Contributions to the Research on Risk Attenuation, Risk Amplification, Trust, and Stakeholder Involvement

Implications of an uncertainty-based risk perspective

by

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Thesis submitted in fulfilment of the requirements for the degree of
PHILOSOPHIAE DOCTOR (PhD)

Faculty of Science and Technology
Department of Safety, Economics and Planning
2021

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www.uis.no

ISBN: 978-82-7644-982-2

ISSN: 1890-1387

PhD: Thesis UiS No. 569

Forsidefoto: Ingrid Time

Preface

The work presented in this PhD thesis is funded by the Norwegian Ministry of Education and Research (Kunnskapsdepartementet). The thesis is submitted in fulfilment of requirements for the degree of Philosophiae Doctor at the University of Stavanger, Faculty of Science and Technology, Norway.

The process of doing a PhD has often been compared to that of a journey, the traveling of a long distance and often in dangerous or difficult circumstances. It is also used as a metaphor for life progression or the gaining of important life experiences. Looking back at my time as a PhD student, I find these descriptions fitting. It has been a journey, and although not in dangerous circumstances, it has sometimes been difficult. Doing a PhD involves getting to know yourself, your strengths and weaknesses. From time to time you question your abilities and the significance of your research, you spend hours searching for the perfect words to describe what you want to say, you become impatient or discouraged. But, if you hang in there, take a little break or drink a cup of tea, the inspiration may come back, and you suddenly find the words you were looking for. Or, you may come across an illuminating article that makes you see something in a new way. All of a sudden something opaque becomes clear, things fall into place and you remember why you embarked on this journey. And for a while, you feel the joy of the moment and enjoy the scenery along the way. During my time as a PhD student, these moments, the victories that have followed periods of struggle, have turned out to be highly important for my professional, but also personal development. Writing these words on the last leg of the journey, it becomes clear to me that the most valuable lessons I have learnt as part of this PhD lie within these moments.

Many people have contributed to increasing the comfort and quality of the journey along the way. However, in doing so, some people have been

more central than others. One of these people has been my supervisor, professor Terje Aven. I consider myself very lucky for having had your support and guidance these years. You have taught me so much and have meant an awful lot for my development as a researcher. Thank you for believing in me, for your patience with such an 'impatient' student, for your quick feedback, advice, inspiration, optimism and encouragement. Some of our 'samlinger' I will never forget.

I also wish to express my gratitude to professor Ole Andreas Engen, my co-supervisor. Your door has always been open for discussions of all sorts. I want to thank you for your professional advice and sharing of important experiences that have proven useful throughout the process of doing this PhD. In addition, I have really appreciated our talks about fictional literature and your recommendations of books worth reading.

Another important character in this story, is Caroline, my 'office -wife'. Since day one, your company has been dear to me. Thank you for every morning you have greeted me with your smile, for all the laughs and tears we have shared and for all the conversations we have had. Thank you for being such a good-hearted person, for always being so helpful, for answering the questions, for solving my technical problems and reminding me about all the things I need to remember. If I am Frodo in this story, you are Sam.

I want to thank every single one of my fellow PhD students in 'C-fløyen' and ISØP- colleagues for creating such a supportive, inspiring, fun and unique working environment. You have all been important parts of the story. The days would not have been the same without all the small, but valuable moments spent next to the coffee-machine, the laughter in the hallway, the lunch conservations, Reidar's cunning comments, Eirik's funny stories, Roger's twists, Sindre's music playing through the walls, the comfort of Marie's chair, Kenneth's freshly baked bread and food supplies, Lars' intriguing theories, hearing of Christian's adventures,

Tonja's reminders of the importance of learning, Omer's telling of the hard realities of life, the synchronized meetings with Tone in the kitchen, Surbhi for cooking advice, Rune's specialist knowledge of fishing and strange fish species, Sanja's movie suggestions, Christine's enthusiastic chatting and so on. This is only a small selection of the all 'stuff' that have added extra color to my period as a PhD student at the University of Stavanger.

Last, but not least, a million thanks go to my nearest and dearest. To my three kids, Malena, Magnus and Ingvild, my mother, father and sister, my fantastic friends and to my closest ally, Kenneth. The motivation, support and shelter you have provided during this period have meant the world to me. I could never have done this without you.

Lisbet Fjæran

Stavanger, October 2020

Summary

The overall objective of this thesis is to contribute to the development of new knowledge related to risk perception and communication, particularly emphasising the issues of risk attenuation, risk amplification, trust, and stakeholder involvement. The thesis consists of five papers (Part II) and an introductory part (Part I).

The main elements of the thesis research are illustrated in Figure 1, which indicates that new knowledge is developed by using an uncertainty-based perspective on risk and enhancing the Social Amplification of Risk Framework (SARF). 'Risk perspective' relates to how to understand and characterize risk. Traditionally, the perspective on professional risk assessments and characterisations in risk perception and communication research has to a large extent been based on risk being equated with historical data and probabilities. Following contemporary risk science, this thinking is replaced by perspectives highlighting uncertainties and knowledge aspects beyond probabilities and related quantitative concepts. Such perspectives are referred to as uncertainty-based and provide a new pillar for conducting risk perception and communication research.

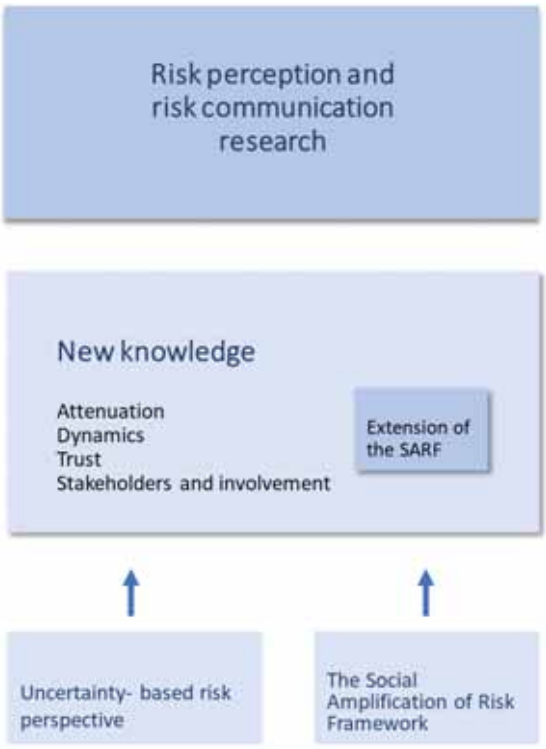

Figure 1. Main elements of the thesis research

The SARF is one of the most recognized frameworks in risk research. It provides a conceptual model and approach for understanding how risks and risk events assessed by experts as low or minor risks can still end up generating considerable public concern and amplification or have the opposite effects, leading to risk attenuation. It shows how risk amplification or attenuation can generate ripples of unexpected and far-reaching effects spreading the impacts of the initial risk event away from where it originally took place.

This thesis establishes new knowledge related to the basic ideas of the SARF, and an extended version of the SARF is developed and discussed as part of the work. These developments are built on and shaped by the uncertainty-based perspectives on risk as well as research on risk

attenuation, the dynamic nature of risk amplification and attenuation, and trust. Figure 2 depicts the main topics and contributions of this research as well as work concerning stakeholders and involvement issues.

Figure 2. Main topics and contributions of the research

The work conducted as part of this thesis illustrates the dynamic nature of risk amplification and attenuation processes and shows how these concepts should be understood as two forces constantly in play. However, depending on which actors and stakeholders are the most active or dominating at different points of time, the 'power' of these forces fluctuates. Based on these fluctuations, risks can be described as going through various phases characterized by attenuation or amplification through their 'course of life'.

Where most SARF research centres around the 'consequential end of things', this work revolves around the early history of risks and studies practices of the first actors 'in touch' with the risks. Focusing on the scientific risk assessor in risk development processes, the work attempts

to make visible the less researched and less visible phases preceding amplification. An important finding in the work is that the amplification caused by many risks and risk events, the kind described by much SARF-research, can to a large extent be seen as a result of previous risk attenuation. Based on the findings and insights following from the research, an extension of the SARF covering phases of attenuation is proposed to allow for more comprehensive analyses using the framework.

In addition, the work provides suggestions for avoiding risk attenuation in order to prevent it from spreading and reduce the associated effects and consequences. Across the papers, how this can be achieved is explored in different ways using an uncertainty-based risk perspective as a conceptual platform and point of departure for the work of those in charge of assessing risks, but also for those managing risks.

For instance, it is shown how this entails approaching distrust from a different angle than the way it is usually understood in society. The research challenges the prevailing idea of trust as an ideal state of affairs and distrust as the opposite—namely, as a complicating factor and negative situation. The work presents the complexity of the trust concept and argues for the importance of approaching what is commonly called distrust as a potential resource. It shows the value of building critical trust into risk assessment, management, and communication processes.

The research also shows that different actors and stakeholders rely on different types of knowledge and emphasise different aspects of risk when understanding and making judgements about risk. For stakeholder involvement to be effective, a common conceptual basis for the actors involved is required. It is argued that an uncertainty-based risk perspective can provide such a foundation. It not only represents a broad understanding of risk, but also entails an extended understanding of knowledge, allowing for the increased integration of stakeholders and

their knowledge, concerns, and values in the early framing, assessing, and evaluating of risks.

This research is oriented toward foundational concepts and builds on real-life examples. However, further work is needed to show the practical relevance and potential impacts of the research. In particular, the thesis points to the need for larger-scale testing of the concepts and ideas developed as part of this thesis.

Contents

List of papers

Paper I

Fjæran, L., & Aven, T. (2017). Do non-governmental organizations relate to risks and uncertainties in an extreme manner? In M. Čepin, & R. Bris (Eds.), *Safety & reliability, theory and applications. Proceedings of the European Safety and Reliability Conference (ESREL)* (pp. 1827–1833). CRC Press.

Paper II

Fjæran, L., & Aven, T. (2019). Effective stakeholder involvement requires a common understanding of the risk concept. In *Proceedings of the 29th European Safety and Reliability Conference (ESREL)* (pp. 171–179). Research Publishing Services.

Paper III

Fjæran, L & Aven, T. (2019). Making visible the less visible - how the use of an uncertainty-based risk perspective affects risk attenuation and risk amplification. *Journal of Risk Research*, 1-19.

Paper IV

Fjæran, L., & Aven, T. (2021). Creating conditions for critical trust—how an uncertainty-based risk perspective relates to dimensions and types of trust. *Safety Science*, *133*, 1–12.

Paper V

Fjæran, L., & Aven, T. (2020). The games and dynamics of the social amplification and attenuation of risk.

Part I

1 Introduction

1.1 Background

This thesis aims to develop new knowledge related to the field of risk perception and communication, with special attention paid to four concepts: risk amplification, risk attenuation, stakeholder involvement and trust. The work presented in this thesis has adopted the definition of risk communication as the exchange or sharing of risk-related data, information and knowledge between and among different target groups or parties (SRA, 2015). Such parties include governmental institutions, regulators, corporations, industry groups, unions, the media, scientists, professional organizations, consumers, public interest groups, and members of the general public.

In line with Kasperson et al. (2003), risk communication is seen as an interactive process of exchange of information and opinions among individuals, groups, and institutions involving multiple messages about the nature of risk, but also about the perceptions, concerns, opinions, or reactions to risk messages or to legal and institutional risk management arrangements.

The concept of risk perception refers to people's subjective judgement or appraisal of risk (SRA, 2015). Different factors like knowledge, feelings, values, and the judgements of others influence the processing and perception of risk-related information, and the mental models and heuristics used as part of this process are constantly moderated by the media's portrayal of news, the influence of social groups and peers, social media, and other communicative processes (Renn & Levine, 1991).

The way risks are perceived and communicated can spur different psychological, social, and political responses. These societal

repercussions are vital elements of the analysis of risk communication (Kasperson et al., 1988). In this context, risk amplification, risk attenuation, and trust are major issues.

Amplification refers to the intensifying, emphasising, or increasing of the 'volume' or importance of specific signals, characteristics, and symbols in a message. Risk amplification is generally associated with heightened perception of risk and tends to trigger risk-reductive measures. This phenomenon can be exemplified by an actor or a group of stakeholders providing information to consumers about a certain food product or a chemical used in this product. When communicating information about the product, she/he stresses the possibility of serious future effects, highlights data indicating a potential connection between the product and some negative effects on health or the environment, and underscores the lack of knowledge and the existence of scientific disagreement about effects. This way of portraying the product results in an increase in the perception of the risks related to this product, which can have consequences for the levels of trust in producers and risk-managing institutions. Consumers may respond by not buying these and other similar or related products. If the information is communicated to risk-managing institutions and regulators, as part of a risk assessment, for example, it might have justified more restrictive regulations, like raising the threshold levels or requirements of alternative production methods.

Risk attenuation represents the opposite phenomenon: the weakening, deleting, ignoring, overlooking, or toning down of the 'volume' of certain signals and symbols. This commonly contributes towards lowered apprehension of risk and compromised risk reduction and regulation. So where, for instance, an accident or a report showing increased numbers of injuries may result in more restrictive regulations and/or distrust of risk managers, a scientific document or a report demonstrating no harmful effects of exposure to a certain chemical or a

decline in injuries may result in increased perception of safety and in relaxed regulations. The phenomenon of risk attenuation may also be illustrated by how an actor or a group of stakeholders can present the same information in different and even conflicting ways. This can yield entirely different interpretations, reactions, and responses. When risk signals are downplayed, ignored, or put in the background at the expense of other signals, such as data indicating that the product is safe, effective, and has no previous history of causing harmful effects, the result can be increased levels of trust in risk assessors and regulators while the demand for products may remain unaffected or even increase.

Various stakeholders and the way they understand risk and risk-related information can influence the development of risk amplification and attenuation processes in different ways. In showing how actors can understand and present risks in different ways, the last example in previous paragraph also illustrates another important tendency. This tendency refers to the fact that technical experts and risk assessors tend to judge certain risks as low whereas laypersons, members of the public, and specific stakeholder groups judge the same risk as high and in need of strict(er) regulation. Risks for which there are differences in risk understanding often bear a common set of characteristics. Such risks are generally associated with a potential for serious and uncertain consequences, complex causal relationships, and value differences. Other factors, like the level of knowledge, degree of control, and negative feelings (e.g., dread, fear) evoked by risk, are also associated with high or increased public risk perception (Slovic et al., 1986). Although low expert risk evaluation versus high public risk perception is the most common expression of differences in ways of understanding risk, there are also risks for which this relationship works the other way around—namely, that risks judged by experts as high and serious receive comparatively less attention from society. Examples of risk subject to such social attenuation are naturally occurring radon gas, car accidents, and smoking (Kasperson et al., 2003). Various stakeholders and the way

they understand and approach risk and risk-related information influence the development of these processes in different ways.

The discrepancy in the how the general public and expert risk assessors understand such risk is the starting point for the Social Amplification of Risk Framework (Kasperson et al., 1988). This framework is an attempt to bring together what often appears as two separate 'worlds': the technical analysis and the social experience of risk. It provides a detailed description of how risks or risk events assessed by experts as low or minor risks can still end up generating considerable public concern and amplification. It shows how this amplification can generate ripples of effects having large societal impacts and spreading the impacts of the original risk event away from where it initially took place while still having large societal impacts.

Since its introduction in 1988, the SARF has been and still is widely used within risk research. While amplification processes and effects have been thoroughly described and empirically demonstrated in a wide range of contexts, the concept of attenuation has received less attention in both the framework and related research. Although the SARF treats both the concepts of amplification and attenuation, it clearly emphasises that of amplification. However, consequences of underestimation and under-response (i.e., attenuation) may have potentially serious adverse consequences (Kasperson et al., 1988). For situations with a high degree of uncertainty and potentially serious consequences, attenuation may downplay important risk signals and create an impression of effective risk management and safety that can have severe consequences for safety and crisis management (O'Neill et al., 2016).

Although not explicitly treated in the original framework, years of research (e.g., Kasperson et al., 2003) have also shown trust to be an important factor in amplification dynamics. Despite some disagreement about the strength of the relationship, there is in risk research a general

understanding that trust affects how one understands and perceives risks and risk events and how these are responded and reacted to. In general, trust is associated with the acceptance of risk-related messages, compliance, and the effective functioning of democratic processes and societal functions. Distrust, on the other hand, is often seen as being related to heightened public concern, risk amplification, questioning of the work of risk regulators, stimulation of risk reduction or avoidance, and the selective use of information sources (Walls et al., 2004). Recent studies have proposed that the understanding of trust and distrust as either–or states does not cover the multidimensional and complex character of the trust concept and that trust may not be descriptive of how the public relates to risk-managing institutions and information coming from these (Pidgeon et al., 2010). Kasperson (2012) holds that there is an urgent need to understand how trust is shaped, altered, lost, and rebuilt in processing of risk-related information in social amplification research. No considerable amount of attention seems to have been devoted to attenuation and the role of trust in such processes either. Also, Kasperson (personal communication, March 1, 2018) has acknowledged that attenuation has received far less attention than amplification and has stated that, in order to raise the understanding of trust and its effects, it is important to gain more knowledge on the relationship between trust and uncertainty.

However, studying attenuation and the early phases of risk development processes as well as the role of trust within these involves extending the use of the SARF to contexts and situations to which it is not usually applied. Doing so requires taking a step away from the technical understanding of risk that dominates assessment and management practices where risk is typically defined by a combination of a set of consequences and associated probabilities.

To capture the complex nature of many risk problems and the varying ways in which different stakeholders or actors understand and judge

risks and risk-related information, a broader perspective of risk is needed. Similar thoughts are increasingly expressed within risk research (e.g., Kasperson et al., 2017). Uncertainties play an important role in processes related to risk amplification, attenuation, and trust, but the traditional understanding of risk is not able to properly reflect or deal with all of these uncertainties, as will be thoroughly discussed in Section 2. Recent research on the foundation of risk analysis and risk management, particularly on how to conceptualize and characterize risk, has shown how the traditional understanding of risk can be replaced by a new set of concepts, principles, approaches, methods, and models allowing for due considerations of the uncertainties. These represent an opportunity to restudy and enhance our knowledge about processes concerning risk amplification, attenuation, and trust. By replacing the probability-based perspective on risk with an uncertainty-based perspective, the understanding of the more blurry and less clear risk and risks events associated with risk attenuation as well as the dynamic nature of risk amplification, attenuation, and trust-related processes can be significantly improved. Section 2 will provide argumentation and examples illustrating this.

1.2 Objectives

The overall objective of this thesis is to contribute to the development of new knowledge related to risk perception and communication, emphasising the issues of risk attenuation, amplification, trust, and stakeholder involvement. To meet this aim, the thesis addresses three sub-objectives concerning improving the understanding of risk:

- the role of attenuation in risk amplification processes
- the role of trust (and distrust) and different stakeholders in risk amplification and attenuation processes

- the dynamic nature of risk amplification and attenuation processes.

Insights into these issues are gained by using an uncertainty-based risk perspective and the Social Amplification of Risk Framework.

1.3 Scientific approach

The Norwegian Research Council links the scientific quality of research to three aspects: originality, solidity, and relevance (NRC, 2000). The originality of scientific work lies in the fact that it should result in something novel—some new knowledge related to, for example, new or modified concepts, theories, principles, approaches, methods, or models. Solid scientific work implies that the research must meet some established fundamental principles for research, such as providing clear explanations of terms, methods, or data used or being based on existing literature and papers going through peer reviews. Third, for it to be considered relevant, it should make a useful contribution towards solving, developing, or increasing the understanding of the problem it studies.

Throughout the work presented in this thesis, the author has, to the best of her ability, aspired to meet the three criteria of scientific quality as proposed by the Norwegian Research Council. The thesis has been developed based on the European PhD model. Following Day and Gastel (2006), the work according to such a model is composed of a series of published papers (Part II) in combination with an introductory part in which the papers are framed within a broader context (Part I). The papers presented in Part II represent the main scientific contribution of this thesis. The work covered by this thesis has been carried out as part of an integrated process in which the following activities have been central:

- Study of literature in specific fields related to the objectives presented

- Document analysis and searches for and studies of relevant literature related to specific cases concerning food and feed risks (genetically modified organisms, feed additives, farmed salmon)

- Guidance from and discussions with supervisors

- Discussions and brainstorming with colleagues and correspondence and communication with researchers in similar and related disciplines

- Paper-writing processes of an incremental nature: drafting, revising, and continuous improvement based on comments and feedback

- Publication of papers in conference proceeding and articles in journals with peer-review arrangements

- Presentation of papers and research at international conferences with subsequent discussions, feedback, and questions

The research resulting from these processes and activities bears different characteristics. There are several ways to categorize research. It is common to distinguish or contrast descriptive categories with more analytical ones, such as applied versus fundamental, quantitative versus qualitative, and conceptual versus empirical (see, for example, Kothari, 2004). These basic categories are not mutually exclusive and, as with most research, the work presented in this thesis fits in many of these categories.

First, the research is of a clear conceptual character and can be described as being representative of generic, fundamental risk research. It generates what Aven (2018) referred to as type B knowledge. This type of research concerns ‘knowledge on concepts, principles, theories, frameworks, approaches and methods, and models to understand, assess, characterize, communicate, and (in a broad sense) manage risk’ (Aven, 2018, p. 2415). According to Aven (2018), the result of such research is

largely normative and provides recommendations of future use of, for instance, conceptualisations, frameworks, and principles. This also holds relevance for the work in this thesis.

However, although the work treats abstract concepts and foundational ideas, it also has an empirical dimension. Conceptual ideas are applied to empirical contexts and used to analyse real-life events and examples. Accordingly, it also concerns the generation of the sort of knowledge referred to as type A knowledge. Such knowledge is commonly produced by applied research, but since research of a conceptual character often also relates to real-world activities, situations, and contexts, it can also generate knowledge of this type. The papers presented in this thesis provide detailed descriptions of real-life situations and contexts, analysing them based on conceptual ideas and frameworks. In this way, returning to the categories of research, the work also contains elements of a more empirical and qualitative character. Yet despite being related to specific cases and examples, the research can be classified as generic and fundamental in that it aims to produce findings, conclusions, and recommendations that are generalisable and applicable across different contexts.

Among the research categories presented thus far, it is the conceptual, fundamental, and analytical ones that are most descriptive of the qualities of the work presented in this thesis. In addition, as mentioned, it is towards the production of type B knowledge, where the main contribution of this thesis lies.

1.4 Thesis structure

This thesis has two parts. Part I describes and motivates the research areas and questions. It summarises, ties together, and frames the work conducted as part of this thesis in a broader context. More specifically, it provides a description the background, objectives, scientific approach, and main contributions of the work. Part I thus provides a summary of

and contextual background for Part II of the thesis, which consists of a collection of papers that present and make up the scientific contributions of the thesis.

Part II consists of five papers. Four of these papers have already been published: two in the peer-reviewed proceedings of the European Safety and Reliability (ESREL) conference, one in the peer-reviewed journal *Safety Science* and another in *Journal of Risk Research.*

The remainder of Part I is organised as follows. Section 2 summarises and contextualises the contributions of the scientific papers in Part II. Then, in Section 3, ideas and recommendations for potential areas and directions future work and research are outlined. These are mainly built on the scientific contributions of the thesis papers.

2 Research areas and findings

This section presents the main scientific contributions of the papers presented in Part II of the thesis. All papers aim to contribute to the development of new knowledge related to risk perception and communication, particularly the topics of stakeholder involvement, trust, and risk amplification and attenuation (see Figure 3). The five papers of the thesis relate to the topics shown in Figure 3. Only the main contributions are illustrated. Some papers touch upon many or all topics; for instance, Paper IV addresses trust, risk amplification, and attenuation, but also provides important insights relating to stakeholder involvement. Although Paper V mainly revolves around risk amplification and attenuation, the paper can also be seen as a synthesis of all three topics. In addition, Papers III, IV, and V are closely connected; they build on each other and are all based on a case concerning the assessment and regulation of risks related to the use of a feed additive (i.e., narasin). In this way, there are some overlaps in the papers. The exact contributions of each paper are provided in the articles presented in Part II of the thesis.

The main contributions of the papers lie within different topics, as indicated by the arrows in Figure 3.

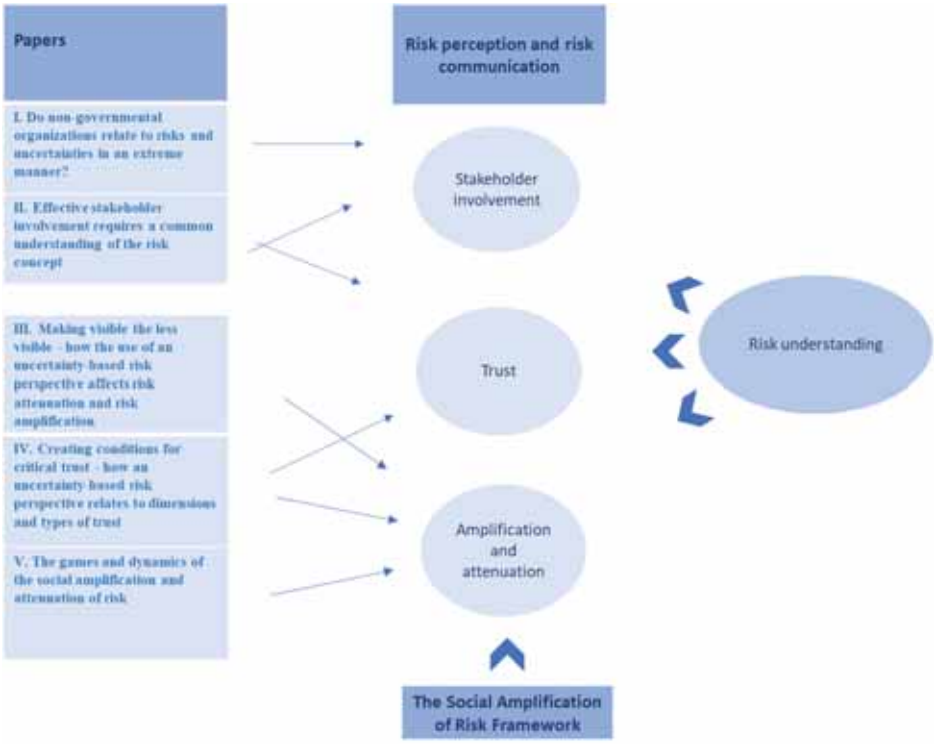

Figure 3. Main contribution of the papers

Insights into all three issues have been obtained using an uncertainty-based risk perspective as a theoretical framework. This way of understanding and conceptualising risk in different ways has implications for stakeholder involvement, trust, and risk amplification and attenuation and will be further explained as part of the presentation of the papers in Sections 2.1.–2.3. In Papers III–V, the Social Amplification of Risk Framework, as introduced in Section 1.1, is also applied to study the topics.

In the subsequent sections, the papers will be presented depending on what topic they mainly address. Section 2.1 treats stakeholder

involvement and presents the contributions of Papers I and II relating to this topic. As mentioned, Papers III–V are intimately related; all three draw on the same case and make use of the SARF. However, the papers study different topics. Paper IV is presented in Section 2.2 and covers the concept of trust, while Papers III and V address the issues of risk amplification and attenuation and are presented in Section 2.3. The different sections open with a brief introduction to the topic addressed before describing more specific problems and findings of the papers.

2.1 Stakeholder involvement

Various actors and stakeholder groups understand and relate to risks in different ways. Stakeholders differ significantly in their willingness to take on risks to achieve potential benefits, make risk judgements based on different sets of data and knowledge bases, and often arrive at conflicting conclusions about risks. This is especially common when it comes to risk problems characterized by a high degree of uncertainty, where causal connections are complex and attached with different and/or conflicting values.

Knowledge of how different stakeholder groups understand risks and uncertainties and how they make use of data and information in their risk judgements and communication can provide risk assessors, risk managers, regulators, and policymakers with valuable information. Stakeholders and actors with different agendas can impact public risk perception and responses, influencing the political landscape and the quality and shape of regulatory policies. Such knowledge may be especially important where the representation and power of stakeholder groups are unevenly distributed. According to the IRGC (2008), the lack of adequate knowledge on stakeholder values, beliefs, and interests is described as a risk governance deficit.

Advocacy non-governmental organizations (NGOs) play an increasingly active role in politics and policymaking and may act to shape public opinion and attitudes. According to Tait (2009), given the power and opportunity, this group of stakeholders "can be just as unscrupulous as any multinational company in their manipulation of policy processes and their misrepresentation of information" (p. 9). The adoption of the cautious European GMO-regulations has, for instance, been directly linked to the extensive risk communication of politically powerful and ideologically motivated advocacy NGOs.

The main aim of Paper I is to provide new insights into how advocacy NGOs understand and relate to risk. The paper asks if NGOs relate to risk in an unbalanced and extreme way, which involves placing uneven weight on certain aspects of risks.

Using an illustrative example related to the introduction and use of GMOs, the paper discusses the indications that NGOs tend to emphasise uncertainties, the potential severity of long-term consequences, and the need for precautionary measures when judging risks.

Two hypotheses are put forward and discussed:

1. The risk judgements of NGOs are grossly in favour of the matter they are advocating.

2. The viewpoints of NGOs are more about value judgements than risk assessments.

The analysis shows how NGOs selectively refer to, use, and interpret data, information, and research when making judgements and communicating about the risks related to the use of GMOs. Support is found for the tendency to find new data reliable and informative if consistent with initial beliefs and ideas and to dismiss contradictory data and information (Slovic et al., 1979). However, the tendency to make use of data and information that fit or match the agenda and matters

advocated is not unique to NGOs; it is also identified for other stakeholder groups. In the process of making a case for or against GMOs, Tait (2008) argued that advocacy groups and the industry used invalid and biased data. The first assertion stating that the risk judgements of NGOs are grossly in favour of the matter they are advocating is only partly true and cannot fully describe how this stakeholder group understands and judges risks. When making judgements and conclusions about risk, NGOs emphasise uncertainties of potential consequences and limitations of existing knowledge. Despite this focus on uncertainty aspects of risk, the analysis shows that it is the values held by this group of stakeholders that exert the largest influence on their risk judgements. This way, despite the existence of risk assessment results demonstrating that risks are low, the values promoted and protected by the NGOs will most likely make them characterize risk as high. This inclination is also identified in Paper II relating to salmon farming and can be illustrated by a statement by Max Bello, a natural resources specialist, concerning plans to expand the Norwegian salmon farming industry to Argentina: "No amount of economic growth justifies the destruction of Patagonian ecosystems" (Gutnam, 2018).

The aspects of risk considered important by NGOs were not captured in the scientific risk assessments in the GMO example. These were of a technical character depicting risk as the combination of some consequences and probabilities. Such a way of understanding and expressing risk does not correspond with the way risks are understood by NGOs, and the ignorance of or failure to draw on knowledge of different concerns and to include aspects relating to uncertainties may encourage NGOs and other stakeholders to misuse or overemphasise data and information indicating uncertainties. As mentioned, in the GMO example, the risk framing and communication of NGOs and anti-GMO campaigners (e.g., Greenpeace International, Friends of the Earth

International) came to significantly affect public perceptions of GMOs and the degree and form of related policies and regulations.

To avoid making imbalanced decisions and policies where regulations favour the interests of certain actors, stakeholder involvement and participation in risk governance processes are important strategies. However, in practice, many involvement attempts do not produce the expected effects (e.g., Wynne et al., 2007) and, in fact, can sometimes act to hinder risk governance processes (Löfstedt & van Asselt 2008). In Paper II, it is argued that this may be partly attributed to the fact that the implementation of such efforts is often confined to risk management and decision-making. Here, participation is intended to offer or add social perspectives for evaluating risks or risk management plans (Renn & Walker, 2008). As argued in Paper II, for stakeholder involvement to be successful, it should start from an earlier point in time—namely, from the very start of the risk assessment process. However, this requires broadening the conceptualization and understanding of risk and what is considered relevant and valid knowledge in risk assessment and risk management contexts.

As described in this paper and in Paper I, various actors and stakeholders hold different and often conflicting understanding and judgements of risk, which can complicate involvement attempts in different ways. Drawing on examples related to salmon farming, Paper II shows how industrial actors and those in charge of assessment and regulatory processes (also referred to as group 1) relate risk and knowledge in relatively narrow terms. Risk is described as the combination of a set of consequences and associated probabilities. A limited set of historical, statistical data forms the knowledge base for the assessments that again provide the basis for regulations. Considerations of uncertainties in the assessments are of a limited character and generally reflect statistical variation. The existence of data limitations and epistemic uncertainties is acknowledged, but merely as statements having no impact on risk

characterization or final conclusions. The situation in which scientific uncertainties are acknowledged, but without altering the outcome of the risk assessments has been described by Weimer (2015) and Van Asselt and Vos (2008) as ‘the uncertainty paradox’.

This way of approaching risk and uncertainties deviates from the way in which risk is understood by what is referred to as group 2 actors or stakeholders in the paper. In terms of the salmon farming examples, these are represented by members of the public, representatives of local communities, fishermen, certain scientists and researchers, and—as shown in Paper I—interest groups and advocacy NGOs. It is argued that the traditional, probabilistic understanding of risk held by group 1 actors dominates risk assessment processes and hinders stakeholder involvement from having a real effect on these and related results. In addition to representing a narrow conceptualization of risk, such perspectives also similarly correspond to slim ideas of what qualifies as valid data and input when assessing risks.

Wynne (1992) demonstrated the incompatibility between the intellectual frameworks and culture of scientists and community members with hands-on experience and information (e.g., sheep farmers). He showed how this incompatibility was associated with the failure of scientists (and ministry officials) to recognize and acknowledge important local knowledge, insights, and expertise when assessing and managing risks over a period of many years. The knowledge provided by local sheep farmers was not acknowledged as scientific because it clashed with the ‘scientific culture’ of simplistic reasoning and prediction, standardization, and control, in which uncertainties were ‘naturally’ deleted (Wynne, 1992). Similar findings were reported in a Canadian project in which scientists engaged with local lobster fishers in the ‘joint production of knowledge’ when assessing the relationship between lobsters and the aquaculture industry (Maillet et al., 2017). Although concluding that the collaboration led to a more comprehensive

knowledge base, the experiential data of fishermen were not incorporated into the project because they did not correspond with the idea of what was believed to constitute objective scientific data by certain scientist groups in the project.

In his work and studies, Wynne has repeatedly voiced a need for those in charge of assessing, handling, and managing risks to be more uncertainty accommodating and reflexive. Studying stakeholder involvement and contributions related to biotechnology, Lightfoot (2017) made the same suggestions and reported that non-expert participants found engagement in risk assessment and hazard prioritization difficult and 'felt that the process should be designed to incorporate uncertainty'.

Based on such arguments and findings, in Paper II we argue that, for involvement strategies to be effective, a shared conceptual understanding of risk among the different stakeholders is of crucial importance. The paper also suggests that what is referred to as an uncertainty-based risk perspective can provide a common conceptual platform for the actors involved in the risk assessment and risk management process.

An uncertainty-based perspective of risk

The adoption of such a perspective involves moving away from the more limited, probabilistic approach to uncertainty and risk and extending the understanding of risk to cover aspects considered important by group 2 actors or stakeholders as well. Compared to the traditional, probabilistic approach to risk identified in the narasin case, such an uncertainty-based risk perspective involves giving stronger weight to uncertainties and knowledge aspects. Where the main component of risk following a traditional risk perspective is probability, here the main component is uncertainty. Risk is understood as the combination of two components: (i) the consequences of an activity (events and their effects) related to

something of human value and (ii) the related uncertainties— what will these consequences be?

To describe these uncertainties, probabilities are often used, but probabilities alone are not considered sufficient to fully describe risk. The fact that probabilities and related risk characterizations are founded on some knowledge and that this knowledge can be of varying quality is emphasised. The informativeness of probabilities is highly dependent on the strength of this knowledge. Therefore, the knowledge base and its strengths and weaknesses, together with the fact that surprises relative to this knowledge can occur, must constitute central parts of the characterization and final judgement in any risk assessment process.

This perspective of risk is based on ideas going back many decades. In their celebrated paper, Kaplan and Garrick (1981) referred to risk as 'damage + uncertainties'; in recent years a risk science has been developed providing concepts, principles, approaches, methods, and models founded on this perspective (e.g., Aven, 2020; Renn, 2008). Several guidance documents and videos have recently been developed by the Society for Risk Analysis (SRA) to support and explain the basic pillars of this science and, in particular, its foundation on risk conceptualization and characterization (SRA, 2015, 2017a, 2017b, 2020).

Such a risk perspective not only means broadening the risk concept, but also extending the understanding of what is considered relevant and valid knowledge when characterizing and evaluating risks. Uncertainties must be actively addressed and investigated using all available knowledge. An uncertainty-based risk perspective permits and promotes the use and integration of quantitative and qualitative methods and data. Knowledge is seen as representing a set of justified beliefs and, when judged scientific, they are the most epistemically warranted assertions existing at a certain point in time. This allows including data and

information that, following conventional, probabilistic perspectives, does not correspond to what is believed to constitute valid and objective data or 'evidence'. Following Wynne (1989), for instance, the use of a multiple set of knowledge in tandem increases the value of science. Accordingly, the recognition and integration of 'alternative ways of knowing' (e.g., experiential data, public accounts, knowledge about stakeholder values and perceptions) increase the scientific quality of risk assessments.

Extending the knowledge base and foundation for risk assessments by using diverse and nuanced data and information can act to avoid risks being framed too narrowly or in an imbalanced way early in the process. This is especially important for risk problems where uncertainties are high and value differences are large.

This last statement points to an important challenge also addressed in Paper I: the irreconcilable values of various stakeholders (e.g., protection versus development). Because of the competing nature of such values, some stakeholders may not be interested in increased involvement in and representation of risk assessment and management processes. The making of balanced assessments may challenge the power of certain stakeholder groups. For example, Norwegian salmon farming regulations have faced criticism for favouring the interests of the industry and economic benefits over long-term environmental protection. The quality of the risk assessments and processes behind regulations has been questioned for being based on pro-salmon farming data and for excluding research demonstrating negative effects and critical voices from the process. In analysing the processes behind the introduction of GM technology in Europe, Tait (2008) claimed that the failure to include all aspects related to different concerns and values of different stakeholders early in the risk assessment process had substantial effects on the degree and form of regulations. As mentioned,

regulations came to favor of those opposing the use GMOs and promoting the values of precaution and protection.

2.2 Trust

Closely connected to discussions concerning value differences and stakeholder involvement is the concept of trust, which is the topic of Paper IV. The paper opens by laying out some the general trends, complexities, controversies, and unresolved questions in risk-related trust research. In general, trust is associated with the acceptance of risk-related messages, compliance, and effective functioning of democratic processes and societal functions. Distrust, on the other hand, is often related to the opposite tendencies: heightened public concern, risk amplification, questioning of the work of risk regulators, and a selective use of information sources (Walls et al., 2004).

Although it is generally agreed that trust plays a central role in shaping risk perception and risk responses, the fundamental questions relating to the causality of trust and the strength of the effect of trust remain open for debate after more than 25 years of trust research in the risk domain (Siegrist, 2019). Another dispute within trust-related risk research relates to the drop in public trust. Declining public distrust has been described as a key issue in research related to European health scares and regulatory food and feed scandals, such as the bovine spongiform encephalopathy (BSE) crisis (e.g., Lofstedt, 2004, 2013; Lofstedt and Schlag; 2017) and the use of GMOs (e.g., Albach et al., 2016; Gaskell et al., 2000). The reported drop in trust in European food safety regulators has been described as representing a change from an era of trust toward an era of post trust, where main risk communicators are increasingly distrusted by consumers (e.g., Lofstedt, 2013).

In parallel, others have questioned the idea of declining public trust. Raaphorst and Van de Walle (2018) argued that ‘evidence of declining

trust can be complemented by an almost equally substantial body of evidence of stable or increasing levels of trust' (p. 469). Siegrist (2019) recently reported findings indicating that trust is more stable that previously supposed in much of the risk literature. Wynne (2006) used the term 'public mistrust myth' and argued that the conventional wisdom stating that, until the BSE risk event, the European public trusted science and scientists should be rejected.

Despite such dissent within the scientific community, the idea of public distrust as a hallmark of today's society prevails and dominates the political discourse and work of many governments, policymakers, and risk-managing institutions and scientists. Similarly, many researchers describe the landscape within which various risks today are regulated and managed as one of social distrust (e.g., Albach et al., 2016; Frewer, 2017; Leisinger, 2016; Lofstedt, 2013; Lofstedt et al., 2011; Renn, 2008; Tuler et al., 2017).

Changing the ideas of trust and distrust

Ideas put forward decades ago challenging the prevailing notion of distrust have also started to gain ground again within risk research. Barber (1983) held that the importance of trust was exaggerated and that distrust could be functional and necessary for political accountability in a participatory democracy. Short (1992) argued that a balance between trust and distrust was critical to public acceptance of risk-related decisions and their implementation. In a more recent study relating to pandemic situations, Wong and Jensen (2020) pointed to problems associated with high levels of public trust that may lead to the underestimation of losses and reduce the belief in the need to take action to control risks when necessary. According to Tuler et al. (2017), more than aiming to reduce distrust and build or restore trust, one should accept distrust and proceed in a middle ground by creating appropriate mixtures of distrust and trust. However, despite the existence of such

insights and ideas, they have yet to be incorporated into contemporary institutional practices or procedures. The dominating understanding seems to be of trust as a complexity-reducing factor and as an ideal state of affairs, where strategies like stakeholder involvement, public participation, and communication of scientific uncertainties in risk governance processes are implemented to rebuild or increase levels of public trust. As described in Paper II, these strategies have yet to produce the expected effects.

In Paper II, we argue that—for stakeholder involvement attempts to be effective—a common risk understanding for all stakeholders is needed; an uncertainty-based risk perspective could provide such a foundational platform. Paper IV can be seen as an extension of Paper II as it proposes that the increased success of involvement attempts also requires understanding and acknowledging the complexity and different dimensions of the trust concept. The paper builds on insights from Poortinga and Pidgeon (2003) indicating that the conceptualization of trust and distrust as mutually exclusive states does not describe how the public perceives the government and its policies. Similarly, Walls et al. (2004) stated that 'the binary opposition of trusting or not trusting is inadequate to understand the often ambiguous and contradictory ideas people possess' (p. 133).

In line with the above propositions, we challenge the dominating idea of 'full' trust as an ideal situation and of distrust as the opposite: a complicating factor and situation that should be prevented or counteracted. We argue that, for stakeholder involvement and deliberation initiatives to positively affect what is commonly described as trust, distrust should be understood in more positive terms and trust and distrust should not be approached as either–or states. In the paper we study the role of the scientific risk assessor in this context and show how the adoption of an uncertainty-based risk understanding can help

achieve a balance of trust and distrust in the processes in which risks are assessed and regulated.

Building on work conducted in Paper II and drawing on the typology of trust from Poortinga and Pidgeon (2003), the paper explores how such an uncertainty-based risk perspective relates to different types and dimensions of trust (see Figure 4).

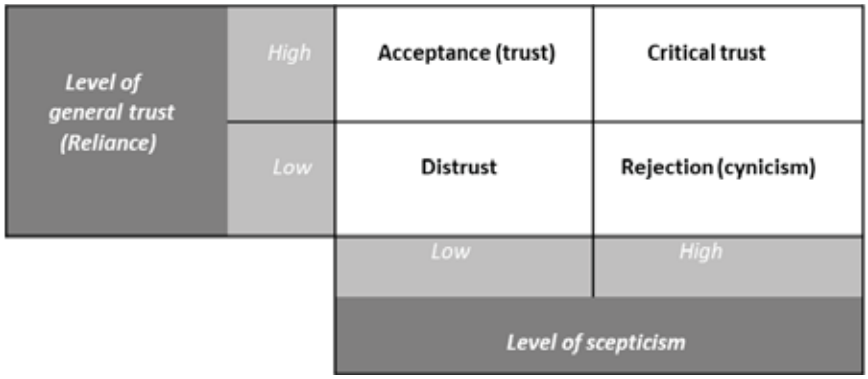

Figure 4. Typology of trust (based on Poortinga & Pidgeon, 2003)

Where the typology was developed to describe how the public perceives government and its policies, it is here used to analyse a case concerning levels and types of trust between the different actors involved in the authorization and regulatory process related to the use of the feed additive narasin.

The analysis of the case showed that the actors in charge of these processes possessed the same technical and probabilistic understanding of risk as identified in the examples relating to GMOs and salmon farming. The paper illustrates how this approach to risk goes hand in hand with generally high levels of both trust between actors and a

relatively uncritical reliance on and acceptance of risk-related information and data. First, the hypothetical effects of using an uncertainty-based risk perspective on trust as a filter for the processing and interpretation of risk-related information are explored, before it is shown how such a perspective relates to and impacts public trust in different ways.

Compared to the levels observed in the case, an uncertainty-based risk perspective entails relatively lower levels of general trust/reliance and higher levels of the scepticism. For instance, using such a perspective as a theoretical foundation for such processes does not allow for using trust as a cue allowing recipients to make simple inferences and judgements about information. It requires applying reflexive and critical ways for processing and using information, which Cacioppo and Petty (1984) described as the central route for informational processing. Here, risk messages and information go through processes that foster what Cacioppo and Petty (1984) called high elaboration likelihood. This means that it is likely that recipients will engage in effortful thinking and an in-depth analysis and evaluation of risk-related information and its merits. Using SARF terminology, it is explained how this way of understanding risk (and knowledge) entails the injection of a degree of amplification into the processes studied in the paper. Adekola (2019) also concluded that more elaborate ways of processing information can act to amplify uncertainties and gaps in knowledge. However, although risk amplification often is associated with negative effects, in this paper we argued that such amplification can be of a healthy character by creating awareness of and acting to filter out sources of attenuation. In this way, an uncertainty-based risk perspective can introduce similar qualities to what Barber (1983) described as the functional or effective character of distrust into risk assessment processes by, for instance, revealing information coloured by the vested interests and agendas of powerful stakeholder groups and contributing to keeping power imbalances in check.

The paper concludes that an uncertainty-based approach to risk corresponds with the type of trust referred to in the typology as critical trust. Critical trust reflects a pragmatic practical reliance on an institution, paired with a sceptical or critical attitude towards the effectiveness, motivations, and independence of this agency (Pidgeon et al., 2010; Walls et al., 2004). In addition to being useful for explaining the public perception of governmental policies and information, it also proved valuable for describing relationships between the actors involved in the assessment and regulatory process and their use and understanding of risk-related information. Yet, more than introducing changes in actual levels of trust, an uncertainty-based perspective corresponds with activating the scepticism dimension of the trust concept.

Following the SARF structure, it is explained how the impacts on public trust are closely related to both the variable of time and effects on risk attenuation and amplification. Uncertainty-based approaches to risk may act to negatively impact trust on a short-term basis; however, in the long run, they may have positive effects on public trust. Despite recent indications of trust being more stable than previously supposed (Siegrist, 2019), the analysis of the narasin case supports points made by, among others, Pidgeon et al. (1992), Kasperson et al. (2003), and Haynes et al. (2008) in stating that, if risk and uncertainty are not adequately considered or managed, trust in institutions may still be highly sensitive to the occurrence of risk events.

2.3 Risk amplification and attenuation

The last points presented above bring us directly to the topic of Paper III: the connection between risk attenuation and amplification.

Paper III sheds light on the less visible processes and mechanisms preceding amplification and argues that risk amplification and the degree of amplification generated by risks or risk events can be seen as

a product of attenuation over time. Little SARF-related research investigates the early stages of risk development processes. This may be related to the fact that, in both the framework and in related research, the concept of attenuation has stood in the shadow of that of amplification. Yet studying attenuation and the periods prior to amplification can be critical to understand the later interaction between risks or risk events and psychological, cultural, institutional, and social mechanisms and processes. Similarly, Poumadere and Mays (2003) argued that the degree of amplification may sometimes be a function of the degree of prior attenuation in the given social context and that there is a need to research the dynamics and phases that precede and shape risk and risk events.

Using the SARF to study the early life of risks involves using the framework prior to which it commonly applied. At the stage where risks are amplified, risk or risk events are usually well-defined, risk problems are often already exacerbated, and positions of actors are polarized (Poumadere & Mays, 2003). Before such amplification, risks are of a very different character; not only are risks opaque and less clear, but their consequences are also more hidden and harder to define. In addition, analysing these stages of risk development processes requires focusing on different actors than what is seen within most SARF-related research. Where the focus of amplification research is generally on the 'consequential end of things' and the public reactions to risk events or to the actions of governmental institutions, in this paper we direct the main attention towards the scientific risk assessor.

The SARF and its terminology are used to analyse the same case as in Paper IV, thereby demonstrating how the risk understanding of the actors involved in the processes related to the authorization and regulation of narasin is associated with a significant downplaying and attenuation of risk signals and aspects in the communication,

interpretation of, and responses to risk-related information and risk events.

The analysis of the case showed that, for the purpose of studying attenuation and early history of risks, the SARF did not prove to be as 'equipped' as for the points of time where risks have been amplified or are in the process of becoming amplified. Based on these experiences, the paper suggests an extension of the SARF to allow for more comprehensive analyses covering attenuation processes. This extension involves adding a phase or sequence to the original framework (Figure 5).

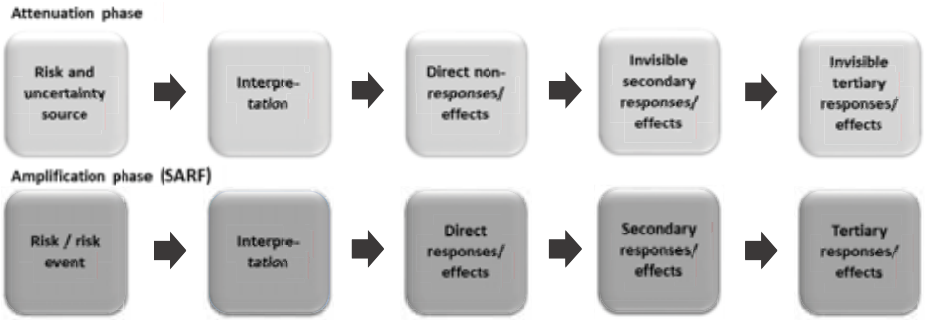

Figure 5. An extension of the SARF

In practice, this means using a conceptualization of risk focusing on uncertainty aspects (i.e., the uncertainty-based risk perspective as described in Section 2.1) and a somewhat different terminology than in the framework. Where the SARF starts out with a risk or risk event, here it is replaced by that of a risk or uncertainty source. This notion is more descriptive of and to a larger extent covers the fuzzy and more hidden risks in the early stages of risk development processes. These can also be described as 'non-events', which Weick and Sutcliffe (2001) described as events resulting in no direct materially adverse outcome and for which there seldom exists much statistical data. Based on the

findings in the case, Line 1 of Figure 5 illustrates how the communication and interpretation of information related to such risk and uncertainty sources (Box 1) in different ways may spur ripples of less visible responses (i.e., non-responses) and effects. In this case, those in charge of assessing and regulating risks responded to incoming information and risk events in ways that gave the impression of them being in control, current regulations provided sufficient protection, and no risk existed. Such 'do-nothing' responses in which a business continues as usual and no further changes to the legislative or regulatory framework is brought (Pei et al., 2011) can contribute to the spreading of attenuation. Although less noticeable, these non-responses are interpreted and absorbed in society in ways that produce hidden impacts, often acting to compromise risk reduction and prevention. These may manifest in a gradual drift away from focusing on the risks as issues in merit of societal attention and to reinforce public perception of risks as low. This extended form of risk attenuation forms the context within which new risks or risk events (Box 1, Line 2) are interpreted and responded to. As stressed in this paper, the sequence of events as depicted in Line 1 may serve to explain the degree of amplification generated by the introduction of later risks and risk events. This process of social risk amplification is illustrated by Line 2 in the figure. A more detailed description of this process can be found in the original SARF (i.e., Kasperson et al., 1988).

In addition to being valuable for placing risk attenuation and its consequences 'on the map', the paper argues that an uncertainty-based risk understanding can be useful for reducing or preventing such attenuation. The paper describes how an increased focus on uncertainty aspects of risk paired with a broader understanding of knowledge in different ways can act to 'break the chain of attenuation' identified in the case and prevent attenuation from spreading from one level to another: from the risk producer to the risk assessment, from the risk

assessment to risk management and regulatory responses, and from risk management to the public and society at large.

Although the paper focuses on attenuation and the prevention of attenuation, it must be noted that this should not be taken to imply that the attenuation of risks is necessarily negative. It can also serve important functions. Risk attenuation can, according to Kasperson et al. (1988), be seen as indispensable by allowing individuals to cope with the multitude of risks and risk events encountered on a daily basis. However, systematically underrating, ignoring or downplaying risk and uncertainties could lead to what Versluis et al. (2010) called 'uncertainty blindness', a situation where only yesterday's accidents are managed and significant future risks are overlooked. For risk problems of high uncertainty and for which there exists a potential for serious consequences, like the ones addressed in this thesis, such risk attenuation may end up having considerable societal impacts.

Despite contributing to increasing the knowledge of attenuation processes and mechanisms, as well as the understanding of the role of prior attenuation in later amplification processes, the work presented in Paper III does not fully capture the fluctuating nature of risk amplification and attenuation processes.

For instance, the addition of a phase of attenuation to the original SARF does not sufficiently illustrate how risks develop, grow, and change character over time. The continuously ongoing and dynamic nature of these processes challenge the sequential, chronological structure of both the SARF and the extended version presented in this paper. Similar observations have been made by Wirz et al. (2018) in stating that they did not find the framework a useful foundation for interpreting variations over time.

The recognition of risk amplification and attenuation processes as complex and dynamic forms the basis for the work conducted in the last

paper presented in this thesis. Based on the narasin case, the paper describes how amplification and attenuation can be seen as two forces constantly in play. Where amplification and attenuation often come across as 'either–or' processes and mechanisms in the SARF in SARF-related research, the paper shows the parallel existence of these forces. This simultaneity can be seen, for instance, within the communication of a specific piece of information by a certain actor, where the attenuation of some risk signals, characteristics, and aspects almost automatically seem to involve the amplification of others, and often the opposite signals, and vice versa. It can also be seen on a larger scale like when different stakeholders and actors communicate conflicting risk signals and messages in the media.

However, the main contribution of the paper does not lie in demonstrating the concurrent existence of amplification and attenuation, but in showing that the 'power' of these forces fluctuates depending on which actors are the most active or dominating at different points of time. Drawing on findings from Paper III, it is shown how risks through their course of life can be described as going through different phases or waves characterized by attenuation or amplification.

In the paper, these fluctuations are illustrated as waves (see Figure 6), where amplification is illustrated by the rise and crests of waves and attenuation by the troughs or lower points of waves. In the case, the combination of actors and signals communicated by them resulted in large fluctuations consisting of relatively deep and long troughs of attenuation now and then disrupted by sudden waves or flows of amplification of gradually increasing size and amplitude.

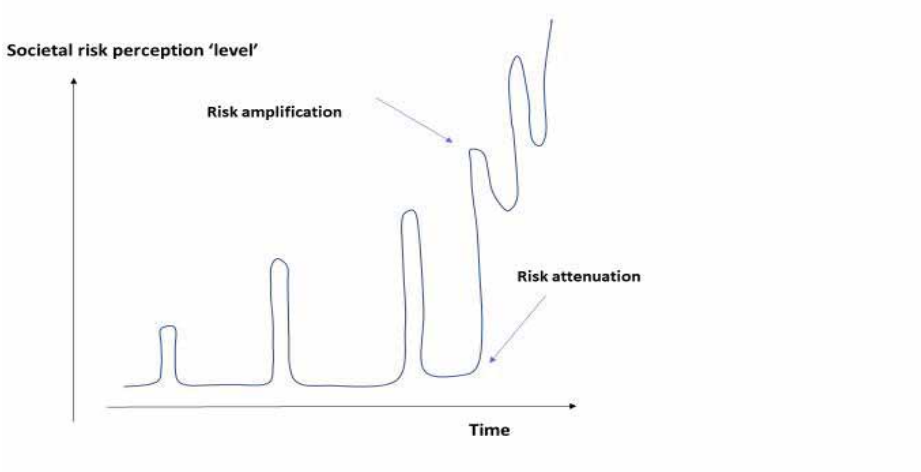

Figure 6. Illustration of the waves of risk attenuation and amplification in the narasin case

The developments and course of events in the case illustrate that these waves are intimately connected. What happened—and, equally important, what did not happen—in one wave largely affects what happened in the next. The analysis of the case shows that the size and shape of the waves can, to a large extent, be traced back to how the risks were first understood and communicated by the group of actors referred to by Hilgartner (1992) as the system builders. In the case studied in the paper, these are represented by the industrial companies making the products containing narasin (i.e., risk producers) and the actors and institutions in charge of assessing and regulating the risks related to the use of narasin. These actors are similar to the group of actors or stakeholders categorized as group 1 in Paper II.

From the very start of the case, the technical and probabilistic risk understanding held by these system-builders appears to dictate how risks, risk events, risk messages, and information are interpreted and responded to. The narrowness and uncertainty-intolerance of their risk perspective seem to deprive them of any flexibility in the communication of and responses to risk related information and to

deadlock them into the roles of risk attenuators. White and Eiser (2010) described risk attenuators as actors or stakeholders demonstrating a 'strict response bias', implying that they are less likely to declare the presence of risks than other groups of actors and require large amounts of data or strong evidence before warning the public.

Throughout the entire course of the case, the actors and institutions in charge of assessing and controlling the risks related to narasin showed such a strict response bias in their consistent reluctance to respond to and declare the presence of risks. Although this acted to leave the 'ocean' quiet for periods of time, their systematic non-responses to uncertainties and indications of risk resulted in a less visible accumulation of 'energy' over time. The last three peaks in Figure 6 illustrate how, towards the end of the case, the waves of amplification quickly grew in force before they finally erupted into large ripples of effects having far-reaching societal consequences.

The paper also aims to make a practical contribution in indicating that an answer to prevent such incubation and build-up of 'energy' and to reduce of the amplification and attenuation fluctuations may lie in changing the risk perspective of the system builders, starting with the risk assessor. By actively addressing uncertainties and welcoming a greater heterogeneity of actors and diversity of voices into processes in which risks are framed, assessed, and evaluated, the adoption of an uncertainty-based understanding of risk may contribute to the communicative processes described in the SARF set out from a different track—a track less likely to end up in large amplification at the end of the road.

Accepting amplification as a natural and important part of the game may positively affect later moves, responses, and reactions of other players. In addition, the adoption of broad and uncertainty-tolerant risk perspectives provides a more natural platform for the scientific risk

assessor to play the part of a risk arbitrator (i.e., moderator), a position that, based on the analysis of the narasin case as well as examples relating to GMOs and salmon farming, seems to stand vacant in many of the defining moments of the game. According to White and Eiser (2010), risk arbitrators are actors attempting to weigh and balance competing claims of, for instance, danger and safety and that, compared to risk attenuators and risk amplifiers, require a moderate amount of data and information before warning the public and declaring the presence or existence of a risk.

The paper emphasises that a one-time injection of amplification into the risk assessment process is not enough to smooth the waves of amplification and attenuation. It requires that those in charge of assessing and managing risks continuously try to read the landscape as well as learn from and adapt to changes as risks evolve and knowledge develops. In the case studied, the narrowness of the probabilistic and technical risk understanding did not allow this, instead giving away static responses and acted to place those in charge on the side-lines when amplification occurred. In comparison, the risk concept following an uncertainty-based approach is broader and flexible and puts the assessor in a more proactive position when changes occur. This also facilitates using the risk assessment as a dynamic tool that is able to absorb and adapt to the twist and turns of risk amplification and attenuation processes.

In this way, changing the very idea of what risk is all about can act to change some of the rules and roles of the societal risk games as well as prevent or reduce some of the effects (i.e., visible and invisible ones) that accompany them.

The findings from Papers III and V, as well as Papers I, II, and IV, concur with the point made by Hilgartner (1992): to increase the understanding of the processes in which risks are created, constructed,

and de-constructed, one should focus on the system-builders and the arenas of specialized professionals and technical experts. It is in in these arenas and by the actors operating in them that the first seeds to risk amplification and attenuation processes are planted. Accordingly, focusing on the media and the public, which much risk- and SARF-related research tends to do, means starting the analyses and studies of risk development processes at the wrong end.

3 Further work

As discussed in Section 2, all five papers in this thesis are closely related. During the work conducted for one paper, the ideas of another were often born. Some of these ideas were pursued and formed the basis for new papers; others had to be abandoned along the way. In this section, some of the unpursued ideas are briefly presented and connected to what is seen as important possibilities for further research.

Papers I, II, and IV mention that the introduction of uncertainty-based perspectives on risk may act to challenge the economic or political power of certain stakeholders or actors and their influence over the framing and evaluation of risks and/or decision-making outcomes. It would be of interest to see studies providing detailed insights into the implications of such perspectives on risk and the understanding of knowledge this entails on existing power balances, governance structures, and stakeholder relationships.

Paper II suggests that, for stakeholder involvement to be effective, a common understanding of the risk concept is necessary; an uncertainty-based risk perspective could provide such a theoretical and conceptual foundation. As an extension of this paper, Paper IV argues that an uncertainty-based way of understanding risk can help achieve a balance of trust and distrust (i.e. critical trust) in the processes in which risks are assessed, but also regulated. Parkins et al. (2017) claim that ‘critically trusting’ citizens are more likely to take part in public engagement and participation initiatives than trusting ones. This underpins the relevance and importance of the work conducted in the papers, but also indicates the value of seeing these works in unison. A next step and valuable approach would be to combine the work of Papers II and IV for testing the usefulness of an uncertainty-based risk perspective as a platform for stakeholder involvement and engagement processes in practice.

As mentioned, despite being oriented toward foundational concepts, all papers in the thesis build on real-life examples. Further work addressing the practical relevance and implications of the research is needed. The concepts and ideas developed as part of this thesis should be tested across different contexts and on a larger scale.

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Part II

Paper I

Do non-governmental organizations relate to risks and uncertainties in an extreme manner?

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Published in: M. Čepin, & R. Bris (Eds.), *Safety & Reliability, Theory and Applications. Proceedings of the European Safety and Reliability Conference (ESREL).* 18-22 June 2017 Portorož, Slovenia, 18-22 June. CRC Press. pp. 1827-1833.

Do non-governmental organizations relate to risks and uncertainties in an extreme manner?

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ABSTRACT: Advocacy non-governmental organizations (NGOs) play an active role in influencing the public and policymakers on issues and decision-making that relate to risk. The general impression is that these organizations show a tendency towards emphasizing uncertainties, long-term consequences and the need for precautionary measures. It seems that their attitude to risk is rather unbalanced and extreme. The present paper discusses these indications, the main aim being to provide new insights on how advocacy NGOs relate to risk. We question whether NGOs make judgments about risk and uncertainties that are grossly in favor of the matter they are advocating or whether their conclusions are in fact more a result of value judgments than risk assessments. We perform the analysis mainly by looking into the example of genetically modified organisms, but we also draw on other examples, using recent conceptualizations of risk, which allow for considerations of uncertainty as an important aspect of risk.

1. INTRODUCTION

Since the second half of the 1990s, stakeholder involvement in the regulatory processes of health and environmental risks has increased in Europe. This can be attributed to increased public risk awareness, growing societal demands and the acknowledgement that facts and values play a role in all types of riskrelated decision-making (Dreyer and Renn 2014). According to Lofstedt et al. (2011), increased public distrust has contributed to regulation models based on public participation, transparency and increasingly powerful NGOs. Various stakeholders relate to risks in different manners and often express conflicting attitudes towards risks and uncertainties. This is especially the case when it comes to complex, uncertain and ambiguous risk problems (as defined by IRGC 2005).

Stakeholders comprise individuals, organizations, communities, agencies and governments with a vested interest in a risk issue (CEGEH 2013). Generally, the risk attitudes of stakeholders can be split into two main camps. On one hand, we have stakeholders that typically emphasize uncertainties and the need for protection; on the other, we have stakeholders focusing on opportunities, income and benefits. Nongovernmental groups (NGOs) generally form part of the first group of stakeholders, whereas industrial firms, risk analysts, experts and governmental institutions often represent the second grouping. The values of different stakeholders' groups are often fundamentally and ideologically conflicting. Stakeholders differ significantly in their willingness to take on risks to achieve potential rewards, make risk judgments based on different sets of data and knowledge bases, and often arrive at conflicting conclusions about risks.

This paper focuses on the NGOs (as a stakeholder group) and their way of thinking in relation to risk. It seems that NGOs show a strong tendency to emphasize uncertainties, the severity of potential long-term consequences and the need for protection and precautionary measures. An illustrative example is the introduction and use of genetically modified organisms (GMOs), to which we will return later in this paper. The point of departure for the present paper is the hypothesis that NGOs relate to risks and uncertainties in a rather extreme manner, placing

uneven weight on certain aspects of risks. More specifically, we will look more closely into the following hypotheses:
1. The risk judgments of NGOs are grossly in favor of the matter they are advocating 2. The viewpoints of NGOs are more about value judgments than risk assessments.

To discuss these hypotheses, we will seek to identify the underlying assumptions of the NGOs' risk judgments and views. We will relate these findings to current ideas and theories about risk and uncertainties, including the categorization of risk problems as mentioned above, distinguishing between complexity, uncertainty and ambiguity.

Knowledge and awareness of how NGOs judge risks and uncertainties can provide policymakers with valuable information about how NGOs may affect the public, the political landscape and the quality/shape of regulatory policies.

The article is structured along the following lines. Firstly, in Section 2, we present the example of genetically modified organisms. Then in Sections 3 we discuss Hypotheses 1 and 2, respectively, using the example of GMOs, as well as some others, in order to illustrate the discussion. Finally, in Section 4, we provide some conclusions and recommendations.

2 THE EXAMPLE OF GENETICALLY MODIFIED ORGANISMS

The introduction and use of genetically modified organisms (GMOs) has long been – and remains – subject to considerable debate. The term 'GMO' refers to an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination (Dir.2001/18). The controversial debate concerning GMOs started in the 1980s (Tait 2009). GMOs represent a risk, as they pose a threat to something of human value. This involves the possibility of severe and irreversible consequences to both the environment (resistance to pesticides and fertilizers, reduced biodiversity, cross-pollination) and our health, but it can also lead to great benefits (technological development, reduced use of pesticides and fertilizers, economic benefits).

The uncertainty related to the type and magnitude of consequences, ambiguous data and lack of scientific consensus have led to various forms of GMO risk regulations and policies throughout the world. The differences between individual countries' policies are considerable, ranging from active promotion of GMO in food production (e.g. US, South America, China, Canada, India) to more cautious approaches (e.g. EU, Norway, Austria).

In countries where NGOs are powerful and play an active role, we find more cautious and risk-averse policies and approaches towards consumer and environmental GMO regulations. Environmental NGOs such as, especially, Friends of the Earth and Greenpeace have played a critical role in mobilizing European public opposition to GMOs and have gained increasing political power. According to Lynch and Vogel (2001), NGOs in Europe have enjoyed considerable access to and influence of the regulatory processes of GMOs. In Western Europe NGOs and state actors have ensured that GM foods are neither grown nor consumed (Jasanoff 2005). The European regulations are characterized as restrictive and complex; the precautionary principle is formally articulated and endorsed (Dir.2001/18) and often evoked by NGOs to justify the need for caution. Hom et al. (2009) tie variations encountered in risk regulation regimes to differences in adaptations and interpretations of the precautionary principle.

NGOs are playing an increasingly active role in politics; they draw on the political support of a number of EU member states and have shown both stridency and persistency in their opposition to GMOs (Tait 2009). Arguments provided by NGOs opposed to GMOs are more or less the same globally. Incomplete evidence of long-term effects; unethical tampering with nature; threats to human health and the environment; industrial cynicism: these are the arguments commonly used by NGOs. The industry, on the other hand, emphasizes the benefits of technological innovation and often refers to studies demonstrating the harmlessness of the use of GMOs. Reports and documentation, which are heavily relied upon by one stakeholder group, are neglected or dismissed as invalid by the other camp. According to Tait (2009), both advocacy groups and industry have misrepresented knowledge related to GMOs, but the reception of this knowledge has been seriously unbalanced in favor of the NGOs: Data and information with the slightest connection to the industry are challenged and publicly disputed, whereas data and information presented by advocacy groups are not questioned in the same way. Politically powerful and ideologically motivated advocacy NGOs have been given more or less free rein to communicate and sustain the public perception of GMOs.

3 DISCUSSION

3.1 *Hypothesis 1: The risk judgments of NGOs are grossly in favor of the matter they are Advocating*

Selective representation of data, information and research is a way in which different stakeholders can use knowledge to substantiate and support the matter advocated. NGOs refer to different GMO research and information than stakeholder groups with the opposite view of GMOs. The tendency described by Slovic is highly prevalent in the GMO case: “New evidence appears reliable and informative if it is consistent with one’s initial beliefs, contrary evidence is dismissed as unreliable, erroneous or unrepresentative” (Slovic 1979). Tait voices a concern over the framing power, tactics and use of evidence by NGOs in the GMO debate and over their influence of public opinion. She holds that NGOs (but also industrial firms) are less careful about the validity of the evidence used to support their views. Given power, advocacy interest groups “can be just as unscrupulous as any multinational company in their manipulation of policy process and their misrepresentation of information to support their case”.

Despite the existence of several scientific studies demonstrating that the use of GMOs is not dangerous to human health, these studies are not referred to by NGOs. Risk assessments and detailed explanations provided by industrial firms have generally been regarded as suspect and have been countered by the simpler messages from advocacy NGOs opposed to GMOs. On its webpage, Greenpeace holds that there is “growing scientific evidence of the health and environmental impacts of genetically modified crops” (Greenpeace 2008). Greenpeace criticizes the European Food Safety Authority (EFSA) for not addressing divergent scientific opinions. It refers to the existence of studies pointing out numerous unexpected effects and specifically emphasizes a study commissioned by the Austrian Government, revealing that the fertility of GM-fed mice became impaired. Veland (2016) holds that the studies referred to by NGOs are often small studies, encumbered with professional weaknesses.

There is clearly a lack of consensus between stakeholders in respect of what constitute valid GMO data and studies. The extent to which data and information are interpreted and referred

to selectively can be said to be arguments in favor of the hypothesis that the risk judgments of NGOs are tailored to support the case they promote. However, this tendency is not a hallmark of NGOs as a stakeholder group. As Tait holds, in the process of making a case for or against GMOs, both advocacy groups and the industry have used invalid and biased data. The tendency to treat data as reliable and valid if it corresponds with initial beliefs and dismiss contradictory data or information is more or less universal.

Despite the steady growth of data and research on the effects of using GMOs, NGOs characterize the state of knowledge as uncertain. According to the IRGC (2008a), situations are uncertain when there is a lack of clarity or quality of scientific data, which makes it hard to predict the occurrence of events and their consequences. Furthermore, uncertainty can lead to dissent about the risk characterization. NGOs like Greenpeace maintain, "The most striking concern we have concerning human health and GMOs, is the absolute lack of long term studies on human beings and consumption" (Contiero 2016). Others, however, hold that the uncertainties that previously existed "have been replaced by in-depth understanding of the technology, its mechanisms and consequences, including potential adverse effects" (Hansson 2016). Scientific uncertainty has been replaced by scientific knowledge. For example, Tait (2008) and Veland (2016) find the degree of knowledge concerning the effects of GMO to be sufficient to demonstrate that GMOs are harmless. The statements above illustrate how different actors define the state of knowledge about GMOs and GM-technology in divergent manners.

The EU directive (Dir.2001/18) on the deliberate release into the environment of genetically modified organisms, Annex II, describes the objectives, elements, principles and methodology for performing an environmental risk assessment of individual GMOs. The directive states that risk assessments must evaluate the magnitude and the likelihood or probability of adverse effects. "An estimation of risk to human health and the environment posed by each identified characteristic of the GMO which has the potential to cause adverse effects should be made as far as possible, given the state of the art, by combining the likelihood of the adverse effect occurring and the magnitude of the consequences, if it occurs." In the EC-regulation no. 178/2002 laying down principles and requirements for food law and procedures for food safety, it is stated that risk assessments should be undertaken in an independent, objective and transparent manner. Many experts agree with Tait (2008) when she states that, "...a wide range of potential hazards has been identified and their risks estimated with no evidence of harm." Veland (2016) also claims that, "For many GMO-cases there is sufficient knowledge in order to do a proper risk assessment and demonstrate that the GMOs are harmless."

The view of many experts and the view expressed by the EU directive concerning risks and risk assessments correspond with a traditional approach to risk assessments, in which probabilities (and/or expected values) are used as the main measure of uncertainties. Risk is seen as the combination of the severity of the consequences and associated probabilities. The use of probability as a measure of uncertainty can be suitable when a substantial amount of relevant data exists but, if such data are scarce, the probabilities will be based on a poor knowledge base and will not be very informative. Consequently, using probability statements alone is not sufficient for making judgments about the risk associated with GMOs; the knowledge base need to be included (Aven 2014, SRA 2015). Risk assessments and probability statements are conditional on some knowledge, and different bases of knowledge can produce completely different risk descriptions. The knowledge, which in essence is justified beliefs, can be more or less strong and even erroneous. Hence, there is a potential for surprises relative to the knowledge. All this challenges the idea that risk can be objectively

described and that risk assessment reveals the 'truth' about the risk. Understanding and framing risk in this way explains the many possibilities for identifying aspects of risk that support the matter the stakeholders are advocating. NGOs can argue that the knowledge base supporting the probabilities derived is weak and therefore also that the risk is high. There is no objective way of characterizing the risk – it concerns argumentation and justification of beliefs. NGOs emphasize uncertainties related to knowledge and long-term effects, and these aspects are not easily captured by the probability-based approach to risk. However, recent risk perspectives highlight uncertainties and knowledge aspects beyond probability (Aven and Renn 2014, SRA 2015) and are more suitable for explaining the thinking of the NGOs. These perspectives provide platforms for the risk thinking but do not express any stand on what are acceptable or tolerable risks. As any risk perspective, they can be misused in the sense that data and information, which favor a specific view, are selected.

Greenpeace states that the EFSA risk assessments are solely based on data submitted by the company applying for GMO authorization and that these data are often incomplete and of poor quality (Greenpeace 2008). Many NGOs stress the need for more data before decisions are to be taken and claim that the current available data are insufficient, limited, non-existent or invalid. Thompson (2003) provides an illustrating example of the challenges related to input data and the related knowledge base; in order to evaluate the agriculturally based environmental risk of GM crops versus conventional crops, one must make assumptions about the farmer's and farm worker's handling of key materials, yet the empirical basis for such human factors in agriculture is virtually non-existent. Knowing that risk assessment results are sensitive to the input and the knowledge on which they are based may explain why NGOs do not place much weight on risk assessment results in their risk judgments. According to Thompson (2003), those that see transgenic/GM crops as posing new risks tend to apply conceptualizations of nature that are inconsistent with a scientific emphasis on quantifying the probability that harmful outcomes occur. He holds that the comparison of risks involves an array of interpretative judgments. Variations in the ways of interpreting the input and results of risk assessments are referred to by IRGC as interpretative ambiguity (IRGC, 2005). This is illustrated by the divergent interpretations of GMO data, statements and risk assessments concerning their relevance, meaning and implications for decisions by different stakeholders.

It is also common for NGOs to use the argument of scientific uncertainty to evoke the precautionary principle in order to justify measures in support of their case. Precaution means that regulatory measures should be taken in situations of scientific uncertainty about the consequences of an activity (UNCED 1992, H.S.E. 2001, Aven 2011). Scientific uncertainty relates to the difficulty of establishing not only models that can accurately predict the consequences but also causal relationships between factors. Tait (2008) holds that the precautionary principle has enabled advocacy groups to maintain a public perception of GM crops as risky and a dialogue focused on negative future visions, despite the available evidence. The uncertain nature of risks and, more specifically, the uncertainty related to knowledge are often used by advocacy NGOs as arguments for the need for precautionary measures. For example, Greenpeace holds that EFSA does not identify scientific uncertainties in their risk assessments and that knowledge on the long-term effects of risk posed by GMO plants must be required before EFSA should be allowed to publish any opinions on GMOs. The call for the application of the precautionary principle can be said to have been used strategically by NGOs, but it can also be traced back to a perspective on risk in which uncertainty constitutes a significant aspect. Interpretation of the content and the application of the precautionary principle is influenced by the risk perspectives of the various stakeholders.

Stakeholders do not agree on the existence of scientific uncertainty or the degree to which scientific uncertainty exists.

The claim that the risk judgments of NGOs are grossly in favor of the matter they are advocating is a strong assertion. It suggests that information, data and research are used in order to substantiate, support and justify the matter they advocate. One can, to a certain degree, hold that it is the case: that data is referred to, used and interpreted selectively, but this propensity does not characterize the way in which NGOs relate to risks. It is a common tendency that can be associated with all stakeholder groups.

More than the strategic tailoring of data and information, it is the prevalence of ambiguity and the variations in the ways of interpreting the input and results of risk assessments that we see in the way NGOs relate to GMOs. Uncertainty of knowledge is stressed, which, according to risk theory, is adequate. The fact that industry to some extent ignores this aspect of risk may encourage the NGOs to misuse it somewhat, by going to the other extreme, placing too much focus on the uncertainties. For many people (e.g. politicians), a sound balanced approach to risk characterization is probably found somewhere between these two extremes.

We find that the risk perspectives of different stakeholders affect the way in which they judge risk and interpret the existence of scientific uncertainties and the need for precautionary measures. The focus that NGOs have on insufficient knowledge, scientific uncertainties and long-term consequences makes them less inclined to rely on the same research, information and data as the other stakeholder groups. The NGOs approach to risk addresses uncertainty as a crucial aspect of risk and therefore does not place much emphasis on risk numbers derived by traditional risk assessments. The focus on uncertainties seems to be an explanation of why certain data and information are highlighted.

3.2 *Hypothesis 2: The viewpoints of NGOs are more about value judgments than risk assessments*

Two actors can agree fully on the risk descriptions and characterizations but still come to different conclusions concerning the tolerability or acceptance of risk. The point is that the values are different. They give different values to the uncertainties and the concerns that are at stake. The previous section has argued that the NGOs may consider GMO risk differently than other stakeholders, by highlighting uncertainties to a greater extent than the industry does. Yet it is appropriate to question whether the real reason for this difference concerns values more than risk and uncertainties. How do NGOs value the potential changes that can occur because of the use of GMOs? How important are the potential effects on the environment, the resistance to pesticides and fertilizers, the reduced biodiversity, the cross-pollination, and the potential effects on human health, considered in relation to the potential benefits? Can these values be traded against economic values or is this an unacceptable and unethical view?

When there are different opinions on what values to protect, tolerability and what priorities to make, or conflicting views on moral or ethical issues, we talk about normative ambiguity. Following Slovic (2007), affect, emotions and values play an important role in decision-making processes, especially when it comes to decisions involving difficult trade-offs and ambiguities. In the GMO case, there are clear examples of normative ambiguity and the prevalence of diverging values or beliefs about the consequences between different stakeholder groups. For example, NGOs emphasize the need for protection of the e

nvironment and human health. They either question the benefits or do not consider them significant. “The biodiversity and environmental integrity of the world’s food supply is too important to our survival to be put at risk” (Greenpeace 2017).

We see the same tendency when it comes to exposure to electromagnetic radiation (EMR); NGOs and stakeholders opposed to EMR assign more weight to the risk and uncertainty of long-term health consequences than to the potential technological development and benefits. In relation to petroleum activities in the Barents Sea, Aven and Renn (2012) also found that NGOs focused on the environmental values at stake and found risk and uncertainties unacceptable. “The notion that high vulnerability could be traded off against economic benefits was rejected as morally illegitimate” (Aven and Renn 2012). This is in line with what Tait (2008) states: that, for those fundamentally opposed to GM crops, there are no acceptable risk management options. It is clear what is considered “acceptable risk” to some stakeholder groups are not considered acceptable to others. Despite EFSA (2017) claim that the environmental risk assessments they carry out help risk managers and policymakers to ensure that products do not cause unacceptable harm to the environment, NGOs do not agree. Greenpeace underlines that the opinions presented by the GMO-panel to EFSA must reflect all unanswered questions, uncertainties and assumptions without prejudice (Greenpeace 2006).

It is evident that the values NGOs emphasize guide their judgments strongly. Factual knowledge, probabilities and uncertainty analysis do not provide sufficient answers in order to weigh different concerns and values.

Tait (2009) points to the fact that public advocacy groups should relate to risk in a more evidence-based manner. The statement reflects quite a common viewpoint: that the ideal way to make risk-related decisions is to base them on evidence and scientific knowledge, also called risk-based decision-making. The problem is, however, as discussed in the previous section, that evidence and knowledge are not objective and do not provide a basis for prescribing the best decision. The value dimension cannot be removed. Although limiting it to “some cases”, the importance of diverse input and considerations in the decision-making is also recognized in EC regulation no. 1829/2003 paragraph 32 and EC-regulation no. 178/2002, paragraph 19. “..scientific risk assessment alone cannot, in some cases, provide all the information on which a risk management decision should be based, and that other factors relevant to the matter under consideration should legitimately be taken into account including societal, economic, traditional, ethical and environmental factors and the feasibility of controls”. Risk assessment should inform the decision makers not replace them (Apostolakis 2004). Risk assessment is one of many inputs in a process of weighing different concerns and values. In this sense, it can be argued that NGOs generally adopt a risk-informed approach rather than a risk-based approach.

The various interpretations of the meaning of the precautionary principle also involve moral considerations and value judgments. Invoking the precautionary principle is an explicit endorsement of certain values (Myers, 2002). For example, determining the level of evidence required for scientific proof involves value judgments (Sandin et al. 2002). The fact that NGOs evoke the precautionary principle reflects a value judgment in itself. It implies that the NGOs judge the scientific uncertainty to be so substantial that precaution is needed. Simultaneously, other stakeholders would judge the opposite to be the case: that sufficient scientific evidence already exists. Whether the more general cautionary principle should be applied, rather than the precautionary principle, could also be discussed. In the Barents Sea

case, Aven and Renn (2012) find that the judgments of the NGOs could be better justified by the cautionary principle because their concern was related to a larger extent to the fact that uncertainties existed than to actual scientific uncertainties.

Kelly et al. (2015) point out that is very hard to resolve value-based disagreements on the basis of scientific evidence. Thompson (2003) also finds that the scientific comparison of risks related to GM and conventional crops and the divergent opinions about the relevance of the anomalous results related to GM crops requires a series of value judgments.

In the risk field, there is an established general principle of separation between risk analysis and value judgements. Professional and scientific risk perspectives distinguish between what risk is and what are feelings, emotions and value statements about risk. The way in which NGOs relate to risks in the GMO, EMR and Barents Sea cases illustrates the difficulty of achieving a clear separation between risk assessments/judgments and value-based judgments.

It seems clear that the views of the NGOs are largely rooted in the values at stake. Risk assessments are relied upon to a lesser extent by NGOs than by the other camp of stakeholders. The results of risk analyses are placed in a larger context and are outweighed by the values they consider significant and important to protect.

4 CONCLUSION AND IMPLICATIONS

The starting point of the paper was the hypothesis that NGOs relate to risks and uncertainties in a rather extreme manner, placing uneven weight on certain aspects of risks. To a certain extent, one can hold that this assertion is correct. The fact that NGOs strongly emphasize uncertainties related to knowledge and potential consequences concerning the use of GMOs is an argument in favor of this hypothesis. However, the same can be said about other stakeholder groups: the industry emphasizes the computed probabilities with minimal focus on uncertainties and the potential for surprises.

From our analysis, Hypothesis 1, which states that the risk judgments of NGOs are grossly in favor of the matter they are advocating, is only partly true. NGOs regard uncertainty as a crucial aspect of risk, and we can interpret this to mean that there exists a need for seeing beyond the results from traditional risk assessments. The focus on uncertainties and interpretative ambiguity can explain why only certain data and information are relied upon, but it cannot fully describe how NGOs relate to risk.

Hypothesis 2, holding that the viewpoints of NGOs are more concerned with value judgments than risk assessments, seems a more appropriate way to explain how NGOs judge risk. The weight given to values seems to have a significant impact on the risk judgments of NGOs. This focus on value-dimensions can appear extreme, but NGOs generally consider it unethical to trade long-term, environmental and health values for economic and more short-term values. The introduction and use of GMOs is viewed as an activity involving unethical tampering with important environmental and health values. It serves as an example of normative ambiguity.

NGOs play an increasingly active role in politics and policymaking. The way NGOs relate to risk forms an important part of the contextual setting, in which risk management and governance take place, and can have a crucial effect on the form and degree of risk governance and policy. Knowledge about how various stakeholders focus on different aspects

of risk, how they use data and information selectively, and insight into how NGOs are guided by their values when they judge risk is of importance to decision and policy-makers. The IRGC (2008b) categorizes lack of adequate knowledge on stakeholder values, beliefs and interests as a risk governance deficit and explicitly ties the failure to deal with this to the adoption of cautious European GMO-regulations. Knowing that the values the NGOs promote and protect most likely will make them characterize risk as high, despite risk assessment results demonstrating the opposite, is of special importance where NGOs are powerful and the roles of various stakeholders in a matter are not equal. A too strong focus on uncertainties may lead to little development and risk-averse decision- and policymaking. Since the risk judgments of NGOs and other stakeholders have the potential to affect public opinion, politics, risk-related decision and policy-making, it is of importance to make clear the background knowledge, data, assumptions, preferences and values on which the risk judgments rest.

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Paper II

Effective stakeholder involvement requires a common understanding of the risk concept

Authors: Fjæran, L. & Aven, T.

Published in: *Proceedings of the 29th European Safety and Reliability Conference (ESREL).* 22-26 September 2019 Hannover, Germany. Research Publishing Services. pp. 171-179.

Effective stakeholder involvement requires a common understanding of the risk concept

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It is broadly recognized that risk is more than technical risk estimates and probabilities. Failure to recognize and include the uncertainties, knowledge, concerns and values of those affected by the risk problem can have strong negative consequences for the legitimacy and quality of risk management strategies, public trust and behavioral and communicative risk responses. Increased stakeholder involvement, democratic dialogue and analytic-deliberative approaches are commonly seen as means to avoid such consequences. However, many practical attempts at deliberation and inclusion have been shown to be time-consuming, contributing to risk amplification and complicating decision-making. Stakeholder involvement often becomes reduced to an "add on", limited to a specific stage of, or question in, the risk assessment process or to a separate analysis or document having no actual effect on the risk judgments and risk management decisions. In the present paper, we argue that different and often conflicting risk understandings of various actors complicate the stakeholder involvement attempts; a common understanding of the risk concept is needed to obtain effective stakeholder involvement. A main aim of the work is to show how this type of understanding can be achieved by proper conceptualization and broader framing of the risk problems. The discussion is illustrated by examples related to salmon farming.

Keywords: stakeholder involvement, deliberation, risk perspective, uncertainties, risk assessment, decision-making, knowledge

1. Introduction

In relation to risk problems where there is high uncertainty about consequences, and where various actors attach different values to these, stakeholder involvement can yield important benefits. It can potentially improve the quality and appropriateness of risk management strategies, positively affect public trust and confidence in risk management institutions and decisions, improve communication and increase understanding of societal and stakeholder concerns, perception and values. However, practice shows that many attempts at involvement do not yield the intended benefits or effects, and, in fact, sometimes serve to hinder risk governance processes (Löfstedt and van Asselt 2008). If participation and deliberation are performed improperly, they may actually increase risk levels, lead to inefficiency, prolong and complicate decision-making and immobilize institutions (Renn and Walker 2008), as well as contributing to opposition and giving certain groups the power and opportunity to frame risk problems (Tait 2008).

The integration of the involvement of stakeholders and their knowledge is an important aspect of both risk assessment and decision-making (Pohjola and Tuomisto 2011), but most efforts at stakeholder involvement and deliberation have been in the risk management phase. In this phase, involvement is more direct and intended to offer or add social perspectives for evaluating risks or risk management plans (Renn and Walker 2008). Engagement in the assessment stage of risk problems has been more limited. Although risk assessment is increasingly intertwined with societal concerns, stakeholders (including community groups, environmental organizations, industry, and consumers) are often disengaged from the risk assessment process (Abt et al. 2010). When practiced, such involvement generally seems to be limited to an add-on or a specific step or question in the risk assessment process (Pohjola and Tuomisto 2011). Also, studies of stakeholder concerns and values come in the form of a separate analysis or document (e.g. concern assessments, risk perception studies), but these often do not have any real effect on risk judgments and risk management decisions. Lightfoot (2017) stresses the need for risk assessments to be able to make use of non-technical input and argues for a role for stakeholders throughout the risk assessment process, not only after it has been completed, as commonly practiced. Studying stakeholder involvement and contribution in relation to biotechnology, Lightfoot (2017) found that stakeholders could contribute towards enriching and increasing the scientific quality and validity of risk assessments by, for instance, providing significant system knowledge, diverse conceptual models and knowledge of divergent values. Similarly, the US National Research Council (2009) recommended that risk analyses, in addition to being able utilize increasingly sophisticated scientific information and methods in order to get "the science right", should aim to become more societally relevant, to get "the right science". The inclusion of practitioner expertise and perspectives in risk assessment involves getting "the right science" and addressing relevant societal problems, as determined by a spectrum of interested and affected parties (Dana et al. 2012).

The International Risk Governance Council (IRGC) has long argued for stakeholders to be

included in risk governance and has developed frameworks to include more diverse participation and knowledge at various stages of the risk assessment and risk management processes (Renn 2008, Renn and Walker 2008), providing insights on how to structure and organize such participation (Renn 2015). Approaches aiming to integrate social impact assessment and risk assessment in relation to environmentally risky projects have been put forward by, for instance, Mahmoudi et al. (2013). In these and other related works (e.g. Kasperson et al. 1988), risk is recognized as more than technical risk estimates or probabilities. Many of these works or frameworks are largely built on the differences in the way lay-people and scientific experts understand risks and how this can produce amplification, resulting in large secondary effects. "It is important to appreciate that human behavior is primarily driven by perception and not by facts or by what are understood as facts by risk analysts and scientists" (Mahmoudi et al. 2013, p. 2).

Yet, despite the existence of such frameworks, real-world implementation of formal participatory risk analyses remains limited (Dana et al. 2012). According to Renn (2008), the inclusion of social criteria in the formal risk evaluation process is still in its infancy. Attempts have been made to educate and teach lay-men how to understand statistical data and understand risk the "expert-way". Work has also been done to "turn the lens", and it has been emphasized that policymakers and risk managers can learn from the public and other stakeholders. Wynne (1992) demonstrated the reflexive capability of lay-people and showed the failure of scientists to recognize the important knowledge of local farmers in risk assessment, serving to hamper crisis management. Although discrepancies in the way risk analysts and the public understand risks are commonly recognized, work aiming to establish a shared risk conceptualization and understanding for different groups and actors, in order to improve stakeholder involvement, does not seem yet to have been addressed in the scientific risk literature. The issue has, to a certain extent, been touched upon by Veland and Aven (2013), as they demonstrate that differences in risk perspectives can cause communication barriers and problems and as they attribute the main barriers to good risk communication to the failure of risk analysts to establish scientific pillars for their work. Comparably, we argue that the different understanding of risk by various actors complicates stakeholder involvement attempts. As long as the risk understanding of the actors involved is conflicting, efforts at involvement and participation will continue to be complicated and have imbalanced, symbolic or little effect on actual risk assessment results and risk management decisions. In order for such involvement attempts to be effective, we claim that a shared conceptual understanding of risk between stakeholders is of crucial importance. In the paper, we show this can be achieved by adopting an uncertainty-based risk perspective when assessing and managing risks. Following such an understanding, uncertainty is seen as a main component of the risk concept. Uncertainties related to the occurrence and magnitude of consequences, and the quality and strength of the knowledge supporting the risk judgments made, are central aspects when understanding and characterizing risk based on this perspective. This way of looking at risks acknowledges aspects commonly regarded as important by the public when judging risks and allows for the use of a broader and more diverse knowledge base. Adopting such a risk perspective as the foundation for risk assessment and management allows for better integration of stakeholders and their knowledge in these processes. This can act to avoid narrow framing of risk problems, which is especially important where high uncertainty and differences in values exist.

In the paper, we specifically set out to test the following hypothesis:

An uncertainty-based understanding of risk in risk assessment and management leads to effective stakeholder involvement.

By 'effective stakeholder involvement', we mean that relevant knowledge provided by stakeholders is actually used to help frame risk problems and to inform risk assessment, and carries a real potential to affect risk characterization, final risk judgment and related risk management decisions.

The rest of the paper is structured as follows. In Section 2, based on some examples related to salmon farming, we show how conflicting perspectives on risks complicate and make stakeholder involvement attempts less effective, in different ways. In Section 3, we briefly describe the main differences in the way the stakeholder groups in the examples understand and relate to risks; we show how an uncertainty-based risk perspective can provide a shared platform for stakeholder groups and discuss how this can affect the effectiveness of stakeholder involvement in risk assessment and risk management processes. The examples referred to in Section 2 form part of the discussion. Then, in Section 4, we conclude and provide some recommendations.

2. Example

Many of today's risk problems are characterized by potentially large consequences, limited knowledge and the complexity of causal relationships. The risks are often value-laden, and stakeholders commonly diverge in their values and hold different views about the interpretation of the risks and their tolerability. Examples of such risk problems are climate change, nuclear power, electromagnetic radiation, nanotechnology, food and feed risks, like, for instance, genetically modified food, and the use of chemicals and additives. For such risk problems, there is often a discrepancy between stakeholders on how they interpret and judge risks, the need for corresponding action and what they consider relevant and valid risk in relation to information and knowledge. In the following, we present some examples where such discrepancies complicate and hinder stakeholder involvement in different ways, when it comes to the assessment and management of risks in connection with salmon farming.

Norway has the largest salmon farming industry in the world. On a daily basis, it produces large economic benefits, and large amounts of salmon are consumed nationally and internationally. However, as with many risk problems, there are not only benefits and positive sides, and various actors emphasize different aspects in relation to the risks associated with salmon farming. There is a divide between how the authorities, risk managers, risk assessors and the industry, on one hand, and how some fishermen, non-governmental organizations, certain scientists and groups of the public, on the other, relate to these risks. The divide between the groups can be illustrated by the media coverage of salmon farming over the last couple of years. Here, the "objectivity" of scientists and the role of national authorities and marine science institutions in risk management have been questioned, and assessments of risks related to salmon farming have been criticized for not including experiential and critical knowledge. Research demonstrating negative consequences related to either the consumption or production of farmed salmon (e.g. Bolann and Bjørke Monsen 2013, Bjørke Monsen 2016, Mortensen 2016, Bohne 2018) has been disregarded or disqualified. Local fishermen have communicated concern and experiences regarding the consequences of salmon farming in, for example, town hall meetings/hearings concerning the establishment of new production sites (Jørstad 2016, Sollund 2016), presenting accounts of, for instance, the spread of lice from farmed salmon to wild fish (Eide 2016) and die-off of shrimp and shellfish, due to the spill out and use of chemicals (Larsen 2016); however, they experience that their input is labelled as 'unscientific'. Risk assessors and managing authorities point to the lack of knowledge and the need for long-term exposure data, while existing regulations and threshold levels guide industry use of such chemicals. Similarly, when assessing diseases and infections on farmed and wild fish, large uncertainties due to the lack of available data and the need for more knowledge are pointed out (Grefsrud et al. 2018), and the vast majority of related risks are judged to be low.

Similarly, Canadian regulators and authorities stress their commitment to scientific and evidence-based decision-making in relation to salmon farming and aquaculture regulation. Federal Fisheries Minister D. LeBlanc emphasizes that "Our government is committed to sound science. We use scientific advice when making decisions affecting fish stocks and ecosystem management, and this risk assessment provides clear, scientific information to help us do that" (Dawson 2018). In New Brunswick, Canada, groups of scientists actively engage with local fishermen in the production of knowledge when assessing the relationship between lobsters and the aquaculture industry (Maillet et al. 2017). However, wide stakeholder involvement proved impossible in this project and, here, the aquaculture industry was not included, due to high levels of distrust and differences between fish famers and local fishermen regarding the acceptability of impacts of risk (Maillet et al. 2017). In the end, although the project showed how collaboration led to more comprehensive knowledge, experiential data of fishermen proved hard to incorporate in the project.

In the state of Washington (USA), we see opposite tendencies. Here, the State Legislature has been criticized for not making evidence-based decisions related to future aquaculture. In March 2018, after the escape of a large number of salmon from a fish farm, a law was passed banning commercial future aquaculture of Atlantic salmon. The ban has been criticized by the industry for being an emotional and science-deficit response, prompted by the anti-fish farm lobby (Dawson 2018). Also, a group of scientists have questioned the "Washington State Ban". In an open letter to the Washington State Legislature, four scientists urged members of the Senate and the House to reconsider the decision to stop future salmon farming before letting scientists and researchers in the fields "present science in a clear and objective light - rather than in a climate fueled by fear and propaganda" (Chaves et al. 2018).

3. Discussion

The above examples illustrate that stakeholders diverge in how they understand and relate to risks and risk-related information. Below, we briefly describe some main differences between the risk perspectives of stakeholder groups regarding how they understand the risk concept, what they consider relevant knowledge when characterizing and making judgments about risks, differences in aspects emphasized when making risk management decisions and in decision-making style. Based on the examples, we show how these differences complicate or contribute to ineffective stakeholder involvement in risk assessment and risk management. We show how an uncertainty-based risk perspective involves a broader way of looking at risks that comprises aspects considered important by both groupings when judging risk and how it can serve as a common platform for the stakeholder groups and increase the effectiveness of involvement attempts.

3.1 Different risk perspectives of the stakeholders

Based on the examples related to salmon farming, especially in Norway and Canada, stakeholders can be categorized in two main groups, according to their perspectives on risks. The grouping represented by governments, authorities, scientific risk assessors, experts and the industry judges the risks related to salmon farming as small and bases its risk judgments on scientific risk assessments, data and research demonstrating low or minimal risks. Decisions on risk management responses and regulations are based on what is considered "sound science", and risk assessments are thought to provide "clear, scientific information" and "objective evidence" for decision-making purposes. Risks are understood and described as the combination of probabilities and consequences and are estimated based on statistical frequency and/or exposure data. "Scoring" of the environmental impacts of the aquaculture industry and the assessment of risks are based on sustainability indicators, developed by the Veterinary Institute and Marine Research Council in 2012. When assessing diseases and infections on farmed and wild fish and the environmental impacts, large uncertainties due to the lack of available data and the need for more knowledge are pointed to (Grefsrud et al. 2018), but the vast majority of related risks are judged to be low. The need for long-term exposure data to establish causal connections is stressed. Meanwhile, existing regulations and threshold levels guide industry use of chemicals.

The second camp, also referred to as group 2 in the following, is represented by fishermen, NGOs, local communities, medical professionals and certain researchers and experts. In the Washington example, the composition of the groups is somewhat different. Here, the legislature and risk managers are also placed in this camp, group 2. This group of stakeholders judges the risks related to salmon farming as high and unacceptable, and emphasizes uncertainties, the potential severity of consequences and the need for protection and precautionary measures. Their risk judgments are made upon the basis of knowledge that differs from that of the other group. Risk assessment results and risk estimates are given less weight, and research, data and information found important by the first group of actors is generally interpreted differently, questioned or disregarded. The different stakeholder groups emphasize different values in relation to salmon farming; in addition to emphasizing uncertainties related to knowledge and long-term consequences, values constitute a central aspect when judging risks and the corresponding need for measures or action. There is a fundamental discrepancy between the values of various actors. The values of protection and precaution of the second group contrast with the focus on development, opportunities and economic benefits of the other group of actors.

3.2 A shared perspective on risks

Following the examples, the industry and those in charge of risk assessment and risk management generally display a narrower and more technical perspective on risks and uncertainties than that of the second group of stakeholders. Here, the risks related to salmon farming are generally considered low and acceptable. Statistical data are used to estimate and predict future risks. The concept of risk is treated more or less synonymously with its measurement; low probabilities of, for example, disease or environmental impacts related to exposure to chemicals are regarded equally of low or minimal risk. Description of uncertainty is restricted to representing the difference between the risk estimate and a supposedly underlying true value. Uncertainties in the form of knowledge gaps or limitations are acknowledged, but no uncertainty assessment beyond the statement of the existence of scientific uncertainties is conducted, and the risk characterization or final risk conclusion remains unaffected by these uncertainties. This way of relating to uncertainties can be described by what is referred to as "the uncertainty paradox", which is a situation in which scientific uncertainty is merely acknowledged but does not alter the outcome of the risk assessments (Weimer 2015). Such a limited approach to uncertainties contrasts significantly with the way group 2 understands risks and uncertainties. An uncertainty-based risk perspective, also referred

to in the following as the (C,U)-perspective, involves emphasizing uncertainty dimensions in risk conceptualization and characterization. As we have seen, uncertainty in relation to consequences and knowledge is an aspect considered important by the second group of stakeholders when judging risks and the corresponding need for action and responses. Within this perspective, risk is understood as the two-dimensional combination of consequence, C, of an activity and the associated uncertainties, U. Risk is described by specifying the consequences, C′, and using a description, Q, of uncertainty. In addition, the knowledge supporting C' and Q is added (Aven 2014). Following such a perspective, probabilities, P, can be used as a measure of uncertainties, but it is emphasized that probabilities alone cannot fully describe uncertainties. Judgments related to the strength of the knowledge also need to be addressed.

Adopting a (C,U)-perspective on risk involves extending the risk perspective of the first group by looking beyond probabilities and relating to uncertainties in a broader sense and when characterizing risks. It requires a distinction to be made between the risk concept and how the risk is described. Within such a perspective, the uncertainty component of risk covers not only the representation Q – the measure of the uncertainty (either a probability, probability interval or a qualitative method, etc.) – but also the background knowledge that supports the measures and the fact that surprises can occur relative to this knowledge. The fact that all uncertainty descriptions and measures are conditional on some knowledge is emphasized and made part of the risk description. This knowledge can be of varying quality. It can be weak, narrow and imbalanced, consisting of limited or even irrelevant data and carrying significant assumptions, or it can be diverse, solid and comprehensive, or something in between. Having adopted an uncertainty-based perspective on risks, the strengths and weaknesses of the knowledge base upon which the probability or another measure, Q, rest must be assessed and evaluated as an integral part of the risk assessment. This is represented by the denotation, Q = (P, SoK). Here SoK provides a qualitative measure of the strength of the knowledge supporting P. Following a (C,U)-perspective, the fact that the probabilities in the risk assessment related to salmon farming are founded on narrow and limited statistical data containing assumptions would have been made part of the risk characterization and reflected in the final risk judgment, by potentially affecting the score of the uncertainties, and not only exist as separate statements.

3.3 Implications for the understanding and use of knowledge in risk assessments

The way one understands risk also has implications for what is considered relevant and valid knowledge. In the examples, we see that the stakeholders do not agree on what constitute valid data and knowledge and that there is a tendency for data and research referred to by group 2 not to be included in risk assessments. We see this in how experiential and observational data of local Norwegian fishermen is disregarded in risk assessment. This indicates that, in risk assessments based on a traditional and probabilistic understanding of risk, there also often exists a narrow understanding of what constitutes valid knowledge. This tendency is also reflected in outcomes of the "Joint Production of Knowledge" project in relation to lobsters and the aquaculture industry. Despite the aim of the project to include "alternative ways of knowing", by engaging with New Brunswick fishermen in the assessment of risks, the "fishermen's on-the-water observations" were not used, in order to avoid criticism of using unreliable and "potentially biased or incomplete" data. Instead, data from provincial sources on stocking and the industry on pesticide were used, despite the admission of the insufficiency of this information (Maillet et al. 2017). Although considered insufficient, these data were used because they corresponded, to a larger extent, with the general understanding of natural scientists involved in the project on what constituted objective data. The incompatibility between the intellectual frameworks and culture of scientists and e.g. farmers, identified by Wynne in 1992, is still most prevalent today and continues to hamper the inclusion of diverse stakeholder knowledge in risk assessment and management. In a study related to the risk problems of radiation, Wynne showed how scientists (and ministry officials) over many years failed to recognize important local specialist knowledge, insight and expertise. According to Wynne, this knowledge was not acknowledged as scientific "because it was not formally organized in documentary, standardized and control-oriented ways recognizable to scientific culture" (Wynne 1992, p. 296). It clashed with the "scientific culture" of simplistic reasoning and prediction, standardization and control, in which uncertainties were 'naturally' deleted (Wynne 1992).

Wynne voiced a need for risk assessors to be more uncertainty-accommodating and reflexive in their risk assessments, to increase the public uptake of risk-related information and advice. The findings of Lightfoot (2017) in relation to stakeholder involvement suggest the same. Here, non-expert

participants found engagement in risk assessment and hazard prioritization difficult and "felt that the process should be designed to incorporate uncertainty". In a (C,U)-perspective on risk, uncertainty is the main component of risk and builds on such an incorporation of uncertainty into the risk assessment process. This way, it can be argued that it also provides a better match with the risk understanding of the public, lay-men and actors categorized in group 2. It means moving away from the more limited, probabilistic approach to uncertainty and risk, seen in group 1, and extends this to cover and recognize the significance of aspects considered important by the second group. Adopting an uncertainty-based risk understanding as the point of the departure for risk assessment involves acknowledging aspects considered important by both camps of stakeholders.

A (C,U)-understanding of risks also has implications for the understanding and use of knowledge and data. Such a way of looking at risks corresponds with a broader approach on how to represent epistemic uncertainties than seen in the risk assessment related to salmon farming. Such a way of understanding risks allows for the use of both quantitative and qualitative methods and data and promotes the combination and use of different types of data from stakeholders. In the risk assessment of salmon farming, the conceptualization of risk itself does not allow for the use of experiential and observational data provided by local stakeholders when characterizing risks. The knowledge base is limited to a set of "objective" data that allows statistical calculation of risks: data compatible with the "scientific culture", as defined by Wynne.

An uncertainty-based risk understanding means broadening the understanding of what is considered valid knowledge. It does not restrict the knowledge base to consist of supposedly 'true' beliefs or 'objective' evidence; it involves looking at knowledge as justified beliefs and allows the use of more diverse knowledge when assessing risks. Knowledge of relevant values, concerns, experiences of different stakeholders are allowed to form part of this base and carry the potential to affect the risk judgment of the risk assessor. This means that risk assessment results can be founded on a more comprehensive and heterogeneous knowledge base. When only historical, statistical data are used to assess risks, it can lead to the overlooking of important uncertainty aspects. A narrow knowledge base can result in difficulty in specifying consequences and in fully specifying the risk event/scenario itself, and can lead to, for example, inappropriate or reactive responses. In the Norwegian example, we see that situations and problems already addressed by local fishermen were not included in risk assessments, but that research later conducted by the Institute of Marine Research (2018) showed what the fishermen had already reported: that many marine species do not survive and/or are sensitive to exposure to even low doses of regular amounts of the chemicals used in delousing. In addition, in spite of public and fishermen accounts of shrimp-death in many coastal areas, research was confined to large commercial areas like the Barents Sea, Skagen Channel and North Sea. In retrospect, representatives of the Institute of Marine Research admitted that too little research on environmental impacts of aquaculture had conducted the last 5-6 years (Nepstad 2016) and that coastal areas should have been covered (Søvik 2016). In Wynne's case study, risk assessment and advice were made upon limited data, conditioned upon significant assumptions, which later proved wrong. Information on the incorrectness and unsuitability of assumptions had already been pointed out by farmers but was ignored in the scientific assessment of the radiation risks, leading to bad advice and mismanagement of the "crisis".

Making use of diverse knowledge, directing attention towards uncertainties, the fact that surprises may occur relative to available knowledge instead of focusing on probabilistic and historical data, involves relating to risks in a more proactive manner. Incorporating stakeholder knowledge, experience and values can offer valuable input to risk assessment by, for example, contributing to identifying potential consequences, scenarios, appropriate responses or possible approaches to handle risk problems and to evaluate impacts. However, because of the often fundamentally different and competing values and concerns of stakeholder groups, it is of importance that these are juxtaposed and that the weighting, evaluation of stakeholder knowledge, values and concerns and final risk judgment are conducted by the professional risk assessor. In a study related to the introduction of GM technology in Europe, Tait (2008) showed how failure to include all aspects related to different concerns and values of different stakeholders at an early stage in the risk assessment process had large regulatory effects. She stressed the importance of the role of the professional risk assessor in balancing these values, in order to avoid imbalanced framing of risks and negative consequences for risk management.

3.4 Implications for decision-making and risk management

A more nuanced and balanced risk assessment may prove more informative and valuable in a risk management and decision-making context than a risk assessment conducted based on a more traditional approach to risks. However, following an uncertainty-based risk perspective, the risk assessment must be complemented with broader decision-making and risk management processes. It is stressed that risk assessments and risk assessment results are not treated as evidence and a prescription for decisions and responses. Decision-makers are presented with the limitations of the risk assessment, the potential for surprises, uncertainties, assumptions and the strength/weakness (SoK) of the knowledge base upon which the results are founded. This gives more room for recognizing uncertainties, stakeholder concerns and values in the decision-making processes. This risk- and knowledge-informed approach to decision-making contrasts with the more technical and evidence-based approaches to decision-making, often coupled with traditional approaches to risks, as seen in relation to Norwegian and Canadian salmon farming. Here, decisions often directly follow risk assessment results, with stakeholder input, concerns and values receiving little weight in the decision-making process. An uncertainty-based approach to risks and decision-making better matches what, according to Lindblom (1959) and Parsons (2002), decision- and policymaking in reality are all about: namely, using judgments to muddle through; that is, to make context-sensitive choices in the face of persistent uncertainty and competing values.

This last statement also points in the direction of an important challenge when it comes to stakeholder involvement: namely, competing stakeholder values. As mentioned, these are often fundamentally conflicting; what is viewed as acceptable by group 1 is considered acceptable by group 2 and vice versa. This can be illustrated by the following statement Max Bello made concerning plans to expand the Norwegian salmon farming industry to Argentina: "No amount of economic growth justifies the destruction of Patagonian ecosystems" (Gutnam 2018). This statement illustrates the fact that some stakeholders or stakeholder groups may not be interested in balanced risk assessments and informed decisions. Adopting an uncertainty-based approach to risk means directing attention towards uncertainties and the limitations of risk assessments and may, in some cases, result in a higher risk judgment. Actors and stakeholder groups advocating values, like, for example, development and profit, may fear restrictions, cautious policies and decisions like the Washington ban. A (C,U)-perspective also means moving away from looking at some data and risk assessment results as evidence. For those that previously have had evidence working in favor of their interests, values or standpoints, such a way of understanding risk can represent a threat. As described, the integration of diverse stakeholder knowledge and values can produce more balanced, nuanced and informed risk assessments and decisions and may – in relation to risks where certain actors or stakeholders, for instance, hold economic or political power to influence the framing, definition, evaluation of risks and/or decision-making outcomes – involve a shift in existing power balances between stakeholders. For such reasons, an uncertainty-based risk perspective as a point of departure for stakeholder involvement may meet resistance. However, if stakeholders' values, concerns and knowledge are not recognized and not integrated into risk assessments, it is likely that we will see more decisions like the Washington ban. The ban has been criticized by industry representatives and certain scientists, and the criticism points in the same direction as Tait's findings: that decisions were unrelated to any professional risk assessment, that they were not evidence-based and were made without any balancing of values. However, the ban itself can also be seen as a response to what most criticism of risk management decisions still concerns: that the majority of decisions seem to be based on risk assessment results demonstrating low risks and in favor of the economic interests and values of the first stakeholder group. This is also what criticism of Norwegian salmon farming mostly concerns: imbalanced research and assessment of risks and decisions, where economic profit outweighs protective values and favors the aquaculture industry. This indicates a perceived unfairness between stakeholders and that "science" and "scientific" risk assessments do not appear balanced and a useful decision-making tool to the second stakeholder group. This highlights the importance of the processes of stakeholder involvement, where stakeholder knowledge and values carry a real potential to affect risk judgments and decisions.

4. Conclusion

A (C,U)-perspective on risks covers aspects considered important by all stakeholder groups; it does not express any stand on matters and can provide a common platform for a shared understanding of risk as a point of departure for increased integration of diverse stakeholder knowledge, concerns and values. According to Wynne (1989), the value of science increases when multiple knowledge sets are used in tandem. By allowing risk assessments and decisions to rest

on a more diverse and comprehensive knowledge base, an uncertainty-based risk understanding can increase the scientific value of risk assessment and its usefulness as an informative decision-making support. It may also be the case that such a way of looking at risks in practice does not imply different decisions or lead to the risk amplification that is feared by the second stakeholder group. Research shows that, as long as the public perceives processes as fair, competent and effective, they may, for instance, accept decisions, even though they do not agree with them. However, without a shared understanding of what risk is all about, stakeholder involvement attempts are likely to fail from the very start.

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Paper III

Making visible the less visible - how the use of an uncertainty-based risk perspective affects risk attenuation and risk amplification

Authors: Fjæran, L. & Aven, T.

Published in: *Journal of Risk Research*, 2019,1-19.

This paper is not included in Brage for copyright reasons.

Paper IV

Creating conditions for critical trust - how an uncertainty-based risk perspective relates to dimensions and types of trust

Authors: Fjæran, L. & Aven, T.

Published in: *Safety Science,* 133, 2021, 1-12

Safety Science 133 (2021) 105008

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/safety

Creating conditions for critical trust – How an uncertainty-based risk perspective relates to dimensions and types of trust

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A B S T R A C T

Although some disagreement about the strength of the relationship, it is generally agreed within risk research, that trust plays a central role in shaping risk perception and risk responses. Over recent decades, risk managing institutions have experienced what by many has been described as a decline in public trust. Strategies like stakeholder involvement and communication of scientific uncertainties are increasingly implemented to rebuild levels of trust but often prove less effective. Also, trust-related research mainly revolves around the relation between regulators and authorities, on one hand, and the public, on the other, with less attention given to the role of the scientific risk assessor. In this paper, we argue that assessors can act to improve conditions of trust by adopting an understanding of risk, stressing uncertainty and knowledge aspects when conceptualizing and characterizing risk. While 'full' trust commonly is seen as an ideal situation and distrust as a state of affairs to be prevented, this approach involves recognizing distrust as a resource. Based on an example regarding the authorization and regulation of a feed additive and the Social Amplification of Risk Framework, we show how such a perspective affects trust, both as a filter for processing, interpreting and responding to risk-related information and as an impact following such processes. Drawing on a typology of trust, we also illustrate how this relates to different dimensions and forms of trust.

1. Introduction

Trust presupposes a situation of risk (Luhmann, 2000) and involves a choice to make oneself vulnerable to another entity (Earle et al., 2012). In risk research, there is a general understanding that trust affects how one understands and perceives risks and risk events, and how these are responded to. However, there is some disagreement about the strength of this relationship. Where this relationship historically seems to have been approached in deterministic and causal terms, it now appears to be more and more researched based on an associationistic understanding (e.g. Eiser et al., 2002, Poortinga and Pidgeon, 2005), in which trust is seen only as indicative of risk perception. Simultaneously others find a low correlation between the variables of trust and perception (e.g. Sjoberg, 2001). Nonetheless, trust is commonly associated with acceptance of risk-related messages, compliance and effective functioning of democratic processes and societal functions. Distrust, on the other hand, is often related to heightened public concern, risk amplification, questioning of the work of risk regulators, risk reduction or avoidance and selective use of information sources (Walls et al., 2004).

Today, many risks are regulated and managed in what has been characterized as a landscape of social distrust (e.g. Tuler et al., 2017; Leisinger, 2016; Lofstedt, 2004, 2013; Albach et al.; 2016, Frewer, 2017). Public distrust has been described as a key issue in research related to European health scares and regulatory food and feed scandals, such as the BSE (Bovine Spongiform encephalopathy) crisis (e.g. Lofstedt, 2004, 2013; Lofstedt and Schlag, 2017) and the use of GMOs (Genetically Modified Organisms) (e.g. Gaskell, et al., 2000; Albach et al., 2016). In response to such risk events, and first and foremost the BSE crisis, institutions like the European Food Safety Authority (EFSA) were established to provide independent scientific advice on food safety. However, the creation of EFSA and the functional separation of risk assessment from risk management did not increase public trust in those responsible for risk analysis (Frewer and Salter, 2010; Jensen and Sandøe, 2002). The public distrust in the motives of regulators, science and industry has been associated with the failure to take into account public concerns when assessing, managing and communicating about risk (e.g. Frewer and Salter, 2010; Jensen and Sandøe; 2002; Wynne, 1989).

Many reasons for public distrust have been proposed; among other the lack of acknowledgement of public reflexivity and capability to evaluate science (Barber, 1983; Nowotny et al., 2001; Wynne, 2001; Lidskog, 2008); ignorance of local knowledge, competence, concerns and values (e.g. Wynne, 1989; Frewer and Salter, 2010; Jensen and Sandøe, 2002); differences between laymen and expert risk perspectives

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https://doi.org/10.1016/j.ssci.2020.105008
Received 28 February 2020; Received in revised form 17 August 2020; Accepted 16 September 2020
Available online 1 October 2020

(e.g. Wynne, 1989; Kasperson et al., 1988; Slovic, 1993); vested interests and close ties between scientists and industry (O'Brien, 2000; Frewer, 1999; Frewer et al., 1996; Jasanoff, 2009); and failure to recognize the more relational and emotional character of trust (Wynne, 1992; Engdahl and Lidskog, 2014). The reported fall in trust in European food safety regulators has been described as representing a change from an era of trust toward an era of post trust, where main risk communicators are increasingly distrusted by consumers (e.g. Lofstedt, 2004, 2013).

However, the idea of declining public trust has also been drawn into question. Van de Walle et al. (2008) have stated that the claims of public distrust held by policy makers and academic scholars were based on insufficient opinion poll results and data, and Raaphorst and Van de Walle (2018) have claimed that "evidence of declining trust can be complemented by an almost equally substantial body of evidence of stable or increasing levels of trust". Siegrist (2019) recently reported that findings from longitudinal studies showed trust to be a more stable phenomenon across time than previously supposed in much risk literature. Wynne (2006) used the term 'Public Mistrust Myth' and argued that the conventional wisdom stating that until the BSE risk event the European public trusted science and scientists should be rejected.

Despite dissent within the scientific community about the decline or stability of trust and the strength of the relationship between risk perception and trust, the idea of the existence of public distrust in today's society still influences much research and dominates the political discourse and work of many governments, policy makers and risk managing institutions. Strategies like stakeholder involvement, public participation and communication of scientific uncertainties in risk governance processes are increasingly drawn upon in order to rebuild or increase levels of public trust. However, in practice, these strategies have yet to produce the expected effects on trust. Following the above statement of Wynne (2006), such attempts at rebuilding trust, can be seen as attempts at rebuilding something that never may have existed. Or, as we propose in this paper, it may be the case that what we are 'talking about' are not expressions of trust or distrust, but of something more complex and multidimensional, and that trust or distrust is not necessarily descriptive of how the public perceive and relate to risk managing institutions and information coming from these. This is in line with research of Poortinga and Pidgeon (2003) demonstrating the coexistence of trust and distrust in the public perception of government and its policies, and of Walls et al. (2004) holding that "The binary opposition of trusting or not trusting is inadequate to understand the often ambiguous and contradictory ideas people possess…" (Walls et al., 2004, p. 133).

In practical attempts at creating or rebuilding trust the complexity of the trust concept does not seem to be fully understood or appreciated. The dominating understanding of trust and distrust is as two mutually exclusive states and of 'full' trust as a complexity-reducing factor in society and an ideal 'state of affairs', and of distrust as the opposite: a negative and complicating factor and situation that should be prevented or counteracted. We argue that for stakeholder involvement and deliberation initiatives to positively affect what is commonly described as trust, it is of importance that distrust is understood and related to in more positive terms. This corresponds in different ways with the ideas and statements of previous research. Following Barber (1983), distrust can be effective, with a certain amount of distrust being necessary for political accountability in a participatory democracy. Similarly, Tuler et al. (2017) hold that distrust serves important functions, for instance ensuring social and political oversight, generating alternative control mechanisms and holding in check the power of elites and technical experts. A balance between trust and distrust is critical to public acceptance of risk-related decisions and their implementation (Short, 1992).

Different frameworks for studying trust and distrust exist. The Social Amplification of Risk Framework (Kasperson et al., 1988) provides one such representation. It provides a detailed description of how risks and risk events can have significant and unexpected impacts on trust and may generate effects that also spread to affect perceptions and levels of trust of other previous unrelated risks. Issues of trust are highly interrelated with mechanisms and components of amplification dynamics, but a host of questions surrounds the interpretation of trust and its effects (Kasperson et al., 2003). According to Kasperson (2012), there is an urgent need to understand how trust is shaped, altered, lost and rebuilt in the processing of risk-related information in social amplification research. Following Tuler et al. (2017), independent scientific expert assessments merit special attention in confronting 'conundrums' relating to trust and are of particular importance in climates of social distrust. The use and communication of risk assessments and related results can impact trust in different ways. Jensen and Sandøe (2002) have for instance connected public distrust to the presentation of food safety issues as purely objective scientific events and to a form of risk communication based on a notion of risk that does not take account of the public's perception of food risks and the complex value questions involved in food production. Yet, the main body of research and work concerning trust focuses on the relation between risk managing authorities and the public, and less attention has been paid to the role of the risk assessor in this context. In this paper, we 'turn the lens' towards the scientific risk assessors and the risk assessment process and show how assessors can act to improve conditions of trust, by adopting what we refer to as an uncertainty-based perspective on risk. This means broadening the understanding of risk compared to more traditional and probabilistic approaches where risk commonly is defined in more narrow terms as the combination of a set of consequences and the associated probabilities. Such an understanding particularly entails emphasizing uncertainties and knowledge aspects when conceptualizing and characterizing risk. Adopting such a perspective enables approaching distrust as a resource, a different angle than in most risk assessment and risk managing contexts.

This way of relating to distrust requires an acknowledgment of the complexity of the trust concept and that distrust and trust are not 'either or' states. Walls et al. (2004) argue that trust and distrust exist along a continuum, ranging from critical emotional acceptance at one end of the extreme to downright rejection at the other. In between these two extremes on the continuum of trust lies what is defined as a healthy type of distrust, reflecting that the public can rely on institutions and at the same time possess a critical attitude towards them. To illustrate the multidimensional and complex character of the trust concept, we draw on the typology of trust put forward by Poortinga and Pidgeon (2003). In a study of public trust in governmental risk regulation, Poortinga and Pidgeon found that different degrees of trust coexisted with different degrees of skepticism. The typology combines varying degrees of the two independent dimensions: general trust and skepticism, into different categorizes of trust; see Fig. 1. The dimension of general trust covers aspects of competence, care, fairness and openness, while skepticism, the second dimension, concerns a skeptical view of the process by which policies are brought on and put into practice and includes the credibility and reliability of the enactor. Skepticism also includes the 'vested interest' factor, put forward by Frewer et al. (1996) as a measure of integrity, and has an affective character. The typology ranges from full trust (acceptance/trust) to deep distrust (rejection/cynicism). The category of trust called critical trust in the typology is similar to what Walls et al. (2004) describe as a healthy form of distrust. Critical trust is defined in Pidgeon et al. (2010) as a practical form of reliance on a person or institution combined with a degree of skepticism.

Where the typology of trust originally was constructed to describe how the public perceives government and its policies, we use it to analyze the relations of trust between the different actors involved in risk assessment and regulatory processes. In this context, special attention is paid to the skepticism dimension of the trust concept and the role of the risk assessor. Based on an example concerning the authorization and regulation of the feed additive, narasin, and related risk events, and on the Social Amplification of Risk Framework (SARF), we show how the introduction of an uncertainty-based risk perspective in theory relates to and can impact different dimensionalities and types of public trust

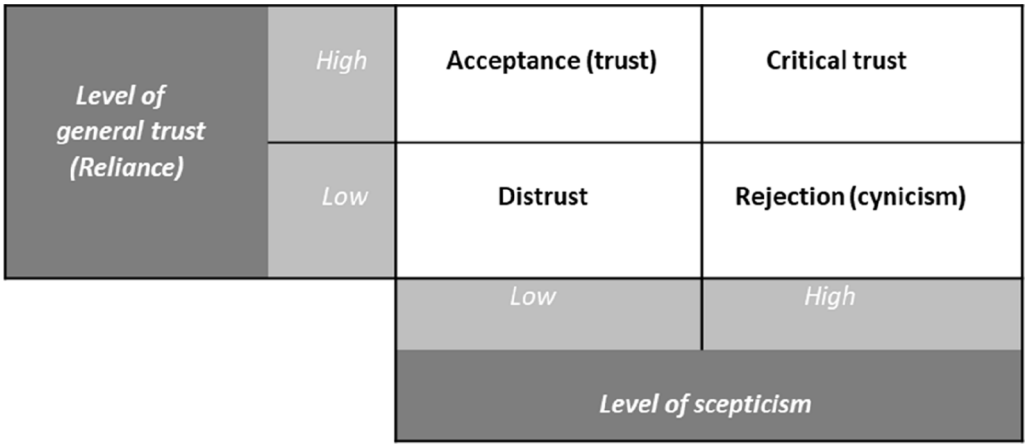

Fig. 1. Typology of trust (based on Poortinga and Pidgeon, 2003).

(Fig. 1) both as a filter for processing, interpreting and responding to risk-related information and as an impact following such processes.

The rest of the paper is based on the following structure. In addition to some other examples related to food and feed risk, the narasin case is used throughout the paper to illustrate the discussion. In Section 3, we analyze the case based on the stages and the structure of the SARF. We show how the different actors involved in the authorization process relate to, understand, make use of and respond to risk-related information and data, while relating the findings to different aspects and types of trust. We also discuss the impacts on trust across shorter and longer time horizons. In Section 4, we conduct a thought experiment, showing how an uncertainty-based risk understanding theoretically impacts levels and relations of trust in the example. Here, we perform the same analysis as in Section 3 and pay special attention to how this potentially affects the understanding and interpretation of data, information and knowledge, how risk-related information is used, communicated and responded to. The outcomes are related to the different categories and aspects of trust, as described in the typology of trust. Based on this twofold analysis, we provide some final conclusions and recommendations in Section 5.

2. The narasin case

The narasin case covers a set of risk events, spans a period of many years and is separated into two parts or stages. The first part concerns the authorization of and direct regulatory responses to the risks related to narasin, an additive (coccidiostat) used in poultry feed. The second encompasses the communication, interpretation and broader societal responses to messages of risks and risk events in Norway in the period stretching from 2006 to 2016. This part of the case is further divided into two sub-phases, the first of which comprises the years of 2006 and 2012, while the second covers the years from 2014 to 2016.

It must be noted that there have been some recent developments in EFSA practices regarding stakeholder involvement in food and feed risks and the development of guidelines regarding transparency and reporting of uncertainties within risk assessments. The case in the paper does not cover these developments; it concerns only risk events and the situation up to and including 2016.

2.1. Part 1 of the case

The first part of the case mainly concerns the authorization process of the European Union, concerning the risks related to the use of narasin. Following Commission Regulation (EC) No 1464/2004 (EFSA, 2004), narasin is authorized as a feed additive for chicken fattening, with a maximum content of the active substance in feed of 70 mg/kg. When a company wants to put a product containing narasin on the market, it must apply for authorization. As part of this process, following Council Regulation 2003/1831/EC (EC, 2003), the applicant company must provide all data required for toxicity assessment and hazard characterization related to the various target animal species for which the product is to be used. Information is required on the toxicological prolife of the additive, control methods, conditions for use and data demonstrating efficacy and safety (Dorne and Fink-Gremmels, 2013). FEEDAP, EFSA's panel on additives and products or substances used in animal feed, reviews the information submitted by the applicant company and conducts assessments in which product efficacy and safety related to the environment and to human- and animal health are examined. When assessing the risks, estimated exposure levels are compared to acceptable daily intake limits (ADIs), to conclude on human health risks (Dorne and Fink-Gremmels, 2013) and propose maximum residue limits (MRLs). These FEEDAP assessments are to a large extent based on the data provided by the company applying for authorization and commonly show estimated exposure below threshold values (ADIs) and conclude that narasin does not have any adverse effects on animal or consumer health or the environment. When EFSA's opinion is favorable, the European Commission prepares a draft regulation to authorize the additive.

2.2. Part 2 of the case

2.2.1. Phase 1

In the second part of the case, the focus is the communication and consequences of messages of risks related to narasin in a Norwegian setting. For all coccidiostats expect one (nicarbazin), Norway complies with EU decisions and regulations. This represented the regulatory background, when the media in 2006 reported that residues of the "forbidden drug" narasin were found in two egg samples in Norway. In responding to these findings, the feed producer stressed that 99 percent of the feed for egg-laying hens was produced under safer conditions (Rasmussen, 2006) and that this probably was a one-time occasion of cross-contamination (Totland, 2006). Shortly after these responses, the issue disappeared from the media.

In 2012, the media again brought reports of the risks related to narasin as antibiotic-resistant bacteria were found in 32% of Norwegian chicken fillets and narasin in 8 egg samples (Norwegian Food Safety Authority, 2012). The authorities responded to the risk messages by referring to existing EU legislation and focused on the fact that concentrations of narasin in most egg samples, except one, were below threshold levels values and therefore safe to human health. The authorities and the industry attributed the bacteria findings to the import of breeding material and pointed to the low level of antibiotic-resistant bacteria in Norwegian chicken, relative to other European countries. Again, the media put the issue to rest briefly after these responses.

2.2.2. Phase 2

In 2014, the risks related to narasin and antibiotic-resistant bacteria were again brought to public attention. Antibiotic-resistant bacteria were detected in 70% of chicken fillets in Norwegian grocery stores. This time, the findings received considerable media coverage and were followed by a long-lasting debate, in which different stakeholders communicated conflicting opinions and concerns. Some scientists and medical professionals claimed that the use of narasin should be banned and that chicken should be labeled as a risk product (e.g. Sunde, 2014; Gjessing, 2014; Midtvedt, 2014, 2015), whereas risk managing institutions stressed that the risk of bacteria transference was small, as long as recommended hygiene and cooking advice were followed (NFSA, 2014). The Norwegian Scientific Committee for Food Safety conducted new risk assessments judging the probabilities of consumer exposure to coccidiostats and to resistant bacteria in heat-treated chicken meat to be negligible (Nesse et al., 2015). However, despite authority assurance that chicken consumption was safe, demand for "narasin chicken" dropped significantly and, soon after, industry actors started phasing out the use of narasin in chicken feed. Public response brought about substantial changes in chicken production and also came to affect other sectors (e.g. public health, seafood) and influenced national strategies and goals.

3. Traditional, probabilistic approaches correspond with low levels of skepticism and high levels of trust

In traditional approaches to risk, risk is conceptualized and characterized as the combination of the consequences (C) of an activity and the related probabilities (P), often summarized by the expected consequences (loss), E[C], i.e. the sum of the product of the various outcomes multiplied with the associated probabilities. A typical perspective adopted is the risk triplet of Kaplan and Garrick (1981), reflecting i) what can happen? (i.e., what can go wrong?) (events/scenarios A), ii) if it does happen, what are the consequences? (C) iii) How likely is it that that will happen? (P). Risk is thus described by (C,P), (A,C,P), or E[C].

The probabilities are often estimated based on historical, statistical data and measurements concerning the occurrence of similar or related activities. The probability is often interpreted as an objective property of the activity being studied. In the following, we show how such a traditional probabilistic understanding of risk is related to different dimensionalities and types of trust in attenuation and amplification processes, as described in the SARF. First, we approach trust as a cognitive mechanism or filter affecting the processing, interpretation of and direct responses to risk-related information, whilst relating the discussion to risk assessment, decision-making and risk management processes in the first part of the case. Then, we move on to the second part of the case and explore the impacts on public trust over different periods of time.

3.1. Effects of trust on the processing, interpretation of and responses to risk-related information

3.1.1. Risk assessment

As information about a risk or a risk event is communicated from a source to a receiver, this information may be amplified or attenuated in different ways. This commonly happens by the intensification (amplification) or weakening (attenuation) of signals, symbols or aspects in the information and as the messages pass through selection filters, serving to sieve information and signals in the information (Kasperson et al., 1988). Although trust is not explicitly addressed in the original SARF, processes and mechanisms in the framework are closely linked to issues of trust. In the filtering process, levels of trust and of skepticism work as filters for incoming risk messages and information. Within this process, both signals in the message and the source of the message are perceived. Information produced by or that comes from sources that are trusted and seen as credible tends to be accepted and to pass through selection filters more easily than information from sources that are not trusted (Kasperson et al., 1988). Similarly, Lewicki and Brinsfield (2011) and Cummings (2014) have argued for understanding trust as a heuristic. Lewicki and Brinsfield (2011) describe trust and distrust as cognitive frames aiding the interpretation and organizing of new experiences. Once a trust/distrust frame is formed it functions as a shortcut for decision making. Other cognitive mechanisms, shortcuts and heuristics also affect this filtering process, for instance the fact that we tend to reject or disregard information that contradicts our prior beliefs and to pay more attention to data that correspond with or reinforce our pre-existing values and ideas (e.g. White et al. 2003) and that disproportionate attention often is given to negative information over positive information (Poortinga and Pidgeon, 2004; Siegrist and Cvetkovich, 2001). In addition to affecting the processing and filtering of risk-related information, dimensions and forms of trust also impact how this information is interpreted and responded to.

In the authorization procedure related to products containing narasin, as sketched out in Section 2.1, risk- related information produced by the Applicant Company (AC) is communicated to the European Food Safety Authority (EFSA). The FEEDAP, EFSA's panel on additives and products or substances used in animal feed, reviews the information from the AC and conducts a risk assessment. The assessments are performed based on the ADI-MRL approach (Mantovani et al., 2006): To conclude on human health risks and propose Maximum Residue Levels (MRLs), estimated exposure to narasin is compared to acceptable daily intake limits (ADIs) (Dorne and Fink-Gremmels 2013). In the assessments, estimates showing exposure below MRLs are interpreted and presented as low probabilities of adverse consequences and as representing no or low risk. The FEEDAP risk assessment is conveyed to the European Commission (EC) in the form of EFSA's scientific opinions on the licensing and regulation of certain products.

The SARF shows that, as information travels from a source/transmitter to a receiver, it sometimes also passes through an intermediate transmitter. In the example related to narasin, the AC (the risk producer) and the EFSA/FEEDAP (the risk assessor) may 'at first glance' appear as separate sources or transmitters of risk-related information. But, as the risk assessment to a large extent is based on data generated by the applicant, the AC may be considered the primary source of information and EFSA as an intermediate transmitter that information travels through on the way to the EC (the decision-maker and risk manager). However, independent of who represents the main source of information, the point here is that both transmitters, including the receiver, engage in attenuation of the risks related to narasin, although in different ways, and that these attenuation process are connected to levels and types of trust between the actors involved in the authorization process. The importance of addressing trust in such contexts is also underscored by Adekola (2019). She points out that the SARF focuses on "who" (sources, transmitters etc.) and the nature of the risk-related information, but that it is crucial to also study underlying social and institutional factors such as trust and power when studying risk amplification and attenuation.

The relations between the actors in the authorization process – the risk producer, risk assessor and risk manager/regulator – are characterized by what seem to be relatively high levels of trust. In this context, trust can be seen as an expression of confidence between parties in an informational exchange transaction. Trust plays a role in how much weight is assigned to information received form a source (Mase et al., 2015). Adopting the more multidimensional understanding of trust to this context, as proposed by Poortinga and Pidgeon (2003), allows further distinctions between different aspects of trust when analyzing the relations between these actors. The way the risk assessor (FEEDAP) more or less automatically seems to accept and heavily rely on the information and data provided by the applicant points in the direction of a low 'score' on the dimension concerning skepticism of risk-related information. Risk messages and information pass through the selection filters of the scientific assessor and appear to go through what Cacioppo

and Petty (1984) describe as the peripheral route. This route of decoding and processing information utilizes external cues, like trust, credibility or familiarity of source, in ways that allow recipients to make simple inferences and judgments about the content value, without further elaboration, scrutiny or in-depth processing.

The FEEDAP/EFSA does not appear reflexive of or skeptical of data used in the risk assessment. The fact that a large proportion of the information used in the risk assessment does not come from an objective source and that 'vested interests', agendas and perspectives of the risk producer may color data do not impact risk characterization or final risk judgment. Van Asselt et al. (2009) found similar tendencies concerning authorization of GMOs, processes equal to those related to narasin. In the GMO case, the assessments conducted by applicant companies, in this case Montsanto, were phrased in a language of safety. Here, the risk producer appeared dedicated to proving zero adverse effects, and the assessments were described as "deliberate attempts to transform risk into absolute certainty of safety". Assessments by EFSA's GMO Panel mainly consisted of reviewing data provided by the risk producer and were characterized as "de facto meta-analyses" of the assessment of the risk producer. The inclination to rely on industry data in assessment and regulatory contexts is also stressed by O'Brien (2000) in, for instance, referring to studies reviewing 600 Threshold Level Values (TLVs), where it was found that least 104 relied heavily or only upon unpublished information from corporations. O'Brien emphasizes that "…numbers representing accepted TLVs plugged into risk assessments bear the danger of being biased by political or economic factors" (O'Brien, 2000, p. 29).

Weakening, ignoring, deleting or toning down signals and symbols in information are powerful ways to attenuate risks or risk events. When information in which a language of certainty and safety is strategically used and where uncertainties and gaps of knowledge are framed as a lack of causal evidence, and pass through filters of high trust and low levels of skepticism, risks may be further attenuated. If such information is 'directed' through the peripheral route and accepted and relied upon without questioning its rationale and further investigation of uncertainties, this may contribute to transporting attenuation of risk and uncertainty signals originating from the industry and applicant companies into the 'independent' scientific risk assessments.

It can be argued that the manner of relating to information described above is closely coupled to the risk perspective of the assessor. A technical, probabilistic understanding of the risk concept is generally paired with the belief that risks can be estimated based on statistical data, even when limited. A narrow understanding of what constitutes valid information, data and science can restrict the use of diverse and balanced data and information when assessing risks. In the narasin case, we see that such an understanding of risk dominates. Statistical, heterogeneous data are used to estimate and predict future risks. Low probabilities of adverse effects on animal- and human health and the environment due to exposure to narasin are seen as equivalent to low or no risk. Uncertainty is limited to representing the difference between the risk estimate and what is believed to be the true underlying value of the risk and is accounted for by applying an uncertainty factor. Van Asselt et al. (2009) found that such a perspective of risk also prevailed in the assessments concerning GMOs. Monsanto's risk assessments followed "the famous formula of risk = probability × effect, with zero effect meaning zero risk" (Van Asselt et al., 2009, p. 369), i.e. risk was expressed by the expected effect or consequences E[C] using the terminology introduced in the beginning of this section. A narrow understanding of what is considered scientific issues to be covered by risk assessment allowed the scope of risk assessment to be minimized and the assessor tasks in relation to uncertainties to be eased. In our example, the FEEDAP/EFSA states that data related to the use of narasin and its effects are scarce, limited and for some areas (e.g. certain tissues, aquatic environment and secondary poisoning) even nonexistent. Still, no uncertainty assessment is conducted. Nor did the EFSA's GMO Panel actively try to identify uncertainties overlooked by the risk producer. Reliance on industry data makes assessors vulnerable to the willingness of the risk producer to disclose all relevant information and data. In only a few instances did narasin- and GMO assessors ask applicant companies for more data, but, again, informed by their own assessments, it was concluded that products were safe. Different types of data and knowledge were not sought or acquired, and uncertainties had no bearing on final risk judgments or conclusions. This approach to uncertainties is referred to by Van Asselt et al. (2009) and Weimer (2015) as the uncertainty paradox: a situation in which uncertainty is merely acknowledged but does not alter the outcome of risk assessments. Wynne (e.g. 1992, 2001, 2006) has linked this tendency to a narrow and simplistic scientific culture and understanding of what constitutes science and has repeatedly voiced a need for scientists and risk assessors to be more reflexive of uncertainties. These statements and assertions correspond with our findings of a low or inactive skepticism dimension of the trust concept.

3.1.2. *Decision-making and risk management responses*

As now seen, acceptance/trust ((upper left box in the typology Fig. 1) works as a complexity-reducing filter or factor for the processing of risk-related information. It not only characterizes how the assessor relates to and makes use of information and data, it can also serve to describe the relation between the risk assessor and the risk manager/regulator, and it affects how risk messages are interpreted and responded to. In the example of this paper, we see that the interpretation and responses directly concur with the risk assessment result; authorizations are granted and the suggested MRLs are followed. The manner in which decisions on authorizations and regulations are reached indicates high levels of trust and low levels of skepticism. Again, risk messages automatically pass through the selection filters of decision-makers. This acceptance seems to be based on an understanding that risk assessment results in the form of probabilities and risk estimates represent scientific evidence that can be used as prescriptions for decisions and responses. Such an evidence- or science-based decision-making style is linked to a technical comprehension of risk, involving a belief in the objective character of data and risk assessment results, and assumes high trust in sources of information.

Van Asselt et al. (2009) also argue that the European Commission's uncritical compliance with EFSA opinions seems to be founded on an established pattern of trust. Analogous to the question concerning who in fact represented the primary source or transmitter of information in the assessments of risk related to narasin, one can ask who in fact is the real decision-maker. Our answer to this question is in accordance with the reasoning of Van Asselt et al. (2009), who state that "Since Commission decisions are based on EFSA advice, the advisory institution is the 'de facto decision-maker" and risk manager (Van Asselt et al., 2009, pp. 377-378). Even when member states reported doubt in EFSA's science and objected that assessments heavily relied upon short-term industry data and did not take into account uncertainties, the Commission turned to the same institutions and the same science for 'certainty' to justify decisions. Lofstedt (2005) also connects this technocratic decision-making style to systematic underrepresentation of uncertainties and to a tendency for risk managers to largely trust risk assessors. Experts and scientists are commonly considered highly trusted sources, and, as described, in situations where there is trust of sources, the peripheral route is likely to be used for the processing of information. Following this route, risk messages are generally accepted as valid and relied upon without going through critical evaluation or further scrutiny. Our example of the authorization procedure and practices concerning narasin illustrates this tendency and shows how high trust, paired with low skepticism of information, can contribute to transporting attenuation from risk assessment, often originating from the risk producer, over into risk management and risk-regulatory responses and processes. When 'objective evidence' represents the main or sole justification and basis for risk management decisions, this transportation of attenuation becomes even more likely.

3.2. Impacts on public trust

As we have seen in the above section, trust has a filtering effect on how information, risk messages and risk events are understood and responded to, but these responses and reactions can also have secondary and tertiary impacts on trust itself. What is presumed to be a minor risk or assessed by an expert as a risk or risk event with low probability of adverse consequences can still end up generating considerable amplification and significantly impact public trust. The second part of the narasin example illustrates such ripple effects. The division of this part of the case into sub-phases shows how the manifestation of such effects differs, depending on the variable of time.

3.2.1. Phase 1

In 2006 and 2012, detections of antibiotic-resistant bacteria in Norwegian chicken fillets and of narasin in egg samples were reported in the media. The findings received brief and little media coverage and attention. The authorities responded to the risk messages by referring to EU legislation and regulations and focused on the fact that most concentrations were below TLVs and therefore safe to human health. The discourse was highly influenced by a technical understanding of risk, with references to risk assessment results and low probabilities of effects. Also, the authorities, risk managers and the industry downplayed the bacteria findings, by linking them to imported breeding material and pointing to low levels of antibiotic-resistant bacteria in Norwegian chicken. Reports had little or no impact on consumer trust and behavior, and demand for chicken remained stable.

These 'non-responses' of the consumers in this phase of the case indicate what is described by Berg et al. (2005): namely, that consumers depend on large food producing and control systems that are only partly familiar and transparent to them. In such situations, it again becomes evident how trust can function in ways already described by Luhmann in 1979: namely, as a mechanism for reducing societal complexity. Individuals rarely internalize the full array of information to which they are exposed and often choose to rely on sources they mostly trust (Mase et al., 2015). On this account, trust operates as an external cue that allows information to be 'sent' through peripheral routes. Trusting in such a sense can also be associated with a form of practical attenuation that allows individuals to more easily deal and cope with risks and risk events on an everyday basis.

Research shows that trust and knowledge affect risk perception together, but, when knowledge is low, limited or absent, trust takes the center stage in forming risk perception (Siegrist and Cvetkovich, 2000; Earle et al., 2012). Also Cummings (2014) state that trust can bridge gaps in one's knowledge and facilitate making judgments. Similarly, Cacioppo and Petty (1984) find that the possession of little prior knowledge on an issue is a factor reducing recipient motivation or ability to elaborate and effortful thinking, thereby increasing the possibility of information going through peripheral routes. As mentioned, this type of message processing commonly contributes towards uncritical acceptance of information. With such peripheral processing, there is a danger that errors, distortions and knowledge gaps in risk messages are received without scrutiny. This may lead to a 'false' perception of risk (Adekola, 2019).

Following the development of the case, it is natural to assume that the public had little or no knowledge of narasin and its related risks prior to 2006 and 2012. The 'non-responses' of the public indicate that the public trusted the authorities, risk managers and regulators and saw information coming from these as reliable, and public perception of the risks stayed low. We again see a situation of acceptance/trust in which high general trust and low skepticism exist about institutions and what these communicate and or decide. This situation corresponds with an understanding in which "…'trust' means the acceptance of decisions by the constituents without questioning the rationale behind it" (Lofstedt, 2003, p. 419). A setting characterized by such a form of trust can contribute to upholding the status quo and maintaining risk attenuation. The non-responses of risk managers, regulators and the public may serve to further extend attenuation into a societal drift away from focusing on feed additives and narasin as risk sources or as important issues of attention.

3.2.2. Phase 2

In the case, in 2014, amplification occurred when the risks related to narasin and antibiotic-resistant bacteria were again brought to public attention. This time, the findings received considerable media coverage and were followed by a long-lasting debate in which different stakeholders voiced conflicting concerns and opinions in the media.

When risk messages and advice conflict or diverge, one generally chooses to trust information from sources judged most reliable and trustworthy. According to Luoma and Lofstedt (2007), "Conflicting interpretations about an important consumer issue add to the growing erosion of public trust in advice from experts". Although authorities continue to place significant trust in scientific risk assessors and lean on these for 'certainty' and advice (as in Section 3.1.2), the way members of the public relate to information at this stage of the case can be characterized by relatively low trust and high levels of skepticism. The public now rejects risk assessments showing negligible probabilities and the authorities' advice claiming that consumption of heat-treated chicken is safe. Instead, consumers now rely on information from those claiming the opposite: that the use of narasin should be banned and that chicken should be labeled as a risk product (e.g. Sunde, 2014; Gjessing, 2014; Midtvedt, 2014, 2015). This distrust and the rejection of risk assessment results and advice are in accordance with the findings of Slovic (1999), which show that when trust does not exist, referring to risk assessments has little effect and may in fact serve only to increase public concern. A common reason for such distrust is the belief that information may be adapted to 'match' the vested interest of a source (Frewer et al., 1996).

At this point of time in the case, people have also gained more knowledge about narasin and its related risks. Demand for narasin-produced chicken dropped and we see changes in consumer behavior that indicate increased perception of risks related to narasin. This amplification is in line with research showing that increases in knowledge about a risk, where initially trust existed, often leads to more concern (Malka et al., 2009; Earle et al., 2012). The typology of trust, see to Fig. 1, distinguishes between two categories in which trust is low. The categories differ, based on the level of skepticism. The first type is labeled "distrust" and refers to a context in which both trust and skepticism are low. The second refers to a deeper sort of distrust, where the public has no trust in an institution and is skeptical of its intentions. Here, the low trust is paired with a higher level of skepticism. Any information coming from or produced by this institution is likely to be discarded or rejected. The responses of the public in phase 2 can be interpreted as reflections of this category of trust. At this point, information and messages of potential risks generate considerable amplification in ways that negatively affect trust. The public appears skeptical of governmental information and discards messages from sources it previously relied upon. In this way, our case also shows that risk messages and information are evaluated differently following an attribution of trust than of distrust, that the dark lens of distrust seems to blacken the associated interpretations (Slovic, 1999) and contributes to heightened resistance in risk arguments (Adekola, 2019). Similarly, loss of trust can increase risk perception and intensify public responses. Although there is an ongoing discussion concerning the strength of the connection between trust and risk perception, much research has demonstrated the asymmetrical relation between the time and effort it takes to gain trust, compared to the time it takes to destroy trust, and that trust in institutions is sensitive to specific risk events (e.g. Slovic, 1999, 1993; Kasperson et al., 2003; Pidgeon et al., 1992; Haynes et al., 2008).

4. An uncertainty-based risk understanding promotes higher levels of skepticism and critical trust

Compared to the traditional, technical approach to risk, as seen in the authorization process concerning narasin, an uncertainty-based risk perspective involves understanding the risk concept in a broader sense (SRA, 2015; Aven et al., 2014; Aven, 2020a, 2020b). Where the main components of risk following a traditional risk perspective are events (A), consequences (C) of these events, and probability (P) - often summarized by the expected consequences E[C] - here the main components are events (A), consequences (C) of these events, and uncertainty (U). Risk is defined by the combination of

1. these events A and the consequences C of these events, and
2. the associated uncertainties, U, regarding both A (will A occur?) and C (what value will C take given A?)

For short we write risk = (A,C,U). To describe these uncertainties U, probabilities can be and often are used, but it is stressed that probabilities alone are not sufficient to fully describe risk. A clear distinction is made between the measure (e.g. the probability), and the risk concept itself. It is recognized that probabilities are based on some knowledge, K, and that this knowledge can be of varying quality. The value and the usefulness of probabilities are highly dependent on the strength of this knowledge. Therefore, the knowledge base and its strengths and weaknesses, together with the fact that surprises relative to this K can occur, must form a central part of the characterization and final judgment in any risk assessment process.

Broadening the understanding of the risk concept also means extending the understanding of what is considered valid knowledge and input to risk assessments. An uncertainty-based risk perspective entails an extended approach on how to represent epistemic uncertainties and promotes the use of both quantitative and qualitative methods and heterogeneous data when assessing risks. See Aven (2012, 2016, 2020a) for further motivation and details concerning the uncertainty-based approach, including some historical perspectives on the development of the risk concept.

In the following, we demonstrate how the introduction of such a comprehension of risk can affect aspects and levels of trust between actors involved in risk assessment and management processes. We show how this way of understanding risk can have consequences for the processing, interpretation of and responses to risk-related information, whilst using the first part of the case concerning the authorization process to illustrate the points made. Applying the same structure as in Section 3, we then show how this uncertainty-based risk perspective hypothetically affects levels and dimensionalities of public trust and how these effects relate to amplification- and attenuation processes.

4.1. Effects of trust on the processing, interpretation and responses to risk-related information

4.1.1. Risk assessment

Adopting an uncertainty-based approach to the processes concerning communication of risk-related information involves increasing the volume of many of the risk characteristics and signals commonly downplayed following a more traditional probabilistic perspective on risk, as seen in the authorization process related to narasin. In both the construction and communication of a risk message, uncertainty and knowledge aspects would be emphasized. This entails adopting a language and vocabulary different from that used by companies applying for authorization, in which information about safety and certainty is stressed. Relating to uncertainty and knowledge aspects as central components of risk automatically leads assessors to assume a more critical attitude to the information, data and input used in the risk assessment process. It directly involves activating the skepticism component of the trust concept.

Such an approach requires the identification and investigation of uncertainties and knowledge gaps overlooked by the risk producer and the evaluation of the quality of the knowledge base. The fact that data concerning exposure to narasin are limited, homogenous and provided by an actor holding interest in portraying products as safe and risks as low or nonexistent, points in the direction of a relatively poor knowledge base. Judgments pointing in the direction of weak knowledge could serve as a rationale for seeking more and more diverse and nuanced data. As mentioned, an uncertainty-based risk perspective is coupled with a broader approach on how to represent epistemic uncertainties than conventional risk perspectives. Here, knowledge is understood as justified beliefs, and when judged scientific, these being the most epistemically warranted assertions existing at a certain point of time. The knowledge base is not restricted to representing a set of statistical, historical and what is presumed to be objective true beliefs. This comprehension promotes combining different types of knowledge and 'alternative ways of knowing' when assessing risks. Knowledge of stakeholder values, concerns and experiences are also considered relevant and important input to the knowledge base. Examples of such inputs are: knowledge of consumer behavior, trends, values and attitudes towards of the use of chemicals and contaminants in food and feed; input from a broad range of fields (i.e. ecology, medicine, psychology); scientific research indicating consequences and trends deviating from those reported by risk producers; practical experiences of those directly exposed to additives or contaminants; and insights into alternative methods of chicken production.

For risk and risk events holding what is referred to as signal value, using such knowledge in addition to technical, probabilistic data may be especially important. The combination of characteristics like little or no knowledge (e.g. new risk, delayed effect, unobservable) and 'high dread' (e.g. uncontrollable risk, consequences for future generations) is associated with high risk perception and the potential for amplification and subsequent ripple effects (Slovic et al., 1986; Kasperson et al., 2003). The risks associated with the use of narasin bear many of the characteristics associated with signal value. Using alternative sets of knowledge in such contexts when, for instance, specifying potential consequences and the risk events/scenarios themselves, makes risk assessors less vulnerable to risk producers not revealing all relevant information, and can contribute to avoiding attenuation and a narrow framing of risks from the start of the risk assessment process. This can act to prevent what Van Asselt et al. (2009) observed: that risk producers set the agenda, define the problems and frame the issues in their safety assessments in ways that only allow the risk analyst to assess risks within a framework constructed by the industry.

However, the use of comprehensive and nuanced data when assessing risks is an ideal situation and cannot always be achieved in practice. Collecting, filtering and evaluating a wide array of data is time-consuming. The time constraints within which the risk assessments of EFSA are conducted have been pointed to, as well as the fact that insufficient time is allocated for gathering more comprehensive data. But, when EFSA accepts and chooses to primarily rely on limited data from risk producers as the basis for their scientific opinion, this is also a reflection of uncertainty intolerance, as described in Section 3.1.1. Following an uncertainty-based risk perspective, if time constraints were arguments for not seeking or collecting more and nuanced data, an active skepticism dimension and critical way of relating to information and uncertainties would function as a 'safety valve', holding the potential to remove or prevent attenuation. The judgments and evaluations of the strength of the knowledge (SoK), would directly affect the risk characterization and could justify a higher risk judgment and/or recommendations of more cautious regulations or management strategies. Contrary to the narasin- and GMO examples, uncertainties would not be, as Wynne put it, naturally deleted or black-boxed away because uncertainty forms a central part of the risk concept itself.

This manner of understanding risk, relating to and using data, information and knowledge implies lower levels of trust and higher levels of skepticism relative to the one seen in the case. Compared to both the narasin- and GMO examples, it would require a degree of amplification

to be added into the authorization process. As mentioned, this may result in a higher-risk judgment but not necessarily. It may still result in the same or similar conclusions and recommendations as those of EFSA, but the processes and reasoning modes behind the risk assessment results would be of a different character. In the narasin case, high trust and low skepticism worked to allow the transportation and spreading of attenuation. Although EFSA did not deliberately promote the interests of the risk producers, their reasoning modes were mutually supportive (Van Asselt et al., 2009). The way the risk assessor accepted and heavily relied upon data from applicant companies in the analyses to a large extent permitted the risk producer to carry the role of the independent scientific assessor.

The language and the reasoning mode of a risk assessor holding an uncertainty-based understanding of risk do not coincide with those of the risk producer. Here, a higher degree of skepticism paired with generally lower levels of trust and acceptance become filters or mechanisms working in the opposite sense and act to send information via the central route. Following Petty and Cacioppo (1986) and Cacioppo and Petty (1984), this route for processing information is more likely to be used where trust is low or absent. Here, an in-depth analysis of the risk message received is carried out, and information is carefully examined. As Adekola (2019) also has stated, this process can act to amplify uncertainties and gaps in knowledge. Compared to the manner in which risks are communicated and portrayed in assessments in the examples shown, we argue that integrating a degree of amplification into the risk assessment process could prove 'healthy', by making assessors aware of and detect and/or filter out attenuation. On that account, an uncertainty-based risk perspective can introduce similar qualities to what Barber (1983) describes as the functional or effective character of distrust into risk assessment processes, by, for instance, revealing information colored by the vested interests and agendas of powerful stakeholder groups and contributing to keeping power imbalances in check.

Still, the processing of risk-related information through the central route does not necessarily imply that there is no trust between actors, but that trust is not blind, uncritical or naïve, and that risk judgments are reached as part of a more critical and reflexive and uncertainty-accommodating process. More than introducing changes in actual levels of trust, an uncertainty-based perspective involves activating the skepticism dimension of trust.

4.1.2. Decision-making and risk management responses

The way of understanding risk as described above also has consequences for the decision-making process and may affect risk management and regulatory responses. As explained, it may alter the risk assessment result but may also produce an equal conclusion. The main change represented by an uncertainty-based risk understanding is the fact that it alters the way the risks are portrayed and communicated to the decision-maker. Risk characteristics, signals and aspects, hidden, concealed or briefly mentioned, would be openly displayed. Assumptions, uncertainties and limitations of the knowledge base form part of the risk description itself and are explained and made visible to decision-makers. Risk assessment results and probabilities are not presented to decision-makers as objective 'answers' but presented as expressions of the uncertainties and the degree of beliefs the risk assessor has concerning the occurrence of a risk event, based on the knowledge available at a certain point of time.

Such an approach to risk and the communication of risks to a greater extent facilitates critical reflection and evaluation of the risk assessment and its conclusion. Once again, we see how an uncertainty-based risk perspective is tightly connected to an active skepticism dimension. High levels of skepticism may be interpreted to reflect corresponding low levels of general trust, but it is important to note that even though skepticism is high, relations between the risk assessor and risk manager may still be characterized by trust. The point here is the same as in Section 4.1.1: that the trust between actors is not blind and is not associated with direct acceptance and reliance on information. Trust here implies what Poortinga and Pidgeon (2003) describe as a practical reliance on an institution. Because of a 'high score' on the skepticism dimension, trust here does not operate as an external clue, sending incoming information through peripheral routes. The risk understanding itself demands that risk messages and information go through processes that foster what Cacioppo and Petty (1984) call high elaboration likelihood. This means that it is likely that recipients will engage in effortful thinking and evaluation of risk-related information and its merits, as happens when information travels through the central route. Actively considering and investigating information makes the recipient more knowledgeable of the risks and limitations of a risk assessment. And, as research has demonstrated, when knowledge is high or increases, the importance of trust as a factor shaping interpretation and responses becomes reduced (e.g. Earle et al., 2012).

Where risk assessment results previously have represented the evidentiary basis for decisions on responses, displaying uncertainties and limitations within risk analyses can challenge decision-making. Risk assessment may not provide clear answers or support for a specific response and may complicate the decision-making process or may lead to 'decision paralysis'. As put by O'Brien (2000), it becomes harder to hide behind the rationality and objectivity of risk assessments. It may change or challenge existing structures and relations of power. At the same time, it could contribute to the opposite: that decision-makers strategically make use of uncertainties and indefinite results in order to pursue their own agendas. It may also produce risk amplification, by leading decision-makers to overemphasize uncertainties, spawning an interpretation of risks as higher than necessary and manifesting in little 'action' and overly cautious responses.

However, in the same way as emphasized in Section 4.1.1 concerning outcomes of risks assessments, an uncertainty-based risk perspective does not automatically imply altered decision outcomes. The important message is that the responses do not directly follow probabilities and risk assessment results as seen in the technocratic science- or evidence-based decision-making style in the case. An uncertainty-based comprehension of risk supports what we describe as a knowledge- and risk-informed approach to decision-making. This involves using the risk analysis as an input to a wider process of weighing and balancing a broad range of values, interests and concerns. Contrary to the 'non-decisions' on the authorization of both GMOs and narasin products, decisions are arrived at as a part of a more critical reflexive process. Also, if risk signals, characteristics or information are downplayed or camouflaged in analyses, such a form of decision-making holds the potential to stop attenuation from spreading into risk management, by providing the rationale for different decisions and/or more cautionary and restrictive responses. Yet again, this illustrates how introducing skepticism into the decision-making and risk management process can prove functional. Much trust-related literature and research does not seem to distinguish between different aspects and components of trust, and this skepticism often appears to be referred to as distrust. As we have seen, this skepticism can exist in parallel with trust, and the category labeled "critical trust" in the typology appears to be a good candidate to describe the relations between actors and their way of relating to information following the application of an uncertainty-based risk perspective.

4.2. Impacts on public trust

Compared to traditional, technical approaches to risk, an uncertainty-based risk perspective represents some fundamental changes that potentially can affect public trust and the development of attenuation and amplification processes. The two sub-phases of this part of the case illustrate that these effects are time-dependent.

4.2.1. Phase 1

Assuming the adoption of an uncertainty-based approach to risk, one could hypothesize that the reports of detections narasin in eggs in 2006

and of antibiotic-resistant bacteria in chicken and eggs 2012 were interpreted and responded to differently by various actors. First, this way of dealing with risk requires uncertainty aspects to be emphasized, and, by relating to these as central aspects of what risk is all about, the detections could have been interpreted as warning signals, indicating that narasin could have other and larger consequences than those predicted. They could also have been seen as indicators that the knowledge base behind the risk assessment was even weaker and less informative than previously assumed. These judgments justify revising the scientific risk assessments and reconsidering the responses. As described, this approach to risk also corresponds with the use of more diverse and heterogeneous data. This encourages relating to different signals and types of information in a more proactive sense, for instance making use of knowledge about stakeholder values, concerns and preferences to identify risks holding the potential for high risk perception and large amplification. Subsequently, the detections could have been interpreted as holding signal value: as early messages and signs pointing at risks that potentially are in need of stricter regulation and increased societal attention. Accordingly, an active approach to uncertainties and knowledge can act to avoid 'continued' attenuation associated with not responding to or not absorbing new information and knowledge into risk assessment and risk management processes.

An uncertainty-based risk perspective alters the way risks are portrayed and communicated to the public. In the example, the 2006- and 2012 findings were communicated as non-risks and presented to the public in ways that involved significant attenuation. Authorities and risk mangers stressed 'safety' aspects, by emphasizing concentrations below EU regulation levels, low probabilities of adverse effects, and by stressing low levels of antibiotic-resistant bacteria relative to other countries. An uncertainty-based risk understanding corresponds with a more transparent and open style of risk communication, and the risk conceptualization itself requires that uncertainties and knowledge limitations are explicitly addressed. This manner of communicating risks could potentially have given a more balanced picture of the risks related to narasin and inspired reflexivity and critical thinking among the public. It stimulates using more elaborate strategies of thinking and of processing information in ways that could serve to increase levels of public awareness and knowledge, and lead to more informed and independent consumer choices.

As we now know, increased knowledge of an issue makes trust less influential in affecting risk perception and subsequent responses. When one is well informed and knowledgeable about a topic, one can use this available knowledge when making decisions, and trust becomes superfluous (Earle et al., 2012). Hence, by facilitating consumers and the general public to actively and skeptically relate to information and by increasing their knowledge and awareness of risks, an uncertainty-based risk perspective can act to diminish the role of trust when it comes to how these groups interpret and respond to risk-related information.

At the same time, exposing and emphasizing uncertainties and knowledge gaps when communicating risk-related information can generate risk amplification in different ways. Risk assessors and risk managers may appear less competent and less in control and may lead the public to interpret risk as higher than following a more traditional, technical approach to risk and risk communication. Studies have, for example, shown that when there initially is trust, reception of knowledge is associated with more concern and higher risk perception (Malka et al., 2009; Earle et al., 2012). Also, stimulating careful evaluation of the information about risks can serve to amplify signals or aspects previously ignored or overlooked and affect how this information is perceived and reacted to. It may, for example, lead to cynicism or rejection of information, decrease the perception of safety of food products (Frewer et al., 2003; Jansen et al., 2019) and negatively affect levels of trust. This may spur responses resembling those seen in 2014–2016.

It has been hypothesized by many (e.g. Frewer et al., 2003; Van Asselt et al., 2009) that the fear of increasing public distrust lies behind much of the unwillingness to disclose uncertainties. However, studies have also demonstrated that the general public is familiar with and capable of handling uncertainties (e.g. Wynne, 1992, 2006; Frewer et al., 2003), and that uncertainty constitutes a central element in how the public understands and relates to risks (Fjaeran and Aven, 2019a). Generating some distrust and amplification in the early life of risks may prove an important investment in the long run. Honestly and openly displaying uncertainties, stimulating skepticism of information and enabling public awareness at an early stage, can act to avoid or reduce later amplification. And, as indicated by research (e.g. Earle et al., 2012; Malka et al., 2009), when the background is characterized by skepticism, low trust or distrust, the reception of more or new knowledge does not necessarily entail increased risk perception and concern. It is when there is initial high trust that the impact on risk perception is greatest.

4.2.2. Phase 2

The course of the events and reactions seen in phase 2 of the second part of the narasin case illustrate the last statement in the section above. The media reports of high levels of antibiotic-resistant bacteria and concerns of certain scientists and medical professionals in 2014 initiated considerable amplification that was to bring ripples of effects. In this part of the case, conflicting messages and advice were communicated to consumers and the general public, and consumption of narasin-produced chicken quickly fell. Authorities responded to the amplification by ordering new risk assessments from the Norwegian Scientific Committee for Food Safety. These echoed the same technical understanding of risk as the FEEDAP/EFSA assessments and, although these admitted a possible connection between the use of antibiotic-resistant bacteria and the use of narasin, probabilities of consumer exposure to coccidiostats and to resistant bacteria in heat-treated chicken meat were judged negligible (Nesse et al., 2015). As we know, risk assessment results and authority assurance were again rejected, dismissed and/or ignored. Consumers now chose to rely on information from sources stressing uncertainties, knowledge gaps and the potential for long-term and serious effects. Uncertainties were interpreted by the public as indicative of high risk and as a reason for precaution, and demand for 'narasin chicken' continued to drop.

Throughout the entire case, the authorities appeared to place a high level of trust in experts and their advice. In both parts and phases of the case, risk communication was directly rooted in risk assessments, their conclusions and statements related to or derived from the assessments. Presenting the public with an 'objective', technical and narrow picture of risks and stressing safety aspects where uncertainties, concern and low trust exist can, as seen in the case, have the opposite effects of those expected. Referring to risk assessments and estimates in such settings may increase concern, lead to amplification and, according to Frewer and Salter (2012), result in distrust in the motives of regulators, science and industry. Such distrust is connected to the belief that information has been distorted and that the source of the information is protecting its own interests rather than providing good information out of concern for the public welfare (Frewer et al., 1996, 2003). In general, the public places substantial trust in independent scientists but gives little weight to statements it believes to be made by scientific 'guns for hire' (Jenkins-Smith and Silva, 1998; Tuler et al., 2017). This can result in distrust of sources traditionally providing risk-related information. A consequence of such distrust, or of what may be better described as skepticism, is that the public looks elsewhere for information. When there is conflicting information, people often choose to trust information from the 'watchdogs': independent organizations and experts that keep an eye on developments and inform the public about potential consequences (Pidgeon et al., 2010). According to Slovic (1999), in such settings, the bare mentioning of possible links or associations and statements of potential risks outweigh any statement of lack of evidence of causal effects and low probabilities. In the development of the case in this phase, we see all these tendencies.

The responses of the public and the degree of distrust or skepticism

these reflected can be tied to the failure of risk assessors and managers to recognize the role of uncertainties in the way the general public understands risks. The technical language used by those in charge of assessing and managing the risks and the understanding of risk it reflected did not match the public interpretation of the risks. Risk estimates and probabilities do not cover what risk is to most people. The public considers food risks in a broader value context than the technical narrow notion of risks (Jensen and Sandøe, 2002; Fjaeran and Aven, 2019a). An uncertainty-based approach to the communication of risk-related information to a larger degree resonates with the public understanding of risk than the one used in the case. Had risk assessors and managers, for instance, proactively addressed uncertainties of the consequences and knowledge limitations and seriously taken care of these aspects in their communication of the risks related to narasin, one could hypothesize that some of the amplification seen, when the public turned to risk protestors and 'watchdogs' for information and advice, could have been reduced or avoided. Using such a perspective as a foundational basis for risk communication one could also potentially 'block' or pre-empt some of the amplification generated by distrustful stakeholder groups and those opposing the risks. Following Van Asselt et al. (2009), an unintended consequence of avoiding addressing and not recognizing the importance of uncertainties is the increased distrust among risk protestors themselves. These actors may exaggerate uncertainties and/or misuse information, in ways that may produce unnecessary amplification. If these groups 'reveal' camouflaged or downplayed information, presenting risks as mismanaged and attenuated, this may seriously harm public trust. This point illustrates how amplification and the extent of such amplification can be tied to the degree of prior attenuation (Fjaeran and Aven, 2019b; Poumadere and Mays, 2003). Similar points are made by, for instance, Pidgeon et al. (1992) and Kasperson et al. (2003), who state that, if risk and uncertainty are not adequately managed or considered, the occurrence of a risk event can severely impact trust in institutions and may potentially lead to a complete breakdown in trust.

Yet, for an uncertainty-based risk perspective to genuinely impact the extent of amplification and subsequent ripple effects, more is required than an open communication of risk and uncertainty aspects when a risk events occurs. It demands that changes have been made at a much earlier point, from the very start of the risk assessment process when risks are initially framed, as described in Section 4.1. Building public trust demands fair procedures and processes truly involving the public (Trettin and Musham, 2000) including public concerns, values and meaning-making regarding issues at stake (Engdahl and Lidskog, 2014). As we have shown, doing so requires acknowledging the value of what commonly is referred to as distrust, but what may be more correctly an expression of healthy skepticism, throughout the whole risk assessment and risk management processes.

5. Conclusion and recommendations

Based on a case concerning the authorization and regulation of narasin, we have shown how a technical, probabilistic understanding of risk goes hand in hand with high levels of both trust between actors and reliance on and acceptance of risk-related information and data. Following the structure of the Social Amplification of Risk Framework, we have shown how such 'Acceptance/trust' appears to facilitate the spreading of attenuation from one level or actor to another: from risk producer to risk assessor, from risk assessor to risk managers/regulators, from risk manager/regulators to the members of the public and to the larger society. As shown, such attenuation can go unnoticed for a long time without having any visible consequences, but when a related risk event take place, this attenuation can bring substantial amplification, having far-reaching and negative effects on what is typically referred to as public trust.

Risk events similar to those seen in the second part of the case have led risk managers and authorities to recognize the importance of being open about scientific uncertainties in risk assessments and of involving stakeholders in risk governance processes when it comes to building trust. This paper argues that, for such efforts to 'bear fruit', a broader understanding of the risk concept is required, and trust and distrust must be approached from a different angle. Prevailing concepts of both risk and trust fail to give realistic pictures of how people understand and judge risks and risk-related information and their relationship, as well as their perceptions of the institutions in charge of assessing and regulating risks. These are a lot more nuanced and complex than suggested by conventional conceptualizations.

The dichotomous comprehension of trust and distrust does not, according to Pidgeon et al. (2010), cover the set of subtle and complex relationships, discourses and perceptions that the public holds about risk-managing organizations. As described by others (e.g. Walls et al., 2004; Poortinga and Pidgeon, 2003) and in this paper, different degrees of trust and distrust exist in parallel, and what generally is understood as distrust may actually represent a healthy portion of skepticism. The way the public understands, perceives and relates to risk-managing and regulatory institutions is best described by the notion of critical trust: a pragmatic practical reliance on an institution, paired with a skeptical or critical attitude towards the effectiveness, motivations and independence of this agency (Pidgeon et al., 2010; Walls et al., 2004). Already in 1983, Barber described what he called effective public distrust, arguing that distrust could serve essential functions in a society and that the importance of trust was exaggerated. More recent studies related to the COVID-19 pandemic have also emphasized problems associated with high levels of public trust stating that it may lead to underestimation of losses and reduce the belief in the need to take action to control risks when necessary (Wong and Jensen, 2020). Parkins et al. (2017) reported that 'critically trusting' citizens are more likely take part in public engagement and participation initiatives than trusting ones. Although such ideas today have started to gain ground again within risk research, these do not yet seem to be incorporated into contemporary institutional practice or procedures. These continue to be dominated by the conventional understanding of trust as an ideal situation, paired with a technical, narrow conceptualization of risk.

Since trust does not describe how the public perceives and relates to risk-managing institutions and information coming from these, efforts at restoring trust may not be achievable, or even desirable, and may in fact be efforts at restoring something that never was really there in the first place. More than aiming to reduce distrust and build or restore trust, one should, following Tuler et al. (2017), accept distrust and proceed in a middle ground, by promoting and building critical trust, by creating appropriate mixtures of distrust and trust.

The recognition that distrust can be functional or effective carries implications for those responsible for assessing, communicating and managing risks. In this context, independent scientific assessments play an especially important role. For risk assessments to help warrant such balance and critical trust, they must, according to for instance Tuler et al. (2017), be able to address and internalize stakeholder concerns and values and their acceptance of validity of assumptions and information. It is increasingly realized that this requires a risk concept in which uncertainties are acknowledged and systematically addressed. Through this paper, we have shown how an uncertainty-based risk perspective could provide such a conceptualization and foundational basis that contributes to creating conditions for building critical trust within both the risk assessment and risk management processes. Such a perspective corresponds with what Poortinga and Pidgeon (2003) call the skepticism dimension of the trust concept, and the effects on trust introduced by this perspective are closely related to its effects on attenuation and amplification. Compared to the level of risk amplification and attenuation in the case, an uncertainty-based approach to risk and risk-related information involves some amplification from an early stage of the assessment process and may negatively affect trust on a short-term basis. However, by affecting relations between the different actors involved in the authorization process and by changing how these relate to, interpret, process and make use of information, an uncertainty-

based risk understanding can create awareness of attenuation and stop it from spreading, by breaking the 'chain of attenuation' identified in the narasin case. In this way, it may serve to reduce or prevent later risk amplification brought on by a risk event, the sort of amplification the SARF is designed to illustrate, the sort that holds a potential for large ripple effects, often proving especially detrimental to what commonly is described as public trust.

Acknowledgment

The authors are grateful to two reviewers for their useful comments and suggestions to the original version of this paper.

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Paper V

The games and dynamics of the social amplification and attenuation of risk

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Submitted for possible publication in *Risk Analysis*

The games and dynamics of the social amplification and attenuation of risk

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Abstract

The Social Amplification of Risk Framework (SARF) describes the interaction between risks or risk events and psychological, cultural, institutional, and social mechanisms and processes. The framework explains how this interaction may lead to amplification or attenuation of risks that may have far-reaching effects. In the framework and related research, amplification and attenuation largely appear as "either–or" processes and mechanisms in which attenuation generally stands in the shade of amplification. In this paper, we aim to contribute to increasing the knowledge concerning the complex and dynamic nature of risk amplification and attenuation, particularly for risk problems attached with a high degree of uncertainty. Based on a case concerning the use of a feed additive, we show how amplification and attenuation are two forces constantly in play and that the downplaying and intensification of signals occur simultaneously both within the communication of a specific risk message or risk event and in the "risk-framing game" played out by various actors and stakeholders in the media. By studying risks over longer periods of time and building on previous research emphasizing the less visible stages prior to amplification, we show how risk goes through phases or waves of attenuation or amplification dominated by different actors. In this context, we pay special attention to the role of the scientific risk assessor and the perspective adopted for understanding and assessing risk.

1 Introduction

Much research, within a wide range of contexts, has demonstrated the sequence of events in which the risk description of an expert becomes challenged by a risk event, leading to considerable public concern and societal amplification. This is the main thesis of the Social Amplification of Risk Framework (SARF): showing how hazards interact with psychological, social, institutional, and cultural processes in ways that may serve to either amplify (increase) or attenuate (decrease) public responses to these (Kasperson et al., 1988). The SARF applies communication theory and uses the metaphor of amplification to analyze the ways various social actors generate, receive, interpret, and pass on risk signals (e.g., images, signs, and symbols; Kasperson et al., 2003). Where amplification denotes the process of intensifying and turning up the volume of certain signals during the transmission of information, attenuation refers to the weakening or turning down the volume of signals. Amplification may be generated by an accident or a report showing increased numbers of injuries by spurring higher perception of risk, restrictive regulations, and/or distrust of risk managers. Attenuation, on the other hand, may be illustrated by the opposite tendency, such as when the communication of a risk assessment demonstrates no harmful effects of exposure to a certain chemical or a report shows a decline in the number of injuries, resulting in a lowered risk judgment and heightened perception of safety, relaxed regulations, and increased trust in risk-managing institutions.

The SARF has been criticized for emphasizing an overly simple and static conceptualization of risk communication as a one-way transfer of information and for not dealing adequately with

the complex social organization of risk communication (e.g., Penning-Roswell & Handmer, 1990; Petts et al., 2001; Rayner, 1988). As an alternative to the linear model of risk communication and subsequent ripple effects of the SARF, Petts et al. (2001) have argued for a more interactive model of communication in which the actors involved compete to advance their preferred view of issues and mobilize action, continually launching initiatives and responding to others' moves (Bakir, 2010). In response to such critiques, SARF proponents have stressed that the framework is not intended to be an all-encompassing or predictive model; rather, the simplicity of the SARF must be regarded as a useful starting point from which to empirically investigate real-world complexity in risk communication. They acknowledge that risk communication is an interactive process of the exchange of information and opinions among individuals, groups, and institutions involving multiple messages about the nature of risk, but also about concerns, opinions, or reactions to risk messages or to legal and institutional risk management arrangements (Kasperson et al., 2003). According to Pidgeon et al. (2003), using the SARF in a nuanced way, and in conjunction with other theoretical models, can help understand some of the complexities, constructedness, and messiness of real-world risk communication contexts and that the knowledge of such processes can aid policymakers. This implies a need to explore the context (and the history) of events and understand key actor issues related to specific cases (Pidgeon et al., 2003).

Despite these developments toward increased recognition of complexities within SARF research, little SARF-related research seems to investigate the early stages of risk development processes. Studying these phases requires the inclusion of contexts and situations prior to which the SARF is usually applied. A key issue here is that less attention, both in the framework and in related research, has been devoted to the concept of attenuation. Studying attenuation and the periods preceding amplification can be critical to understanding the later interaction between risks or risk events and psychological, cultural, institutional, and social mechanisms and processes. Poumadere and Mays (2003) argued that the degree of amplification may sometimes be a function of the degree of prior attenuation in the given social context and that there is a need to research the dynamics and phases that precede and shape risk and risk events. In addition, within these contexts, the role of the risk assessor seems to be largely overlooked or forgotten. The focus remains on the public and governmental institutions. Much SARF-related research revolves around the consequential end of the SARF and has presented recommendations for policymaking and risk management, in which increased stakeholder involvement and deliberation have often been central (e.g., Freudenberg, 2003; Renn, 1991; Tuler et al., 2017). Apart from representing a party or side of the starting point in the framework—namely, the discrepant risk understanding and risk judgment of the public and technical experts—the risk scientific assessor seems to be more or less left out of the picture.

In a more recent attempt to go beyond common applications of the framework, Fjaeran and Aven (2019a) studied the less visible processes and mechanisms prior to the more visible stages of amplification and the role of the risk assessor within these. Based on a case related to the assessment and regulation of a feed additive (narasin), Fjaeran and Aven (2019a) showed the importance of addressing these less apparent phases in order to understand the amplification as well as the extent of the amplification generated by certain risks or risk events. The research showed that, for the purpose of studying attenuation and early stages in the life of risks, the SARF did not prove to be as equipped as for the points of time where risks have become amplified or are in the process of being amplified. The experiences of Wirz et al. (2018) when using the SARF to study the role of media platforms in amplification and attenuation of risk

perception pointed in the same direction: They did not find the framework to be a sufficient foundation for interpreting variations over time.

In order to better capture the less apparent and blurry risks, events, and effects associated with attenuation and to allow a more comprehensive understanding of the SARF processes, Fjaeran and Aven (2019a) suggested adding a phase or sequence to the framework (Figure 1), which would allow the incorporation of the early history of risks and less explored contexts into the SARF. Such an approach would also facilitate the application of the framework to periods in time before risks take on visible forms and bring any directly observable consequences. In practice, this involves using a broad understanding of what constitutes risk and a somewhat different terminology than in the framework. Whereas the SARF starts out with a risk or risk event, here it is replaced by that of an uncertainty or risk source. Line 1 of Figure 1 illustrates that the communication and interpretation of such risk and uncertainty sources (e.g., the use of a chemical in food production, the introduction of a new technology or procedure) generate some direct non-responses. Although less visible, these responses are absorbed in ways that may contribute to preserving the perception of risks as low and upholding and substantiating current practices and regulations. These secondary responses or effects, in turn, contribute to a third round of less noticeable effects, thereby spreading the attenuation even further. These may manifest in an extended societal drift away from focusing on these uncertainty sources as potential risks or issues that warrant attention. This social risk attenuation and the related ripples of effects (line 1) represent the context in which new risks and risk events are interpreted and reacted to (box 1, line 2), and may, as mentioned, serve to explain the degree of amplification generated by these. This process of social risk amplification is depicted by line 2 in Figure 2 and is described in detail in the original SARF.

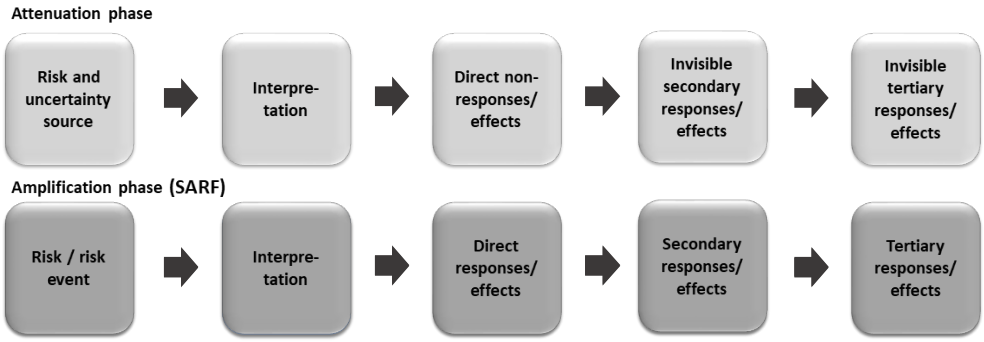

Figure 1. An extension of the SARF (based on Fjaeran & Aven, 2019a)

Although useful for understanding the role that prior attenuation can have in later amplification processes, the addition of a phase of attenuation to the SARF does not fully capture the dynamic nature of risk amplification and attenuation processes. Risks go through different phases; they evolve, grow, and/or change character over time. The dynamics of these continuously ongoing processes challenge the sequential, chronological structure of both the SARF and the extended version presented above.

In this paper, we focus on risk problems characterized by a high degree of uncertainty and build on the increased understanding and recognition of the dynamics and complexities within SARF-related work. However, compared to such works, we paint a more fluctuating picture of risk amplification and attenuation in which the time dimension constitutes a central factor. Based

on a case concerning the use of an additive in poultry feed and with the extended version of the SARF (Figure 1) as a theoretical framework for the analysis, we show how risks go through what can be described as waves or rounds of amplification or attenuation in which different actors and stakeholder groups dominate the risk communication. We also show that the downplaying and intensification of risks and risk signals are not mutually exclusive or "either–or" processes, as they may appear to be in the SARF, but that they occur concurrently in these phases—both within the communication of a specific risk message or risk event by a specific actor and, on a larger scale, in the competition played out in the media between stakeholders over who gets to frame and control the risks. In doing so, we pay special attention to the role of the scientific risk assessor within these risk communication processes.

Having the risk assessor and scientific assessment as a point of departure for the analysis involves taking a different approach than what is done within most work conducted in relation to the SARF. It also allows for addressing the point made by Hilgartner (1992) that, in order to increase the understanding of the processes in which risks are created, constructed, and de-constructed, one should focus on the system builders and the arenas of specialized professionals and technical experts. Here, our work also takes a step further than much SARF-related research as it aims to make a practical contribution by showing how the use of a broad perspective on risk and knowledge could change the role of the risk assessor and increase the adaptability, relevance, and usefulness of risk assessments throughout the various phases of risk development processes. This again could act to even out or decrease the amplification and attenuation fluctuations and, in this way, potentially reduce the amount and degree of associated consequences and ripple effects.

The remainder of this article is organized as follows. In Section 2, the narasin case is briefly outlined. Building on the previously mentioned research concerning the narasin case (Fjaeran & Aven, 2019a), in Section 3, we show how the communication of the risks related to narasin can be divided into different phases or waves of attenuation or amplification based on how they were communicated and responded to in the media over a period of years. In parallel, we show the complex character and simultaneity of attenuation and amplification processes and mechanisms. Following the analysis, in Section 4, we describe how the use of a broad risk understanding could theoretically change the role of the risk assessor and improve the value of the risk assessment tool through the various waves of attenuation and amplification. Lastly, in Section 5, we provide some conclusions.

2 The narasin case

The case discussed herein concerns the communication of risks and risk events related to narasin, an additive (coccidiostat) used in poultry feed. Following European Commission Regulation (EC) No 1464/2004, narasin is authorized as a feed additive for chicken fattening.

In 1995, the use of the antimicrobial growth promoter avoparcin in broiler chickens was banned due to the reported association between its use and the occurrence of antibiotic-resistant bacteria (enterococci) in animal husbandry. In the same year, the Norwegian food animal production industry voluntarily abandoned the use of all antimicrobial growth promoters, which were replaced with the use of coccidiostatic growth promoters; since 1996, the usage of coccidiostats in Norwegian poultry production has been dominated by narasin (NORM/NORM-VET, 2003).

Three years later, in 1998, the non-medical use of antibiotics in animal feed was prohibited in the European Union (EU). However, a large amount of antibiotics is still being used today in animal feed in many European countries (e.g., Spain, Italy, Cyprus).

For all coccidiostats (with the exception of nicarbazin), Norway complies with EU regulations. According to the Norwegian Food Safety Authority (NFSA), narasin is used in feed in order to prevent coccidiosis, an intestinal poultry infection. Although narasin is classified as a coccidiostat, it also has antibacterial properties and is, in many other countries (e.g., the US), classified as an antibiotic.

The use of narasin is regulated with threshold limit values, allowing a maximum of 70 mg/kg in feed. Narasin is not permitted for use in feed for egg-laying hens. However, production of feed containing narasin has also shown contamination of feed for non-target animal species, which may result in unexpected human exposure through the consumption of animal products containing narasin residues (Aleksander et al., 2007), such as eggs. Commission Regulation (EC) No 124/2009 established regulations and maximum levels for the presence of coccidiostats in food resulting from cross-contamination.

The case treats the communication of risks and risk events as they occurred in Norwegian media between 2006 and 2016. It also addresses signals communicated by European regulatory institutions and the actors involved in creating the basis behind these, which are important for understanding the events in the studied period (i.e., 2006–2016).

3. Phases and dynamics of attenuation and amplification

In this section, we show that amplification and attenuation are two forces continuously in play. Despite their parallel existence, the 'power' of these forces fluctuates depending on which actors and stakeholders dominate the communication of and responses to information concerning the risks at different points of time. These fluctuations can be illustrated as waves of different shapes and sizes, where amplification is represented by the rise and tops of the waves and attenuation is illustrated by the troughs or lower points of the waves. Using this wave analogy, Figure 2 presents a simplification of the risk amplification and attenuation trends and developments in the narasin case. The societal risk perception level axis summarizes a qualitative judgment of the level (interpreted in a wide sense) of the total societal perception of the risks, which includes the interpretations, ideas, and beliefs held by various stakeholders concerning the existence, importance, and magnitude of the risks in question.

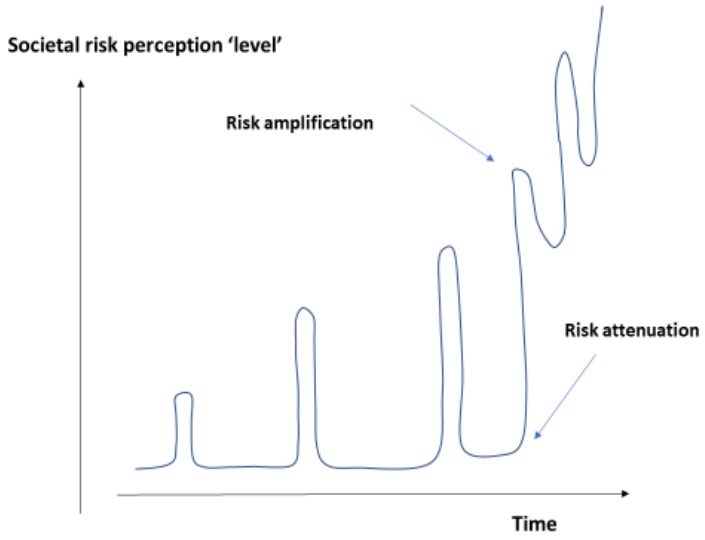

Figure 2. Illustration of the waves of risk attenuation and amplification in the narasin case

In the case, the combination of actors and signals communicated by these resulted in large fluctuations consisting of relatively deep and long troughs of attenuation now and then disrupted by sudden waves or flows of amplification of gradually increasing size and amplitude. As illustrated by the last three peaks in Figure 2, toward the end of the case, the waves of amplification quickly grew in force and energy before they finally burst into large ripples of effects (described as wave 4 below).

3.1 The early life of risk

In order to comprehensively understand the dynamic nature and the developments of attenuation and amplification processes, we must first direct attention toward the first actors and institutions involved in the production, assessment, regulation, and control of the risks. Hilgartner (1992) made a similar point when stating that it is in the arenas in which the facts and the machines (products), laws and regulations, organizations and management systems are initially constructed. Accordingly, starting the analysis of risk development processes with the media and the public would be starting the analysis at the wrong end.

Hilgartner (1992) referred to the actors operating on such arenas as system builders. In our case, these are represented by the applicant companies, scientific risk assessor (i.e., European Food Safety Authority), and the risk regulator (i.e., the European Commission). The ways in which risks are first communicated and understood in the early outset by these actors and institutions set the standard for how later risks and risk events are communicated, interpreted, and responded to as well as the amount of amplification and attenuation generated by these.

In what we have defined as the first stadium of the case, the risks related to narasin are primarily communicated within the documents concerning applications and assessments from companies seeking to authorize and market products containing narasin based on the scientific opinions

(i.e., risk assessments) of the European Food Safety Authority (EFSA)[1] and the regulatory documents of the European Commission (EC). It is within these documents the first seeds of risk attenuation (and later amplification) are sown. Already in their "birth" the risks related to narasin were subject to attenuation by the applicant companies, the risk producers themselves, in the risk assessments required in order to apply for authorization. These were based on limited data and framed in a language of safety that to a large extent set the tone for the vocabulary as well as the type and amount of data used in the scientific risk assessment; they were also normative for the final advice of the EFSA, which again formed the rationale for the regulations and decisions reached by the EC.

The language used in all the identified documents are of a technical character in which central signals concern the safety and efficacy of products, the lack of adverse effects on animal or consumer health or the environment, estimates showing exposure below threshold limit values, low probabilities of negative effects, and negligible risks. This way of communicating such risks has previously been linked to a narrow, technical understanding of risk, in which risk is commonly described as the combination of consequences and associated probabilities, and it has been shown how this way of relating to risk is associated with attenuation (Fjaeran & Aven, 2019a). In the narasin case, this probabilistic understanding of risks as simple and objectively quantifiable was reflected in the communication and practices of all the actors involved in the authorization and regulatory processes concerning the risks and in different ways involved a significant downplaying or deleting of important risk signals. In addition, Van Asselt and Vos (2008) coupled "the famous formula of risk = probability * effect" to a tendency for risk producers, assessors, and regulators to transform risk into certainty about safety and to equate the findings of zero effect with basically zero risk. In a similar manner, Weimer (2014) described the reluctance to acknowledge the existence of uncertainty in risk assessments—or at least deem it relevant—instead of genuinely and systematically investigating it as an expression of an uncertainty intolerant attitude.

3.2. Troughs of attenuation and crests of amplification

The documents and practices described thus far lay the foundation for what and how risks are accepted and introduced into society as well as how these risks are regulated and managed. Nonetheless, despite their significance, without the media's attention, these documents and the related processes remain largely invisible to the larger society. The public is generally unknowledgeable about the processes in which risks are created, sought, controlled, and managed. According to Hilgartner (1992), these processes are so embedded in the social fabric that, in addition to going unnoticed by most people, other specialists and actors within the professional communities themselves know very little of these and even of the risk source itself.

Wave 1. In 2003, the media shared information about narasin with the public. The media reported that narasin had been found in Swedish chicken and eggs. Swedish authorities were accused of keeping quiet about these findings, and narasin was presented as a poison that just a couple of milligrams of which could kill a horse (Aftenposten, 2003; Rossland, 2003). The

[1] Conducted by two respective panels: the Scientific Panel on Additives and Products or Substances used in Animal Feed (FEEDAP) and Scientific Panel on Contaminants in the Food Chain (CONTAM)

authorities dismissed such accusations, replying that the chicken was safe and emphasizing the EU's zero tolerance for narasin in eggs. Ultimately, the media coverage was short-lived, limited to Swedish conditions, and caused no noticeable consumer concern or reactions.

In the same year, the National Veterinary Institute (NVT) detected narasin residues in Norwegian egg samples and, as part of their annual testing procedures, an increase in the prevalence of antibiotic-resistant bacteria (Campylobacter jejuni) in broiler chickens; this information was reported to the Norwegian Food Safety Authority (NFSA). According to NVT, the findings reflected the usage of antimicrobials. However, as noted by the NVT, apart from coccidiostats—predominantly narasin—antimicrobials were rarely used in poultry production. Yet despite the NVT's indication of a potential connection between the use of narasin and the occurrence of antibiotic-resistant bacteria, the Norwegian use of narasin was not questioned or reevaluated. Like the documents described in Section 3.1., these findings and reports never reached the public's eyes or ears.

Wave 2. In 2006, the risks related to narasin caught the attention of the media again. This time the media informed the public that residues of the "forbidden drug" narasin were found in two egg samples in Norway. This information generated a wave of amplification. However, this wave was also brief and was quickly cut off from developing further by the responses of NFSA and industrial actors. The risk messages communicated by the media were rapidly downplayed as NFSA demanded that the feed producer (Felleskjøpet) had to document that findings only represented a one-time occasion of cross-contamination (Totland, 2006) and, as Felleskjøpet stressed, 99 percent of the feed for egg-laying hens was produced under safer conditions (Rasmussen, 2006.)

By stressing such signals and aspects in their communication, the authorities and the feed producer acted to attenuate the risks. This way of communicating involves severing or breaking the linkage between the risk object and potential harm and can be seen as examples of what Hilgartner (1992) called risk displacement or deconstruction. The voices in the media were limited to these actors alone, and shortly after their communicative responses, the issue disappeared from the media. The flow of amplification quickly ebbed out and did not result in any apparent changes in consumer behavior. It was followed by a longer period of attenuation in which the risks received little or no attention by regulators and the media. Again, we see the same kinds of responses (i.e., non-responses) as previously discussed: The risks related to narasin were not reassessed or reconsidered. This way of responding to risk-related information is also in accordance with the findings of White and Eiser (2010), in which the industry and the government were found to have a strict response bias and to require large amounts of data or strong evidence before warning the public. Based on their tendency of being less likely to declare a risk present than other groups of actors, these actors were categorized as risk attenuators. This response bias can also serve to explain the inclination for these actors to respond in accordance with the "do-nothing policy" option, which—according to Pei et al. (2011)—involves introducing no changes to the legislative or regulatory framework and continuing business as usual.

Wave 3. In 2012, the risks related to narasin reappeared in the media and set off another wave of amplification as antibiotic-resistant bacteria were again detected and found in 32% of Norwegian broiler chickens and chicken fillets while cross-contaminations of narasin were also detected in two egg samples (Gronningen, 2012). However, this time the wave was small in

size and short in duration. Once more, risk signals in the information were rapidly attenuated by the responses of authorities and chicken producers. Authorities referred to risk assessments and stressed that concentrations of narasin in most egg samples, except one, were below threshold level values and, therefore, were safe to human health. Yet again, nothing was said of that fact that the egg testing only represented the investigation of a very small percentage of the annual egg production and that the real numbers could potentially be far higher. Furthermore, the resistant bacteria were attributed to the importation of breeding material and, again, the low levels of antibiotic-resistant bacteria in Norwegian chicken relative to other European countries was emphasized. In addition, the findings were further attenuated as they were compared to findings from 2011, when the occurrence of resistant bacteria was higher and found in 43% of the chicken products.

Thus, risk attenuation involved the strategic use of information and data. Information and signals presented by the relevant stakeholders appeared tailored to leave an impression that no risk existed and that risks were under control. Once again, we see how a wave with the potential for large ripple effects is "amputated" by the attenuation of risk signals and how this attenuation involves the amplification of other and, often, opposite signals, characteristics, and symbols. Although this wave or flow of amplification did not generate any visible effects, it did bring ripples and consequences of a different kind. Authorities' and industrial actors' responses were absorbed in society in ways that produce less apparent and more hidden impacts, often acting to compromise risk reduction and proactive risk management. The signals communicated in the messages kept public perception of the risks low and contributed to sustaining the regulatory status quo and the current way of doing things. In the following two years, the risks related to the use of narasin more or less disappeared from the societal agenda.

Wave 4. In 2014, we again see the importance of the media as an agenda setter bringing hidden risks to light. This time, the risks related to narasin were communicated to the public as antibiotic-resistant bacteria were detected in 70% of chicken fillets in Norwegian grocery stores. However, this time, the communication in the media was not limited to the authorities, risk-managing institutions, and producers of chicken feed or chicken products (in the following also referred to as Group 1); now other stakeholder groups and actors like medical professionals, independent scientists, experts (in the following also referred to as Group 2) also entered the arena and communicated signals opposite and conflicting with those of Group 1.

According to White and Eiser (2010), independent scientists and medical professionals are generally perceived to have a moderate approach to risk by potentially acting to weighing up and balancing competing claims of safety and danger; thus, they have been categorized as risk arbitrators. However, in the narasin case, this group of actors did not come into play as arbitrators. T. Midtvedt (2014), a professor in microbiology, took the lead in the debate and explicitly connected the findings of antibiotic-resistant bacteria in chicken to the use of narasin in poultry feed, arguing that the use of narasin should be banned. The head of the Norwegian Medical Association and a former member of the national expert group on antibiotic resistance (Gjessing, 2014; Sunde, 2014) further claimed that Norwegian chicken should be treated as a high-risk product due to the high level of antibiotic-resistant bacteria and the uncertain effects posed to human health. Although communicating signals that could have potentially given a

more balanced portrayal of the risk connected to narasin, the statements of these actors acted to produce concern and amplification more than moderating or balancing the debate.

Simultaneously, Group 1 continued on the same track. However, at this point in the case, the authorities acknowledged the need for more research and knowledge to identify the source of the resistant bacteria and the effects on human health, although they kept emphasizing that the risk of bacteria transference was small as long as recommended hygiene and cooking advice were followed (NFSA, 2014). As before, Group 1's communication was of a technical character, rested heavily on EFSA's risk assessments results, and stressed the low probabilities of adverse effects and the safety of chicken products.

Contrary to the prior stages of the case, the statements and signals presented by authorities did not dictate the direction of the debate. Amplification endured—and even increased—as Midtvedt (2015) publicly called into question the quality of FEEDAP risk assessments by arguing that these were based on incomplete data. He also accused the authorities and chicken industry for hiding the problem of narasin and multi-resistant bacteria and stressed that, although narasin was not classified as an antibiotic, it undoubtedly was one. Furthermore, he questioned their morality in their setting aside the law in ways that might have large consequences for the environment and humans (Midtvedt, 2015).

The media debate developed into a long-lasting battle between the rival signals of the risk amplifiers and risk attenuators. It was protracted in time and continued off and on in the media for nearly 2 years. In this battle, the media displayed its dual role. By functioning as a channel through which signals and information were communicated and transmitted, the media provided the battleground for the debate. However, by actively turning up the volume of specific and conflicting signals as well as selecting which signals and messages were given the most coverage, the media steered the direction of the debate and demonstrated its own role as an amplification agent. The tendency for the media to create, stimulate, and/or increase amplification has been identified by many. White & Eiser (2010) argued that the media require relatively little evidence before sounding the alarm and, based on the inclination to quickly declare a risk present, the media have been placed in the category of risk amplifiers. Similarly, Slovic (1999) described the bias in media news reporting, where disproportionate attention is generally given to negative, trust-destroying events (e.g., accidents, discoveries of errors, or mismanaged risks).

In the narasin case, the propensity of the media to focus on negative events is also prevalent. The media's coverage of conflicting statements and signals of the different stakeholder groups developed into widespread public concern and came to affect public trust negatively. To this development the authorities responded by requesting new national risk assessments from the NFSA. When they arrived, the NFSA's risk assessments showed a possible connection between the use of antibiotic-resistant bacteria and the use of narasin in poultry feed, but the probabilities of consumer exposure to coccidiostats and resistant bacteria in heat-treated chicken meat were still judged to be negligible (Nesse et al., 2015). Overall, these assessments were of the same character as EFSA's risk assessments; uncertainties were framed as a lack of evidence of the effects, they reflected the same language and the same type of data and procedures, and they drew the same conclusions.

Bringing up risk assessments results in such settings of worry and disquiet will generally not have a calming effect and often only serve to increase public concern. According to Slovic (1999), in situations of low trust, the bare mentioning of possible links or associations and statements of potential risks outweigh any statement of lack of evidence of causal effects and low probabilities. In their interpretation of risk related information the public (i.e., lay-people) show a tendency similar to that of the media: They generally perceive sources of bad (trust-destroying) news as more credible than sources of good news and place more confidence in statements and data demonstrating negative effects than those demonstrating no such effects (Slovic, 1999). Pidgeon et al. (2010) have also shown that when there is conflicting information, people are inclined to trust information from the 'watchdogs': independent organizations and experts that keep an eye on developments and inform the public about potential consequences (Pidgeon et al., 2010).

What happened in the narasin case was in accordance with the above assertions: The public ignored the authority's advice and risk assessment results, relied on statements like those of Midtvedt, and the sales of "narasin chicken" dropped significantly. At this stage, we see how all actors came to contribute to risk amplification in different ways. The media focused on negative events, the independent scientists and medical professionals revealed new knowledge and previously attenuated signals, and the risk assessors and risk-managing institutions repeated the "risk assessment refrain" while stressing the low probabilities of risk in the face of concern and worry.

The public responses generated waves of effects that quickly came to affect the entire chicken industry and even spread to other areas. National goals were set for the reduction of the use of narasin in animal feed and for the use of antibiotics in animal food production. Goals for reduction were also established for other sectors (i.e., the public health and seafood sector). Nonetheless, despite these ripples of effects, authorities and those in charge of managing the risks stood firm in their roles as attenuators. Despite its antibacterial properties and introduction of national goals to fight antibiotic resistance, the use of narasin in poultry feed is to this day still permitted, still founded on the same risk assessments, and still covered by the same regulations.

4. Smoothing out the waves

As seen in the case, various actors and stakeholders played different roles in affecting the form, direction, and duration of the waves of attenuation and amplification. In addition, the developments and course of events showed how the waves all were part of the same "ocean." What happened—and, equally important, what did not happen—in one wave or phase largely affected what happened in the next.

The ways risks were communicated and responded to along the way were closely connected to how the risks were first understood, communicated, and dealt with by the system builders (i.e., Group 1). As described in Section 3, particularly Section 3.1, this is intimately related to the probabilistic and technical risk perspective held by these actors. From the very start of the case, this understanding of risk appears to set the rules of the game. Throughout the entire course of

the case, the narrowness and uncertainty-intolerance of this risk perspective seem to deadlock Group 1 actors into the roles of risk attenuators, robbing them of any flexibility in their communicating and responding to risk-related information.

We argue that using what we refer to as an uncertainty-based risk perspective as a conceptual foundation for the communication, work, and practices of the system builders, especially that of the scientific risk assessors, could potentially change some of the rules and roles of "the attenuation and amplification game". Compared to the traditional, probabilistic approach to risk identified in the narasin case, such an uncertainty-based risk perspective involves giving stronger weight to uncertainties and knowledge aspects. Uncertainty constitutes a key component of risk, and any characterization of risk using probabilities needs to also address the knowledge supporting the probabilities, particularly the strength of this knowledge (Aven, 2017; SRA, 2018a; 2018b). In this way, risk as a concept captures two components: (i) threats/hazards and related effects on something valued by people and (ii) associated uncertainties.

To describe these uncertainties, probabilities are often used, but probabilities alone are not considered sufficient to fully describe risk. The fact that probabilities and related risk characterizations are founded on some knowledge and that this knowledge can be of varying quality is emphasized. Accordingly, the informativeness of probabilities is highly dependent on the strength of this knowledge. Therefore, the knowledge base and its strengths and weaknesses, together with the fact that surprises relative to this knowledge can occur, must constitute central parts of the characterization and final judgment in any risk assessment process.

Such a risk perspective not only means broadening the risk concept, but also extending the understanding of what is considered relevant and valid knowledge when assessing risks. An uncertainty-based risk perspective promotes using both quantitative and qualitative methods and integrating different types of stakeholder knowledge as well as alternative ways of knowing when framing, assessing, and evaluating risks (see Fjaeran & Aven, 2019b).

We next show how the adoption of such a perspective on risk and knowledge can increase the flexibility, relevance, and context sensitivity of the scientific risk assessment, thereby acting to improve its usefulness throughout the changing waves of amplification and attenuation. This way of understanding and relating to risk requires greater proactivity from the scientific risk assessor than seen in the narasin case and enables her/him to enter into the role she/he should ideally possess in the amplification and attenuation game—namely, that of a risk arbitrator or moderator. As previously mentioned, according to White and Eiser (2010), risk arbitrators attempt to weigh and balance competing claims of, for instance, danger and safety and require a moderate amount of data and information before warning the public and declaring the presence or existence of a risk. Consequently, the adoption of an uncertainty-based risk perspective as a theoretical point of departure for the risk assessment may have consequences for how risks are further interpreted, communicated, and responded to by the other actors in the game and may, as illustrated in Figure 3, act to even out and reduce the size risk amplification and attenuation fluctuations as well as the associated effects, as seen in the narasin case.

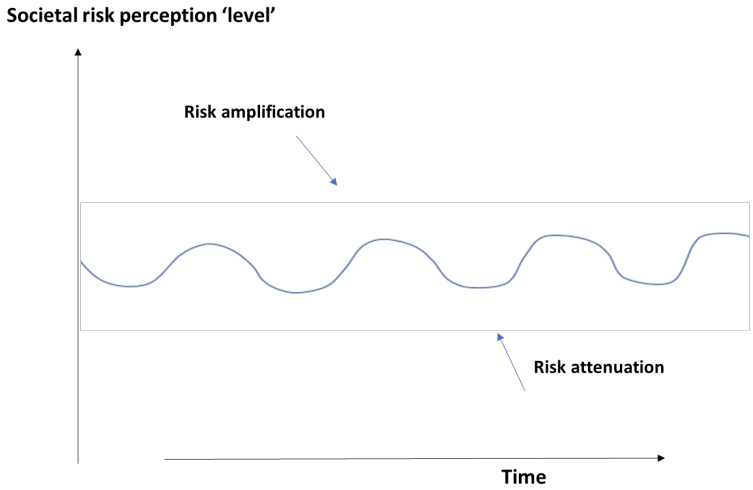

Figure 3. Illustration of the waves of risk attenuation and amplification using an uncertainty-based risk perspective

Smoothing out the waves of amplification and attenuation requires welcoming some risk amplification into very start of the scientific assessment process. This, to a large extent, starts out by turning up the volume of the signals initially muted or downplayed by the system builders in the case. This requires that the risk assessor actively investigate and consider uncertainties and make use of diverse and nuanced knowledge and data from different stakeholders when framing, assessing, and evaluating risks. However, this operation cannot be done once; a one-time injection of amplification into the risk assessment process is not enough to even out the waves. Thus, the risk assessor must continuously read the landscape, and the assessment must also be able to absorb, adapt to, and learn along the way as risks evolve and knowledge emerges and develops.

Table 1 summarizes the differences related to the societal risk perception level for the two risk perspectives considered in this paper. As highlighted in Section 3, the traditional, technical probability-based risk perspective is characterized by a gap in the understanding and characterization of the real risk versus the professional risk. This assertion is based on the argument that there exist considerable aspects of risk that are not captured by a pure probability-based approach. When adopting the uncertainty-based approach, these aspects are acknowledged as risk or risk contributors. The implication is that this perspective adds a component to the risk concept that is not included in probability-based thinking. Ignoring this component means that real aspects of risk are camouflaged.

In the early stages of the development of a risk or risk event, this gap is not broadly visible following a traditional perspective; it is to a large extent suppressed. The professional risk understanding and characterization downplay the uncertainties as these uncertainties are not considered an integrated element of the risk. This downplaying creates energy and increases the potential for a strong uprising wave of risk-related worries and concerns. However, in uncertainty-based thinking, this gap is to a large extent acknowledged as uncertainties, and knowledge aspects form an important part of the risk characterization and risk evaluation; they are openly discussed, evaluated, and communicated to decision-makers and risk managers. This gap is also considerably smaller than what one would have using a probability-based perspective.

Over time, as new knowledge is revealed, emerges, or develops, this gap may be indicated in different ways and on different occasions. In the narasin case, as risk messages were reported and waves of amplification came washing in, the actors holding a traditional perspective of risk demonstrated a consistent reluctance to respond to and declare the presence of risks (i.e., showed a strict response bias; White & Eiser, 2010). Although this may act to leave the "ocean" quiet for periods of time, this way of responding to risk-related information contributes to maintaining and upholding the gap. In this way, these periods or troughs of attenuation can also be understood as periods of incubation in which the force and energy of the next wave(s) is gradually accumulated by the systematic non-responses to uncertainties and less observable risks and risk events.

In later stages of the risk-development process, we may again experience clearer indications and stronger signals calling attention to the gap. This is often the case when different stakeholder groups enter the arena of the media. Several examples of such indications and signals were mentioned in Section 3, including the independent scientists arguing that the risks discussed were not negligible and should not be ignored. When the perspective held by those in charge of assessing the risks is a traditional one, the result is often strong risk amplification. The amplification observed herein can, to some degree, be seen as justified as key uncertainty aspects of risk have been systemically suppressed along the way. For the uncertainty-based perspective, effects would potentially be of a more limited character as the gap is already largely absorbed and reflected by the risk framework used from the very start of the risk assessment process.

Table 1 *Summary of Differences Related to the Societal Risk Perception Level for the Traditional Technical Probability-based and Uncertainty-based Risk Perspectives*

	Traditional technical probability-based perspective	**Uncertainty-based perspective**	**Comments**
Societal risk perception level – general	Large gap between the 'real risk' and the professional risk understanding and characterization	Considerably smaller gap between the 'real risk' and the professional risk understanding and characterization	Acknowledging the uncertainty aspects of risk as a central element of risk means that the 'real risk' is judged higher by following the uncertainty-based perspective than the traditional technical probability-based perspective Communicating uncertainties and using broad and diverse knowledge to a larger extent enable the assessor to take on a risk-moderating role than the risk-attenuating role typically associated with the traditional probability-based perspective

- Early stages, framing	This gap is not broadly visible; it is to a large extent suppressed Case: The uncertainty dimension of risk was downplayed in the professional risk understanding and characterization	This gap is to a larger extent acknowledged and communicated	The suppression in the technical perspective case builds energy, and there is a potential for a strong outburst
- Middle stage, responses along the way	The gap is indicated several times (e.g., in NVT reports, by the media in 2003, 2006, 2012); indications are repeatedly downplayed, ignored, or explained away Case: Information and risk signals are disregarded, and risk characterizations and evaluations are not revised and remain unchanged	Risk assessment can be used proactively and absorb and adapt to changes as risk develops; in this way, the size gap can be reduced as new knowledge emerges	Failure to recognize less visible risks or risk events and to make use of knowledge other than objective historical data continues to substantiate the gap and accumulate energy Traditional perspective can produce ignorance and periods in which risks incubate
- Later stages	New knowledge, risk signals, and risk events call attention to the gap, and strong risk amplification may occur Case: For example, independent scientists argued that the actual risk is not negligible, that we should be concerned, and that risk assessments are founded on incomplete data	Risk events may occur and new knowledge may emerge, but effects can be reduced as the gap, to a large extent, is already acknowledged and communicated In addition, if a gap exists, it can be reduced; the risk concept is broad and flexible and can capture changes and new knowledge	For the traditional technical perspective, the amplification to some degree is 'justified' as key uncertainty aspects of risk have been suppressed In this stage, by remaining in the role as a risk attenuator, the risk assessor contributes to increased amplification

5. Conclusion

Understanding the complexities and dynamic nature of risk amplification and attenuation requires studying risks over periods of time. By giving room to the variable of time and using a broad uncertainty-based risk perspective in the analysis of the case examined in this paper, we have shown how risks—from the moment they are born into existence—are subjected to various forms of amplification and attenuation as they are constantly molded, shaped, and reshaped in the communication and responses of different actors in society.

Depending on which stakeholders are mostly active at different points in time, risks—through their course of life—go through different waves or phases dominated by either attenuation or amplification. However, the analysis of the narasin case also demonstrated that the forces of amplification and attenuation are constantly circulating and occur simultaneously within these waves. For instance, this can be seen within the communication of risk messages, where the attenuation and downplaying of some signals, characteristics, and aspects almost automatically seem to involve the amplification of others and vice versa. This simultaneity can also be seen on a larger scale and is at its clearest when risks are amplified or are in the process of being amplified, as seen when different stakeholders communicate conflicting risk signals and messages in the media.

The narasin case demonstrates how this risk communication takes on the form of a long-lasting game in which various actors compete to frame, define, and control the risks. The first rounds and middle parts of the game were dominated by the system builders starring in the roles as risk attenuators while leaving little room for other players. Yet, as the game develops, actors communicating signals questioning the technical probabilistic risk understanding of the system builders enter the arena from time to time. At this stage, these are quickly fought back, but as the game proceeds and new knowledge emerges or develops, players again challenge the reign of the system builders. Although the system builders withstand these attacks, their strategies gradually become less effective. In later rounds of the game, as knowledge has grown stronger and risk events occur, the existence of the gap between the ‘real risk’ and the professional risk understanding becomes clearer. At this point, the uncertainty-intolerance and narrow idea of risk held by those in charge of assessing and controlling the risks place them on the sideline, outside the events and happenings of the game. Their defensive tactics, non-responses, and static way of communicating now only act to exacerbate amplification and worry. The public turns to other sources for risk-related advice and information and respond in ways generating large ripples of societal effects.

This consistent resistance to the waves of amplification results in a less visible build-up of energy over time, creating far-reaching societal consequences when the wave(s) finally erupted. We have, as part of this paper, indicated an answer to preventing such an accumulation of energy, and reducing the fluctuations and amplitudes of the waves of amplification and attenuation may lie in changing the risk perspective of the system builders, starting with the risk assessor. By acknowledging uncertainties and drawing on diverse knowledge and information throughout the entire risk assessment process, risk communication sets out from a different track—a track less likely to end up in large amplification at the end of the road.

Actively addressing uncertainties and welcoming a greater heterogeneity of actors and diversity of voices into the early rounds and along the way may act to change some of the rules and roles of the game. Accepting amplification as a natural and important part of the game may positively

affect later moves, responses, and reactions of other players. In addition, the adoption of broad and uncertainty-tolerant risk perspectives provides a more natural foundation for the scientific risk assessor to play the part of a risk arbitrator (i.e. moderator), a position that seems to stand vacant in many of the defining moments of the societal risk game.

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