentially storytellers" [43], and in a risk description the scenarios are "the story". The more details are provided concerning the scenario in question, the easier it is for a person to relate it to something he or she is already familiar with. It simply becomes easier to judge the credibility of the claims made in the risk description since the scenarios allow that person to assess its *narrative coherence*, i.e., whether there are gaps in the logic of the scenario, and its *narrative fidelity*, i.e., whether the scenario appears credible, bearing in mind the knowledge and experience of the person in question [43]. The first hypothesis we tested is:

H1. Risk descriptions are perceived as more useful if they include scenario descriptions than if they do not.

This hypothesis (*H1*), and those presented below, all claim that there is a relationship between the independent and the dependent variable of interest. We will test the null hypothesis (*H0*), i.e. that there is no relationship between the variables, for each hypothesis to see if it is possible to reject it.

Another aspect of scenarios that we believe will influence the usefulness of a risk description is whether the description includes information related to how and why the specific scenarios that are included in the risk description were chosen. This type of information is reflected by a variable we call $A_{Background}$. It is a dichotomous variable that can assume the value "yes" or "no". The hypothesis we tested is:

H2. Risk descriptions are perceived as more useful if they include background information for scenario descriptions than if they do not.

The third variable is called *description of likelihood,* and is denoted $Q_{Likelihood}$. This variable represents how the likelihood that a scenario (provided that they are used) will occur is described. Based on previous studies of the current Swedish RVA system [30,44–46] we have found that a suitable scale to describe

$Q_{Likelihood}$ is an ordinal scale with five categories. The categories that $Q_{Likelihood}$ can assume are "Not included", "Qualitative description", "Qualitative ranking scale", "Semi-quantitative ranking scale", and "Quantitative scale (probabilities or frequencies)". A more detailed scale could have been used, for example, one reflecting whether probabilities are interpreted as a relative frequency or as a measure of degree of belief (Bayesian perspective). However, such detailed classification is not suitable here since none of the RVA documents included in this study describe those aspects. Few of the documents employ probabilities, and when they do, it is very difficult to determine how the probabilities should be interpreted. The motivation for including $Q_{Likelihood}$ in the present study is that it influences *the type of information that can be communicated.* For example, if no description of likelihood is given in a document it is obviously impossible to communicate anything regarding the likelihood of various events/scenarios and their consequences. Even if a qualitative description of likelihood is included, it is not possible to communicate any order between the events and their consequences in terms of likelihood. The reason for this is that people show considerable variation in the interpretation of qualitative descriptions of likelihood (see, for example, [47–49]). Thus, even if one person believes that a "probable" event will occur more often than one that is "likely", others will not necessarily share this interpretation. However, a scale can be established that allows order among events and consequences to be communicated in terms of likelihood. The most basic type of scale found in the material studied here (RVA documents) is a scale with five categories, where each category is described using words such as "Highly unlikely", "Unlikely", etc. The key point is not the terms themselves (as they might still be interpreted differently by different people), it is the fact that descriptions of risk including information on the assessment of whether a specific event or consequence is more or less likely than another can be communicated using that scale. The difference between a qualitative ranking scale and a semi-quantitative ranking scale is that the categories in the semi-quantitative ranking scale include numerical descriptions in terms of frequencies or probabilities, e.g. "Very likely, once every 10 years". Such numerical measures are not included in the categories of a qualitative ranking scale.

Depending on how the likelihood of events and consequences are expressed, it is thus possible to communicate different aspects that can be used in different ways. In fact, the information that is communicated can be used in the same way as different types of measurement scales. Stevens [50] describes the four basic scales of measurement: nominal, ordinal, interval and ratio. Using a nominal scale allows the communication of equality, which means that one can describe two (or more) events or consequences as being equally likely. The ordinal scale allows the communication of greater or less, which means that it is possible to say that one event or consequence is more or less likely than another. The interval scale allows the communication of equality of differences, which means that one can say that the difference in terms of likelihood between two events or consequences is the same as the difference between two other events or consequences. Finally, the ratio scale allows the communication of equality of ratios, which means that one can say, for example, that the ratio between the likelihood of events A and B is the same as the ratio between the likelihood of events C and D. In the same sense as the measurement scales can be used to perform different operations (determination of equality, etc.) $Q_{Likelihood}$ reflects what can be communicated in terms of equality of likelihood, greater or less likelihood, equality of the interval between likelihoods and the equality of ratios between likelihoods. Therefore, we believe that people will perceive a risk description that contains a semi-quantitative ranking scale, for example, to be more useful than one that only contains qualitative descriptions. Thus, the hypothesis that we tested is:

H3. Risk descriptions that allow more information concerning the likelihood of events and consequences in terms of determination of equality, determination of greater or less, determination of intervals or differences, determination of ratios, to be communicated are perceived as more useful than others.

Although descriptions of the likelihood of various events and consequences represents an important part of a risk description, other components related to likelihood are also important. In particular, the background knowledge on which the likelihood description is based might play a crucial role in determining whether the risk description is useful or not for a decision maker [51,52]. Here we use the variable $K_{Likelihood}$ to represent whether a specific risk description contains an explanation of the assumptions on which the likelihood descriptions are based. This is also a dichotomous variable that can assume the states "yes" or "no". Admittedly, it is a rather crude way of classifying risk descriptions as there are many ways of expressing background knowledge that influence the usefulness of the risk description. Nevertheless, we find it difficult to achieve a high inter-coder reliability for more detailed ways of describing this variable (see Section 5.2), and we have therefore chosen not to use more states to represent this variable. The hypothesis that we tested is:

H4. Risk descriptions that include descriptions of background knowledge concerning estimated likelihoods are perceived as more useful than if they do not include such descriptions.

In addition to the two variables focusing on likelihood estimates ($Q_{Likelihood}$ and $K_{Likelihood}$) we included two similar variables that are related to the consequences. We call them $C'_{Consequences}$ and $K_{Consequences}$). The reasons why these two variables are likely to be important are the same as those presented above for $Q_{Likelihood}$ and $K_{Likelihood}$. The hypotheses we tested are:

H5. Risk descriptions that allow more information concerning the consequences in terms of the determination of equality, determination of greater or less, determination of intervals or differences, determination of ratios, to be communicated are perceived as more useful than others.

H6. Risk descriptions that include descriptions of background knowledge concerning estimated consequences are perceived as more useful than if they do not include such descriptions.

In conclusion, we used six variables to describe a specific risk description. Each variable is associated with a hypothesis concerning the usefulness of a risk description. Table 1 presents a summary of the variables and their possible states.

5. Method

5.1. Analysis and evaluation of municipal RVA:s

The empirical data set used in the present study is the result of a content analysis [53] of all 33 RVA documents submitted to the county administrative board of Scania by the local municipalities in 2012. Each of these RVA:s is between 30 and 155 pages long, including appendices. Two coders who read through these documents performed the content analysis, looking for sentences and sections of text containing descriptions of various aspects of risk descriptions that were deemed to be important for the usefulness of a risk description (see Section 4). The coders used a coding scheme [53] developed in a previous study [30]. The coding scheme contains many more variables than the ones of interest

Table 1
The six variables and their possible states. Brackets ([ ]) are used to illustrate the possible states.

Variables	Possible states
$A_{Scenario}$	[Yes] or [No]
$A_{Background}$	[Yes] or [No]
$Q_{Likelihood}$	[(1) Not included], [(2) Qualitative description], [(3) Qualitative ranking scale], [(4) Semi-quantitative ranking scale], [(5) Quantitative scale (probabilities or frequencies)]
$K_{Likelihood}$	[Yes] or [No]
$C_{Consequences}$	[(1) Not included], [(2) Qualitative description], [(3) Qualitative ranking scale], [(4) Semi-quantitative ranking scale], [(5) Quantitative scale (probabilities or frequencies)]
$K_{Consequences}$	[Yes] or [No]

Table 2
Questions used to guide the process of analysis and evaluation of the documents.

Variables	Questions
$A_{Scenario}$	*Are risk scenarios explicitly described?*
$A_{Background}$	*Is the process used to select scenarios described and are the selection motivated?*
$Q_{Likelihood}$	*In what way is the likelihood of a certain risk scenario assessed and presented?*
$K_{Likelihood}$	*Is there any background/motivation regarding the likelihood assessment?*
$C_{Consequences}$	*Are the potential consequences of each scenario presented? What type of information is given?*
$K_{Consequences}$	*Is there any background/motivation regarding the consequence assessment?*

here. However, only the results pertaining to the six variables of interest here were used in the present study. Questions pertaining to the variables guided the process of analysis and evaluation. They are presented in Table 2 below. Moreover, the two coders also coded all RVA documents produced by the local municipalities in the county of Stockholm (26 documents). The coding of the analyses from the county of Stockholm were only used to calibrate the coders, i.e. to make sure that their assessments were similar, and to assess inter-coder reliability (see below).

5.2. The inter-coder reliability

The 33 RVA:s from local municipalities in Scania were analyzed by one of two coders. Among these documentations, both coders analyzed five of them, as well as four of the ones from the county of Stockholm with the purpose to check the inter-coder reliability (more specifically "inter-coder agreement"; [54–56]). It corresponds to roughly 15% of the RVA:s from the two counties. Two different methods were used in our study: the percent agreement method (also called simple agreement, percentage of agreement, or crude agreement) and Krippendorff's alpha (α) coefficient [57]. The percent agreement is the percentage of all coding decisions made by the coders on which the coders agree. It is simple, intuitive and easy to calculate. However, this method also has some major weaknesses, the most important of which involves its failure to account for agreement that would occur simply by chance, especially when the overall sample size is relatively small [56]. In order to minimize the possible overestimating of the agreement between the coders, Krippendorff's Alpha (α) coefficient was also calculated, not only because it is suitable when the analysis performed by multiple coders, but also because it is appropriate in cases when the variables are described on different types of scales (nominal or ordinal).

In the literature, the criterion for good percentage agreement is 90% [56] and for Krippendorff's alpha (α) coefficient is of 70% [58]. The values that we obtained were .89 for the percent agreement (for all six variables) and between .78 and .99 for Krippendorff's alpha (α) coefficient, which means there was very good agreement between the two coders in our study. Therefore, the results of the content analysis can be considered to be sufficiently reliable.

5.3. Ranking of the risk description's usefulness

5.3.1. The professionals

The document analysis was followed by a workshop (half a day) held with representatives from the county administrative board of Scania, who are responsible for the region's RVA work. Written information was sent to the board, prior to the workshop, to provide some background information concerning the study, the purpose of ranking the RVA:s, and instructions for the ranking. The participants in the workshop use the RVA documents in their jobs and they were therefore familiar with the material beforehand. Moreover, they also met several times before the workshop when the ranking was conducted and discussed the task. All county administrative boards have the task of evaluating the RVA:s produced within their geographic area of responsibility and therefore the participants were familiar with assessing the material from different perspectives. During the workshop, six representatives from the county administrative board were asked to rank all the RVA:s produced by the local municipalities in Scania. The ranking was performed with respect to how useful these documents were perceived to be as a basis for decision making on the regional administrative level, i.e. when the regional RVA document is developed. Each RVA was read thoroughly by at least two participants to reduce individual variation in the rankings. The group discussions also served to reduce individual variation. The result was an overall ranking of the municipal RVA:s within the region, with respect to whether they contained useful descriptions of risk that could be used to serve as a basis for decisions and further develop a regional RVA.

5.3.2. The students

In addition to arranging the workshop with the professionals from the county administrative board we also arranged two workshops with students from the master's program in risk management and safety engineering at Lund University. The students were all close to the end of their education (they had less than a year before graduation). They were given the same task and almost the same information as the representatives from the county administrative board. The only difference was that the number of RVA:s the students used was less than number used in

the county administrative board workshop. Since 10 of the 33 RVA:s contained classified material they were excluded from the student workshops. However, the remaining 23 RVA:s were identical to the ones rated during the county administrative board workshop. Five students participated in the first workshop and five in the second.

5.4. Correlational analysis

The aim of this study was to explore the question of what constitutes a useful description of risk, from the county administrative board's perspective, based on the description of risk communicated by the municipal RVA documents. In order to identify variables that are of importance in the usability of the municipal RVA:s, particularly when used as input for the regional risk assessment, statistical analysis was conducted to identify any possible correlations between the overall rankings of municipal RVA:s and the six variables used in analyzing the 33 municipal RVA:s (23 for the student groups). The software IBM SPSS Statistics and Spearman's rho [59] were used for statistical analysis (two-tailed test, $\alpha=.05$).

6. Results

Table 3 shows the results of the statistical analysis regarding correlations between the overall ranking of the county administrative board and the students, and the variables in Table 1.

The findings of our study indicate that there is a moderate correlation between $A_{Scenario}$ and the rank provided by the county administrative board. Although the results are statistically significant ($\alpha=.05$) for the county administrative board it is not so for one of the student groups. Nevertheless, despite the fact that the results are somewhat ambiguous we still find that they support hypothesis *H1*, i.e. that the inclusion of scenario descriptions in risk descriptions leads to greater perceived usefulness. However, we cannot find support for hypothesis *H2*, i.e. that including background information concerning how scenarios were selected will lead to greater perceived usefulness.

Moreover, the findings also indicate that there is a relationship between the way in which information concerning the likelihood *(H3)* and consequences of events *(H5)* is presented in a risk description and the perceived usefulness of that risk description. The results are statistically significant ($\alpha=.05$) for both variables ($Q_{Likelihood}$ and $C'_{Consequences}$) and for all groups (county administrative board and students). The strength of the correlations is moderate from the county administrative board workshop and student workshop 2, while the indicated correlation is slightly stronger from the student workshop 1.

Finally, the results supports hypothesis *H4*, i.e. they show that there is a relationship between the presence of background information concerning likelihood in a risk description and its perceived usefulness. The result is statistically significant ($\alpha=.05$) for all groups. However, we did not find support for hypothesis *H6*, which is concerned with the presence of background information regarding consequences. Although the results from the student groups show a significant result in terms of that hypothesis, the results from the county administrative board are not statistically significant.

Table 3
Results of the correlation analysis (Spearman rho, two-tailed test). Test results presented in bold are significant on α-level .01 and those presented in italics are significant on α-level .05.

Variables	County administrative board ($n=33$)	Student group 1 ($n=23$)	Student group 2 ($n=23$)
$A_{Scenario}$	*ρ=.42, p=.015*	ρ=.26, p=.223	*ρ=.50, p=.016*
$A_{Background}$	ρ=.12, p=.502	ρ=−.22, p=.303	ρ=.30, p=.158
$Q_{Likelihood}$	**ρ=.59, p<.001**	**ρ=.74, p<.001**	**ρ=.57, p=.004**
$K_{Likelihood}$	**ρ=.54, p=.001**	**ρ=.56, p=.006**	**ρ=.71, p<.001**
$C'_{Consequences}$	**ρ=.59, p<.001**	**ρ=.75, p<.001**	*ρ=.52, p=.012*
$K_{Consequences}$	ρ=.33, p=.058	*ρ=.45, p=.032*	**ρ=.54, p=.009**

7. Discussion

The present study represents an attempt to investigate what professionals working in disaster risk management systems perceive as useful ways of communicating descriptions of risk. We believe that this is of the utmost importance as many countries have recently developed, or are developing, "all-hazards/whole of society" approaches that are considered essential to prevent and prepare for various disastrous events. Developing these systems also involves constructing different guidelines and regulations on how risk descriptions should be communicated between stakeholders. Our study contributes to the design of such a process by providing insights into what kind of risk descriptions are perceived as useful. However, it should be noted that "useful risk descriptions" are not a goal in themselves. Rather, they are a *means* of achieving the *goal* of less damage to the things that human beings value, which in this context of societal safety often refer to critical societal functions, life and health of the citizens and their basic requirements (see for example [60]). However, it is very difficult to investigate the effect of different risk descriptions on actual losses. It would, for example, be difficult to collect a sufficient amount of data because disasters do not happen very often, and it would be very difficult to account for all the contextual variables that might influence the occurrence and development of disasters. Therefore, we consider the approach taken in the present paper to be more practical to investigate the issues of interest. Obviously, the relevance of the present study rests on the assumption that if some risk descriptions are perceived as more useful than others, it will be more likely that these descriptions lead to good decisions to prepare for or prevent disasters, which will then be implemented and hopefully influence the actual outcome in a positive way. However, the appropriateness of that assumption must be tested in future research. For example, using a specific type of risk description might increase the likelihood of well-grounded risk management decisions even though the professionals might not consider them to be more useful than others. In the present context, i.e. when focusing on disaster risk management, we expect that including background information regarding consequence estimates should lead to an improved situation, although we could not detect any significant difference due to this variable in our study. The reason is that if background information is included it helps the decision maker to judge the credibility of the assumptions underlying the assessments. Moreover, describing the background information would be even more important in situations characterized by deep uncertainties (see discussion in [20]).

Other aspects of the present study that should be developed in future studies include the addition of more variables, the development of more refined scales for the variables, and the replication of the results in controlled experiments. The strengths of the present study are that (1) it involves professionals, i.e., people actually working in a disaster risk management system, and (2) real risk descriptions, i.e., the actual documents that are sent to different stakeholders with the aim of communicating risk. This affords the study a high degree of relevance, both in terms of the material used (the actual documents) and in terms of the people/individuals making the estimates. However, paradoxically, it is also a weakness, as it can be argued that the documents that we have

used contain much more than descriptions of risk, and the assessment of their usefulness may thus be influenced by other factors. Moreover, since we did not have any control over the form of the documents, it was impossible to ensure that there was an even distribution between the states of the variables. If we had been able to control the material, as in a controlled experiment, we could have ensured that all possible states of the variables were equally represented in the material assessed by the participants in the study. It would also have been possible to make the distinction between the different states of the variables clearer, and avoid ambiguous examples. For example, in the material we used, some documents were not easily classified according to the variables. It may be that in one part of the RVA, a particular variable, for example, $Q_{Likelihood}$, was expressed in a certain way, while in the rest of the document it could be expressed in another way. This is also the reason why it was important to investigate the inter-coder reliability in the present study. Such analysis would not be necessary in controlled experiments. Another aspect that should be included in future studies is the investigation of the effect of more aspects of the risk descriptions. For example, the descriptions of the knowledge on which the consequences and uncertainties are based (K) may take many forms and include many types of information (see, for example [41]). It is highly likely that the extent to which such information is included in a risk description, and the way in which it is presented, will influence the perception of the usefulness of that risk description. However, K was only represented by dichotomous variables in this study (either there is background information, or there is not). It would be interesting to use a more detailed description of the variables representing K in future studies.

Despite the many drawbacks of using real documents in a study such as the present one, we believe that the approach is justified as a first step in gaining a better understanding of what professionals perceive as a useful risk description. The most reasonable continuation of the present research seems to be to carry out controlled experiments in which the hypotheses are tested again to investigate whether it is possible to replicate the results. Such a study is presently being conducted.

8. Conclusions

We have conducted experiments with a group of six risk management professionals at a county administrative board in southern Sweden. They were asked to rank a set of 33 risk and vulnerability assessments from municipalities in their county, based on the perceived usefulness. We then analyzed the documents based on the risk descriptions they provided and tested six hypotheses concerning the usefulness of the risk descriptions. We also invited 10 master students who were trained to be the professionals in the field of risk management and safety engineering to do the same task as the representatives from the county administrative board did.

Based on the results of our analysis, we conclude that the way in which estimates of the likelihood of events and consequences are described influence the perceived usefulness of a risk description. Similarly, the way in which estimates of consequences are described also influences the perceived usefulness of a risk description. More precisely, it seems as the more of the following operations that can be performed using the estimates of either likelihood or consequences, the greater the perceived usefulness: (1) determination of equality, (2) determination of greater or less, (3) determination of equality of intervals or differences, and (4) determination of equality of ratios. Furthermore, including background information in the estimates of likelihood in a risk description positively influences the perceived usefulness. Finally, we also found that including descriptions of scenarios appears to positively influence the perceived usefulness of the risk description. Although we were not able to find support for the importance of including background information concerning consequence estimates and concerning the choice of scenarios, we still believe that these aspects are important in a risk description.

Despite the fact that the number of participants in this study was limited in that we only included professionals from one county administrative board, of which there are 21 in Sweden, we believe that the results are valid in a broader disaster risk management context.

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Paper III

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Communicating risk in disaster risk management systems – experimental evidence of the perceived usefulness of risk descriptions

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Disaster risk management (DRM) requires the collaboration of a variety of stakeholders working in different sectors. They depend on each other to share risk information, and effective collaboration requires efficient communication. Clearly, the communication of risk descriptions is a key issue for the success of DRM activities. This study investigated the communication of risk-related information between DRM actors, and how to present such information in order to improve its usefulness as a basis for decision-making. Two experiments were conducted to investigate the issue. The first related to the type of hazard, while the second examined the presentation of likelihood and consequences. We addressed two research questions: *Does the presentation of a risk description influence its perceived usefulness for decision-making in a DRM system? If so, which format is perceived as most useful?* Our findings indicated that the type of hazard did not affect perceived usefulness to any significant extent. However, the presentation of likelihood and consequences did have a significant effect. These results indicate that the presentation of risk information greatly influences stakeholders' ability to make well-informed decisions. Specifically, quantitative scale and semi-quantitative ranking scale formats are perceived as most useful.

Keywords: disaster risk management (DRM); risk communication; risk description; perceived usefulness; decision-making

Introduction

Societies around the world are suffering increasing losses due to disasters, and it is of the utmost importance to improve our ability to manage disaster risks (CaDRI 2011; UNISDR 2007, 2015). However, it is not easy to accomplish in practice. One important reason for this is that in modern societies the authority, resources and expertise to manage risk are distributed among many different actors. Therefore, even the actions of a government might not alone be enough to prevent and/or respond to disasters. Instead, the focus needs to be on the collective ability of many

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actors, both public and private, to work towards improved management of disaster risk (World Economic Forum 2014).

An important reason for the increasing need to address the management of risk collectively is the increased complexity of modern societies. High dependencies between different functional sectors (e.g. power distribution and transport) and geographical areas necessitate extensive collaboration (OECD 2010). More precisely, when individual actors identify, analyse and respond to risks using a narrow perspective of what is worth protecting and how to achieve it, their efforts are likely be ineffective and perhaps even harmful to the overall ambition of reducing losses due to disasters. Effective collaboration, in turn, requires efficient communication of risk-related information (Wyman 2009).

In this article we focus on the communication of risk-related information between actors involved in disaster risk management (DRM), and how to present such information in order to increase its usefulness as a basis for decision-making. The decisions of interest here pertain to the management of risks in so-called DRM systems; for example, how to manage flood risk in a municipality, or how to deal with threats to critical infrastructure.

We conducted two experiments to investigate the perceived usefulness of some common ways to present risk descriptions in DRM systems. The first focused on the type of hazard, and the second related to the presentation of likelihood and consequences. They addressed the following two research questions: *Does the presentation of a risk description influence its perceived usefulness for decision-making in a DRM system? If so, which format is perceived as most useful?*

This paper is structured as follows. We first provide a brief overview of DRM systems, focused on how descriptions are used and how they support decision-making. We also provide a brief account of previous research focused on the communication and presentation of risk. Next, we introduce the theoretical concepts used in the present study and describe the two experiments that investigated perceived usefulness. We then discuss the implications of our results and the limitations of the study, together with some suggestions for future research. Finally, we present our conclusions.

Background

Decision-making in DRM systems

Worldwide losses due to disasters remain high. In the past 10 years alone, 700,000 people have lost their lives, and economic losses are estimated to exceed $1.3 trillion (UNISDR 2015). There is already agreement that greater focus needs to be put on disaster risk reduction to reduce future losses (UNISDR 2015) and to achieve this, so-called ‘all-hazards’ and ‘whole-of-society’ approaches are crucial. These approaches imply the involvement of many different actors, both public and private, and the consideration of a broad range of hazards that threaten what is considered valuable (G20 and OECD 2012; Von Lubitz, Beakley, and Patricelli 2008). Different countries use different terms to denote the process(es) implemented to achieve this; for example ‘country risk management’ (OECD 2011; Wyman 2009). Here, we use the term DRM. DRM has been defined as ‘the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse

impacts of hazards and the possibility of disaster' (UNISDR 2009). Moreover, we use the term 'DRM system' to describe the stakeholders, technical systems, mechanisms, etc. that are involved in the implementation of DRM activities (Lin and Abrahamsson 2015; Rivera, Tehler, and Wamsler 2015).

The overall purpose of DRM is to limit the impact of hazards and reduce the likelihood of disasters. To achieve this, actors in DRM systems must be able to identify, assess and evaluate different risks and make informed decisions on how to deal with them. However, many disaster risks are transboundary (Ansell, Boin, and Keller 2010; Boin 2009), i.e. they may result in disasters that affect several functional and policy sectors, and be spread over vast geographical areas. Therefore, a single actor, such as a local rescue service or a hospital seldom has all the information necessary to make an adequate assessment. They are, instead, dependent on information from others in order to produce credible assessments that can serve as a basis for decision-making. In the institutionally fragmented, but technically tightly-connected environment that characterizes today's societies, it is highly likely that most stakeholders in the DRM system are dependent on information from others to assess risk (Almklov and Antonsen 2010; De Bruijne and van Eeten 2007; De Bruijne et al. 2006).

Since many of the risks addressed by DRM systems cannot be easily managed by one or a few actors, or within a specific policy area, it is often difficult to identify 'the' decision-maker(s) or risk analyst(s) in a particular context. Separating the risk analyst from the decision-maker is an old idea; it was first suggested in a report prepared by the United States National Research Council in 1983 (National Research Council 1982). The change was motivated by a desire to protect the risk assessment process from potential bias resulting from values related to risk management. It was thought that by separating the two activities the risk assessment could be kept 'value free'. The focus would be on science and facts, and thereby the assessment would be more credible (National Research Council 1982).

Although the practice of separating the analyst from the decision-maker might have avoided problems of undue influence on risk assessment, it created others, for example shutting the public out of the decision-making process (Vareman and Persson 2010). In addition, it suggests that some people are 'producers' of risk-related information (analysts) and others are 'users' (decision-makers). However, in modern DRM systems, this is not the case. Most professionals working in DRM systems are both producers and users of risk information. For example, a person who produces a risk assessment focused on hazards at a regional level may also use risk assessments produced at the local level. Thus, even though a person might not be a decision-maker (in the traditional sense of having a formal mandate to make specific decisions) he/she may still use risk assessments as a basis for his/her work. More importantly, the risk assessment produced at the regional level will be highly influenced by the quality of the information supplied at the local level.

The decision-making context in modern DRM systems has been described in more detail by other authors who have investigated some of the challenges (Månsson et al. 2015; Vastveit, Eriksson, and Njå 2014; Vlek 2013). An important policy question is how to communicate risk in ways that are suitable for decision-making and address challenges. For example, in Sweden the legislation clearly states that an important purpose of the risk assessments produced by the actors in the DRM system is to support decision-making (Abrahamsson and Tehler 2013). The government authority responsible for legislation (the Swedish Civil Contingencies

Agency) has recently issued new regulations that aim, among other things, to improve the usefulness of assessments produced at lower administrative levels (e.g. municipalities) as a basis for decision-making at higher levels (e.g. county administrative boards and national authorities). Legislation, guidelines and recommendations for the communication of risk in DRM systems are continuously being improved, not only on a national level (Vlek 2013) but also internationally (The European Commission 2010; Wyman 2009). This highlights that the issue of how to present and communicate risk information in a DRM system is a relevant and important practical problem.

Risk communication research

Despite the practical importance of how to present and communicate risk in DRM systems, little research has explicitly addressed the problem. Previous studies suggest that good-quality inputs and evidence contribute to sound risk-based decisions (Pollard et al. 2008). While various authors have pointed out the importance of communication in contexts where risk is managed by many actors (van Asselt and Renn 2011; IRGC 2009; Renn 2014), few have focused on the presentation of risk.

One reason for this might be that risk communication research was initially focused on communication with the public in order to convince them of the quality of the assessments made and measures taken by experts (Fischhoff 1995; Renn 2014). Risk communication was widely regarded as a one-way process focused on getting the appropriate message across. The field has advanced considerably since then, and it is now recognized to be a much more complex activity (see, for example, reviews in Gurabardhi, Gutteling, and Kuttschreuter (2004, 2005); Bradley, McFarland, and Clarke (2014)). It is seen as an imperative in risk management involving multiple stakeholders, and in contexts characterized by high levels of ambiguity, complexity and uncertainty (van Asselt and Renn 2011; Hermans, Fox, and van Asselt 2012). However, research remains concentrated on the relation between experts and the public, while considerably less attention has been paid to communication between experts (Bier 2001; Thompson and Bloom 2000).

Our focus on the communication of risk among professionals in a DRM system is therefore different to previous work. Although the study presented here can be related to experimental studies of risk perception (see for example Renn and Benighaus (2013)), it is nevertheless new. Risk perception research usually focuses on how participants perceive risk in various circumstances. However, here we focus on the usefulness of risk descriptions as a basis for decision-making. Although participant's perceptions may be different, they might still find descriptions equally useful as a basis for making decisions.

Although unlike risk communication and perception research, this study is similar to previous contributions in terms of its focus on professional communication and its experimental approach. For example, the difficulty of communicating risk between experts from different sectors was investigated following disasters such as the 9/11 attacks in the United States in 2001 (Kramer 2005) and hurricane Katrina in 2005 (Comfort 2007; Garnett and Kouzmin 2007). Challenges related to the presentation of risk have been investigated in the Swedish DRM system (Abrahamsson and Tehler 2013; Tehler, Brehmer, and Jensen 2012).

With respect to methodology, Dieckmann, Mauro, and Slovic (2010) took an experimental approach in their investigation of the presentation of analytic uncertainty

in intelligence forecasts. They focused on, among other things, how useful risk descriptions were perceived to be based on the presentation of background information. Their results indicated that intelligence forecasts were perceived to be more useful if background information was present; specifically, if explanations were included, and probabilities were presented as a range rather than a single number (Peters et al. 2009). Their study also investigated the effect of participants' numeracy on the use of narrative evidence and found that the less numerate relied on it more than the more numerate.

The experiments described by Peters et al. (2009) and Dieckmann, Mauro, and Slovic (2010) were performed with participants drawn from the public and students, and focused on the expression of uncertainty based on probabilities. However, in DRM systems much of the information concerning risks is not communicated in this format (Månsson et al. 2015) and the persons communicating it are often professionals with at least some experience in the area. Therefore, in a previous study we investigated how different aspects of the risk description contributed to its perceived usefulness as a basis for decision-making (Lin et al. 2015). Using risk descriptions taken from the Swedish DRM system, we asked professionals to judge their usefulness. The results confirmed a relationship between the presentation of risk descriptions and perceived usefulness.

As our previous study used real documents that were produced and used in the Swedish DRM system, our ability to control external factors was restricted. Consequently, an experimental approach was taken in this study. This offered greater control over external variables, resulting in higher internal validity. Moreover, we were able to investigate the generalizability of our results to other groups of professionals and nationalities.

This study aims to improve our understanding of how to improve the presentation of risk descriptions in a DRM system so that stakeholders perceive them as a useful support for decision-making. Although we acknowledge that a risk description may serve several purposes (Goble and Bier 2013), providing a basis for decision-making is one of the most important.

Theoretical concepts

The theoretical concepts used in this study are similar to those employed in our previous study (Lin et al. 2015). As before, perceived usefulness was defined as 'the degree to which a person believes that a specific risk description would enhance the basis for decision-making' and is the dependent variable in the two experiments described here. The risk framework presented by Aven (2010, 2011) was the point of departure.

The present study investigates how the presentation of risk descriptions influences their perceived usefulness for decision-making. The notation is drawn from Aven's risk framework and takes the form (C', Q, K), where C' denotes consequences, Q represents the uncertainty concerning consequences and K is background knowledge (Aven 2012). Specific events that lead to consequences C' are denoted A' (Aven 2012). Independent variables are also based on Aven's framework. The first (*type of scenario*) is denoted A'_{Type}. This refers to a specific hazard that triggers a scenario. Two scenarios were considered: flood and fire. Thus, A'_{Type} may be either *Flood* or *Fire*. The effect of varying A'_{Type} was investigated in the first experiment (Experiment 1), while Experiment 2 only considered flood ($A'_{Type} = Flood$). As in

our previous study (Lin et al. 2015), we investigated the effect of the presentation of consequences ($C'_{Consequences}$) and their likelihood ($Q_{Likelihood}$).

Likelihood and consequences were presented as: (1) Not included; (2) Qualitative description; (3) Qualitative ranking scale; (4) Semi-quantitative ranking scale or (5) Quantitative scale (probabilities or frequencies). These ways of presenting risk are commonly found in DRM systems, for example Dutch and British risk assessments use semi-quantitative ranking scales (Ministry of Security and Justice 2014; The Cabinet Office (UK) 2015). Moreover, studies of local, regional and national administrative levels in the Swedish DRM system found all of the above types (Lin et al. 2015; Månsson et al. 2015). These formats are not exclusive; for example a risk description may describe the likelihood of certain consequences using a ranked semi-quantitative scale, whereas the consequences themselves could be described using a ranked qualitative scale.

Unlike Lin et al. (2015), this study presented both likelihood and consequences in the same format. Thus only one variable (QC') denoted how both likelihood ($Q_{Likelihood}$) and consequences were described ($C'_{Consequences}$) taking one of the five values given above.

Two experiments were conducted. The first investigated whether the scenario influenced perceived usefulness, and served as a pilot study for the second.

Experiment 1 – the influence of scenario

Overview

Although the type of scenario was expected to influence perceived risk, we did not expect it to greatly influence perceived usefulness, especially for descriptions that contain similar amounts of information expressed in the same way (e.g. a description of the context followed by a description of the consequences). Before selecting the scenario to be employed in the main (second) experiment, we tested whether this assumption was correct. As it was clear that we could not test all possible DRM scenarios, we limited the experiment to two situations commonly found in the Swedish system: flood and major fire. The first hypothesis was:

> The scenario does *not* influence the perceived usefulness of the risk description.

We tested this hypothesis by comparing the perceived usefulness of risk descriptions in which QC' was the same, but A'_{Type} differed. Constructing scenarios that only differed with respect to A'_{Type} was not easy, as we did not want to introduce additional factors that may have affected the results. For example, we were concerned that the length of the risk description might influence its perceived usefulness. We therefore used almost the same number of words to describe both scenarios, while likelihood and consequences were formatted in the same way. Although previous work indicates that there are five main ways to express likelihood and consequences, we only used quantitative descriptions ($QC' = Quantitative\ scale$).

Method

Participants

A seven-point Likert scale was used to measure perceived usefulness and it was not assumed that the results were normally distributed. Non-parametric methods were thus used in the analysis, which required an approximation of the minimum sample size. As perceived usefulness was investigated using the Wilcoxon signed-rank test, the required sample size was first calculated assuming that a paired *t*-test would be used. This was then adjusted to take into account the fact that the Wilcoxon signed-rank test would be used[1] and led to the addition of roughly 5% to the required number of participants, making a total of 21.[2]

A class of 30 students from the Master's Risk Management Program at Lund University was identified as a suitable group. Students were chosen because it was important that participants could easily comprehend risk descriptions, and all of the selected students had passed a basic course in risk assessment. They were recruited by email and 28 agreed to participate in the study; 15 women and 13 men. They were aged between 22 and 31 years, with a mean age of 24.

Procedure

Participants were sent a link to a web page. A short description of the study was provided on the first page. This informed them that the subject of the experiment was the usefulness of different types of risk descriptions, and that on the following pages they would be presented with two types of risk description from a local municipality. They were also informed that they would be asked a series of questions about each description.

One scenario involved severe flooding ($A'_{Type} = Flood$) and the other severe fire ($A'_{Type} = Fire$). The descriptions were short enough to avoid scrolling through several pages. Both descriptions were similar in length and structure (see Appendix 1), and the language and content was similar to real risk descriptions used in the Swedish DRM system. Participants were asked to assume the role of a professional who must use the descriptions as the basis for decision-making, e.g. to determine whether risk reduction measures were necessary. Finally, they were asked to indicate the extent to which they agreed with the statement: 'The risk description is useful for decision-making' on a seven-point Likert scale (1 indicating that they strongly disagreed, and 7 that they strongly agreed). Each participant rated the usefulness of two risk descriptions related to two types of hazards (flood and fire).

Results

The mean rating of the usefulness of risk descriptions was 4.8 for flood and 4.4 for fire (the median was 5 for both scenarios). The Wilcoxon signed-rank test showed that the difference was not significant ($W = 34$, $p = 0.203$).

Despite this result, it is of course possible that a difference may exist when comparing risk descriptions of other types of scenarios. Nevertheless, given the small difference that was found, the second experiment focused on only one scenario: flood.

Experiment 2 – the presentation of likelihood and consequences

Overview

The second experiment investigated whether the presentation of likelihood and consequences influenced the usefulness of the risk description. The quantitative description of flood scenarios used in the first experiment was complemented by the four other types of descriptions described above. These descriptions only differed in how likelihood and consequences were described, and all other information was identical (see Appendix 2).

Our previous study (Lin et al. 2015) had indicated that professionals working in DRM perceived the usefulness of risk descriptions to be different depending on how likelihood and consequences are expressed. Therefore, we expected to see a similar difference in the present experiment and the second hypothesis was formulated as:

> Changing the way in which consequences and likelihood are expressed *will* influence the perceived usefulness of the risk description.

Moreover, consistent with our previous study, we expected quantitative scale and semi-quantitative ranking scale formats to be perceived as most useful.

Method

Participants

Three groups participated in the experiment. The first (Group 1) was made up of graduates from the Bachelor's Program in Fire Safety Engineering and the Master's Program in Risk Management at Lund University. They were recruited by an email sent to approximately 400 graduates that had been randomly selected from all graduates of the programs (approximately 800). Fifty agreed to participate; 40 men and 10 women. Participants were aged between 23 and 62 years old; the mean age was 35 and they had been working in DRM (including fire safety) for an average of 8 years. Since group members had formal training in risk assessment and considerable experience in working with risk and safety issues, we expected their perception of the usefulness of the risk descriptions to differ from that of other groups with no formal training or experience.

To investigate if this was indeed the case, we identified a second group of urban planning students with some experience of reading and producing risk assessments, and a third group of urban planning professionals working in Nicaragua. Although urban planners do not have any formal training in risk assessment, they frequently deal with issues related to hazards such as floods. Thus, while they were not as experienced in risk assessment as the first group, they did have sufficient knowledge to understand DRM risk descriptions.

Not only were the second and third groups different from the first in terms of their expected degree of risk knowledge, they also differed in terms of nationality. We denoted the student group as Group 2, and the professional group as Group 3. Group 2 consisted of 31 individuals, 17 male and 14 female, aged between 19 and 33 years (mean 21 years). Group 3 consisted of 33 participants, 19 male and 14 female, aged between 23 and 62 years (mean 36 years). They had between one and 25 years' experience as an urban planner (mean 6 years).

Thus, a total of 114 participants took part in the second experiment.

Procedure

This experiment was both web- and paper-based. Groups 1 and 3 completed the web-based version and Group 2 the paper-based version. Group 1 completed the task in Swedish, while Groups 2 and 3 carried out their respective tasks in Spanish. The authors, who include native speakers of both Swedish and Spanish, translated the two versions. Participants who completed the web-based task were provided with a link to a web page, where a short introduction was provided. After reading the introduction, they were instructed to click a button leading to a web page that gave one of the five risk descriptions. Students completed the same task, but on paper. Participants were shown a risk description, and asked to rate how useful they thought it was as a support for decision-making on a seven-point Likert scale (as described above). They were also asked if some descriptions were perceived to be easier to use than others, and whether they were clear, logical and realistic, i.e. if they could be part of a real risk and vulnerability assessment. As for perceived usefulness, all of these aspects were measured on a seven-point Likert scale.

As we wanted participants to evaluate alternative risk descriptions we used a within-subjects design. The drawback of this approach (compared to a between-subjects design) is that the demand effect may introduce spurious artefacts. This implies that subjects anticipate the intentions of researchers, and consciously or subconsciously attempt to provide answers that fulfil their expectations (Charness, Gneezy, and Kuhn 2012). Although participants were aware that we were investigating the perceived usefulness of the descriptions, they were not provided with any information that would help them to discern the intentions of the researchers. Another bias that can occur in a within-subject design is the learning effect, i.e. respondent's answers to later questions may be affected by their response to previous questions. To reduce the learning effect descriptions were presented to participants in random order.

Results

As in the first experiment, means were calculated and the results are given in Table 1.

A Friedman test determined whether perceived usefulness differed depending on how the risk was described using an α-level of 0.05. Statistically significant differences were found in all three groups: Group 1: χ^2 (4, n = 50) = 96.8, $p < .05$; Group 2: χ^2 (4, n = 31) = 15.6, $p < .05$ and Group 3, χ^2 (4, n = 33) = 20.7, $p < .05$. This result rules out the possibility that the way in which likelihood and consequences are expressed in risk descriptions has *no* effect, and supports Hypothesis 2.

Table 1. Mean Likert scale values for group assessments of the five flood scenarios.

Description of likelihoods and consequences (QC′)	Group 1	Group 2	Group 3
1. Not included	2.94	5.61	4.70
2. Qualitative description	3.32	5.06	5.00
3. Qualitative ranking scale	3.98	5.23	4.91
4. Semi-quantitative ranking scale	5.56	6.23	5.45
5. Quantitative scale	5.08	5.68	5.67

Table 2. Differences between risk descriptions.

Comparison between descriptions	Group 1			Group 2			Group 3		
	P	W	A_{12}	P	W	A_{12}	p	W	A_{12}
1 & 2	9.27×10^{-2}	84	0.61	0.100	149	0.45	3.22×10^{-1}	56	**0.74**
1 & 3	$\mathbf{8.20 \times 10^{-4}}$	79	**0.71**	0.101	89	0.55	3.56×10^{-1}	58	0.65
1 & 4	$\mathbf{2.07 \times 10^{-8}}$	24	**0.89**	4.15×10^{-2}	35	0.53	3.49×10^{-2}	56	0.70
1 & 5	$\mathbf{5.54 \times 10^{-7}}$	94	**0.85**	0.933	97	0.66	1.12×10^{-2}	49	0.53
2 & 3	$\mathbf{2.21 \times 10^{-4}}$	11	0.67	0.492	87	0.63	5.78×10^{-1}	79	0.55
2 & 4	$\mathbf{1.05 \times 10^{-8}}$	4	**0.91**	$\mathbf{1.42 \times 10^{-3}}$	35	0.65	5.86×10^{-2}	15	0.58
2 & 5	$\mathbf{1.75 \times 10^{-6}}$	72	**0.82**	7.85×10^{-2}	82	0.61	4.12×10^{-2}	51	0.67
3 & 4	$\mathbf{3.50 \times 10^{-7}}$	23	**0.82**	$\mathbf{8.56 \times 10^{-4}}$	5	0.53	1.64×10^{-2}	19	0.50
3 & 5	$\mathbf{1.32 \times 10^{-3}}$	130	**0.72**	0.241	60	**0.71**	1.02×10^{-2}	33	0.62
4 & 5	2.60×10^{-2}	319	0.61	3.40×10^{-2}	133	**0.73**	6.10×10^{-1}	74	0.67

Note: A p-value below 0.005 is statistically significant (Bold). W is the Wilcoxon test statistic and A_{12} is the measure of stochastic superiority. A large effect size, i.e. an A_{12} value of 0.71 or more is represented in bold.

A Wilcoxon signed-rank test investigated differences between ratings in more detail. A Bonferroni correction was applied, resulting in a significance level of $p < 0.005$ for each group. Results are given in Table 2. Statistically significant differences in perceived usefulness are indicated by p-values in boldface (i.e. $p < 0.005$).

The effect size was estimated using the A_{12} measure of stochastic superiority (Delaney and Vargha 2002). A_{12} is the probability that the perceived usefulness is higher for the first risk description than the second for a randomly selected participant. For example, Table 2 shows that for Group 1 the difference between the perceived usefulness of descriptions 1 and 4 is 0.89. This means that there is an 89% probability that a randomly-drawn participant from Group 1 has expressed a higher perceived usefulness for description 1 than description 4. The results given in Table 2 show that the effect size was moderate to high for Group 1 (graduates in fire safety and risk management), except for descriptions 1 and 2.[3] The effect size for the other two groups (students and practitioners of urban planning) was more varied.

Spearman rank order correlations determined if the perceived usefulness of a risk description was related to its ease of use. The results showed that they were strongly related in all three groups ($r_s(50) = 0.80$, $p < 0.001$; $r_s(33) = 0.79$, $p < 0.001$; $r_s(31) = 0.70$, $p < 0.001$). Similarly, a relationship was found between the usefulness of a risk description and the extent to which it was perceived as clear and logically structured, although its strength differed between groups, ($r_s(50) = 0.52$, $p < 0.001$; $r_s(33) = 0.71$, $p < 0.001$; $r_s(31) = 0.37$, $p < 0.001$). The correlation was stronger in professional groups (1 and 2) than the student group (3).

Discussion

There are several reasons why it is difficult to draw firm conclusions from these results. First, we only investigated two scenarios (flood and fire) and other scenarios commonly found in DRM systems may have a significant effect. However, from a practical perspective, it is more interesting to establish whether other scenarios would lead to a different ordering of usefulness. If this is robust, the best format

would remain the same. Although more experiments are needed, we see no reason why the ordering would be significantly different. Secondly, the limited number of participants meant that the sample was unlikely to be representative of everyone working in a DRM system. Nevertheless, it included people both with and without formal training in risk assessment, and others with different backgrounds belonging to different professions.

Like the results from previous quantitative (Lin et al. 2015) and qualitative (Månsson et al. 2015; Rivera, Tehler, and Wamsler 2015) investigations, the conclusions remain to be confirmed. Nevertheless, although other studies have used different methods, they point to the importance of the presentation of risk information in a DRM system.

This brings us to the issue of external validity. It is of course important to be careful not to exaggerate the practical relevance of the results obtained here. As Richard Eiser et al. (2012) noted when discussing laboratory experiments in the context of disaster management, such procedures are '… often not well suited to the study of dynamic interactions within complex systems over time and space'. Therefore, our findings should not be seen in isolation. Instead, they should be considered in relation to results from similar studies.

An experimental approach can complement more qualitative approaches, as it can be difficult to judge the effect of risk presentation in a real-world DRM context (Falk and Heckman 2009). This is because it is difficult to isolate the effect of a single variable since multiple confounding variables that cannot be controlled influence the results.

As noted above, the results presented here are consistent with the findings of our previous study based on real risk description documents produced in the Swedish DRM system (Lin et al. 2015). This study also showed that the presentation of likelihood and consequence influences the perceived usefulness of a risk description. Quantitative scale or semi-quantitative ranking scale tended to be perceived as more useful than others (not included, qualitative description or qualitative ranking scale). Finally, the study presented here found that differences in perceived usefulness between the five formats seemed to be greater among those with more experience of risk assessment.

These results are interesting given that British and Dutch risk assessments currently use semi-quantitative scales (The Cabinet Office (UK) 2015; Ministry of Security and Justice 2014). However, the Swedish system is different (Swedish Civil Contingencies Agency (MSB) 2015) and the question arises of whether it would be advisable for Sweden to follow the British and Dutch examples. This will of course depend on the purpose of the assessment, given that it is not necessarily to provide a basis for decision-making. Nevertheless, should this be the case, our results indicate that it might be worth adopting a procedure similar to the one already in place in the United Kingdom and the Netherlands. At the same time, it must be noted that semi-quantitative scales used in risk matrices have serious shortcomings (Cox 2008), and these must be taken into account when deciding whether to implement a change.

An additional limitation of our study is the fact that the amount of text used in the various risk descriptions was different. The descriptions contained between 196 (not included) and 484 words (semi-quantitative ranking scale). More text might automatically be perceived as more useful than less. However, this seems unlikely as although the quantitative scale description contained fewer words than the

qualitative description, it was still perceived as more useful. Thus, the effect does not seem to be very strong.

Nevertheless, the importance of narrative information (Peters et al. 2009) in the presentation of risk suggests that more research is needed into its importance in the DRM context. Narrative information can be directly related to the assessment of scenarios, likelihood and consequences as it can explain the background to, and motivate judgements. But it might also be indirectly related to the description of risk – for example through a focus on the context in which the risk description is valid. In studies of the usefulness of capability assessments (which are closely related to risk assessments) both types of information have been found to be important (Lindbom et al. 2015). Therefore, additional research into the inclusion and presentation of background information is needed.

Conclusions

This study investigated how the presentation of risk descriptions in DRM systems affects their perceived usefulness. We conclude that there is a significant effect. Risk descriptions that express likelihood and consequences in a quantitative scale and semi-quantitative ranking scale format were perceived to be more useful than those in which such descriptions are lacking or are expressed in qualitative terms (including ranked qualitative scales). The effect was found in all three groups that were investigated (risk and safety professionals in Sweden, and urban planning students and practitioners in Nicaragua). It therefore appears that the extent of participants' risk assessment knowledge was not a determining factor in the ranking. Nevertheless, those with more experience in risk assessment seemed to be more sensitive to differences in format.

Although our results show that the quantitative scale and semi-quantitative ranking scale risk descriptions were perceived to be most useful, this does not imply that they should always be used. The appropriate risk description will be determined by the aim of the information, and the context. Variation in terms of, for example, the experience and skills of recipients will play a role in the decision. Nevertheless, our results appear to be valid for people with little formal training, and suggest that quantitative scale or semi-quantitative ranking scale formats are a good way to communicate risk in DRM systems, especially when complemented by narrative evidence.

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Notes

1. The power efficiency of the Wilcoxon signed-rank test is 95% of that of the *t*-test for small sample sizes (Siegel and Castellan 1988).
2. The minimum relevant difference between the two experimental conditions was set to one step on the Likert scale. The standard deviation of the difference between perceived usefulness was unknown; however, the standard deviation in a similar study was 1.5. We therefore assumed it to be the same in this study. Finally, α was assumed to be 0.05 and β, 0.2.
3. Delaney and Vargha (2002) suggest that an A_{12} of .56 corresponds to a small effect size, .64 to a medium effect and .71 to a large effect.

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Appendix 1. Experiment 1 – the effect of using different types of scenarios in risk descriptions

Fire scenarios

There are several large public buildings where serious fires might occur in the local municipality. The fire protection measures in most of these are judged to be good and in compliance with current regulations. Therefore, if a fire should occur in any of these buildings the consequences will probably not be serious in terms of fatalities or injuries, as the fire will probably be extinguished quickly. If it is not extinguished quickly, it will probably be possible to evacuate the building. Nevertheless, there is a small probability that the consequences of a fire could be significant if several unfortunate circumstances coincide, for example, if one or more of the emergency exits is blocked at the same time as the fire load on the establishment is higher than expected. Two fire scenarios are used to represent the fire risk in the local municipality: (1) a small fire and (2) a large fire.

Scenario 1: a small fire

A small fire scenario means that a fire with significant smoke generation occurs in one of the larger buildings in the local municipality. Initial attempts by those in the building to extinguish the fire are unsuccessful. During the evacuation of the building it is assumed that several people are exposed to large amounts of smoke, which results in a few fatalities and several people requiring hospital care.

The likelihood of Scenario 1 has been assessed to be once every 30 years. The consequences have been assessed to be the following: 40 people will be seriously injured by smoke and 1 person will die.

Scenario 2: a large fire

A large fire scenario means that a fire with significant smoke generation occurs in one of the larger buildings in the local municipality. Initial attempts by those in the building to extinguish the fire are unsuccessful. In addition, the evacuation of the building is delayed for some reason. Many people are exposed to significant amounts of smoke, which leads to several fatalities and many people requiring hospital care. The likelihood of Scenario 2 has been assessed to be once every 150 years. The consequences have been assessed to be the following: 60 people will be seriously injured by smoke and 20 people will die.

Flood scenarios

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 m above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood of scenario 1 is assessed to be once every 20 years. If the scenario occurs, the consequences are judged to be: flooding of approximately 1000 residential homes, one electrical substation and one highway.

Scenario 2: serious flooding

Serious flooding implies that the water level in the waterway rises 2.5 m above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of scenario 2 is assessed to be once every 100 years. If the scenario occurs, the consequences are judged to be: flooding of approximately 2000 residential homes, one electrical substation, one highway and one railroad.

Appendix 2. Experiment 2 – the effect of describing likelihood and consequences in different ways

Five risk descriptions using different ways of expressing likelihood and consequences were used in Experiment 2.

In the experiment, the order in which the five risk descriptions was presented was randomized in order to reduce learning effects among the participants.

Risk description #1: likelihood and consequences (QC′) not included

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 m above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

Scenario 2: serious flooding

Serious flooding implies that the water level in the waterway rises 2.5 m above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

Risk description #2: qualitative description of likelihood and consequences (QC′)

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 m above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood of Scenario 1 is judged to be moderate. The consequences are judged to be serious for the people that live in AREA 1, as well as for the electrical substations and roads in that area.

Scenario 2: serious flooding

Serious flooding implies that the water level in the waterway rises 2.5 m above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of Scenario 2 is judged to be low. The consequences are judged to be very serious for people that live in AREA 1 and AREA 2, as well as for electrical substations, and road and railway transport in the same areas.

Risk description #3: qualitative ranking scale for likelihood and consequences (QC′)

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 m above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood has been assessed using a five-level scale (very low, low, moderate, high, very high). The consequences have been assessed similarly using a five-level scale (very limited, limited, serious, very serious, catastrophic).

The likelihood of Scenario 1 is judged to be moderate. The consequences of the scenario are judged to be serious. The residents, the electrical substation and the roads will be primarily affected in AREA 1.

Scenario 2: serious flooding

Serious flooding implies that the water level in the waterway rises 2.5 m above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of scenario 2 is judged to be low. The consequences of the scenario are judged to be very serious. The residents, the electrical substations, the roads and the railroads in AREA 1 and AREA 2 will be primarily affected.

Risk description #4: quantitative scale for likelihood and consequences (QC′)

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 m above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood of scenario 1 is assessed to be once every 20 years. If the scenario occurs, the consequences are judged to be: flooding of approximately 1000 residential homes, one electrical substation and one highway.

Scenario 2: serious flooding

Serious flooding implies that the water level in the waterway rises 2.5 m above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of scenario 2 is assessed to be once every 100 years. If the scenario occurs, the consequences are judged to be: flooding of approximately 2000 residential homes, one electrical substation, one highway and one railroad.

Risk description #5: semi-quantitative ranking scale for likelihood and consequences (QC′)

There are several waterways that may cause flooding in the local municipality. However, the risk of flooding has been judged to be greatest along the waterway. The waterway has the

largest catchment area and the most populated areas of the local municipality are located close to it. The areas that are threatened by flooding if the water level in the waterway rises are comparatively flat, which means that the area affected by a flood will be large. In the municipal risk assessment, it is assumed that the flood risk can be represented by two scenarios: (1) slight and (2) serious flooding.

Scenario 1: slight flooding

Slight flooding implies that the water level in the waterway rises 1.5 m above the normal level, which means that AREA 1 will be flooded. There are several residential areas and critical infrastructures (power distribution stations and roads) in AREA 1.

The likelihood of Scenario 1 is judged to be moderate (once in 10–100 years). The consequences of the scenario are judged to be serious. The residents, the electrical substation and the roads in AREA 1 will be primarily affected.

Scenario 2: serious flooding

Serious flooding implies that the water level in the waterway rises 2.5 m above the normal level, which means that AREA 1 and AREA 2 will be flooded. There are residential areas as well as several critical infrastructures (electrical substations, roads and railroads) in these areas.

The likelihood of Scenario 2 is judged to be low (once in 100–1000 years). The consequences of the scenario are judged to be very serious. The residents, electrical substations, the roads and the railroads in AREA 1 and AREA 2 will be primarily affected.

Description of scales used to describe likelihood and consequences

The likelihood of the scenarios has been assessed using a five-level scale: very low (less than once in 1000 years), low (once in 100–1000 years), moderate (once in 10–100 years), high (once in 1–10 years), very high (more than once every year).

The consequences were similarly assessed on a five-level scale:

Very limited: Small direct health effects, very limited disturbances in societal functions, temporary distrust in a particular public institution, very limited damage to property and the environment.

Limited: Moderate direct health effects, limited disturbances in societal functions, temporary distrust in more than one public institution, limited damage to property and the environment.

Serious: Considerable direct health effects, serious disturbances in societal functions, lasting distrust in multiple public institutions, serious damage to property and the environment.

Very serious: Very serious direct health effects or considerable indirect health effects, very serious disturbances in societal functions, lasting distrust in multiple public institutions, very serious damage to property and the environment.

Catastrophic: Catastrophic direct health effects or very serious indirect health effects, extreme disturbances in societal functions, permanent distrust in public institutions, catastrophic damage to property and the environment.

Paper IV

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EXPLORING THE DEVELOPMENT AND USE OF MUNICIPAL RISK AND VULNERABILITY ASSESSMENTS IN SWEDEN-CHALLENGES AND OPPORTUNITIES

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Many countries have established disaster risk management (DRM) systems to reduce disaster risks and improve societal safety. Risk assessment in the DRM system is not only an important tool to identify potential risks, but also promotes DRM through conversations among stakeholders from different functional sectors and administrative levels. The municipal risk assessment, produced at the lowest administrative level of the system, is often expected to fulfill two purposes. One is to meet municipalities' own, local DRM needs, while the other is to contribute to regional and national-level work. This article takes the multi-level, multi-stakeholder, bottom-up Swedish DRM system as a representative example to investigate the perceived challenges and opportunities emerging from the preparation of these dual-purpose assessments. Empirical data were collected through 42 semi-structured interviews and related documentation from 18 local municipalities and six regional authorities in Sweden. The findings, representing perceived challenges and opportunities were categorized into six themes: the focus of municipal RVA work; the template and evaluation criteria for municipal RVAs; municipal RVA work as a continuous process; the dissemination of municipal RVAs; feedback from the county administrative board; and the benefits and drawbacks of municipal RVA work.

Keywords: disaster risk management (DRM), risk assessment, risk and vulnerability assessment (RVA), challenges and opportunities, municipalities

I. INTRODUCTION

Worldwide, the losses caused by major crises and disasters are increasing rapidly[1, 2]. Events with disruptive consequences begin locally then spread globally, highlighting the need to improve our ability to manage disaster risks[1, 3, 4]. Many countries have established disaster risk management (DRM) systems that aim to reduce the adverse impacts of hazards and potential disaster[5]. These systems encourage stakeholders from different administrative levels and functional sectors to actively anticipate, prepare for and respond to disaster risks[6]. The risk assessment is an important tool to identify risk. The exercise enhances the awareness and knowledge of those responsible for taking decisions about risks and vulnerabilities. It provides the foundations for planning and implementing measures that reduce risks and vulnerabilities[7], and promotes DRM through conversations between organizations and individuals working in various areas, thus improving crisis preparedness and societal safety at all levels[2]. Nowadays, it is often the case that authorities are legally required to conduct risk assessments[2].

Countries such as Sweden have multi-level DRM systems based on principles of responsibility and proximity. This means that whoever is responsible for an activity in normal conditions also has responsibility in a crisis. A second principle is that a crisis should be handled at the lowest possible administrative level—often represented by local municipalities. Therefore, municipalities must not only carry out their own, local DRM tasks, but they are also expected to contribute to regional and national DRM activities. In particular, the municipal risk assessment is an important input for regional authorities and national governments who must generate a high-level overview. Therefore, the preparedness of local municipalities affects both regional and national DRM performance.

This study examines the perceived challenges and opportunities during the development and use of these dual-purpose municipal risk assessments in a DRM system. The multi-level, bottom-up Swedish system is used as a representative case study. In Sweden, authorities at all levels are legally obliged to conduct a risk and vulnerability assessment (RVA)[8, 9]. In theory, the RVA conducted at a lower administrative level should be used as input for the RVA carried out by the level

above. For example, local municipal RVAs should serve as the basis for generating regional RVAs. In turn, regional RVAs feed into the national RVA. However, previous studies have argued that the system is not functioning as it was designed[10-13]. Various investigations have tackled the issue from different angles, for example evaluating RVA documentation from a design perspective to see if it fulfills its intended purpose[10, 11]. Other studies have suggested ways to improve the quality of RVA documentation[13-16]. Researchers have explored communication challenges and stakeholder collaboration at different administrative levels[12, 17]. Finally, another study compared RVA legislation in Norway and Sweden[18]. Here, however, the focus was on the overall local municipal RVA process (not just RVA documentation) and interactions with the regional administration.

This paper explores the perceived challenges and opportunities during the development and use of municipal RVAs, which must fulfill both local DRM needs and contribute to higher-level RVAs. It addresses the specific question: *What are the perceived challenges and opportunities during the development and use of municipal RVAs, given that they must both fulfill local DRM needs and contribute to higher-level RVAs?* It is structured as follows. The next section outlines the background and principal theoretical concepts. Section III describes the methods. Next, we present the empirical findings and analysis. This is followed by a discussion of the causes of challenges and opportunities in the current DRM system, and some suggestions for improvements from a risk communication perspective. Finally, the conclusions are presented.

II. THEORETICAL BACKGROUND

DRM has been defined by the United Nations Office for Disaster Risk Reduction (UNISDR) as, "the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster"[5]. It is an ongoing process found at local, regional and national levels. A *DRM system* refers to the organizations, technical systems, mechanisms, etc. that participate in the DRM process[12, 19]. The DRM system involves stakeholders at multiple levels, and integrates contributions from actors with different expertise to collectively manage disaster risks.

This article adopts a *risk governance* perspective, i.e. "the totality of actors, rules, conventions, processes, and the mechanisms concerned with how relevant risk information is collected, analyzed, and communicated, and how regulatory decisions are taken"[20-22]. A DRM system is considered as the application or practice of risk governance, as all relevant actors are expected to contribute to managing the disaster risks faced by society[12]. The defining characteristic of both DRM and risk governance is the involvement of multiple stakeholders in managing disaster risks, namely *inclusion*. Inclusion does not simply mean that various stakeholders are included. Instead, they are all expected to play a key role in framing and assessing potential risks. As van Asselt and Renn[22] argue, inclusion should be both open and adaptive. However, more inclusion does not guarantee better DRM. For example, as the number of stakeholders involved in risk management increases, so does the need for good communication and information sharing. Complex bureaucracies only benefit when they strive to improve information sharing and communication[23] as communication failures will result in the failure of DRM activities[22].

Effective risk communication plays an essential role in a multi-level DRM system that brings together stakeholders with different expertise and various backgrounds, as the parties must be able to actively and meaningfully interact with each other. It provides the foundations for stakeholders to responsibly and collectively govern societal risks, and implies internal and external exchanges between policy-makers, experts, and the general public[22]. The risk assessment is seen as a principal, formal channel for exchanging information in the DRM system[12]. However, in the context of risk governance, researchers have claimed that communication is never simple[22, 24] and is always associated with barriers[23]; the same can be said of stakeholders in the DRM system who must communicate information via risk assessments. Not only do stakeholders differ in their assessment and appraisal of risks, but also in terms of their responses that are framed by their own constructs. The end result can be that one stakeholder's risk assessment appears useless to other participants. This can be the origin of many problems in DRM systems, as no single stakeholder owns all of the information, and the overall risk picture depends on contributions from many participants.

Veland and Aven[25] claim that a difference in perspective can lead to serious problems and barriers in the communication of risk-related information, which constitutes the most fundamental building block of a stakeholder's understanding. These fundamental blocks can be based on either a scientific understanding and/ or more informal concepts and judgments[25]. It has been argued that a failure to base the assessment and management of risk on solid scientific foundations is very likely to lead to failures in risk communication. Those who are responsible for the risk assessment must act professionally, and establish the scientific pillars for their work[25], otherwise risk communication may become fragmented. Fragmentation hampers risk communication and information sharing among stakeholders, and weakens risk identification and assessment. Further down

the line, it can make it more difficult for one stakeholder to use another's risk assessment as input, and diminishes the overall performance of the DRM system[11].

Another challenge related to the effective communication and management of risks is the exchange of information between stakeholders[22, 26-28]. In a multi-stakeholder DRM system, risk communication is a multi-dimensional, interactive process that consists of sharing and exchanging the results of risk assessments and other risk-related information[29]. Appropriate and timely feedback is a key part of the process. Tailored feedback offers the information sender an opportunity to reflect upon, and adjust their message. Positive feedback focused on strengths and accomplishments confirms that they are on the right track, and encourage them to continue their work. Negative feedback, on the other hand, can help to address weakness. The sender should modify their message accordingly and use other approaches to achieve their goals[30]. Both positive and negative feedback are helpful and have a role to play. However, it has been reported that little feedback is usually provided[31], which may lead to a failure to achieve intended the outcome[27].

The aim of a DRM system is to gather information and opinions related to hazards and risks from those who are potentially affected, and interested stakeholders. This information is shared via risk assessments. Ideally, information sharing should begin at the start of the risk assessment and continue throughout the process[29]. By studying the perceived challenges and opportunities during the development and use of the municipal risk assessment, this article sheds light on our understanding of how to achieve effective mutual risk communication in DRM systems.

III. METHODS

A content analysis of semi-structured interviews combined with a review of documentation were the main research methods.

Most of the empirical data were collected through 42 semi-structured interviews, involving stakeholders from Swedish local municipalities and their respective county administrative boards. The six counties that were selected represent a wide geographical spread (from the north to the south of Sweden). In each of the six counties, three municipalities were selected with different-sized populations. Eighteen municipalities were approached, but three declined the invitation (although they were involved in the study, see below). A final total of 36 interviews were held with staff from 15 municipalities, while six involved personnel from county administrative boards. Most interviews (with municipality representatives) were completed in 2014, four were conducted in 2013 and the final three took place in 2015.

At municipal level, the process began with an interview with the safety coordinator, who provided information about colleagues whose responsibilities were closely related to municipal RVA work. This snowball sampling method[32] identified other respondents at municipal level. Consequently, all participants had an excellent knowledge of RVA work in their municipality (and the study's findings might reflect a greater level of awareness than in the general population of municipal employees). Interviews were also carried out with representatives from the six selected county administrative boards. All of these interviews were completed in 2014, with regional safety coordinators. These officials are responsible for processing the municipal RVAs within their geographic area. Some of these interviews involved more than one person at a time, depending on how many people were actually involved in this area of work. Questions focused on their opinions of municipalities' RVAs (including the three municipalities that declined to participate).

In addition to this empirical data, we collected official reports related to DRM work (e.g. RVA documentation, Crisis Management Plans and Action Plans). These reports were collected either from official websites, or provided by respondents during interviews. All municipal and regional RVAs were examined, except for one that was classified as confidential (two authorities did not have a RVA document). It should be noted that the three municipalities that declined our request for an interview were nevertheless involved in the study. The analysis of their RVA work was based on information from their websites, interviews with their respective county administrative boards, and other relevant official documents.

Content analysis[33, 34] was used to analyze the empirical data. An analysis template was developed that consisted of headings that guided the interviews, supplemented by other aspects that emerged during the interviews. All interviews were recorded and relevant aspects were identified. The most significant statements were transcribed in full. The quotations that are presented here were translated with great caution, to ensure that the original meaning was not distorted. Finally, the authors carefully examined all of the official documentation. Information about each municipality was summarized, then aggregated into one document.

IV. RESULTS AND ANALYSIS

The following six themes represent the challenges and opportunities that were identified during the development and use of municipal RVAs:

- The focus of municipal RVA work;
- The template and evaluation criteria for municipal RVAs;
- Municipal RVA work as a continuous process;
- The dissemination of municipal RVAs;
- Feedback from the county administrative board;
- The benefits and drawbacks of municipal RVA work.

IV.A. The Focus of Municipal RVA Work

Under Swedish law, all 290 municipalities must implement an RVA[8]. To support this work, regulations[35] describe its structure. Furthermore, the Swedish Civil Contingencies Agency (MSB) has developed a guide for conducting an RVA[36]. Beyond this, the legislation leaves municipalities free to decide how they conduct their RVA. Consequently, while some similarities were found in how municipalities approached their work (for instance, many use a scenario analysis methodology), there were more differences, ranging from the choice of methodology to the focus. As one informant said, "one might think that all municipalities are working in the same way, but when you come to a new municipality, it's like coming to another company. They work completely differently."

IV.A.1. Daily Safety Issues or Disastrous Events?

The municipal safety coordinator's responsibilities often include both day-to-day safety issues and preparing for extraordinary events. Our interviews highlighted these different priorities: Should RVA work focus on daily safety issues? Low-probability disastrous events? Or both? Some argued that the focus should be on day-to-day safety, rather than very unlikely disastrous events. They suggested that by taking care of mundane issues, the municipality would become better able to handle extraordinary events. "We should not adapt to something that […] will come. Instead, we do what we can to make sure it does not happen." In other words, if everyday problems are well-handled, the municipality will also be able to deal with major crises. One informant added, "we cannot cover everything, that is impossible […] but we will still be just as prepared so that we know what we are going to do". Another informant provided a different perspective: as extraordinary events are very unlikely, it is very hard to analyze them. Municipalities have very limited resources, therefore they should focus less on extraordinary events, because they almost never occur. One informant (from a county administrative board) explicitly mentioned that municipalities should not only focus on daily safety issues, but also should identify and analyze unlikely, extraordinary events. However, none of the interviewees were sure how extreme or improbable a risk scenario should be, or how much detail to provide in the RVA.

IV.A.2. Local Municipal Operations or a Geographical Area of Responsibility?

In general, municipal RVA work is seen as only relating to the municipality's own operations, rather than the whole geographic area. This does not mean that informants do not see collaboration with other actors as important, but it is seen as very hard to achieve. Many municipalities focused primarily on their own operations, at least during the first few years of working with RVAs. Consequently, external stakeholders were excluded from the very beginning. One informant emphasized the importance of trust with respect to external stakeholders. This person believed that the municipality should not interfere or take on the responsibilities of others. Data protection was a further challenge in interactions with external stakeholders as their information can be highly confidential. It is difficult to include such information in municipal RVAs that are made public.

IV.B. The Template and Evaluation Criteria for Municipal RVAs

Some informants appreciated the lack of detail in the legislation and guidance, as they were able to conduct their work in the way that suited them best. Others were keen to see more detail and explicit guidance. They described the available guidance as overly general and "very fuzzy", preferring to receive something that describes "what the RVA should look like".

Informants from the county administrative board pointed out that was difficult for municipalities to work with RVAs, because the nature of the task was unclear. Some noted that the regulations simply stated that the RVA should be conducted and that it had a purpose, while the roles of both the municipality and the county remained unclear. This becomes even more difficult when the safety coordinator works alone and has to answer the question "How and what should the municipality do?". "There are no templates and there are no educational programs to learn from," said one regional safety coordinator, "I wonder where I should go to improve my skills? What is a good RVA? From whom can I learn? Who can help me to understand it?" Informants who wanted specific methods and an RVA template were primarily from smaller municipalities. They argued that the municipality should receive more help from the county administrative board and the MSB. Some pointed out that many aspects of the RVAs are universal and should therefore be determined centrally. They considered that the task would be made simpler if they were provided with a template to fill in. Another informant wanted the MSB or another actor to describe in detail what they wanted and what the RVA should look like.

County administrative boards are required by law[37] to evaluate the quality of municipal RVAs. Municipal informants stated that the evaluation is subjective, and that there are no clear rules. While they acknowledged that it was hard to define how it should be assessed, they argued that efforts should be made to provide more detail on what a 'good' RVA looked like. Other interviewees held a different view, and argued that the focus should be on the overall objective of RVA work, rather than the 'best' way to conduct the assessment. It was argued that RVA work should be embedded in the municipality's daily activities. Unlike the MSB or the county administrative board, the municipality knows themselves the best. The choice of method for RVA work should be based on knowledge that has been accumulated during day-to-day work, suggesting less control from above. An informant at the regional level noted that many municipalities try to create a RVA that has a beginning and an end; thus the work becomes an isolated process. They argued that RVA workers should be given more freedom, and that the RVA should not have a fixed format, as the process goes beyond simply structuring, analyzing and compiling risks and vulnerabilities. This approach makes it impossible to hand out a template for municipalities to fill in.

IV.C. Municipal RVA Work as a Continuous Process

Two aspects that were identified that would ensure that municipal RVA work is an ongoing process: first, working with the same method/ process for a long time; and second, having the same safety coordinator for a long time. The latter is closely related to the former. Both the interviews and the documentation showed that very few municipalities have an active, continuous RVA process. The five municipalities that could be said to have an ongoing process all started their work many years ago; furthermore, in all cases the safety coordinator had held their position for many years. For example, one municipality began their first round of RVA work in 2005. An informant from another municipality said that it took seven years before they felt that the process had started to become embedded. Some municipalities had just begun, or planned to re-evaluate their RVA work. This happened when the municipality had just appointed a new safety coordinator (and the new person wanted to adopt a new method), or because none of the work that had been done was useful.

IV.D. The Dissemination of Municipal RVAs

IV.D.1. Limited Dissemination

In general, far more attention is given to the assessment and preparation of the RVA document than to its dissemination. Most municipalities seem to lack appropriate processes. Moreover, official documents (from e.g. the MSB) do not focus on this aspect. When asked how RVAs were disseminated, the standard answer was "it's available on our website/ intranet". A few participants reported that they had presented the RVA document at meetings or workshops in the municipality or with the county administrative board. Some informants said that they felt that the RVA was not rooted in the municipality; it was developed entirely by the safety coordinator, had very limited distribution and was consequently relatively unknown.

IV.D.2. Weaknesses and Sensitive Data

Other causes were given for the failure of municipalities to disseminate their RVAs. Informants highlighted that since RVAs focus on weaknesses, municipalities do not want to broadcast the information. Municipalities are reluctant to openly demonstrate their vulnerabilities and expose management shortcomings. Furthermore, as one interviewee said, "Confidentiality is a big concern" and sensitive information needs to be protected, "we don't want to tell potential terrorists anything […]" Finally, it was pointed out that RVAs had not been systematically communicated to the general public. Some even thought that the results should remain confidential; consequently, in some municipalities the document is classified.

IV.E. Feedback from the County Administrative Board

Under Swedish law[9], the county administrative board has a coordinating function within the region. It is mandated to follow-up on municipal RVA work[37] and must "work to ensure that […] the regional risk and vulnerability assessments are compiled"[9]. With one exception, all of the boards had given (or were about to give) written feedback on their municipalities' RVAs. This is done in conjunction with follow-up visits to municipalities, as specified in the legislation[37]. The one board that had not given feedback confessed, "It is difficult to know what to assess. It's hard to give feedback". Another regional-level informant admitted that providing feedback took a lot of time and that it was difficult to keep up. Informants at this level would have welcomed feedback from the MSB as input to the development of regional RVA work. However, interviewees noted that feedback from the MSB simply focused on whether reports had the correct headings. The problem, according to one regional informant, is that county boards give the same type of unhelpful feedback to their municipalities.

Many municipal informants stated that they had received both supervision and feedback on their RVA work from the county administrative board. County-level representatives had visited their municipalities, both officially and unofficially, to discuss safety/ RVA-related issues. Some municipalities had only received oral feedback on their RVAs, while others said that they had never received any feedback.

IV.F. The Benefits and Drawbacks of Municipal RVA Work

IV.F.1. The Benefits

DRM activities, including RVA work, have been on agenda of Swedish municipalities since 2006. It is claimed that this has led to increased interest and a change in attitudes in how people think and see things from a safety perspective. The RVA process and the final documentation have increased the awareness of decision-makers. Some municipalities have started to tackle the issues that have been highlighted in their RVA. Direct or indirect results have been used as input for decision-making.

Under Section 1, Chapter 2 of the Act on Municipal and County Council Measures prior to and during Extra-ordinary Events in Peacetime and during Periods of Heightened Alert[8], the municipality must, "with regard to the risk and vulnerability assessment […] establish a plan for how to deal with extraordinary events for each new term." The municipalities included in this study had developed such a plan (with the exception of two of the three municipalities that chose not to be interviewed). However, despite its existence, informants were unable to describe the connection between it and the RVA. Furthermore, under Section 8, Chapter 2 of the Act[8], "elected officials and employees should receive education and training in peacetime, so that they will be able to undertake their tasks in an extraordinary event." Although the law does not state the connection between RVAs and crisis management exercises, some informants said that RVAs were used to develop relevant vulnerability scenarios. The reverse link can also be made, and the results of exercises are sometimes used as input to the RVA. At the same time, some informants argued that there was no connection between the two.

RVAs are used in other, less obvious ways. Details of ongoing municipal work are sometimes provided, in addition to issues discussed during the RVA process. The document was used as a way to identify the principal potential risks for the municipality, and prioritize important issues. Some informants mentioned that the RVA process had led to further work connected to societal sustainability. Three municipalities said that the RVA was used, or would be used in their municipal planning. For example, it can be used in urban and social planning as a way to identify "municipal protection values" in major urban construction projects. Some municipalities have begun to develop a climate change adaptation plan, which, according to some safety coordinators, can be partially merged with RVA work.

The Emergency Management and Heightened Alert Ordinance[9] states that regional governments must "work to ensure that […] the regional risk and vulnerability assessments are complied". Accordingly[35], all municipal RVAs are expected to be structured using the same headings, so that the county administrative board can compile them into a regional RVA. However, regional representatives highlighted that RVA work is not simply drawing up an RVA document. Instead, it is a very important process that should be motivated by local self-interest, rather than the requirement to contribute to the regional/ national risk assessment. There is a need to identify local risks and vulnerabilities, and make a capability assessment of essential services and implemented measures. The purpose is to establish how the municipality will collaborate and manage extraordinary events, based on the risks and vulnerabilities that may occur. It is more important that the municipality has an

established work process than that they have a good final document. As one regional informant put it, "one of the most boring things I know is when I get a RVA document and am asked; are you satisfied now?".

IV.F.2. The Drawbacks

Regional representatives highlighted that the purpose of RVA work is to benefit municipalities. However, some municipal representatives complained that they saw no benefits; they simply had to prepare a report for the county administrative board. In some municipalities, RVA work was considered to be an isolated, obscure task. This was illustrated by cases in which RVA work only led to the preparation of one document.

According to the MSB[35], municipalities should report the "planned and implemented measures and an assessment of the need for further action on the risk and vulnerability assessment results" in Section 8 of its RVA document. Municipalities were not sure what this meant. For example, "In the RVA, the municipality must be able to point out things that need to be done but without promising to implement them." Other informants said that it would be useful to note areas where they needed help (e.g. from the county administrative board) in this section.

Last but not least, regulations[35] state that municipal RVAs should provide input to the regional overview of risks and vulnerabilities, and form part of the regional RVA document. Regional informants said that they found it very difficult to use municipal RVAs to create this document as differences in scale and methods made them impossible to aggregate. None of the boards used municipal RVAs as the only source of information to generate the regional RVA. Furthermore, informants argued that the municipal RVA would be better used as an input to the municipal DRM process. For example, one interviewee noted that the MSB assumes that RVAs are comparable, "but if you have 290 different things, it's built into the system that it's impossible to compare them, there must be differences".

V. DISCUSSION

This study notes the lack of constructive feedback given by county administrative boards, who are the recipients of municipal RVA documents. Current feedback, either written or oral (if there is any), was said to be too general. It was rarely described as helpful or insightful, due to the fact that it did not note specific strengths or weaknesses. Effective risk communication is a mutual process consisting of the exchange of risk-related information between DRM stakeholders. Constructive feedback not only ensures a two-way information exchange, but it also aids future municipal RVA work. Timely and constructive feedback can confirm whether the municipal RVA has been interpreted properly. Both positive and negative feedback will influence the quality of future RVA work[30, 38]. Positive feedback encourages good work to be continued, while constructive negative feedback pinpoints where more effort is needed. In this article, we argue that risk communication via RVA documentation is not a two-way process unless there is meaningful feedback. As van Asselt and Renn[22] point out, "risk communication and trust are delicately interconnected processes". Although trust is not the focus of this study, a breakdown in communication increases distrust among stakeholders, and may fragmentize the multi-stakeholder DRM system.

Our study highlights issues related to the dissemination of municipal RVAs and concerns about confidentiality. RVA work is not only about gathering and disseminating vital, risk-related information; it also guarantees the integrity and security of that information. It may be true that the fewer people who know about the risks and vulnerabilities of a society, the less chance that this information may fall into enemy hands. But DRM work is also a balancing art: the more people who know about societal risks and vulnerabilities, the more prepared they are for potential adverse events. The danger of being over-protective with regard to risk-related information is that secrecy can lead to a false illusion of safety. Furthermore, if the RVA documentation is not communicated there can be no learning process, which is an important part of the RVA process.

People manage disaster risks. The successful management of any societal risk largely depends on the quality of risk communication. Many factors can contribute to failure, including different risk perspectives among DRM stakeholders[25]. The empirical findings presented here show that when the legislation does not give detailed and specific guidance on how to carry out an RVA, stakeholders adopt their own risk perspective, which varies from one person to another. Although not all informants complained about their freedom to decide, there were clear consequences resulting from it. For instance, there is no agreed focus for RVA work, and it is very unclear how the RVA should be conducted and evaluated. Meaningful risk communication relies on solid scientific foundations[25]. Risk communication via RVA documentation is no exception. Our findings suggest that there are many gray areas in municipal RVA work in the Swedish DRM system, while improvements can clearly be made. As Veland and Aven put it, "if a concept is introduced, it must be given a meaningful definition and

interpretation"[25]. Unfortunately, this is not the case in many situations, including the DRM system and RVA work studied here. Sound scientific principles and methods would clarify current confusion and improve the level of professionalism. At the same time, municipalities' own needs must not be forgotten. Our study makes it clear that municipalities have very different priorities. Therefore, the development of RVA work must ensure that individual DRM needs are met, and that it will lead to an ongoing process, rather than filling in pre-printed templates.

Previous studies have shown that information generators often tailor their messages to suit whatever they believe the target audiences wants to hear or read[23]. This so-called *audience tuning* means that the communicated information tends to be selectively presented. Similarly, one municipal informant claimed that RVA documents were only useful to the county administrative board, and of no benefit to the municipality. While the municipal RVA document is designed to serve two purposes, this safety coordinator selected the information that they thought the county administrative board wanted to see, leaving aside anything that might be useful to the municipality itself. On the other hand, the different risk perspectives and needs found at the municipal and regional level mean that RVAs that are consistent with what the municipality thinks its regional board wants to hear do not always match the boards' expectations. Furthermore, the lack of detail in feedback to municipalities means that they do not know where to focus their efforts, and makes it difficult for them to improve. In the end, neither party is satisfied with the results.

DRM is not just about minimizing risks; it is also expected to stimulate resilience. In order to be able to withstand or tolerate adverse events, social learning is needed to identify what risk information should be communicated to whom in which phase. Therefore, the RVA process must be open and continuous. Furthermore, the sources of risk-related information must be explored, and the different risk perspectives of stakeholders must be identified. The operation of a multi-level system in which stakeholders undertake complementary work relies on knowing what other stakeholders (especially close collaborators) label as risk problems.

This study complements previous studies of the Swedish DRM system, which have focused on RVA-based risk communication and stakeholder collaboration[12, 17], the preparation of RVA documents that are useful for risk-related decision-making[15, 16], the evaluation of the Swedish RVA system[10, 11], and legislative regimes for RVAs in the context of decision-making[18]. It provides empirical evidence that can help both scholars and practitioners to better understand the multi-level, multi-stakeholder, bottom-up DRM structure, by investigating the development and use of municipal RVAs. This explorative study has raised other questions regarding municipal RVA work, and future work is planned. Follow-up studies will look into issues related to the municipal RVA process and the final RVA documentation. Many informants highlighted that the RVA process is more relevant than the documentation in the context of the DRM system. This is not a new observation, and has been highlighted in the disaster management literature, notably concerning the relationship between the disaster planning process and disaster plans[39, 40]. Although the RVA document is simply a description of the RVA process at a specific point in time, countries such as Sweden (and the European Union) have put considerable effort into emphasizing its importance. In practice, the system relies on higher administrative levels being able to aggregate the lower levels' RVA documents. It would be very interesting to base our next study on topics such as the interconnection between the RVA process and the RVA document, how the RVA process could lead to the development of a truly useful RVA document, or discuss what is really meant by a 'good' municipal RVA. Such follow-up work would add even more value if it could answer questions such as, Is the current DRM system (in particular RVA work) well-designed, or does it fail to meet its intended purpose?

VI. CONCLUSIONS

This article studied the development and use of the municipal RVAs in the Swedish DRM system, based on information from stakeholders at both municipal and regional level. It explored perceived challenges and opportunities concerning municipal RVA work, which is designed to fulfill two DRM purposes simultaneously. The major findings relate to six areas: the focus of municipal RVA work; the template and evaluation criteria for municipal RVAs; municipal RVA work as a continuous process; the dissemination of municipal RVAs; feedback from the county administrative board; and the benefits and drawbacks of municipal RVA work. Understanding the challenges and opportunities perceived by practitioners helps to bridge the gap between how the system was designed to work and what happens in practice. Finally, our study raised a new, interesting question, "What needs to be changed?". Is it the design of the RVA system, or is it how RVA work is currently performed? While this study takes the Swedish DRM system as its subject, there are indications that the challenges and opportunities identified here are not limited to Sweden, and our work may shed light on the function of other multi-level, multi-stakeholder DRM systems in similar settings.

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Paper V

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Integrating a national risk assessment into a disaster risk management system: Process and practice

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Communication

ABSTRACT

The national risk assessment (NRA) has recently become a very important component in a country's disaster risk management (DRM) system. The NRA aims to identify threats and hazards that could affect the entire country, and assess their potential likelihood and impacts from a national perspective. Compared to other DRM activities, NRA work is comparatively new, and is often a response to an external demand. For instance, in the European Union (EU), most member states initiated their NRA process in response to a EU directive. This article investigates how the requirement to conduct a NRA has influenced an existing DRM system, taking the case of Sweden as a study case. Specifically, it examines how the NRA process has been integrated into the multi-stakeholder, multi-level, bottom-up Swedish DRM system. Empirical data were collected through 21 semi-structured interviews with representatives from 13 national authorities, supplemented by Swedish and EU documentation. The results were analyzed following the ISO 31000 risk assessment process. The findings provide an indication of how NRA work has been integrated into ongoing DRM activities, and the level of integration. The results also indicate the extent of stakeholder involvement in the NRA process, the quality of DRM information communication among stakeholders, how the NRA has been implemented in the Swedish context, and the potential to expand the NRA worldwide.

1. Introduction

Globalization has greatly increased interdependencies in modern society, and seemingly minor events can easily spread and cascade into a full-blown crisis [1,2]. Risks, ranging from everyday occurrences to systemic failure, can trigger severe losses. An all-hazards approach is needed to assess them, while collective, whole-of-society efforts are needed to address them [2–4]. This new risk landscape has generated concerns about governments' disaster risk management (DRM) capabilities in dealing with situations characterized by complexity, ambiguity and uncertainty. A second problem is the need to coordinate different administrative levels, cross-sectoral stakeholders, and trans-boundary organizations. Finally, a third issue concerns the reduced capacities of central government due to decentralization and/ or privatization [2,5,6]. Given these conditions, improving a country's DRM is no easy task.

Historically, DRM activities in many countries have focused on the post-emergency response. However, recent progress in science, technology, and information management means that DRM bodies can conduct comprehensive, pre-emergency assessments. These evaluations help to understand potential disaster risks, how they affect vulnerable human beings, and society's ability to handle hazards and threats [6]. Consequently, the focus of DRM activities has shifted from the response phase, to preparedness and prevention. According to the European Commission's Humanitarian Aid and Civil Protection Factsheet [7], it's estimated that for every €1 invested in disaster risk prevention, €4–7 is saved in disaster response. Therefore, governments have been encouraged to invest more in prevention.

Many countries now carry out a national risk assessment (NRA). The aim is to identify the threats and hazards that could affect a country, and assess their likelihood and impacts from a national perspective [6]. As it is carried out before a negative event happens, the aim is to improve prevention policies and mitigation programs by directing limited resources, thereby reducing a nation's exposure and vulnerability. Often carried out in conjunction with a capability assessment (which seeks to determine if a county is able to handle a certain emergency), the NRA helps to understand the potential risks a country faces, and plays an important part in developing its capacity to prevent and respond to disaster risks at all levels [6].

Within the European Union (EU), many security challenges are

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cross-border and cross-sectoral [8], and no single member state is able to handle them alone. In order to minimize potential risks and better prepare for future risks, the European Commission invited all member states to begin developing a NRA by the end of 2011 [9]. Following the adoption of the EU Civil Protection Mechanism in 2013, all member states were obliged to conduct a NRA and submit a summary to the Commission by 22 December 2015, and every three years thereafter [10,11]. Together with the European Commission's Risk Assessment and Mapping Guidelines for Disaster Management [12], it is expected that the coherent NRAs from member states will contribute to a better understanding of the risks faced by EU, so that a comprehensive, Union-wide risk assessment can be prepared.

At the same time, various academic research projects have investigated NRA issues. For instance, Vlek examined Dutch and British NRAs and questioned the scientific robustness of the results [13]. In the Netherlands and Norway, Veland et al. [14] compared methodologies used in practice with existing theories of risk conceptualization and description, and found weaknesses in both countries. Vastveit [15] investigated the actual use and results of Dutch and British NRAs. Finally, Bossong and Hegemann [16] examined the functional and political limitations for the implementation of standard NRAs from a pan-European perspective, and argued that the adoption of common guidelines would be a useful political tool to legitimate internal EU policy initiatives in the domain of risk governance.

Most of the NRA literature focuses on the methodology, the validity of results, and the role of NRAs in countries' DRM activities. As the Dutch and British NRAs are two of the earliest examples in the EU, they are often used as a role model for other countries, and have received most attention from researchers. However, not much attention has been paid to the impact of the NRA on existing, multi-level, multi-stakeholder DRM systems. Is it the case, for example, that it complements ongoing DRM work and brings stakeholders closer together? Or is it an isolated process that remains separate from other established DRM activities? There appears to be no previous work that offers clear-cut answers to these questions.

Based on Rasmussen's study [17], in dynamic modern societies, where DRM stakeholders are from multi-disciplinary backgrounds and various societal levels, general DRM objectives and values formulated by higher levels are interpreted and implemented accordingly at lower levels in the structure. Therefore, it appears interesting to investigate how member states have responded to the call from the EU to implement international NRA guidelines. Previous research into multi-level, multi-stakeholder national DRM systems has pointed out that fragmentation is a common problem [18,19]. Information is produced by various stakeholders, which creates a barrier for its transfer [18,20–22]. It appears likely that the implementation of the high-level requirement to produce an NRA, based on the joint efforts of various domestic stakeholders, will not be a smooth process. Therefore, this paper examines NRA work, taking the example of Sweden. It investigates the collation of DRM information from various national bodies into the NRA, and is designed to contribute to prevention and protection efforts, both nationally and internationally.

Sweden was one of the first EU member states to carry out an NRA. The country's DRM system is rooted in the activities and responsibilities of stakeholders at three administrative levels (national, regional, and municipal). All authorities have been required to carry out a risk and vulnerability assessment (RVA) since 2002, and these assessments form the basis for many other DRM activities. The Swedish Civil Contingencies Agency (MSB) has been tasked by the government to prepare the country's NRA, based on input from the RVAs. This paper focuses on the NRA process and practice: how it interacts with ongoing DRM activities, especially RVA work; whether it actively involves stakeholders from all administrative levels; the perceived quality of DRM information transfer among stakeholders; how EU guidelines are incorporated into national values, and how the NRA contributes to both domestic and international DRM. The research questions addressed are: *Is Swedish NRA work integrated with existing DRM activities? If so, how does it interact, and to what extent is it integrated, e.g., in terms of involving stakeholders from the whole of society and generating credible DRM information from various sources?*

This article is structured as follows. The following section describes the context for NRA activities in Sweden. Section 3 outlines the principle theoretical concepts. The next section introduces the research methods. Section 5 presents the empirical findings and analysis. This is followed by a discussion, which relates the findings of this paper to earlier work. Finally, some conclusions are presented in Section 7.

2. The Swedish context

2.1. The Swedish DRM system

The Swedish DRM system consists of three administrative levels of governance: local, regional and national. It is based on three fundamental principles: responsibility, parity and proximity. Respectively, they mean that: 1) whoever is responsible for an activity in normal circumstances is also responsible during an emergency; 2) how authorities and public services function during a crisis should, as far as possible, be the same as under normal conditions; and 3) a crisis should be handled at the lowest possible administrative level.

The Swedish DRM system is coordinated by the MSB, which is responsible for issues concerning civil protection, public safety, emergency management and civil defense. It is also mandated to take a holistic, all-hazards approach to DRM. The government specifies the MSB's responsibilities, objectives and reporting requirements, and allocates resources. One of the MSB's principle tasks is to enhance the DRM capacity of Swedish society, by supporting and guiding the activities of other DRM stakeholders.

The RVA is one of the most important components of this multi-level, multi-stakeholder, bottom-up system, and forms the basis for many other DRM activities. Under Swedish law [23,24], governmental agencies, regional authorities and municipalities have conducted regular RVAs since 2002. The RVA normally includes an assessment of the potential risks faced by an authority, any other specific scenarios chosen by the MSB, and information about the authority's capability to deal with these risks. The underlying logic is that RVAs conducted by lower-level authorities should contribute to the higher-level assessment. Specifically, regional RVAs should be produced based on input from municipal RVAs, as the two levels share the same geographic focus. Similarly, the national RVA is based on regional RVAs. The system is thus highly dependent on collaboration among stakeholders from different disciplinary backgrounds and levels of society. No individual stakeholder can see the full DRM picture without information from others; collaboration is key.

The MSB (and its predecessor, the Swedish Emergency Management Agency) publishes overall assessments of Sweden's emergency management capability. These are primarily based on RVAs conducted by authorities at local, regional and national levels. However, these lower-level RVAs are designed to facilitate disaster risk preparedness at the relevant level, and there are therefore inevitable limitations if seen from a national perspective. For instance, they differ widely in terms of geographical perspective, as some authorities have functional areas of responsibility (e.g. agriculture, telecommunication, customs, police) that are not geographically delimited [19–22,25]. In addition, different authorities use different methods to select, analyze and evaluate potential disaster risks and their consequences [20–22,25]. Thus, there is a need to improve the coherence of all of these RVAs in order to generate a NRA. In 2010, the MSB issued regulations [26,27] designed to enhance the comparability and transparency of RVAs. However, the system continues to lack a systematic method.

2.2. Sweden's NRA practice following the EU call

In 2011, the Council of the European Union passed the 'Council Conclusions on Further Developing Risk Assessment for Disaster Management within the European Union'. The Council argued that standardized NRAs would contribute to a common understanding of the risks facing the EU [9]. NRAs were expected to facilitate cooperation in the prevention of, and response to, shared and cross-border disasters. It was hoped that comparable methodologies would be adopted by member states that faced similar risks, and joint assessments would be carried out. It was also hoped that these assessments, in turn, would contribute to political contingency priorities.

On 9 June 2011, the MSB was tasked by the Swedish government to conduct a NRA based on the European Council's conclusions [28]. The Agency faced two challenges: developing a method; and conducting the actual NRA [29]. Although the country's RVAs already served as a basis for identifying potential disaster risks, the existing national assessment was very different to the NRA outlined by the European Commission [12]. The Commission's guidelines state that the NRA should be methodologically coherent in terms of scenario analyses. They also require the active involvement of experts and stakeholders from all levels of society, functional sectors, and disciplines, rather than the aggregation of RVA documents. In other words, the EU-style NRA calls for an integrated and comprehensive approach that actively involves relevant DRM stakeholders – which was a new challenge for both Swedish society and its DRM system. The first attempt to develop an NRA took the form of the document *A first step towards a national risk assessment – National Risk Identification* [9,30].

In December 2013, under new civil protection legislation [31], all EU member states were required to submit a summary of risk assessments at national or appropriate regional (sub-national) level to the Commission no later than 22 December 2015, and every three years thereafter. In response, the MSB published an overview of risks, and a synthesis of 14 risk scenario analyses between 2012 and 2015 [29].

2.3. The National Risk and Capability Assessment

The National Risk and Capability Assessment (NRCA) is another important element in the Swedish DRM system. Although the NRCA and NRA are separate processes, serving different target audiences, in practice, they are closely connected. Both are primarily based on RVAs from all three administrative levels, and are designed to facilitate decision-making in order to improve the country's overall DRM capability.

Many Swedish DRM stakeholders argue that a risk assessment, which identifies potential disaster risks without mentioning existing capabilities (and/ or how to improve these capabilities), is less useful for DRM decision-making than an integrated risk and capability assessment. Therefore, the aim is to develop an integrated risk and capability assessment at the national level, which not only lists potential risks the country is facing, but also helps to understand the capabilities that need to be developed to handle these risks.

Currently, there is no clear statement of the relationship between the Swedish NRA and the NRCA, thus one of the aims of this study was to explore the issue.

3. Theoretical background

DRM is "the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster" [32]. It is an ongoing process that can be seen at various societal levels. The organizations, technical systems, mechanisms, etc. that participate in an ongoing DRM process constitute the DRM system [21,22,33]. The DRM system involves stakeholders from the whole of society, and aims to integrate their contributions in order to collectively manage societal risks.

Risk governance refers to "the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analyzed, and communicated, and how regulatory decisions are taken" [5]. From this perspective, it is easy to argue that a DRM system represents risk governance in practice, as all of the relevant stakeholders are encouraged to collectively contribute and manage potential risks [21,22]. Similarly, certain risk governance principles are also applicable within the DRM system, and can be used to indicate issues that need to be considered in managing disaster risks [5].

The first is the communication principle. Effective communication is not just the simple action of bringing stakeholders together and encouraging them to communicate. Interactions between stakeholders from different backgrounds, and at various societal levels, must be facilitated [5]. This does not necessarily mean that each stakeholder communicates with all of the others [5], as values, perceptions and objectives can vary greatly among different participants [17]. Therefore, it is very important that stakeholders learn what type of information to communicate, to whom, when, and how [5]. The aim is to provide a better basis for all stakeholders to continuously and interactively, share and exchange DRM information in ways that help to collectively manage disaster risks. However, achieving this is very challenging, and communication failures might result in the failure of the overall DRM system [5,21,34,35].

The second is the inclusion principle. This reflects the fact that DRM is a multi-stakeholder process. However, it does not suggest that the total number of actors is what matters. Nor does it mean that various stakeholders are simply included in the process. Instead, stakeholders should actively frame or pre-assess potential risks, while inclusion should be as open and adaptive as possible [5]. On the other hand, it is important to bear in mind that the degree of inclusion is not equal to the quality of potential DRM outcomes. In other words, more inclusion does not guarantee better DRM results [5,22]. Thus, careful thought must be given to what inclusion means when selecting participants, in order to make the multi-stakeholder DRM system more effective. Ideally, a range of stakeholders with complementary roles and diverging interests are included, in order to address different potential risks [5].

The third principle is integration. This refers to "the need to collect and synthesize all relevant knowledge and experience from various disciplines and various sources including uncertainty information and articulations of risk perceptions and values" [5]. It reflects two aspects of DRM; the first relates to the end-product (e.g., risk assessments, capability assessments), while the second refers to the process itself (e.g., stakeholder involvement and the generation of DRM information). The first aspect highlights the importance of including multi-dimensional evaluations in the DRM process. Cost–effectiveness and risk–risk trade-off evaluations should supplement the risk assessment and evaluation [5]. In addition to content/end-product integration, the DRM process itself should also be integrated, e.g., the different steps of the process should be interconnected and actively interact with each other.

As stated in Section 1, this paper investigates the NRA process and practice, with a special focus on how NRA-related work is integrated into existing DRM activities in the Swedish system. While the above-mentioned risk governance principles can be used to evaluate the degree and quality of integration, the risk management process proposed in ISO 31000 is an appropriate point of departure to examine both processes and practices.

ISO 31000 defines the risk management process as the "systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and reviewing risk" [36]. Here, we apply these steps to study the NRA process and practice in the Swedish DRM system. Specifically, this consists of the following: (a) establishing the context; (b) conducting the risk assessment (including risk identification, risk analysis, and risk evaluation); (c) the risk treatment; in parallel with (d) monitoring and review; and

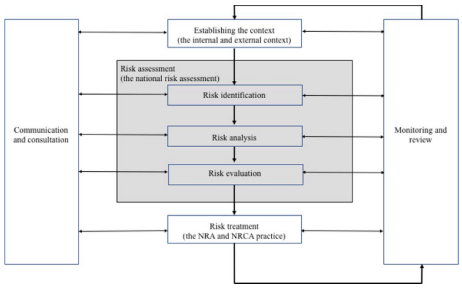

Fig. 1. The NRA process and practice based on ISO 31000.

(e) communicating and consultation. This is shown schematically in Fig. 1. The examination of the overall NRA process and how it integrates with other DRM practices sheds light on the functionality of a multi-stakeholder, multi-level DRM system, and paves the way for the study of the generation of credible DRM information from very different sources.

4. Methods

The main research methods adopted in this study were semi-structured interviews, combined with a content analysis of relevant official documents.

Twenty-one interviews were conducted in two periods. The first round (20 interviews), was carried out between November 2013 and May 2014. They involved 20 participants from 13 national authorities in Sweden. Data collection began with face-to-face interviews with MSB staff, who were heavily involved in preparing the NRA and NRCA, and had direct responsibility for developing RVA regulations and supervising other authorities' RVA work. The snowball sampling method [37] was adopted both during and after these initial interviews, in order to identify other relevant MSB staff, and employees of other national authorities who were responsible for the production of their organization's RVA and had contributed to the production of the Swedish NRA. All the selected interviewees were directly involved in their respective authority's national-level RVA work, which forms the basis for the NRA. Most had also participated in workshops run by the MSB that were designed to contribute to the NRA scenario analysis. At the national level, there are a total 23 authorities (in addition to the MSB) that are obliged under Swedish law to conduct RVAs. Therefore, the sample represents a good range of objectives at the highest administrative level in the Swedish DRM system.

Potential interviewees were approached either by telephone or email. Those who responded and agreed to participate in the study were interviewed by telephone (18) or in person (2). Telephone interviews were preferred as they were easier to fit into busy schedules and were very cost-effective.

Each interview lasted approximately 60–90 min. Issues related to the production of national-level RVAs, and the NRA process. Questions included: how RVAs were conducted; how national authorities involved stakeholders from various administrative levels in their RVA work; how RVAs contributed to the NRA; how NRA work was integrated into the DRM system and built upon RVAs conducted by different authorities; how the NRA process involved stakeholders from different disciplines and administrative levels; what communication tools were used in both the RVA and the NRA; how different stakeholders collaborated with each other, etc.

The second, and final round of semi-structured interview was conducted in January 2017, several years after the first. The goal was to provide a new perspective, and complement the dataset that had been collected almost three years earlier, as NRAs are based on an ongoing process of scenario analysis. By the time the second round of interview was planned, the MSB's NRA work had matured, and authorities had gained experience. It therefore appeared interesting to examine how NRA work had improved in this time, especially from a policymaking perspective. Furthermore, by this time, proposed amendments to RVA regulations had been implemented (which had an impact on the NRA).

Initially, several interviews were planned (mainly with MSB staff). However, a heavy workload at MSB prevented this happening. In the end, one, in-depth interview took place, with one person who acted as a representative for the whole group of experts. This person, who worked on both the NRA and NRCA, and was knowledgeable at the EU policy level, was interviewed via telephone.

This final interview lasted approximately one hour. It was guided by the empirical data collected from earlier interviews, the knowledge gained about NRAs during the intervening period, as well as new questions that had emerged. Consequently, the questions were more focused. Issues included: the transformation of NRA work between 2014 and 2017; the relationship between the NRA, the NRCA, and RVAs; the methods adopted to conduct the NRA and the NRCA; the communication tools available to stakeholders in their NRA work; how RVA work provided input to the NRA and the NRCA, and how they influenced each other; the cooperative areas and stakeholder collaboration in NRA work; how the NRCA influenced the distribution of DRM resources; whether national values were consistent with the EU NRA guidelines; the major challenges in NRA work; and goals for the future.

All 21 interviews were conducted mostly in English, although some terminology, and specific procedures were described in Swedish, in cases where interviewees found it difficult to express themselves clearly. Each interview was recorded and transcribed in full, including any necessary translations from Swedish to English. The transcripts were carefully read through, then analyzed according to a template that was developed from the headings that guided the interviews. Some new aspects that emerged during the interviews were added to the template during this process.

In addition to the empirical data that was obtained from the semi-structured interviews, other documentation was collected and studied. Official documents related to Swedish NRA work were collected from the MSB's website, or provided by respondents during the interviews. Other NRA-related EU regulations, guidelines and policy documents were downloaded from the internet, thoroughly examined and analyzed, using content analysis [38–40]. The following information was summarized and aggregated based on the content analysis of the available documentation: how Sweden had implemented the EU call to conduct a NRA; how the Swedish NRA incorporated national values into EU guidelines; and how NRA work improved as more experience was gained.

5. Results and analysis

Empirical evidence about the integration of NRA with other DRM activities in the Swedish system was analyzed according to the process shown in Fig. 1. The following subsections outline the findings in more detail.

5.1. The internal and external context

Sweden, as a EU member state, must conduct a NRA, and the Swedish government appointed the MSB to carry out this task. The Swedish NRA is a scenario-driven analysis performed at national level, which carefully follows EU guidelines and incorporates Swedish national values. Scenarios are chosen from RVAs that are conducted by authorities at all levels in Sweden, and represent national interests. The MSB carries out the actual analysis, and sends the NRA to the government, which in turn develops a summary that is delivered to the EU.

5.2. The national risk assessment

5.2.1. Risk identification

The risk scenarios that are included in the NRA are based on input from the RVAs. These scenarios are very different in terms of fields and sectors. The MSB selects stakeholders who are most likely to be affected by the risk scenarios (e.g., representatives from municipalities, county administrative boards, county councils, national agencies, volunteer groups, NGOs) and invites them to workshops to develop risk scenarios in more detail. Participants are drawn from "*pretty much the whole of society*", and the risk scenarios that are identified and described are the result of their joint efforts.

5.2.2. Risk analysis

Workshops are the main channel used to bring together relevant stakeholders, collect risk-related information, and carry out a joint assessment. They provide a platform for stakeholders to become familiar with each other's responsibilities, interact, and understand dependencies in the event of a crisis. They promote a wider range of input from different perspectives, and pave the way for potential collaboration among participants.

According to interviewees, these workshops have provided a great deal of useful information, and far more than the previous system in which the MSB sent out forms and asked stakeholders to make self-assessments. However, they also noted that discussions could be dominated by a few very active representatives from certain organizations, while others were more silent. When the workshops end, MSB staff continue to develop the analysis. They attempt to ensure that the views of all parties are represented (for example including the views of less-active participants). Once complete, the analysis is forwarded to all of the participants that were involved in the workshop, asking for further comments. Not all risk scenario analysis is based on workshops. If sufficient information is available from previous assessments, official documents or other scientific reports, the MSB can use this information to produce the risk analysis, rather than arrange a time-consuming, expensive workshop. The MSB has so far selected around 27 risk scenarios to develop for the NRA. Two NRAs have been delivered to the EU, and risk scenario analysis work is ongoing.

5.2.3. Risk evaluation

Under EU guidelines, the NRA should include a statement of whether risks are acceptable or tolerable, and what measures should be prioritized based on this evaluation. However, Sweden holds the opinion that it is very difficult to determine thresholds for acceptable levels of risk without knowing the country's DRM capability to handle them. Furthermore, the government believe that prioritized measures should not be decided based on a risk evaluation, but instead based on vulnerabilities and deficiencies identified in a capability assessment. Swedish authorities therefore argue that the capability assessment is the starting point for deciding what is lacking and what needs to be done.

According to the interviewees, the NRA, as it stands today, focuses on potential consequences. However, in order to move towards limiting these consequences (which is also a governmental requirement), there is a need to identify current capabilities, as well as vulnerabilities and deficiencies in DRM. Once this is done, cost-effective measures can be developed and applied to reduce the potential impact of adverse events, depending on how urgent the situation is.

> "It doesn´t help that we know what the problem is. The government wants to know what to do, where to go."

> "For us at the national level, also for authorities at regional or municipal levels, we need to focus on what to do and that means we have to make the capability assessments as a part of the national risk assessment or as the next step for the risk assessment."

5.3. Risk treatment: the NRA and NRCA practice

Following EU guidelines, the Swedish NRA does not contain much guidance about capability assessments. However, the NRA process highlighted various vulnerabilities and deficiencies to be addressed at the domestic level. Meanwhile, Sweden is seeking to encourage the EU to integrate a capability assessment into the NRA process, based on the experience gained domestically.

The NRA is published on the MSB website and is accessible to authorities and the general public. Interviewees mentioned that some authorities referred to the NRA in their RVAs and used it to draw lessons about their own situation. Moreover, some participants in the NRA workshops continued to work on their risk scenarios even when the workshop had ended, and had developed plans regarding how to deal with these scenarios within their organizations. In addition, the MSB uses the NRA as a primary source to develop the NRCA.

The NRCA is an annual exercise carried out by the MSB. It is an important source of information about the overall situation regarding DRM work nationally. While the NRA is completely based on scenario analyses, the NRCA has a more solid foundation, and draws upon a wider range of source materials. It is mainly based on RVAs, but also takes input from the NRA, together with other relevant scientific reports, evaluations of DRM activities, etc. During the exercise, the MSB checks with RVA producers to make sure that their documents have been understood properly, and are being used correctly. The three main targets of the NRCA and their respective functions are:

- The Swedish government: The government uses the NRCA to understand the country's major risks and vulnerabilities. It guides overall DRM policy, and serves as a basis for decision-making regarding budgets, new legislation, the distribution of resource for crisis preparedness, etc.
- The MSB: The MSB uses the NRCA to steer its own work, e.g., to decide annual strategic plans.
- Cooperative areas: Swedish legislation states that government planning must be coordinated. In order to strengthen society's crisis response, authorities and other actors (municipalities, county councils, and armed forces) cooperate in six areas, namely: economic security; dangerous substances; geographic area of responsibility; protection, rescue and care; technical infrastructure; and transportation. Authorities with different responsibilities are required to agree and synchronize their planning; in particular, they must reduce society's vulnerability in these areas, and ensure that a crisis is dealt with as well as possible. Over the past few years, the NRCA has been used as the basis for decision-making in planning cooperative DRM activities.

To sum up, Sweden's goal is not simply limited to improving its domestic civil contingency capabilities; at EU policy level, the country has also been pushing for the inclusion of a capability assessment in NRAs.

5.4. Communication and consultation among DRM stakeholders

5.4.1. The need to collaborate

Interviewees noted that governmental authorities have realized that they are highly dependent on each other. They acknowledged that it is unwise for agencies to conduct their own risk assessment without knowing the roles, responsibilities and potential risks of others. The NRA workshops and regular DRM-related meetings offer stakeholders opportunities to meet and understand each other's role and responsibilities. Some interviewees called for even more communication and collaboration. They suggested that more information exchange and stakeholder communication should be included in the process, even when each authority conducts their own RVA.

Private stakeholders are largely excluded from the NRA and other

DRM process, since they are not legally required to participate. However, it was repeatedly expressed during the interviews that private stakeholders shall be encouraged, and be more actively involved in the country's DRM activities. Furthermore, the need to invite researchers and research institutes to contribute their perspectives was also noted.

5.4.2. DRM information sharing

It was pointed out that using workshops to collect DRM information could result in the views of some participants being overrepresented, depending on how active they are. Furthermore, some gray areas in terms of DRM information sharing were identified, which made stakeholders uncertain whether they should share this risk-related information with each other or not.

5.4.3. Two-way communication needs to be improved

Effective risk communication relies on two-way communication. Interviewees stated they received little or no feedback on their contribution: *"It feels like it (the information) is going to a black hole"*. This leaves stakeholders unsure about whether the information they provide is useful or not, or whether it is sufficient. Consequently, it has decreased some stakeholders' motivation to improve their analysis, given that they have no idea about how their previous input is evaluated. The MSB has admitted that the lack of adequate feedback is a problem that needs to be solved. However, a lack of human and financial resources means that no solution has so far been found.

5.5. Continuous monitoring and review of NRA work

Interviewees indicated that efforts to involve stakeholders and increase collaboration have positively influenced DRM work in Sweden, especially at the national level. The results can be seen both in the NRCA process, and in practice. Furthermore, interviewees pointed out that the information and knowledge gained while conducting the NRA has fed into the NRCA document and thus influenced the overall DRM work in Swedish society.

According to MSB staff, there was no specific plan to improve the NRA process at the time when this study was carried out. However, there are two directions that demand more effort in the near future: the first is to improve the NRA scenario analysis, and find complementary ways to include more relevant information; the second is for Sweden to influence the EU at policy level. The aim of the latter is to improve NRA guidelines in line with Swedish NRA practice, namely to include a capability assessment into the NRA.

6. Discussion

The Swedish NRA process brings together many stakeholders and provides them with a platform to communicate with each other. It offers them an opportunity to continuously and interactively share and exchange DRM information, both during and after the NRA workshops. However, it is unclear whether the stakeholder communication provoked by the NRA process is effective, as there is no direct evidence found to prove that this is the case. The empirical findings presented in Section 5 suggest that involving stakeholders via NRA workshops does improve communication, and the sharing of risk-related information. However, the quality of such communication largely depends on the personality of participants (e.g., how active they are, whether certain people dominate the group). Moreover, the study made it very clear that almost no feedback is provided by MSB, the lead authority. Without this feedback, communication cannot be claimed to be mutual and meaningful, which raises further questions about the effectiveness of risk communication. Van Asselt and Renn [5] state that "risk communication and trust are delicately interconnected processes". Although trust is not the focus of this paper, a breakdown in risk communication is highly likely to decrease trust among DRM stakeholders, which may result in the failure of DRM activities.

The founding of a multi-level, multi-stakeholder DRM system is closely related to the fact that no single risk owner [36] can see the full risk picture and manage risks without drawing upon input from others [17]. Therefore, it is natural that the NRA process involves stakeholders from various disciplines and administrative levels. The results of this study have highlighted the positive inclusion of stakeholders from the whole of society. On the other hand, more thought needs to be given to the inclusion of other stakeholders who are not obligated by law to participate, such as private stakeholders. Open and adaptive participation will help to improve social learning among stakeholders, so that they can better understand each other's complementary roles. As a result, it may also increase stakeholders' willingness to participate in collective DRM activities (not just the NRA), rather than simply being involved because they have to.

DRM is much more than just minimizing disaster risks. Stimulating societal resilience is another goal [5]. As the results presented here reveal, EU NRA guidelines do not require a capability assessment, which may make it difficult to take further action once potential societal risks have been identified. Swedish practice suggests that if the NRA process is to lead to a less risky, and more resilient society, a capability assessment needs to be included. Furthermore, since budgets for DRM activities are often limited, another useful addition to the risk assessment document would be a cost–effectiveness evaluation, together with an assessment of risk–risk trade-offs, in order to increase the chance that the risk is addressed.

This paper complements previous NRA studies, by broadening the research topics and providing a unique perspective that links the NRA process and practice with other DRM activities. The empirical findings presented in this paper can help both scholars and practitioners to better understand the (comparatively new) NRA process, how it can involve stakeholders, and how it can be integrated into established DRM activities in a multi-stakeholder, multi-level system. It provides food for thought regarding future investigations. Follow-up studies could look at issues related to the NRA process and the final document, in particular the link between the level of integration between the NRA process and other DRM activities, and the quality/ usefulness of the final document. It would be very interesting to understand how integration can improve the usefulness of the NRA, and whether the EU and individual member states share the same point of view regarding its usefulness. Finally, future studies could address questions such as whether a bottom-up, multi-level, multi-stakeholder DRM system fulfills its purpose, and whether it is able to successfully guide stakeholders in collectively managing disaster risks.

7. Conclusions

This article studied the NRA process from end-to-end. It examined how stakeholders from all levels of society are involved, and how it is integrated into existing DRM activities. It investigated stakeholder involvement, the quality of risk communication, and the level of integration between the NRA process and other DRM activities. The analysis followed the risk management process proposed in ISO 31000. The findings suggested that Swedish NRA work has been integrated with other DRM activities, such as the RVA, the NRCA, and emergency planning cooperation. The results also reveal several problems, notably relating to private stakeholder involvement, mutual and effective risk communication, gray areas in the legislation (particularly the sharing of confidential information), and the fact that the EU's NRA guidelines do not include a capability assessment. Furthermore, the paper has raised some interesting questions about future studies. It should be noted that even though this study focuses on the Swedish NRA and DRM system, the findings are not necessarily limited to Sweden. The project sheds light on the NRA process and provides insights into how to improve NRA practice in any, similar, DRM system.

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