Geographical Dimensions of Risk Management

The contribution of spatial planning and Geo-ICT to risk reduction

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Preface and Acknowledgements

Information is regarded as a crucial ingredient for effective risk management. Since a considerable part of the information required for risk management contains specific spatial references (such as the location of toxic clouds or areas prone to flooding), much attention is paid to the development of geo-information and communications technology (Geo-ICT) to support risk management practices. One of the practices that should be supported through Geo-ICT is the management of safety risks in spatial planning. Through spatial planning, for example, vulnerable land use in hazard-prone areas can be regulated or reallocated.

The search for an appropriate role for geo-information and the further development of Geo-ICT to support the consideration of safety risks in spatial planning, however, should not start with a specific technology, but with a conception of the way safety risks are addressed and managed in spatial planning practices. This statement is in agreement with Klosterman (2001), who argued that the search for an appropriate role for computer-based information and methods must begin with the conception of the activity that is to be supported. Therefore, this research focuses on spatial planning practices and on the management of safety risks in these practices. The research provides insight into the ways safety risks are dealt with in spatial planning. This information in turn, is used as a starting point for a discussion about the contribution and further development of Geo-ICT in risk management and spatial planning.

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Last but certainly not least, I would like to thank my family and friends. Even though we are spread out all over the country, we still have great times together. Mom and Dad, I would like to thank you in particular. Many thanks for your continuous support. You encouraged me to follow my heart, which in the end resulted in this thesis. Susan, I also thank you for your support and permanent trust.

Jeroen Neuvel
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Contents

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Dealing with Safety Risks in Spatial Planning

Land use or land-use changes can trigger or generate hazards and affect the potential consequences of these hazards. Deforestation can trigger land slides, for example, and land reclamation or levee construction can increase flood hazards downstream. New dwellings in or near forests can trigger wildfires, especially if home owners fail to prioritise fire safety measures. In addition, if land is used for industrial activities, new technological hazards, such as the risks resulting from the storage or production of hazardous materials, can be introduced into the environment. Moreover, land-use changes can increase damage potential. Residential developments in hazard-prone areas, such as areas prone to flooding or earthquakes, can negatively affect the number of properties and people exposed to hazards. Consequently, spatial planning activities that are concerned with influencing land use by locating physical structures and activities such as agriculture, recreation or industry within a territory (Couclelis, 2005; Tewdwr-Jones, 2001) can result in new or increased safety risks in a particular area.

Even though life expectancy in the Netherlands continues to rise and many uncertainties in life have been strongly reduced (Jongejan, 2008), the number of people and properties exposed to hazards in general continues to increase. Scenario studies of land-use changes in the south-western part of the Netherlands, for example, have shown that almost 50% of the planned housing in urban development plans is located in flood-prone areas (Beckers & Van Heusen, 2008). The result of these current land-use policies is that the population in flood-prone areas is expected to grow (see, for example, Van Schrojenstein Lantman, 2007). The potential damage in areas exposed to industrial hazards is also increasing. Spatial planning policies in the Netherlands are aimed at intensifying the use of space, which also results in more intensified use of land near potentially dangerous activities (Raad voor Verkeer en Waterstaat & VROM-Raad, 2003).

Through risk information, however, planners can consider safety risks and the consequences of land-use changes for such risks. Since much of this risk information, such as the location of hazard zones, emergency routes, damage potential or number of people affected, has an explicit geographical component and can be presented on a map, geo-information is regarded as essential information for risk management. For this reason, the further development of geo-information to facilitate the consideration and management of safety risks, including the consideration of such risks in spatial planning, is regarded as a central objective for both risk and emergency management and developers of geo-information and communications technology (Geo-ICT) (ACIR, 2005; MacFarlane, 2005; National Research Council, 2007).

However, the availability of geographical risk information does not automatically imply that safety risks are considered in spatial planning and that this information is used. The use of Geo-ICT in spatial planning is regarded as problematic, and is far from widespread. Moreover, spatial planning is rarely used as an instrument to reduce safety risks. Therefore, this research concentrates on the consideration of safety risks in planning and the related use of Geo-ICT in planning. The focus is on the consideration of flooding and industrial accidents, since these events represent prominent natural and industrial hazards in the Netherlands (Jongejan, 2008). However, before discussing these issues, the concept of safety risks will be considered, since these risks will play a prominent role in the discussions on spatial planning and Geo-ICT.

1.1 Risk or danger, decision or destiny?

According to Luhmann (1993), safety risks can be perceived as both risks and dangers. When current or future losses are perceived as being the result of decisions, Luhmann referred to risks. When losses are attributed to an external factor, he referred to dangers, which presumes that actors cannot do anything about the damage. However, the question of whether particular events that cause loss are regarded as dangers or risks remains open and depends on the attributions made to the causality of the event by the societies that evaluate the event. Therefore, Luhmann argues that the observation of the various ways that risks are conceptualised, e.g. by examining if future loss is attributed to decisions or external causes or how the controllability of loss is perceived, is important (King & Thornhill, 2003). Nevertheless, different actors can perceive risks in different ways. Decision makers can perceive the potential loss that may result from their decisions as risks, but the same potential loss can be perceived as dangers by those affected, for example, because they do not regard the loss as controllable by their own decisions. In other words, "one man's risk is another man's danger" (Luhmann, 1993).

Beck and Giddens argued that our society is increasingly confronted with risks and dangers (Beck, 1992; Giddens, 1990). These risks and dangers are, to a large extent, portrayed as being the result of technology or the organisation of society. In contrast with risks resulting from early modernity, the risks our society is confronted with are often global rather than personal, invisible rather than visible and cannot always be controlled or even calculated (Beck, 1992). A liquidity crisis in the financial markets, for example, can affect many countries all over the world, but the threat of a nuclear war, a pandemic, extreme weather due to climate change or food insecurity can also be regarded as invisible risks which are likely to be felt worldwide and which can hardly be controlled or predicted. In addition, it seems that citizens are increasingly less willing to accept probabilities of harm, and demand a risk-free society. Consequently, discussions about the distribution of risks are occupying the foreground of public debate (Huysmans & Steenbekkers, 2002; Jongejan, 2008; WRR, 2008). For these reasons, Beck argued that the society we live in can be perceived as a 'risk society' (Beck, 1992).

In addition to these new risks as mentioned by Beck and Giddens, the attribution of losses as previously described can also explain the increased attention for risks in the public debate. Losses are increasingly attributed to decisions and consequently perceived as controllable risks rather than external dangers (Huysmans & Steenbekkers, 2002; Luhmann, 1993). Such reactions could be found after hurricane Katrina in 2005. The damage caused by Katrina was attributed to external sources, such as the occurence of a hurricane in general. Nevertheless, the disaster that resulted from the hurricane was also attributed to decision makers. The decision to allow intensive developments in the flood-prone areas of eastern New Orleans or the Orleans Parish Levee Board's unwillingness to help finance the costs of higher levels of flood and hurricane protection, for example, can be regarded as decisions which increased the impact of the hurricane (Burby, 2006). Other hazards can also be perceived as both risks and dangers. For example, a contagious disease can be regarded as an external danger, but an epidemic can also be attributed to government failure if the causes of the epidemic are attributed to a lack of clean drinking water or inappropriate vaccination programmes. Because real or potential losses are increasingly attributed to decisions, it can be argued that the inclusion of spatial planning should be considered regarding the potential safety risks resulting from such decisions. This implies that we should critically reflect on decision making.

1.2 Risk components

From a system perspective, disasters can be portrayed as resulting from interactions between physical and socio-economic systems (De Bruijn, 2005; Hilhorst, 2004). The physical system, for example, includes geophysical and climatologic systems. The socio-economic system, for example, includes local knowledge systems, legal systems or economic systems. Risk analysis can focus on the system as a whole, but can also focus on a particular subsystem or group of subsystems, such as the interplay between urbanisation and water runoff. In addition to focusing on particular subsystems, the system as a whole can be divided into various geographical parts. The physical and socio-economic processes that can trigger flooding and influence flood impact can be studied at different levels of geographical scale. For example, this can be at a very fine scale, which normally encompasses very small geographical areas, such as the flood risk at a particular building site, or at a very broad level of scale, which often encompasses large areas of analysis such as river catchments. From this geographical point of view, safety risks can be regarded as characteristic of an area (Cutter, 1996). Risks can be understood as a compound function of a hazard to which a specific area is exposed and the vulnerability of the people, structures or services within a particular area. This point of view is elaborated below.

The term hazard refers to the source of threat: the events, phenomena or activity that may cause harm to aspects of things that human beings value. Hazards are often expressed as an estimated probability of occurrence. A distinction can be made between technological hazards and natural hazards. Examples of technological hazards are the production or transport of hazardous materials, or the genetic modification of crops. Natural hazards can be divided into geo-hazards and hydro-metrological hazards (Schmidt-Thomé, 2006). Examples of geo-hazards are earthquakes, tsunamis, volcanic eruptions and landslides. Examples of hydro-meteorological hazards are avalanches, droughts, extreme temperatures, floods, forest fires, storms and storm surges. Nevertheless, natural hazards are not necessarily fully trigged by natural causes. Anthropogenic factors may also trigger natural hazards. For example, floods may be triggered by land use and climate change.

A single area can be affected by multiple hazards, and hazards can also influence each other. For example, the probability of a major accident at a hazardous installation can be increased because of the proximity of other installations with hazardous substances. This is referred to as the domino-effect. Technological hazards can also be influenced by natural hazards. A flood or earthquake, for example, can cause the release of hazardous materials from industrial facilities. Such disasters triggered by both natural and technological hazards are referred to as natech disasters (Cruz *et al.*, 2006).

Vulnerability generally refers to the susceptibility to damage from a particular disaster hazard (Alexander, 1997; Blaikie *et al.*, 1994; Cutter, 1996), but there are fundamentally different conceptual interpretations of this concept. Interpretations either emphasise the exposure to hazards, the social responses – i.e. the capacity of society to deal with hazards and exposure – or the physical and social processes that may lead to vulnerability, such as economic or urban development. Although vulnerability is generally regarded as a combination of these points of view (Adger, 2006; Cutter, 1993; Cutter, 1996; De Bruijn, 2005; De Graaf *et al.*, 2007.), the concept of vulnerability in this research is divided into two interrelated components: exposure and capacities (Table 1-1). These two components can change over time as a result of physical and social processes.

Table 1-1. Risk components

<table>
<tr><th colspan="3">Risk components</th><th>Definition</th></tr>
<tr><td rowspan="6">Risk</td><td colspan="2">Hazard</td><td>A potentially damaging physical event, phenomenon or human activity that may cause injury or loss of life, property damage, social and economic disruption, or environmental degradation.</td></tr>
<tr><td rowspan="5">Vulnerability</td><td>Exposure</td><td>The proneness to a particular hazard, without taking into consideration the capacity to deal with the hazard.</td></tr>
<tr><td>Resistance capacity</td><td>The ability of an area to prevent hazardous events, such as defences to resist high water levels.</td></tr>
<tr><td>Adaptive capacity</td><td>Capacity of an area to adapt and adjust to uncertain future developments and hazards.</td></tr>
<tr><td>Coping capacity</td><td>Capacity to respond in the immediate aftermath of an event.</td></tr>
<tr><td>Recovery capacity</td><td>The capacity to return to the pre-disaster status.</td></tr>
</table>

Based on: De Bruijn *et al*., 2007; De Graaf *et al*., 2007; Schneiderbauer, 2007

Exposure refers to the proneness of an area to a particular hazard, without taking into consideration its capacity to deal with the hazard. Variables related to exposure normally include hazards variables as well, such as the proximity to the source of threat, incident frequency or probability, magnitude, duration or spatial impact (Cutter, 1996). For example, exposure to flooding can be expressed in terms of potential water levels to which a house is exposed, and exposure to dangerous industrial activities can be expressed as the probability that a person permanently residing at a location in the vicinity of a hazardous activity will be killed due to an accident with that activity. Exposure is not the same as susceptibility, since the term susceptibility also takes the capacity to deal with the hazard into account. Floating houses, for example, can be exposed to high water levels, but are not necessarily susceptible to flooding since they are adapted to it (De Bruijn *et al.*, 2007). Measures to reduce exposure are the exclusion of 'susceptible' land-use activities from areas exposed to hazards.

The term 'capacities' can be regarded as an overall term that refers to the differrent types of abilities an area has to resist, adapt, cope with and recover from flooding. The capacity to resist hazards includes those characteristics which influence the ability of an area to resist hazardous events, such as defences against high water levels (De Bruijn *et al.*, 2007; Vis *et al.*, 2003).

Adaptive capacity can be defined as the ability of an area to adjust to permanent short-term changes and gradual long-term trends (De Bruijn, 2005). The time orientation lies in the future (De Graaf *et al.*, 2007), and the emphasis is on the physical adaptations that are made within an area. Building adaptive capacity includes the adaptation of land-use activities or constructing buildings that compatible with potential future events. This could include measures such as the elevation of sites in flood-prone areas.

The objective of building coping capacity is to increase the ability to respond in the immediate aftermath of an event to reduce the impact of the event (De Graaf *et al.*, 2007). Coping capacity refers mainly to the organisational abilities that an area has to prepare for and respond to disasters. It refers to the skills, resources and strengths of communities or societies to help themselves and others shortly before or after an event, including the capacity for evacuation or emergency response. Nevertheless, physical conditions also determine the coping capacities. The road infrastructure in an area, for example, defines the possibilities for evacuation and emergency access.

The term 'recovery' is referred to as the capacity to return to a normal situation, e.g. the situation before the disaster took place. The time focus of recovery is initially on the event itself, but will gradually shift to the longer term (Schneiderbauer, 2007). Recovery capacity includes the ability of societies to reconstruct affected areas. The capacities to cope with an event, together with the capacities to recover from an event, are also referred to as resilience capacity (Cardona, 2003; McEntire *et al.*, 2002; Schneiderbauer, 2007).

The geographical conceptualisation of risk and risk components as discussed above is useful to categorise risk reduction measures or strategies, as will be illustrated by the following chapters. It should be noted, however, that the very idea of a system underlying this conceptualisation assumes that social and physical processes relate in functional and in somewhat predictable ways. This disregards the dynamics of these processes and a society's response to disaster (Hilhorst, 2004). Moreover, a system perspective tends to overestimate the commonalities and differences between systems or system components, which may draw attention away from the strong connections and overlap that exist between different components or subsystems (Hilhorst, 2004). Even though the system perspective is useful to explain the various aspects of the concept of risk, it should still be seen as a conceptual model of reality rather than reality itself.

1.3 The use of geo-information and Geo-ICT in spatial planning

To consider both natural and technological hazards and impacts in spatial planning and to make informed choices between alternative ways of development, spatial planners require information about these safety risks. A considerable part of this risk information can be regarded as geo-information, which is therefore essential for risk management. In addition to information, geo-spatial technologies are required, which users can use to capture, store, update, communicate, manipulate, analyse, model, exchange and display geographical data and information and through which users can interact with it (Vonk, 2006). Not surprisingly, much geographical data has been gathered and processed and many geo-tools, geographic databases, technologies and networks (referred to as Geo-ICT) have been developed to support risk managers and spatial planners. In the Netherlands, for example, flood risk information systems have been developed which provide insight into dike strengths, flood patterns, potential damage or potential numbers of victims (Jonkman, 2007; Ministry of Transport Public Works and Water Management, 2005). In addition, geo-tools have been developed to support quantitative risk assessments with respect to accidents involving hazardous substances (Moen & Ale, 1998). These tools can identify hazard zones for different incident scenarios and can support the consideration of appropriate safety distances between residential developments and hazardous installations.

Nevertheless, the use of Geo-ICT and geo-information in risk management is still regarded as problematic in all phases of risk management and emergency response. This is because the information is unavailable in either the right form or at the right time, or is not exchanged between actors involved in risk and emergency management, which can result in unnecessary damage or even casualties (ACIR, 2005; National Research Council, 2007). Causes for the ineffective use of geo-information in risk management are found in the organisation of geo-information, conceptualised as the spatial information infrastructure (SII). At this SII level, which is also described as the spatial data infrastructure (SDI) level or geo-data infrastructure (GDI) level, particular attention is given to the organisation of geo-information exchange (Mansourian *et al.*, 2006; Nebert, 2004; Williamson & Rajabifard, 2003). A spatial information infrastructure includes not only the geo-data itself or the geo-technologies, but also involves access networks, policies and arrangements, standards and human resources that are required for the collection, management, access, delivery and utilisation of spatial data (Mansourian *et al.*, 2006).

The causes for the limited role of geo-information in emergency management are thus related to:

- the availability of data,
- the data quality,
- the availability of technologies to process and exchange data, such as services,
- the availability of communication networks,
- the agreements between actors regarding the acquisition, use, security and management of data,
- the interoperability of systems, e.g. through standards regarding data, services or semantics,
- the skills of potential users, and finally,
- the organisation of the development of SIIs in general, including visions and leadership (ACIR, 2005; Mansourian *et al.*, 2006; National Research Council, 2007).

Consequently, much effort is made in establishing spatial information infrastructures through which geographical information becomes available to the actors involved in risk management and emergency response (Annoni *et al.*, 2005; Köhler & Wächter, 2006; Mansourian *et al.*, 2006). However, the establishment of SIIs does not imply that geo-information is used for risk and emergency management purposes.

Examinations of the use of geo-tools in spatial planning and decision making have identified that the use of such tools is far from widespread (Stillwell *et al.*, 1999; Uran & Janssen, 2003; Vonk, 2006). These studies not only highlighted the availability of spatial information or the possibilities for information exchange as a central problem, but they also identified a wide variety of other, often related factors that hamper the effective use of geo-tools and, consequently, geo-information (Bednarz & Bednarz, 2008; Carsjens, 2009; Committee on Support for Thinking Spatially & National Research Council of the National Academies, 2006; Couclelis, 2005; De Wit *et al.*, 2009; Drummond & French, 2008; Geertman, 2006; Goosen, 2006; Klosterman, 2001; Uran & Janssen, 2003; Vonk, 2006).

First of all, problems with respect to the tools themselves were identified. The tools can be too complex for users to understand, inappropriate for specific planning tasks (such as design), or mono-disciplinary rather than interdisciplinary in character. Second, the output provided by the tools can be oversimplified or too complex, generic or uncertain for planners, which hampers their use. Third, users can be unfamiliar with, or unaware of, support systems or lack training in the use of these systems.

The problems discussed above are either oriented towards SII, such as the availability or exchangeability of geo-information, or towards the characteristics of geo-information and Geo-ICT itself, such as user-friendliness. More fundamentally, factors related to the way potential users think and reason can influence the use of geo-information and Geo-ICT. Geo-information and Geo-ICT have sometimes not been used effectively because users lacked the ability to think spatially (referred to as spatial literacy). Users can lack the knowledge, skills and habits of mind to use concepts of space, tools of representation and reasoning processes to structure, solve, and express solutions to problems (Bednarz & Bednarz, 2008: 316). Another reason for this lack of effective use could also be that users lacked a sense of urgency about the problem that these tools would have supported (Goosen, 2006). In this respect, the use of geographical risk information and Geo-ICT in policy making depends not only on the availability of appropriate information and tools, but also on the forms of reasoning used by the actors involved in policy-making processes. Consequently, the use of geo-information and Geo-ICT to support the consideration of safety risks also depends on the way safety risks themselves are addressed and dealt with in planning practices. For example, Geo-ICT to support risk management in planning is only of added value to spatial planning if the actors involved have some commitment to the consideration of safety risks in general.

1.4 Spatial planning for risk reduction

With its objective of influencing land use and land-use changes, spatial planning can result in risk reduction. In addition to public bodies, private actors can influence land use and steer risk reduction. The focus of this study, however, is on the spatial planning activities carried out by spatial planners working at the level of public administration. In general, spatial planners can directly and indirectly influence land-use development (Needham, 2000). Examples of direct interventions are land and property acquisition, such as buying flood-prone land to prevent new development. Indirect interventions include land-use regulations such as zoning or incentives to stimulate direct or indirect interventions by others (e.g. the planning requirements of a higher level of government for local governments). In addition to these direct and indirect regulatory interventions, spatial planners can influence land use through other policy tools based on communicative mechanisms or financial mechanisms, like the dissemination of risk information through risk maps or through taxation and fiscal polices to stimulate the adaptation of buildings. Through this influence, the adaptation of vulnerable buildings can be required (e.g. such as flood-proofing a building), the development of vulnerable buildings in hazard-prone areas can be regulated or existing buildings can be reallocated. For these reasons, spatial planning is regarded as an important instrument to reduce both natural and industrial safety risks (Bergström, 2006; Burby, 1998; Christou *et al.*, 1999; Immink, 2007; Mileti, 1999).

In spite of this recognition in risk management and planning literature, studies on the implementation of risk mitigation measures through spatial planning have shown that many local governments avoid implementing mitigation measures through spatial planning, especially when risks are triggered by natural hazards such as flooding or earthquakes (Berke *et al.*, 1996; Burby, 1998; May *et al.*, 1996). Nevertheless, few studies have been conducted to show why local planning authorities do not systematically use spatial planning in advance for reducing natural risks, especially in Europe (Hutter *et al.*, 2007). Also, with respect to industrial hazards and development, research has concentrated more on the siting of new hazardous installations than on the impact of the existing industrial safety risks on development in the locality (Walker, 2000).

1.5 Research aims and research questions

In the previous sections, various aspects of the relationship between spatial planning and Geo-ICT were discussed. In the section on spatial planning and risk management, spatial planning was seen to be an important instrument for reducing both natural and industrial safety risks. Nevertheless, the application of spatial planning for risk reduction was problematic, since planning as such was not widely used to mitigate safety risks. Moreover, the reasons for the use or non-use of spatial planning have rarely been studied. In the section on Geo-ICT, this technology was regarded as an important instrument to support the consideration of safety risks in spatial planning. Nevertheless, the use of geo-information and Geo-ICT in spatial planning was found to be problematic, since its use is far from effective, for example due to limited availability of geo-information, unsuitable geo-tools or limited possibilities for information exchange.

However, it can be argued that problems with respect to the use of planning on the one hand, and the effective use of Geo-ICT and geo-information on the other, are interrelated and partly overlapping, especially with respect to the forms of reasoning used by spatial planners that may cause ineffective use of spatial planning and Geo-ICT. Therefore, this thesis focuses on the forms of reasoning used by spatial planners in general, and on the way they deal with safety risks in spatial planning in particular. These insights will be used as a point of departure for discussing the contribution of Geo-ICT, which is expressed in the following research question:

How are safety issues addressed in spatial planning practices and what contribution can be made by geo-information and Geo-ICT to support the consideration of safety risks in spatial planning?

The first aim of this research was to understand how safety issues are addressed in spatial planning practices in hazard-prone areas, and to explore the reasons for the use or non-use of spatial planning for reducing safety risks in advance. The focus was on the consideration of flooding and industrial accidents, since these events represent prominent natural and industrial hazards, respectively (Jongejan, 2008), the potential effects of which can be considered in spatial planning. The resulting insights contribute not only to conceptions of spatial planning in general or the consideration of safety risks in planning in particular, but also to public discussions on risk management and the role of spatial planning with respect to risk management.

Insights into the use or non-use of spatial planning can also provide points of departure for the further development and application of geo-information and Geo-ICT, which was the second aim of this research. Based on a conception of how risks are, and can be, addressed in spatial planning, the contribution of Geo-ICT is discussed and recommendations are given on the future development and application of geo-information and Geo-ICT for the consideration of safety risk issues in spatial planning.

1.6 Outline of this thesis

The outline of this thesis is illustrated in Figure 1-1. Chapter 2 describes the applied research approach, and together with this chapter, can be regarded as the introduction to the studies that were carried out to answer the central research question. These studies are described in the following chapters. Each study focuses on a particular problem either with regard to the consideration of safety issues in planning or with regard to the further development and application of geographical information and Geo-ICT. Chapters 3, 4, 5 and 6 are focused on the way safety risks are addressed in spatial planning practices. Chapters 3 and 4 focus on industrial risks and Chapters 5 and 6 on flood risks. The emphasis in Chapters 7 and 8 is more explicitly on the further development and application of geographical risk information and information systems. Chapter 7 focuses on the informational requirements and spatial information infrastructures (SIIs). In chapter 8, the ideas as presented in chapter 7 are worked out further through the concept of network centric risk and emergency management. In the concluding chapter, Chapter 9, the insights from the individual studies are brought together to give insight into how safety risks are addressed, what might be done differently and what contribution can be made by geographical risk information and Geo-ICT.

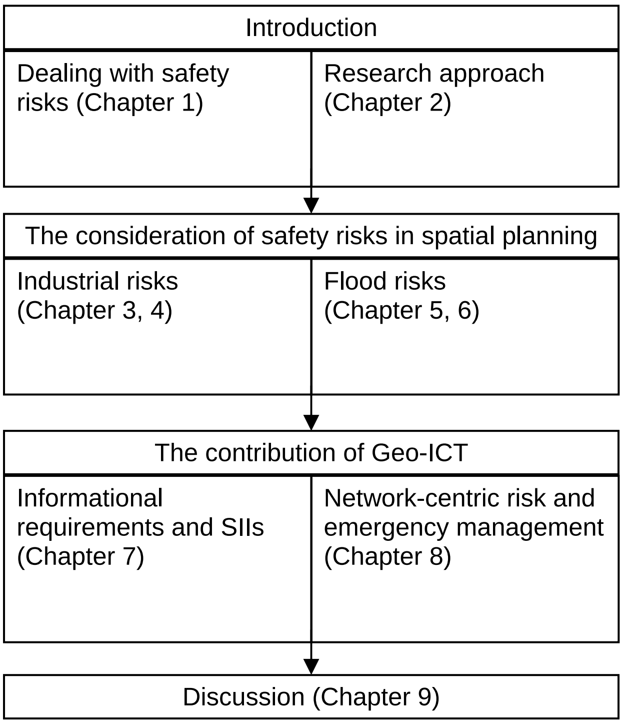

Figure 1-1. Outline of this thesis

2

Research Approach

As stated in the Introduction, the central aim of this research was to develop insight into the way safety risks are addressed in spatial planning practices and into the potential contribution that can be made by Geo-ICT. But how can spatial planning and the potential role of geo-information and Geo-ICT be analysed? This question will be discussed in this chapter on research approach.

Before discussing the research approach, however, a distinction should be made between the research perspectives on which research is based and the theoretical perspectives related to the understanding of society. A research approach focuses on the assumptions and preconditions of science and research, whereas theories and theoretical perspectives focus on specific social phenomena such as risks or society in general, such as theories concerning the ‘risk society’. This chapter concentrates on the research perspectives rather than on theories on society or social phenomena. Nevertheless, these perspectives and theories can influence each other as will be illustrated in Box 2-3.

A research approach can be characterised by the epistemology, research perspectives, methodology and methods that have been applied within a research project and which can be regarded as the building blocks of research (after Crotty, 1998). These four elements can be defined in the following ways:

- Epistemology: the position that is taken on the theory of knowledge, defined as the way of understanding how knowledge is produced.
- Research perspectives: the philosophical stance towards research, which provides the context for the methodology.
- Methodology: the strategy that underpins the way research is carried out, including the research plan and research process. A methodology can be regarded as the basis for the choice and application of methods.

- Method: the operational techniques and procedures that are used to gather and analyse data.

These four elements of the research approach are interrelated. Research perspectives, for example, are implicitly or explicitly based on specific epistemological assumptions. In addition, there is not a clear distinction between specific elements. Methodology, for example, is portrayed as the ‘border’ between research perspectives and the methods or working procedures in specific studies. This border, however, is more vague than sharp. Therefore, distinctions between different elements are necessarily arbitrary, even though these distinctions can analytically clarify the overall research approach as discussed in this chapter.

2.1 Epistemological position

Research perspectives, methodologies and the application of methods are informed by the epistemological position or standpoint from which they are used and defined. The epistemological position has to do with what can be known about reality. Nevertheless, different epistemological positions exist in science, resulting in different perspectives on knowledge and consequently in different research approaches. Objectivist epistemology is based on the core assumption that reality can be known objectively: there is a correspondence between the perceived reality and the reality that exists outside the perceived reality (Morçöl, 2001). The objectivist epistemology is based on a realist ontology. Ontology has to do with the the nature of reality. According to a realist ontology, reality exists independently of our knowledge of it.

The epistemological position taken in this thesis, however, is based on the assumption that realities cannot be discovered objectively. They are produced by human thoughts in cultures. Different people can construct reality in different ways and simultaneously give meaning to it. As a result, there cannot be one universal or objective truth. This does not imply that a particular conception of truth is always contested. The statement that the failure of a dike depends on dike width is generally agreed upon. The extent to which dike width contributes to dike failure, however, can be perceived differently in different practices, for example in different cultures and in different times.

This epistemological position is referred to as constructivism, which implies that knowledge about reality should be regarded as the result of an interplay between reality and the actors who perceive reality (Crotty, 1998). The term constructivism includes both the collective generation and transmission of meaning, and the individual sense making process (Fischer, 2003c). The constructivist epistemology does not exclude a realist ontology, but argues that this reality cannot be known objectively, because interpretation and reality are portrayed as being inextricable from each other. They are two sides of the same coin (Latour, 2004).

Also, researchers following an objectivist epistemology will, to some extent, agree that social realities are socially constructed. What distinguishes constructivism from objectivism, however, is the idea that all meaningful reality, including the reality 'discovered' through natural scientific methods should be regarded as socially constructed (Crotty, 1998).

This constructivist position not only influences research, but also theories on society or phenomena in society, such as theories on the construction of risks, as illustrated in Box 2-1.

Box 2-1. The social construction of risk

From a constructivist point of view, risks can be regarded as constructions of reality rather than reality itself. As stated by Beck (1992), risks only exist in terms of the knowledge about them. Different people, including scientists, can have different methods to assess risks with different assumptions and different outcomes. In addition, risk knowledge can be based on both scientific and non-scientific information, e.g. information based on personal experiences or experiences of others. Both this scientific and non-scientific information on risks can be interpreted in alternative ways, as can be illustrated by discussions about the installation of telecommunication masts. In the Netherlands, numerous local groups heavily criticise the installation of telecommunication masts, which are needed for mobile communication networks. The central government, however, argues that the risks posed by these masts are acceptable and that permission should be granted for placing them.

A great number of stories can be found on the internet about people who live near telecommunication masts and who believe they suffer from the Electromagnetic Ffields (EMF) caused by them (see for example www.stopumts.nl). They experience, for example, serious headaches or suffer from sleep disorders. Based on these experiences, local groups want to prohibit the installation of new telecommunication masts.

However, recent scientific research on the effects of EMF on public health has not proven that telecommunication masts have a negative effect on health (Health Council of the Netherlands, 2005). In spite of this, many local action groups still believe that the electromagnetic fields of these masts harm public health. In addition, local interest groups argue that scientific research cannot fully exclude the possibility of long-term health effects. They argue that harmful health effects have not been totally ruled out, since the long-term effects have not yet been measured.

This example illustrates that different people can conceptualise risks in different ways.

Through an examination of risk perceptions, various factors or risk characteristics that influence risk perceptions have already been identified, such as the controllability, dread or voluntariness of the risk, the familiarity with the risk or risky activities or the potential risk consequences (Slovic, 1987). In this light it is not surprising that involuntary exposure to electromagnetic fields has resulted in local opposition, whereas the assessment of the potential consequences in the light of the probability of these consequences shows that the risks are low.

2.2 Research perspectives

The consideration of safety risks in planning practices will be analysed from an interpretative research perspective. This perspective is characterised by a focus on understanding and interpreting socially constructed meanings (Fischer, 2003c; Howarth, 2000). Based on a constructivist epistemology, interpretative research looks for culturally derived and historically situated interpretations of the social life world.

An interpretative standpoint, however, not only regards social realities as being the result of human action; these realities also shape human actions. Therefore, an examination of how meaning is attributed to risks in spatial planning practices can provide a way to understand how risks are dealt with in these practices. Moreover, it can provide insight into the question of why risks are addressed in a particular way, since meanings that are attributed to these risks also shape action, including the use of information, as illustrated in Box 2-2 on the use of risk maps in spatial planning.

Box 2-2. The use of risk maps

Through risk maps, the potential effects of specific hazards can be visualised, for example the area that can be affected through an incident with the transport of hazardous materials or the flood levels that can be expected in case of a breach in a dike. This information can influence the way spatial planners interpret risk. Risk maps, for example, can stimulate risk consciousness amongst spatial planners. Consequently, human actions (in this case, the presentation of risk maps) influence social reality: how risks are perceived. In this respect, social realities can be regarded as the result of human action. Nevertheless, they can also be regarded as the source of human action. Existing ideas on risks, for example, also shape the need for information, the interpretation of risk information and the actions that are taken as a consequence of these interpretations (In 't Veld, 2000; Ter Huurne, 2008). When spatial planners do not regard themselves as responsible for reducing particular risks, it is likely that no risk reducing measures will be taken as a result of the information presented on the risk maps, even though the risks can be considerable.

For similar reasons, with respect to the examination of planning practices, the interpretative perspective is used as a starting point for discussions on the potential role and subsequent further development and application of geographical risk information. Because the actual interpretation of risks greatly affects the particular need for information and use of it, it makes sense to identify the meanings that are attributed to safety risks and to link these meanings to the potential role of geographical risk information. Consequently, the central research question is discussed from an interpretative perspective, in which social reality is especially understood as a source of human action, rather than a result of such action. Obviously, research perspectives and theories about society are also interrelated. This is illustrated in Box 2-3.

Box 2-3. Planning as a struggle about meaning

The idea that spatial planning can be regarded as a social phenomenon, through which the actors involved try to allocate meaning to actual landscapes, goes hand-in-hand with an interpretive research perspective. From an interpretative stance, the resulting planning processes can, similarly to policy making processes in general (Gottweis, 2003), be regarded as struggles about meaning in which different actors or groups of actors try to pursue their ideas about the actual and desired space (Flyvbjerg & Sampson, 1998). Different people will not only have different perceptions about risks, but also about how society should deal with these risks or how a public body should deal with balancing spatial claims for risk management with other spatial claims resulting from objectives with respect to nature conservation or industrial development. From this interpretative theory about planning, planning processes can be regarded as struggles about meaning.

2.3 Methodology

Interpretative policy analysis can be regarded as a methodological elaboration of the interpretative research perspective (Yanow, 2000). This methodology offers guidance for the examination of planning practices and will therefore be discussed in more detail. Interpretative policy analysis, however, can be regarded as a reaction to neo-positivist policy analysis. Therefore, the interpretative methodology is discussed after the neo-positivist methodology.

Neo-positivist policy analysis

Generally, policy analysis claims to solve public problems and to produce knowledge that can be used in the policy-making process (Wildavsky, 1979). Nevertheless, there is great diversity in the views about what kind of knowledge should be produced by policy analysis and about which methodologies and methods should be applied (Mayer *et al.*, 2004). Interpretative methodologies can be understood as being a reaction to the methodologies used in what Fischer (2003b; 2003c) described as neo-positivist policy analysis. Neo-positivist policy analysts assume that reality can be discovered with analytical precision through natural scientific methods such as empirical measurements. As a result, they regard positivist natural scientific methodologies and methods (such as large-scale experiments) as being the only valid means of distinguishing facts from values, and of making objective value-free assessments (Fischer, 1990; Yanow, 2000).

It can be argued that many GIS based information systems are explicitly or implicitly based on a neo-positivist tradition of policy analysis, since their objective is often to provide objective information. The conceptualisation of risks on risk maps, for example, is generally based on natural scientific methods (i.e. a quantitative risk assessment). Flood risks on risk maps, for instance, are assessed through an analysis of flood probabilities, which can be based on weather models, hydrologic models and models of dike strengths.

Consequently, the objective of neo-positivist policy analysis can be seen as 'speaking truth to power' (Wildavsky, 1979), by providing policy makers and decision makers with factual information about, for example, policy problems and the expected effects of policy measures. The main criticism of neo-positivist policy analysis, however, is that it has over-relied on and misused scientific knowledge due to its adherence to an objectivist conception of this knowledge (Fischer, 1990).

Interpretative policy analysis

In contrast to neo-positivist perceptions of knowledge, interpretative policy analyses take a more complex view of the superiority of scientific knowledge over other ways of knowing. They recognise the value-rational aspects of scientific knowledge following a constructivist epistemology. According to Fischer (2003b: 215), this standpoint should not mean that science, whether physical or social, should not be taken seriously, but that science should be understood to be a more subtle interaction between physical and social factors.

The methodology used in interpretative policy analysis puts human meaning and social realities at the core of the analysis. They assume that different aspects of policies can mean different things to different people. For that reason, interpretative research typically begins with the question: ‘What does a proposed policy mean and for whom does it have meaning?’ (Yanow, 2003: 235). An important subsequent step in interpretative research is identifying different ideas or groups of ideas, the actors who employ these ideas, the assumptions underlying particular ideas and the context in which the ideas are presented (Yanow, 2000). This context dimension can include rules, procedures, cultures, history and traditions that guide both the content and process of spatial planning practice.

Much research focused on the content of ideas follows a language-based approach (see for example Hajer & Wagenaar, 2003; Hajer, 1995; Van den Brink & Metze, 2006). This type of research takes varying degrees of language, or more specifically, language uses, as being the organising framework through which ideas are expressed. Nevertheless, actions and objects can be analysed in comparable ways (Hajer & Laws, 2006; Sharp & Richardson, 2001; Van Assche, 2004; Yanow, 2000). They can also reflect a specific human conceptualisation of reality. Actions or physical measures to prevent flooding, such as dike elevation, also reflect underlying ideas about flood risks, their acceptability or the effectiveness of particular measures. In this light, the present study focuses on how spatial planners look at risks, which forms of reasoning they use in written and spoken texts, and what actions they take to deal with these risks.

2.4 Case study approach

This research was divided into six studies. Each study focused on a particular aspect of the central research question, either with regard to the consideration of flood risks and external safety issues in planning or with regard to the contribution of geo-information and Geo-ICT (Table 2-1). The studies were carried out as part of the research project GeoRisk, funded by the Space for Geo-information programme (*Ruimte voor Geo-informatie)* (www.georisk.nl).

Table 2-1. Overview of the studies

Short title	**Focus**	**Chapter**
Risk maps informing land use processes	A comparison of external safety policies and developments in risk maps in the Netherlands and the UK.	3
The consideration of emergency management issues	An examination of the consideration of industrial risks in spatial planning with particular attention to emergency management issues.	4
Flood risk management in Dutch local spatial planning practices	An examination of the consideration of flood risk issues in spatial planning with particular attention on the reasons for the use or non-use of spatial planning.	5
A spatial planning perspective	An examination of conflicts that may appear during the implementation of flood risk reduction measures and directions for managing these conflicts.	6
Integrated flood management requires an integrated spatial information infrastructure	An inventory of requirements for emergency managers regarding flood risk information, and a comparison of these requirements with the requirements that can be expected from spatial planners when flood risk is addressed in spatial planning.	7
From spatial data to synchronised actions	A conceptualisation of risk and emergency management in order to develop a point of departure for the organisation of geo-information and Geo-ICT to support risk and emergency management.	8

The findings of these studies are based mainly on the examination of specific practices or cases. Case studies are an interesting research method in interpretative research, since they can provide in-depth understanding of specific social phenomena (Yin, 2005). In addition, they can provide context-dependent knowledge, which is crucial for understanding phenomena than cannot be understood by ‘general rules’ (Flyvbjerg, 2001). Another advantage of a case study is that it requires a less structured setup than a large-scale survey or experiment (Verschuren & Doorewaard, 2005). Case studies allow an open starting point. Consequently, they are regarded as especially suitable for answering how and why questions, for example, such as how particular social phenomena work or why they appear as they do (Gray, 2004). Case studies were therefore used in the present research as the central method for answering the central research question. This section provides a general description of the selected cases or practices. Within the individual chapters, however, more extensive descriptions of the applied methods for the analysis of these practices are given.

The study of planning practices starts with national planning and risk management policies. Higher level authorities, such as national governments, can provide frameworks and guidelines for spatial planning and the consideration of safety risks in planning, which can explain to some extent how risks are perceived and managed. Therefore, the national policy frameworks for the consideration of industrial risks (Chapter 3) and flood risks (Chapters 5 and 7) were studied to understand the consideration of safety risks in planning. The study of the policies on industrial risks and planning was carried out in cooperation with another PhD research project conducted by Claudia Basta at the Delft University of Technology. Through this cooperation, the Dutch framework could be compared with the UK framework, which was comparable in character, resulting in some additional understanding of the Netherlands framework and recent developments (Chapter 3).

National frameworks and guidelines, however, can be reformulated during the implementation process at the lower level, since lower level governments also have or take some discretionary freedom in the implementation of higher government guidelines (Majone & Wildavsky, 1984). For that reason, special attention is given to the consideration of safety risks in regional and local practices to understand the actual consideration of safety risks (Chapters 4, 5 and 6). Consequently, the emphasis in Chapter 4 is on the consideration of industrial risks in local practices, since industrial risks are mainly dealt with in planning at this level. Special attention is given to how spatial planners deal with emergency management concerns, since spatial planning is increasingly used for this purpose. Chapters 5 and 6 focus on the consideration of flood risks. In Chapter 5, local spatial planning practices in flood-prone areas are analysed. Planning practices of municipalities in vulnerable, flood-prone areas were selected, since it could be expected that flood risks were considered in these areas. Chapter 6 focuses on the implementation of flood risk reduction measures. Risk reduction measures such as land-use regulations in hazard-prone areas or the location of physical structures in the landscape require land or another use of land, which can be problematic. The problems that are encountered in the implementation phase can also provide understanding about the use or non-use of spatial planning to reduce safety risks; therefore, the implementation of safety measures was examined as well by studying the implementation of local and regional projects for the reduction of risk related to river floods and flooding caused by heavy rainfall and limited drainage capacity.

The studies on the consideration of safety risks in planning were used as a starting point for recommendations for the further development and application of geo-information and Geo-ICT for the support of risk management in planning. The examination of local case studies showed important changes in the way in which risks are addressed in both policies and practices, especially with respect to flood risk management. Consequently, changing informational requirements were expected. For that reason, the expected informational requirements related to flood risks have been examined and described in Chapter 7. Changes in flood management policies were explored together with informational requirements that may result from these changes, providing a point of departure for the further development and application of geo-information and Geo-ICT. Because the exploration showed that spatial planners were increasingly interested in emergency management concerns, informational requirements were compared with informational requirements in emergency management, which provided additional directions for the development of Geo-ICT.

Since spatial planners are increasingly considering emergency management concerns, it can be argued that developments in geo-information and Geo-ICT for emergency management can also be relevant for spatial planning. Therefore, the developments in Geo-ICT in this field are explored in Chapter 8. This exploration was based on the idea that the search for an appropriate role for Geo-ICT and geographical information in emergency response should not start with a particular technology, but with a conception of emergency management and especially with the way decision making is organised in emergency response. Consequently, Chapter 8 describes a conception of risk and emergency management that is based on the previous studies of the consideration of safety risks in planning and on the experiences of the 'Geo-data infrastructure for disaster management' (GDI4DM) project, which focused on the development of a SII for emergency management (www.gdi4dm.nl). The ideas about emergency response, and the related organisation of Geo-ICT, provided some additional points of departure for the development of geo-information and Geo-ICT to support risk and emergency management. Consequently, the ideas presented in Chapter 7 are developed further in Chapter 8.

2.5 Using and producing theories

Theories should not only be regarded as the result of research, they can also be used as an interpretive framework within research. However, prudence is called for when theories are used in this way, since interpretative researchers do not regard these interpretative frameworks as neutral lenses through which reality can be discovered.

There is more to theories than that. They make this reality accessible through constructing it. In this respect, a theory can be seen as a discourse (Allmendinger, 2002), which according to Hajer (1995: 44) can be defined as ‘a specific ensemble of ideas, concepts and categorisations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is allocated to social and physical phenomena’. Consistent with discourses, theoretical perspectives are not neutral conceptualisations of reality, but they highly shape the way people and groups of people perceive reality, define problems and choose to pursue solutions in a particular direction in both research and practice (after Hajer & Laws, 2006).

Consequently, interpretative researchers reject the idea that practices should be analysed from existing and often general theories, referred to as deduction. Deduction implies that knowledge on individual phenomena is derived from universal laws. Interpretative researchers prefer an open starting point, because existing theories would focus the attention of a researcher too selectively (Forester, 1999; Yanow, 2003). For that reason, interpretative methodologies prefer an inductive approach (see for example Hajer & Wagenaar, 2003; Yanow, 2000). Insights are derived from the specific phenomena studied, to illuminate particular concepts or mechanisms in policy practices. Most researchers, however, use both induction and deduction, since there is a necessary interplay between ideas and evidence in each research process (Grix, 2004).

Abduction can be regarded as a way to mediate between the inductive and deductive way of reasoning. A good example of the application of an abductive approach in spatial planning research can be found in Van Dijk (2008). Even though the concept of abduction goes back to Aristotle, the American philosopher Charles S. Peirce developed and applied this concept further and is therefore regarded as one of its major founders (Bertilsson, 2004; Danermark *et al.*, 2002; Glynos & Howarth, 2007). Similar to induction, the starting point of abduction is in the specific rather than the general. The researcher looks at particular, situation-specific phenomena. From an abductive point of view, however, the researcher not only describes these phenomena, but also makes new interpreting links. In this respect, the objective of abduction is:

> […] to interpret and recontextualise individual phenomena within a conceptual framework or set of ideas, to be able to understand something in a new way by observing and interpreting this something in a new conceptual framework (Danermark *et al.*, 2002: 80).

This process of developing conceptual frameworks initially results in some vague concepts through which the specific phenomena can be structured, described or explained (Glynos & Howarth, 2007). Existing theories can be helpful to recontextualise and subsequently interpret or articulate the situation-specific phenomena. Existing theories on how risks can be managed, for example, can be useful to structure and especially interpret examined risk management practices. In contrast to deductive approaches, however, researchers do not use the existing theories as pre-defined categories to search for general truths, but compare the findings derived from the research with existing ideas, e.g. to identify interesting differences between the general theories and the specific practices or to characterise the particular in more detail through comparing them with general, existing ideas. Consequently, the theoretical frameworks that are used must be open and flexible to being ‘stretched’ and restructured in the process of application (Howarth, 2000: 139).

Within an abductive way of reasoning, different empirical and theoretical elements can be combined to define relationships between theoretical elements, empirical elements or empirical and theoretical elements (Glynos & Howarth, 2007). This often results in several frames of interpretation, which are tested separately or used together to complement each other and to provide powerful and convincing explanations of the studied phenomena (Danermark *et al.*, 2002). Special attention should be given to the influence of context on the phenomena that are studied and on the conceptual frameworks that are used to explain these phenomena. For example, the effects on a phenomenon if condition X changes should be considered, as well as the implications for the theories used to explore and explain the studied phenomena (Danermark *et al.*, 2002).

The analysis of case studies was inspired by these abductive ways of reasoning. Consequently, interpretive frameworks and concepts were developed and used to analyse the case studies. Nevertheless, induction was used as a starting point. For example, the examination of the consideration of flood risk issues in planning was initially based on inductive ways of reasoning, resulting in different ideas for understanding the use or non-use of spatial planning to reduce flood risks. These initial results were interpreted further through a comparison with previous literature on spatial planning and risk management. From this literature, factors to explain the use or non-use of spatial planning could be derived. These factors were used as an interpretive framework to structure and understand the ways of reasoning as found in the case studies. In contrast to deductive ways of reasoning, the interpretive framework was not used as a set of fixed, predefined concepts, but resulted from an iterative interaction with the empirical data. Through these interactions, interpretive frameworks could be redefined, through which the area specific context could also be understood (see also Van Dijk, 2008).

2.6 Evaluating research results

Interpretative research results in socially constructed, context-dependant knowledge, which should be aimed at understanding social phenomena rather then explaining and predicting them in causal terms. In contrast to positivist research, interpretative research does not depart from a fixed, given and stable world. Interpretative research assumes that social, political, or natural phenomena – and inseparable from them, their meanings – are constantly changing over time (Gottweis, 2003). This implies that the insights derived from the analyses are both time and place dependant. As a consequence, results of the analysis reflect perceptions of outcomes at a particular point in time in the planning process and often focus on the mechanisms that structure policy processes in specific contexts. This, of course, does not imply that the results cannot be applied in other analysis, for example comparative analysis, but does imply that these ideas should be modified to the particular study for which the ideas are used (Howarth, 2000).

Furthermore, knowledge obtained from an interpretive approach cannot be regarded as value free, universal, explanatory or predictive. Due to this context dependency and the recognition that value-free knowledge cannot be obtained, the resulting insights cannot be valued against the reality that exists out of the reality that is constructed, referred to as the validity criteria (Fischer, 2003c). This implies alternative evaluative criteria for the evaluation of insights into the consideration of planning practices and into the contribution that can be made by geographical information systems. Interpretative researchers therefore suggest that results should be judged in a more pragmatic way. They should be evaluated in the light of their plausibility, trustworthiness, explanatory and convincing power, transparency or the degree to which they make new and meaningful interpretations possible (Crotty, 1998; Fischer, 2003c; Howarth, 2000; Schwartz-Shea, 2006). Results from case studies, however, are not automatically trustworthy or plausible, as desired in the evaluation of interpretative research. In addition, these criteria remain rather vague. Therefore numerous techniques have been identified through which these criteria can be made operational (Hutjes, 1995; Schwartz-Shea, 2006; Yin, 2005). The following strategies have been applied to improve the quality of operational research.

- Triangulation of data: research can become more reliable when data is gathered from multiple sources. Therefore, the analysis carried out in the different studies was not limited to extensive desktop study alone, including the study of literature and policy documents, but was also based on additional interviews with key actors and to some extent on personal experiences through participation and observation.

- Comparison: findings can become more robust if they are compared with findings from similar cases. Hence, the studies have often been based on case studies that consisted of an examination of different, interrelated practices. In addition, comparisons within practices were made. For example: do different actors involved in particular practices act in different ways? Do they have similar problem definitions?
- Explicitness: conclusions are more convincing when it is made clear how the conclusions were derived from the empirical material. Therefore, the empirical material is sometimes cited in the individual chapters to clarify how conclusions have been derived. In addition the context in which the examined practices took place was made explicit, e.g. through describing the actual policy framework in which these practices took place.
- Informant check: insight from the research should correspond with the different social realities experienced in the practices studied (Fischer, 2003c). This correspondence can be improved if the key actors are to some extent involved in the research and if they can check the interpretations made. For that reason, key actors were interviewed and the interview reports and research results were sent to these actors for evaluation.
- Auditor check: a check on both research content and process by external researchers can exclude some inconsistencies and can help to increase transparency. Therefore, the research was discussed within the GeoRisk project, in which universities, governments, research institutes and consultancies participated; it was also presented at both national and international conferences. In addition, the papers resulting from the research were checked by anonymous reviewers.

These techniques, however, do not guarantee that the research can be regarded as trustworthy or convincing. The final judgement is up to the reader or user of the research results, since interpretative researchers recognise that in spite of these techniques, readers or users can have alternative interpretations based on their own background and experiences, resulting in their own ‘meaning making’ of researchers’ texts (Schwartz-Shea, 2006: 108).

3

Risk-Maps informing Land-Use Planning Processes*

Abstract
The definition of safety distances as required by Art 12 of the Seveso II Directive on dangerous substances (96/82/EC) is necessary to minimize the consequences of potential major accidents. As they affect the land-use destinations of involved areas, safety distances can be considered as risk tolerability criteria with a territorial reflection. Recent studies explored the suitability of using Geographical Information System technologies to support their elaboration and visual rendering. In particular, the elaboration of GIS “risk-maps” has been recognized as functional to two objectives: connecting spatial planners and safety experts during decision making processes and communicating risk to non-experts audiences. In order to elaborate on these findings and to verify their reflection on European practices, the article presents the result of a comparative study between the United Kingdom and The Netherlands recent developments. Their land-use planning practices for areas falling under Seveso II requirements are explored. The role of GIS risk-maps within decisional processes is analyzed and the reflection on the transparency and accessibility of risk-information is commented. Recommendations for further developments are given.

Keywords: land-use planning, geographic information systems, Seveso II, risk-maps

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3.1 Introduction

The article is part of a broader comparative study on Member States practices in the field of land-use planning (in the following: LUP) in areas at risk (Basta *et al.*, 2005; Cozzani *et al.*, 2006) and presents recent findings of current research addressing the development of GIS-based tools for risk prevention and emergency response (Neuvel *et al.*, 2006; Van Oosterom *et al.*, 2005). The framework of the study is Art 12 of the Directive Seveso II on dangerous substances (96/82/EC), with a focus on Art 12 "Control of Urbanization" and its implementation in selected European practices. Aim of the article is investigating how LUP decision making processes are supported and informed by "risk-maps" in two selected Member States: the Netherlands and the United Kingdom. These two countries are selected on the base of their comparable methodological approach to LUP for at-risk areas, to which relevant differences between the decisional processes involving the risk-information system are associated.

As well known, Article 12 of Directive Seveso II requires Member States to consider, within their land-use planning policies, the need of defining opportune safety distances between dangerous establishments and urban, natural and infrastructural developments. "Dangerous" refers to the presence of substances which explosion, fire or release could lead to major accidents involving the external areas of establishments. In this respect, safety distances are risk acceptability criteria with a territorial reflection, as they affect the land-use destinations of the surroundings of Seveso sites.

In the last decade, different methods and tolerability thresholds fulfilling the Seveso II requirements were developed in European countries. Analyzed Member State's practices reflect the specific geographical, regulatory and societal background of the country (Basta *et al.*, 2005). The resulting heterogeneity of approaches and regulations may be interpreted, in general terms, as the result of the 'discretionary freedom' (Bakker & Van Waarden, 1999). Member States have in implementing European legislation. In the specific domain of the Seveso II, this discretionary freedom is coupled with qualitative and quantitative variables affecting the development of different regulations and methods. In the analyzed case, a different legal background (common law vs. civil law) (Ale, 2005b), a different population density (resulting in a different land scarcity) and a different configuration of the institutional lay-out are the most relevant ones.

From the European regulatory perspective, in order to achieve a harmonized implementation of Art 12, the heterogeneity of methods and practices which were developed or were under development in the "Europe of 25" had to converge to an agreement about the general principles informing a "safe" land-use planning practice. This objective is stated in the first amendment of the Seveso II Directive (2003/105/EC). The amendment requires to the Commission the elaboration of guidelines defining a d-base to be used as a common reference for assessing the compatibility between Seveso sites and surrounding areas. This requirement gave new inputs to the comparative research investigating the possibility of deriving a general 'good-practice' from national experiences (Christou *et al.*, 1999; Smeder *et al.*, 1996). A relevant part addressed the analysis of the decision-making processes supporting the definition, the enforcement and the communication of risk-reduction measures (Jones, 1997). The issue of the different professional cultures, subjective perceptions and decisional approaches the great variety of actors have in 'coping with risk' are generally outlined (Horlick-Jones, 1998; Vlek, 1996). Facilitating their dialogue and developing a shared understanding of risks is seen as crucial for a proper definition and enforcement of risk reduction strategies (Contini *et al.*, 2000). In this respect, an appropriate (national) risk-information system plays a central role.

As outlined in a previous study, "risk-maps" are a valuable tool for the visualization and exchange of risk-information in an easy-reading language. When responding to an-ambiguous requirements, risk-maps can improve the understanding of the geographical dimension of major accidents (Moen & Ale, 1998). Despite this, the digital representation of risk-information and the creation of national d-bases accessible by different users are very recent in European practices. The Netherlands and the United Kingdom offered the opportunity to investigate on the most recent developments in this field. Both countries have well established risk regulations, a comparable experience in term of risk prevention policy-formulation and a similar methodological approach to LUP for areas at-risk. On the other hand, coherently with their different regulatory backgrounds, they developed different spatial planning systems, risk tolerability criteria and risk informative systems. Risk-maps find a different use during planning processes, and a different consultation procedure for accessing risk-maps by the side public offers the opportunity to reflect on the problematic interface between safety and security.

In order to present its findings, the article starts with a summary of the main differences and similarities between the two national practices. A more extensive description of the Dutch and the United Kingdom land-use planning regulations for areas at-risk follows. Decisional processes are described together with GIS-based risk informative systems and maps. With the support of direct interviews to Safety and Planning Authorities of both countries and in-depth literature analysis, a concluding section reflects on possible further developments in the use of risk-maps as decision-support for risk prevention purposes.

3.2. Risk-maps informing planning processes: a comparison between the two examined countries' practices

The comparison between the United Kingdom and The Netherlands focused on two distinct aspects. Firstly, the regulatory aspects related to the implementation of Art 12 were examined and compared; secondarily, the risk-informative aspects related to the creation of geo-data infrastructures and the development of risk-maps were analyzed and discussed.

The most remarkable similarity in the two regulatory contexts is the common adoption of a quantitative approach to risk assessment. In the context of the Seveso II, this approach involves the estimation of the probability of occurrence of major accidents. Consequently, the likelihood of accidents is a variable of the following LUP evaluation. In this respect, the two approaches are to be considered similar. Nevertheless, relevant differences related to the risk assessment approach (a, b) and to the decision-making process (c) were outlined:

a. The status of the risk acceptability criteria: a strictly quantitative risk assessment (QRA) is required in The Netherlands, where legally binding end-points are defined by law. A judgmental approach, using also consequence-oriented assessments, is instead used in the UK, where the ALARP (As Low As Reasonably Possible) principle applies.
b. A different definition of societal risk: strongly quantitative but difficultly estimable in the Netherlands, it is based on the integration of the individual risk (IR) estimation with population data in the UK.
c. A different configuration of decisional-processes, deriving from a different lay-out of the institutional system: strongly centralized and focused on a unique Safety Authority in the UK, it is a multi-level system involving different institutional competences in the Netherlands.

Concerning the deriving risk-informative systems and the elaboration of risk-maps, differences are:

d. In the Netherlands, shared information platform are used as reference for elaborating risk-maps and delivering risk data. The authority responsible for granting the license to plants' operators (which differs according to the classification of the plant within given dangerous categories) is also responsible for the regular update of the data. In the UK instead, the national Safety Authority Health and Safety Executive (HSE) owns the data, and it is entirely responsible for their regular update.

e. In the Netherlands, the information reported on risk-maps is extended to different kind of risks with a geographical relevance. The specific nature of the substances treated/stored within establishments and, until recently, iso-risk contours were available to general end-users. In the United Kingdom instead, risk-maps report only iso-risk contours with the level of risk/harm: no information is given regarding the dangerous substances.
f. In the Netherlands, risk-maps are used to inform the planning process as well as non-institutional users (i.e. involved stakeholders or general public). In the UK, risk-maps instead are directly delivered to the Planning Agencies by the Safety Authorities, without any direct communication of their content to the population.

In the following sections, details of each country's practice are given.

3.3. Land-use planning and major accidents risk in the Netherlands

Risk assessment method and risk tolerability definition

The Seveso II Directive is implemented in the Dutch legislation by the Dutch Major Hazards Decree (BRZO) and the Dutch Public Safety Decree (BEVI). The BRZO focuses on the management of hazardous installations. The BEVI instead regards the regulation of land-uses around hazardous installations, i.e. the external safety regulation. Spatial decisions related to the adaptations, elaborations, modifications, dispensations and revisions of land-use allocation plans within the sphere of influence of a hazardous establishment fall under the BEVI. The Dutch external safety's methodological approach is extensively described in literature (Ale, 2002; Bottelberghs, 2000). Relevant aspects of the current risk prevention policy which have a direct reflection on the elaboration of geographical risk-information are:

- The adopted quantitative approach to risk assessment, resulting from the estimation of both magnitude and expected frequency of accidental events.

- The definition of individual risk as the chance, for an individual permanently located in the vicinity of a dangerous site, to die as a direct consequence of an accident involving Seveso II substances. Legally binding endpoints apply.
- The classification of vulnerable objects into two classes. The first groups accounts hospitals, schools, and residential areas; for these objects, a risk tolerability threshold of 10^{-6} event/ year applies. The second group accounts less vulnerable objects as industrial zones, office buildings or recreational facilities For these facilities, a tolerability threshold of 10^{-5} event/ year applies.
- The definition of societal risk (SR) as the chance, for a number of people > N, to die as a direct consequence of their presence in the vicinity of a dangerous facility in which an accident occurs; non-binding tolerability endpoints apply. The acceptability criteria for an accident are 100 times stricter for every expected tenfold in number of victim (i.e., the acceptability of a disaster with 10 lethal victims is set on 10^{-5} event / year, for a disaster with 100 lethal victims 10^{-7} event / year, etc.).

The legislation was recently updated. The configuration of the Dutch territory has to fulfil the endpoint reported in point c by the end of 2010.

Risk and LUP: the Dutch decision-making process

While the Dutch external safety methodological approach is extensively described in literature, its connection with the Dutch territorial management practice called for a direct survey. In the Netherlands, the spatial planning system involves three levels: the national, the provincial and the municipal levels. As in the majority of European planning systems, the government establishes principles for spatial planning, defines building regulations and set-up long-term objectives for relevant urban and environmental issues (Van der Valk, 2002). All three tiers of government have independent planning powers, although the consistency requirement stated in the Dutch Spatial Planning Act has to be respected. The interaction between the tiers of government is characterized by consensus building and mutual adjustment. Hierarchical relations are rarely activated (Faludi & Van der Valk, 1994).

This multi-level governance system is reflected in the supervision of hazardous installations by the side of different authorities. The Ministry of Housing, Spatial Planning and the Environment (VROM) is competent for facilities of national interest, such as nuclear power plants (NPP) and nuclear waste disposal. Dangerous establishments falling under the Seveso II requirements are classified in accordance to threshold values considering the quantity of stored/treated dangerous substances. According to their classification, top-tier Seveso plants fall under the provincial competence and, in case of lower-tier plants and small LPG storages, under the municipal competence. Operators whose facility falls under the Seveso Directive are responsible of the elaboration of a quantitative risk assessment (QRA). The supervising authority checks the validity of the analysis, and it is responsible for acquiring and updating all the information which are necessary to assess the compliance of the installation with the operational, spatial and environmental legal requirements.

The described organization in the acquisition and validation of risk-related information responds to a multi-level system, which reflects the institutional decentralization of the Country. Because of this decentralization, until recent developments in the risk-information system, geographical and industrial data of plants were spread out over numerous authorities. As a reaction to the *Commissie Onderzoek Vuurwerkramp's* report (Commissie Onderzoek Vuurwerkramp, 2001), appointed after the accident of Enschede occurred in 2000, a national scale overview of the risk posed by Seveso establishments had to be created. Furthermore, the Seveso II Directive obligation of reporting major accident events to the European Commission Major Accidents Reporting System (MARS) (Joint Research Centre, 20006) posed the problem of centralizing the information relative to accidents. Finally, the need of informing the public had to find a translation into a systematic elaboration and delivery of geographical risk-information. The most relevant initiatives in this respect were the development of the Installations Handling Dangerous Substances Database, managed by the Netherlands National Institute for Public Health and the Environment (RIVM), and the development of GIS-based risk maps ('*risicokaart'*), which realization falls under the provincial responsibility. They are both described in the following section.

Elaboration and representation of major accident risk information

With the development of the Installations Handling Dangerous Substances Database the authority responsible for granting the environmental license to the operator of a given hazardous installations is obliged to forward all relevant information to the database. The authority responsible for granting the license is the owner of the data and it is responsible for their validity. Next to the development of the national database, the issue of delivering risk-information to different authorities and citizens in an easy-reading was addressed. As well known, the individual risk estimation is visualized as a set of concentric areas, representing different effect levels, which origin stands at the emission point of the accident. Effects are experimentally deducted. For each scenario, the probability of its likelihood is calculated; a representative scenario is therefore selected for formulating the planning advice (Ale, 2002; Bottelberghs, 2000). The vulnerability of the involved urban and environmental elements is classified accordingly to vulnerable categories (high, medium, low). Standing to this approach, the visualization of the risk connected to an accident results from the overlap between the selected accidental event, its iso-risk contours and the specific territorial context. Digital risk-maps reporting this overlap are therefore an obvious, although recent, operational development.

For this purpose, risk-maps are developing under the provincial responsibility. The national Installations Handling Dangerous Substances Database is used as informative source together with the ISOR (*Informatie Systeem Overige Ramptypen)* database. ISOR is the result of the cooperation between the twelve Dutch provinces, in which additional risk information such as flood risks and vulnerable objects are collected. Data in this database is owned by municipalities. Thanks to these developments, previously spread out risk information are converging towards national, multi-accessible d-bases.

Provincial risk-maps are realized on a GIS platform. The variety and quantity of reported information is notable and comprise the localization of plants, the amount and nature of substances stored/treated, iso-risk contours and the emergency planning in the area. A recent model plotting societal risks on digital maps was developed by the Dutch Applied Research Institute TNO (Wiersma *et al.*, 2005). A foreseeable evolution of risk-maps is therefore the incorporation of the societal risk contours. At present, individual risk contours are suitable to inform the development of spatial plans, building development plans and single planning permission. Furthermore, a version of risk-maps is used to inform the public and it is available via the Internet. This is discussed in the next section.

Accessing risk-maps: status of the information

In the Netherlands, besides to inform competent authorities, risk-maps have been developed as a tool to inform the public about the risk in their living environment. In accordance with the obligation of informing the citizens about the risk of major accidents stated in the Seveso Directive, risk-maps are accessible via the Internet. The amount of reported information is notable. Citizens can access information about the location of hazardous installations, the hazardous substances that are used or produced, risks related to transport and the vulnerable objects in the area. The understanding of this information is supported by a detailed legend. Other kind of risks like panic in crowd and main aircraft routes are illustrated. Risk-maps do not allow any elaboration of the information and serve only for illustrative purposes;

nevertheless, users can select different layers with the information of interest and visualizing more or less accurate data. Examples can be found on www.risicokaart.nl (last visited: September 2006). The Province of Limburg risk-map is reported in Figure 3-1 and Figure 3-2.

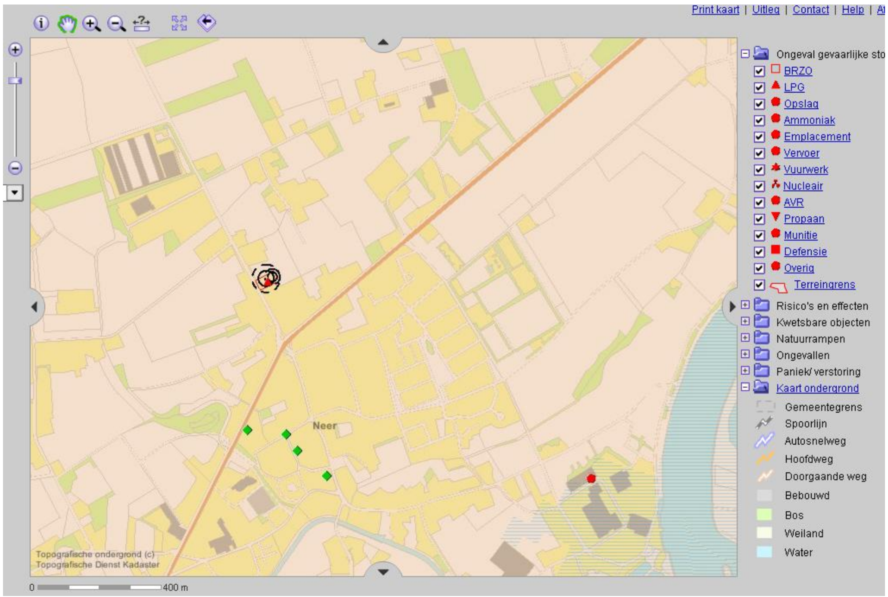

Figure 3-1. Risk-map of the Province of Limburg: general overview of the area

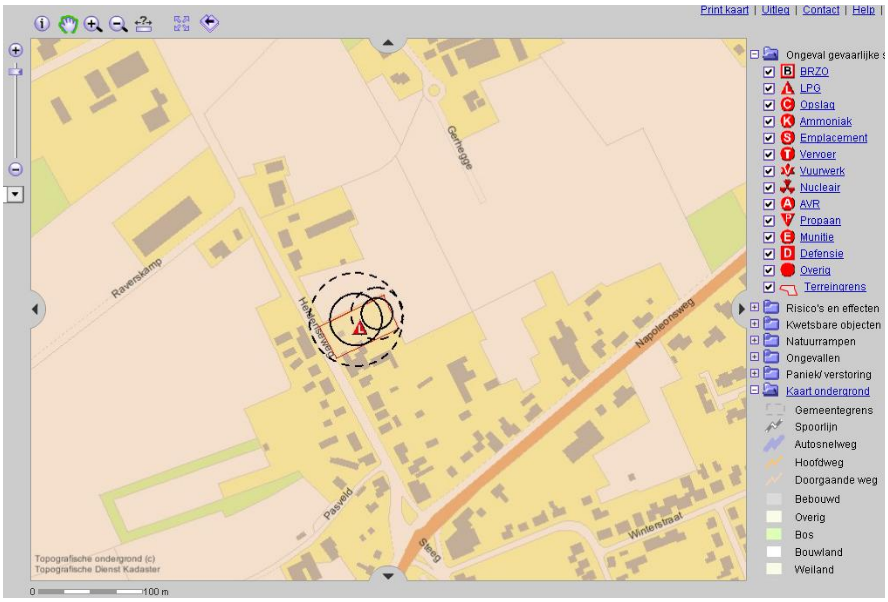

Figure 3-2. Risk-map of the Province of Limburg: the plant

Until the end of 2005, iso-risk contours were also reported in the provincial web-site and had a prominent communicative relevance. Strong of its information accessibility tradition, the underlying intention of the Dutch government was delivering easy-reading geographical information to the public and complying, in so doing, with the Seveso II requirements (VROM Inspectie, 2005). Interestingly, although the accessibility of risk-information was responding to a requisite of transparency, a conflict with the increased European security requirements followed. The European communication of 2004 regarding the protection of critical infrastructures in the fight against terrorism underlined how all those "(…) physical and information technology facilities, networks, services and assets which, if disrupted or destroyed, would have a serious impact on the health, safety, security or economic well-being of citizens or the effective functioning of governments in the Member States (…)" should be carefully monitored and protected (Commission of the European Communities, 2004). The European Communication stressed the need of enhancing the elaboration and the exchange of information relative to critical infrastructures threats among public and private actors. Above all, it stressed the need of increasing the discretion in their dissemination. Being Seveso chemical plants responding to the definition of physical critical infrastructure, a conflict between the accessibility of risk-information and the security of the population had to be considered.

This discussion opens an interesting reflection about the so-called "citizens' right to know" (Gouldson, 2004). Generally, the access to environmental information related to industrial performance enhances a more transparent participation of institutional, industrial and non-institutional parties into decision making processes. Notwithstanding, in the case or risk-information, the same information access may result in a security threat. Once published on the Internet in fact, risk-information is accessible by uncontrollable users. The possibility of quantifying the amounts of safety increase and security loss is an interesting, although irresolvable, topic, which led to a political debate within the Dutch government. The debate led to the cancellation of iso-risk contours from the risk-maps delivered on the internet, as proposed by the cabinet on September the 9th 2005, on the base of the assumption that "[…] currently, security is more important than indefinite access to public government information […]" (Ministerraad, 2005). Interestingly, initially Dutch provinces refused to deny the access to iso-risk contours via the Internet. Their motivation was based on the assumption that accessing risk-information played a role in the improvement of citizens' coping-capacity, and that the adopted risk information policy was in line with the citizens 'right to know'. Nevertheless, after January 1st 2006 iso-risk contours were cancelled from the web and currently the consultation of risk contours by the side of citizens is subject to a specific procedure. This paper reports only general reflections about this controversial issue in the conclusions.

3.4. Land-use planning and major accidents risk in the UK

Risk assessment method and risk tolerability definition

In the United Kingdom, the Seveso II Directive is implemented in several regulations. With respect to the licensing procedure and prescribed risk assessment methods, legal references are the Notification of Installation Handling Hazardous Substances Regulations (NIHHS) and/or the Control of Industrial Major Accidents Hazard Regulation (CIMAH) 1999. Land use planning in the surroundings of chemical sites is regulated by the Planning (Hazardous Substances) Act 1990 and the Planning (Hazardous Substances) Regulations 1992, as amended by The Planning (Control of Major-Accident Hazards) Regulations 1999.

The competent authority for safety-concerned issues is the Health and Safety Executive (HSE). HSE risk assessment method is extensively described in literature (HSE, 1989; Pape, 1989). The Hazardous Installation Directorate (HID) of HSE has developed a judgmental approach to risk assessment. The proportionality principle and an approach to risk estimation that varies depending on the different types of accidental scenarios apply. Although probabilistic in principle, a consequence-oriented approach is usually used to assess accidental scenarios involving the release of flammable liquid to which the risk of fires or explosions is associated. When performing the planning advice, these scenarios are object of a consequence-oriented estimation. Notably, risk assessment is based on the maximum quantity of substance each establishment is allowed to store. This leads to a conservative and precautionary evaluation of safety distances. After the characterization of the accidental scenarios associated to a specific plant is concluded, the one more relevant to perform the LUP advice is selected. As the “risk profile” of a plant usually sees the predominance of a single scenario, LUP evaluations are based on it (HSE, 2004). Concluding, the aspects of HSE risk regulation relevant to land use planning are:

- the ALARP/ALARA principle, which origin can be retraced in the common-law orientation of the UK legal system (Ale, 2005b).

- the quantitative approach to risk assessment, using both the risk-oriented (in case of toxic release) and the consequence-oriented (in case of thermal radiation and explosions) methods for the definition of "consultation-distances" around plants.
- the definition of individual risk (IR), in the first case, as the probability to receive at least a dangerous dose (DD) and, in the second approach, to receive a prescribed thermal dose unit (without any probabilistic judgment) Account is taken of those local circumstances (such as the prevailing wind direction) that are relevant to estimating the area the hazard will affect.
- the definition of societal risk as the integration of the IR judgment with population data.
- the definition of four sensitivity levels for territorial and human targets, supporting the classification of a given area in terms of its specific vulnerability.

The HSE is responsible for the definition of each dangerous installation, of the so-called "consulting-distance", reporting the three inner, middle and outer iso-risk contours. Within this area, the consultation of the agency for planning purposes is mandatory.

Risk and LUP: the UK decision-making process

Differently than the Netherlands, the UK has a strongly centralized safety authority, which is the Health and Safety Executive and, in Northern Ireland, the Health and Safety Executive of Northern Ireland. The Hazardous Installation Directorate (HID) of HSE is competent for all hazardous installations in the Country and it is involved in planning processes regarding chemical installations, pipelines and explosive facilities. The role of HSE is twofold: on the one hand, it advices Local Planning Agencies (LPAs) on the Hazardous Substances Consent (i.e. installation and/or modification of Seveso II plants), while on the other hand it gives advice on the compatibility of proposed territorial developments within pre-existing dangerous areas. This second advice is carried out by personnel of the local offices of the HID Directorate and it is supported by a codified system known as PADHI (Planning Advice for Developments near Hazardous Installations), a software that came into force in 2002 in order to facilitate and speed the advising process. PADHI leads to the outputs "ADVICE AGAINST" or "DON'T ADVICE AGAINST" on the base of both risk analysis data (scenarios, risk contours and/or effects areas) and territorial data (type of targets, proposed developments' sensitivity level, population data) (HSE, 2005a).

Notably, the HID has no enforcement power: it is entirely under the responsibility of Planning Agencies, which are competent for local land-use plans as well as for granting the license to plants' operators, whether to implement the advice stemming from the PADHI procedure. This advisory role of HSE with respect to planning authorities reflects the nature of UK health & safety system, based on a great autonomy of Local authorities on the one hand, and on an efficient cooperation among different governmental agencies on the other hand. Standing to this configuration of the decisional process in fact, the two phases of risk assessment and risk reduction are clearly distinguished: LUP decisions may, theoretically, exceed the safety advice both towards a major than a minor safety level. Practically, HSE advices are followed in the large majority of cases and are implemented by LPAs in the almost totality of land-use plans.

The HSE advice is delivered to LPAs in form of risk-map, where the three inner, middle and outer iso-risk or iso-harm areas are represented on the relative cartographic base. As in the Netherlands, both the individual and the societal risk are LUP criteria. Differently, the societal risk is not numerically assessed and compared with numerical risk criteria. The concept refers to general high-density populated areas and/or specific vulnerable targets (hospitals, schools, elderly, children, etc), which presence has to be considered in order to integrate the judgment resulting from the individual risk criteria. Hence, SR assessment is an integration of the individual risk estimation with population data. Interestingly, this approach to the definition of "societal risk" for modelling major accident scenarios involves a major attention for the vulnerability of the population of a given area. In the UK, this resulted in the development of a national database mapping, using a GIS technology, the population distribution with a specific reference to different vulnerability levels. Its development was commissioned by the Methodology and Standards Development Unit (MSDU) of the HSE in 2002 (Smith *et al.*, 2005). Focusing on the distribution and characteristics of the population of given areas, it aimed at developing the potential for a GIS system to be used to provide data on the targets at risk from hazardous events. Owned and managed by HSE, no direct public access is allowed. Therefore, in comparison to the Netherlands, the UK risk assessment method, the adopted LUP criteria and the societal risk definition led to the development of a remarkably different risk-informative system, in which it is particularly evident a different risk-maps elaboration and accessibility. These aspects are discussed in the following section.

Informing LUP process: the role of GIS risk-maps

In the light of the essential role of HSE in the UK land-use planning processes, a review of its method was initiated in 1998 (HSE, 2005b). The review aimed at clarifying whether HSE role and methods were still valid, robust and in line with broader governmental policies for land development. Being the HSE advice still based on the document *Risk Criteria for Land Use Planning in the vicinity of Major Industrial Hazards* of 1989 (HSE, 1989), verifying eventual bottlenecks in the system was advisable. One of the outcomes of the review was the proposal of developing a modified version of PADHI enabling LPAs to carry out risk-related LUP assessments independently. The project has been carried out by the Geographical Information Systems (GIS) team of the Risk Assessment Section of HSL (Balmforth, 2005). Within the project, a scoping study involving volunteer LPAs and addressed to explore the format of the HSE advice that could have replaced the ordinary paper format was carried out and published in 2005. Results outlined that a GIS format for risk-maps (called, in the document, “3 zone map”) was preferred by LPAs, as they would have had the opportunity of updating their existing database with compatible format data.

The need of facilitating the consultation procedure via GIS-based advices stemmed from the relative frequent update of HSE risk-maps. Each time HSE assessment involves some changes in the risk contours or new developments in the vicinity of installations are promoted, new risk-maps are to be forwarded to LPAs. Hence, evolving to a GIS format represented a natural step of the advice procedure. Other findings of the scoping study were the preference, by the side of LPAs, of the representation of the three-zones in three different GIS layers instead on one layer with three different zones, in order to allow the switch off of different harm/risk areas when desired. Notably, with the came into force of the National Population Database in 2005, an overlap between the three-zones risk-maps and the geographical sensitivity population data is been made possible, enhancing the visualization of all the information relevant to define appropriate land-uses.

Status and accessibility of risk-information

Differently than in other European countries, the increased security needs deriving from (the threat of) terrorist attacks found in the United Kingdom a prompt translation in limited accessibility to risk-related information. Concerning the specific case of risk-maps, a first remarkable point is that they do not contain neither any reference regarding the substance treated/stored within the plant nor a pinpoint regarding the areas of plants where substances are stored. Maps as the one showed in Figure 3-3 report only the three-zones of iso-risk or hazard and the name and address of the hazardous site. Risk-maps are not directly accessible via the Internet although they can be consulted by the citizens upon request. This can be obtained applying both to the HSE and LPAs. In this second case, a procedure concerning the motivations for which subjects want to access risk-maps may be in place. As a result of the IFRLUP project, during the course of 2006 HSE's risk-maps will be stored on a secure electronic server, accessible by LPAs by setting up a user profile. Citizens will not be granted access to this "map library" but they will still be able to access them via specific request.

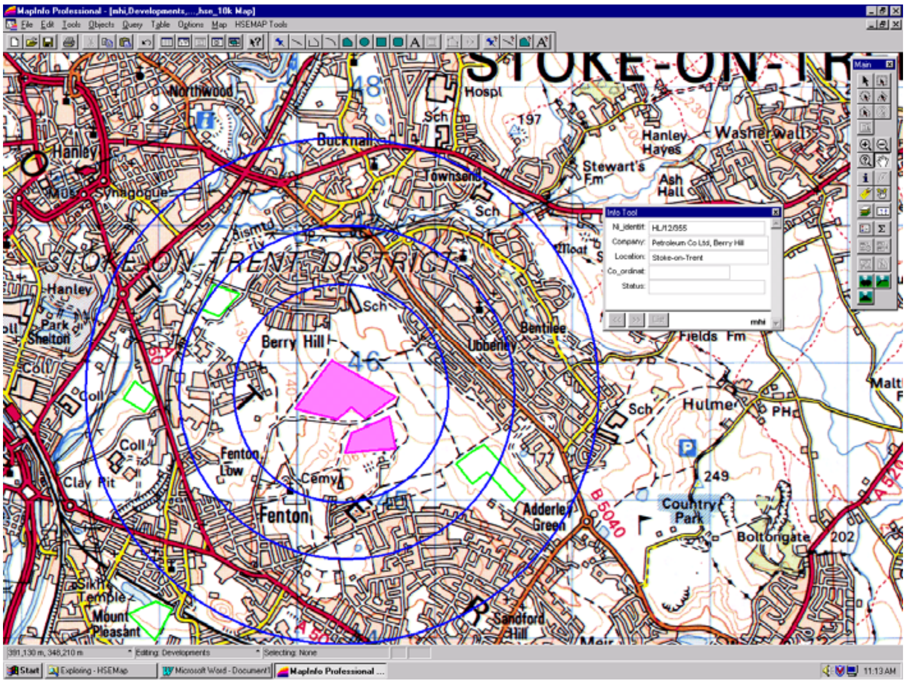

Figure 3-3. Example of a hypothetical three-zone risk-map realized in ArcGIS format, representing the case of a toxic substance for which 3 effects areas with different frequencies values are estimated

3.5. Conclusions and discussion

In both the examined countries, the potential of geographically based risk-informative systems to represent major risks at national scale is evident. Furthermore, the suitability of shared d-base to connect different institutional actors during decision making processes is of outstanding evidence. In both countries, risk-maps are becoming more central to local risk-prevention practices and GIS databases storing the enormous amount of data regarding the national risk situation came recently into force. Although differences in the two risk regulations led to the development of different forms of cooperation among the several competent authorities, a good connection between the operational competences of Safety and Planning Authorities seems to be achieved.

A notable difference between the two examined countries regards the possibility of accessing risk-maps by the side of the public. In the Netherlands, a notable amount of risk information is available for the public via the Internet. In the UK, although the transparency of decisional processes is guaranteed by the public status of the information, risk-maps can be gathered by the public after a specific request.

This remarkable difference cannot be explained in a univocal way. A first explanation might be a different interpretation of the threat represented by the availability of information regarding the existence and localization of chemical sites in the national territories. Evidently, a different estimation of deriving risks and a different priority assigned to the accessibility of information ground the choice of limiting or allowing the access to risk-maps by the side of public. In this perspective, a different interpretation of the precautionary principle (PP) can be brought into the discussion. As well known, there is no univocal interpretation of the PP and the debate about its feasible use within the technological risk prevention domain is still lively. In the Dutch case, where the delivery of risk information might lead to an uncontrollable (and not estimable) decrease of security, a more precautionary approach seems to be in conflict with the transparency informing the planning policy. In the UK instead, a major concern regards the confidentiality of industrial information and the protection of the population from the threat of terrorism; consequently, a precautionary approach applies. Both choices have a consequence in the balance between security and transparency. In the Dutch case, the balance hangs for transparency, with a governmental exposure in terms of responsibility for the exposed citizens. In the United Kingdom instead, the ‘right to know’ of citizens is not interpreted as a passive delivery of risk-information, as the balance hangs for security. Which role, then, for the precautionary principle as a needle of the balance? This question opens to interesting research developments. Generally, the authors believe that the two national orientations are responding to historical heritages and cultural backgrounds.

In the UK, terrorism has been a serious threat during the past three decades, until the recent terrorist attack of Al Qa’ida in 2005. Combined with the traditional confidential attitude of the UK culture, it is not surprising that information which is potentially subject to misuse is carefully protected. Differently, in the recent Dutch history terrorist attacks have been of scarce impact. The risk-regulation policy development shows that the attention given to inform the public lies in the long history of accidental events occurred within densely urbanized areas. In a Country with a population density of 450 inhabitants per km^2 (Ale 2005), which is affected by the prior and constant risk of flood, the full awareness concerning major risks is a key factor of prevention. This explains, at least in part, the tendency of facilitating the access to risk information. In this respect, the choice of binding part of it seems reasonable, as it balances safety and security needs without altering the Dutch political tradition.

In conclusion, the creation of national risk-informative systems on a geographical information platform to enhance the cooperation between authorities and stakeholders seems to be the advisable frontier of European risk prevention practices. Nevertheless, the investigation confirmed that different developments and applications of these instruments are grounded, again, on the political, cultural and historical contexts in which they are created.

Acknowledgments

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4

The Consideration of Emergency Management Issues in Spatial Planning Practices*

Abstract
In the Netherlands, the possibilities for emergency preparation and response should be explicitly addressed when considering land development in the vicinity of hazardous installations or transport routes for hazardous materials. For this reason, regional fire departments provide local planning authorities with safety recommendations regarding the consideration of emergency management issues in their land allocation plans. This paper examines the implementation of these recommendations. We found that possibilities for emergency response could be increased through spatial planning. Therefore, the collaboration between planners and emergency responders in general should be considered. In this respect, the safety recommendations examined in this paper can be regarded as a promising way of organising this collaboration. The communicative character of the safety advice process fits in well with the more general communicative and collaborative approaches to planning. For these reasons, the experiences with the safety recommendations in the Netherlands can also be relevant for other countries.

Keywords: emergency management, industrial hazards, societal risks, spatial planning

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4.1. Introduction

Spatial planning can play an important role in increasing the safety of citizens in industrial areas. Within many European Member States, spatial planning is already used as an instrument to implement safety distances around hazardous installations (Cozzani *et al.*, 2006). These safety distances reduce the exposure of people and property to industrial hazards. The strategic spatial plans and, in particular, the operational land-use plans and building codes resulting from spatial planning processes can also be used as instruments to require the adaptation of buildings in the vicinity of industrial activities. Stronger walls and windows, for example, can protect inhabitants in case of an explosion. Furthermore, the planning process offers the actors involved the opportunity for dialogue, allowing safety issues to be addressed and opportunities for reducing risks to be identified (Walker, 2000). Consequently, many pre-disaster studies have highlighted the fact that a further consideration of safety risk issues in planning is desirable to reduce safety risks (Ale, 2005a; Caragliano & Manca, 2007; Cruz *et al.*, 2006).

In addition to spatial planning, emergency preparation can contribute to the safety of citizens. Preparation includes activities and measures taken in advance to ensure an effective emergency response, such as enhancing emergency capacities by developing a contingency plan or providing training for response activities like evacuation or medical care (Godschalk, 1991).

Whereas strategic and operational spatial planning both focus strongly on influencing the physical characteristics of an area, such as the location of urban development or safety measures for construction projects, emergency preparation focuses mainly on organisational aspects, such as coordination, communication or logistics during emergency response (Caragliano & Manca, 2007). Nevertheless, spatial planning and emergency management activities are interrelated. The physical characteristics of an area greatly influence the possibilities for emergency response. Moreover, emergency response may require specific physical measures. The presence of access routes or a considerable amount of water for fire extinguishing, for example, can increase the possibilities for emergency response. However, limited possibilities for emergency response in an area can be a reason to search for alternative development locations or additional physical measures, such as improving emergency access, for example. For these reasons, collaborative thinking and acting, involving spatial planners as well as emergency managers, can increase the safety of citizens and increase the coherence of safety measures. Nevertheless, little research has been done that explicitly looks at the way emergency management issues, including emergency preparation and response concerns, are addressed in pre-disaster spatial planning practices. Therefore, in this paper we examine the consideration of emergency management issues in spatial planning practices in more detail. The central research question is: how are emergency management concerns addressed and implemented in spatial planning practices?

The findings presented in this paper are based on case study research in the Netherlands. Our aim is to understand how emergency management concerns related to industrial hazards are addressed and implemented in spatial planning practices. We focus on the so-called societal risks, which are addressed in the safety recommendations from the regional fire departments. Since these safety recommendations can be regarded as a central instrument for the consideration of emergency management issues in spatial planning, the central research question will be answered by assessing the content and implementation of these safety recommendations. We will start with an overview of Dutch policies on industrial risks and spatial planning, followed by a description of our conceptual framework and our case study approach. We will then present our research findings. We first examine the content and implementation of the safety recommendations, paying attention to the role and usefulness of these recommendations. Then, in the concluding section, we reflect on these findings and draw more general conclusions about the integration of spatial planning and emergency management.

4.2 Dutch policies on industrial risks and spatial planning

Article 12 of the European Seveso II Directive on dangerous substances (96/82/EC) requires Member States – in their land-use planning policies – to consider the need for defining opportune safety distances between dangerous establishments and urban, natural and infrastructural developments. In the Netherlands, the Seveso II Directive is implemented through the Dutch Major Hazards Decree (*Besluit risico's zware ongevallen* – Brzo, 1999) and the Dutch Public Safety Decree (*Besluit externe veiligheid inrichtingen* – Bevi, 2004). The Brzo focuses on the management of hazardous installations. The Bevi concerns the regulation of land use in the vicinity of hazardous installations, i.e. the external safety regulations. Therefore, this section focuses on the Bevi.

In the Netherlands, land-use regulations in the vicinity of hazardous industrial activities, such as the production of ammonia, storage of fireworks, transport of chlorine or use of airports, are explicitly risk based. Risks are quantified in terms of probabilities and effects, and are expressed as individual risk (IR) and societal risk (SR). National acceptability criteria for IR and SR, among other considerations, should be used to guide land use in the vicinity of hazardous activities.

Individual risk (IR) is defined as the probability that a person permanently residing at a location in the vicinity of a hazardous activity will be killed due to an accident involving that activity (Ale, 2002; Bottelberghs, 2000). In the criteria for IR, a distinction is made between vulnerable and less vulnerable objects. Vulnerable objects include residential areas, hospitals and schools. For these objects, the legally determined criterion is 10^{-6}. In other words, the statistical probability that a person permanently residing at a particular location will be killed due to an incident with the hazardous activity should not be greater than 1 in 1 million, or 0.0001% per year. For less vulnerable objects such as office buildings, hotels, restaurants, shops, recreation facilities and so forth, the IR criterion is 10^{-5}, i.e. a probability of 1/100,000 per year (VROM, 2005). Individual risks can be mapped out by connecting points of equal IR around a facility, creating risk contours as applied in different EU Member States (see for example Basta *et al.*, 2007). Based on the IR criteria, these contours can be converted into safety distances, which are legally binding and must be implemented in local land allocation plans. An example of IR contours is shown in Figure 4-1.

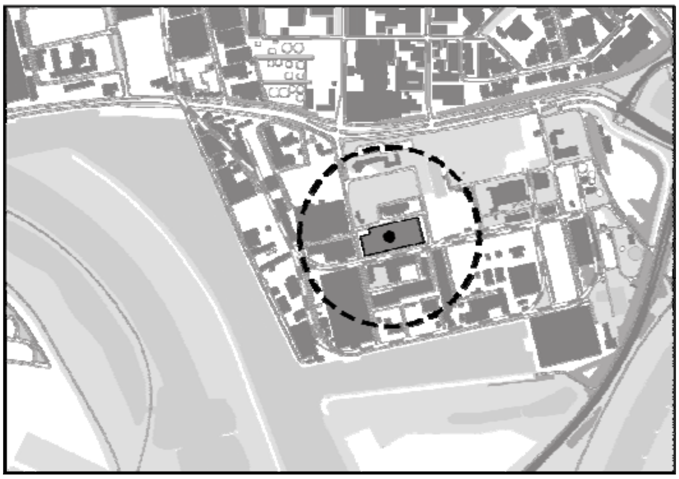

Figure 4-1. IR contours for a fictitious hazardous installation

Societal risk (SR) is defined as the probability that more than a certain number of people will be killed in an accident (Ale, 2002; Bottelberghs, 2000). Figure 4-2 shows a graph, referred to as an FN graph, which displays the cumulative frequency (F) of more than N fatalities. The two diagonal lines represent the orientation values for SR for installations and transportation risks, respectively. The FN graph for hazardous installations illustrates that the acceptability of a disaster with 10 fatalities is set at 10^{-5} per year, and at 10^{-7} per year for a potential disaster with 100 fatalities. In other words: the statistical probability of an accident with an installation resulting in 100 fatalities is acceptable if the statistical probability of such an accident is lower than once in 10 million years or 0.00001%. As shown in Figure 4-2, the SR criteria become 100 times stricter for every expected tenfold increase in the number of victims.

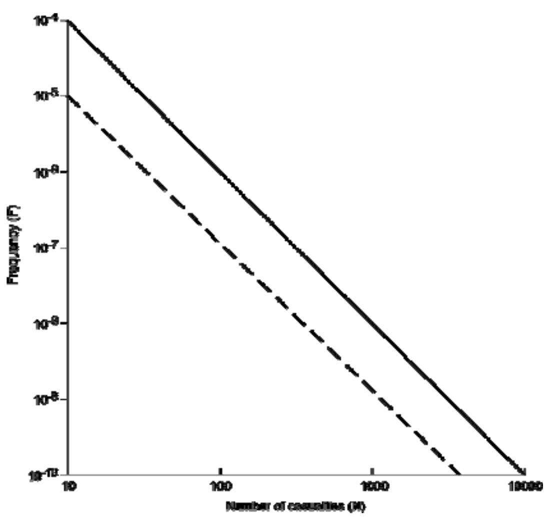

Figure 4-2. FN-curve representing the SR criteria for hazardous establishments (broken line) and the transport of hazardous materials (continuous line)

In contrast to the IR criteria, the SR criteria are not legally binding. They can be regarded as orientation values for spatial planners, amongst others, and show which societal risks are regarded as acceptable in Dutch external safety policies. Consequently, there is room for interpretation, and planning authorities must explain how they take account of the SR in their spatial plans. While the procedures for addressing the SR require special attention for emergency management issues, the discussion generally concentrates on how these issues are dealt with. The remainder of this paper will therefore focus on the SR and on the consideration of emergency management issues to reduce risks.

The procedures for the consideration of SR issues are described in the Bevi. According to the Bevi, the following aspects should be addressed if land development is proposed that can affect the SR within an area (VROM, 2004):

- The existing and new objects (vulnerable and less vulnerable) and people in the sphere of influence of a hazardous activity. The sphere of influence can be described as the area in which, in a specific accident scenario, at least 1% of the people would be killed.
- The SR within the area.
- The contribution of the hazardous activity to the SR.
- The possibilities and intended measures for reducing the SR.
- The advantages and disadvantages of alternatives for spatial development, e.g. development at other locations.
- The possibilities for emergency response and emergency preparation.
- The possibilities for people to save themselves in case of an accident, referred to as self-help.

The Bevi also stipulates that the regional fire department must be consulted about the safety consequences if the SR can be affected by proposed developments or spatial plans. The objectives of the safety recommendations from the regional fire department (NVBR, 2005) are the following:

- to provide insight into the external safety risks and the possibilities for emergency management and self-help;
- to suggest potential measures to reduce external safety risks and especially to increase the capacities for emergency response and self-help, and
- to make land-use authorities more aware of the residual risks in case the proposed spatial developments are implemented.

The regional fire department needs to be consulted if land developments are proposed near installations that fall under the Seveso II Directive. Nevertheless, the fire department should also be consulted if the SR is affected through developments near hazardous installations that do not fall under this directive, such as relatively small installations. This consultation should increase the attention for external safety risks in spatial planning practices. Therefore, we assume that safety recommendations have the potential to contribute to risk reduction. But municipalities also have discretionary freedom in implementing suggested measures to reduce SR, because the SR criteria are not legally binding. In this light, we will examine how the safety measures to reduce SR, as addressed in the safety recommendations, are implemented.

It should be noted, however, that the regional fire department is not the only organisation that advises a municipality on societal risks. At the local level, the planning department can also be advised by the local fire department. But this department is mainly involved in providing advice about building applications and regulations and is less involved in external safety policies. At the regional and national levels, guidelines on external safety can be given by the national government and the provinces. It goes without saying that these guidelines also apply to the regional fire department. Our research therefore focused on the safety recommendations of this department, as it is the main municipal advisor on issues related to the possibilities for emergency management and self-help.

4.3. Conceptual framework

The use of safety recommendations can be analysed from both a conformance and performance perspective. Conformance studies strongly focus on decision-making outcomes in the light of the objective of the policy instrument itself (Faludi & Van der Valk, 1994; Hopkins, 2001; Mastop & Faludi, 1997). However, classic conformance studies have been criticised for not providing insight into what produced conformance (De Lange, 1995; Hopkins, 2001). In addition, some spatial planning researchers have argued that an evaluation should also consider the way a plan, an instrument or a policy was used in the decision-making process and how this helped the community reach outcomes. This view is referred to as a performance view. Mastop and Faludi (1997), for example, emphasised the importance of evaluating the contribution of a plan or instrument to the decision-making process in general. The prime concern should not be whether a plan or recommendation is followed, but whether the plan or instrument plays a role in the decision-making process. As a result, the planning process itself becomes the object of evaluation instead of the planning outcome.

Several factors can influence conformance and performance. Evaluations of the Environmental Impact Assessment, for example, showed that a combination of cooperative and coercive strategies can positively influence the conformance and performance of environmental recommendations. Cooperative mechanisms such as dialogues can stimulate the exchange of tacit knowledge and can result in trust-building between actors. These ideas fit into collaborative and communicative planning approaches (see for example Healey, 2006; Healey *et al.*, 1999; Needham, 2007). Within such collaborative planning approaches, great importance is attached to intersubjective communication and to the quality of this communication. It is preferable that important interests that might be affected by a particular plan are brought up for discussion, and that the individuals representing these interests take part freely, equally and without coercion in a cooperative search for the better argument (Booher & Innes, 2002; Innes, 1998). Coercive activities, such as the application of rules and regulations, can serve as a safety net for crucial issues that cannot be guaranteed by communication and collaboration alone (Van Dijk, 2008). However, an instrument that is too strict or rigid can result in actors focusing on avoiding sanctions instead of on establishing safety interests. Consequently, finding a balance between coercive and cooperative mechanisms remains essential.

Research on hazard management at the local level has led to similar findings (Burby, 1998; Burby & May, 1997; May *et al.*, 1996). However, these studies also emphasised the influence of commitment of public bodies to hazard mitigation. Commitment to hazard mitigation positively influences conformance and performance of hazard mitigation instruments. Besides the coercive and communicative strategies of government actors, this commitment was also influenced by psychological factors, trade-offs between other interests, public commitment and capacities of local authorities (Deyle *et al.*, 2008; Deyle *et al.*, 1998; Godschalk *et al.*, 1999; May & Deyle, 1998; May *et al.*, 1996; Mileti, 1999; Olshansky & Kartez, 1998; White & Richards, 2007). Table 4-1 gives an overview of these factors, together with examples for each factor. A distinction can be made in Table 4-1 between factors that mainly influence the explicit consideration of safety measures and factors that mainly influence the implementation of measures. Government strategies and policies and psychological factors, for example, mainly influence the consideration of measures, whereas trade-offs and public commitment mainly influence the actual implementation of measures in society. Nevertheless, the relative importance of the factors mentioned in the table may differ. For example, Olshansky and Kartez (1998) emphasised that local governments that planned for hazard mitigation had adequate staff, while May et al. (1996) concluded that the capacity of local governments was not a crucial factor that constrained the commitment of the authorities they studied. This table will be used to understand the conformance and performance of safety recommendations that were found, as discussed in the following section.

Table 4-1. Factors that influence commitment

Factors that influence commitment
Government policies and strategies • The lack of an overarching central policy, with clear and realistic guidelines, that gives high priority to land-use provisions for governing land use and development in flood prone areas • The absence of strong monitoring and enforcement policies (such as coercive mandates and sanctions) for local governments which do not address flood risk issues in spatial planning • The lack of policies to stimulate commitment • The presence of other policies that indirectly encourage development in hazardous areas, such as insurance systems, the construction of dikes or the improvement of infrastructure in flood-prone areas, which may limit opportunities for local governments to apply land-use management tools • Lack of technical and other forms of assistance to local governments, such as financial assistance
Psychological factors • The lack of experience with floods, which often reduces the sense of urgency for flood mitigation measures • The perceived remoteness in time of low-probability hazards, which leads to sharp discounting of the benefits of avoided costs • The implementation of recurrence intervals, such as the 100-year flood zone, may result in a perception of absolute boundaries between hazardous and non-hazardous areas
Trade-offs between other interests • The allocation of resources to natural hazards has limited visible rewards • Many flood-prone areas are already fully built up, and remedial actions are costly to implement • Hazard prone areas are often very valuable locations, e.g. through ocean view or access to water and water-based transport, and are attractive for urban development • Land-use regulations in flood prone areas may lead to urban developments elsewhere, which can be undesirable for other reasons such as nature conservation or accessibility
Public commitment • The lack of public recognition of flood risks due to the lack of experience with floods • The lack of public participation in decision-making • Active opposition by other interests such as real estate and property development interests and entitlements based on previous local development plans and measures • Existing rights such as property rights and the right of development may be much stronger, and therefore it may be difficult to limit development in hazardous areas

Capacities of local authorities

- Lack of staff, expertise and resources on hazard mitigation issues
- Lack of clear and authoritative risk maps and risk information
- There is no hazard-free land available for development, e.g. through other regulation policies such as nature conservation
- There is little spatial contrast in levels of hazards, thus it is difficult to define meaningful boundaries between hazardous and non-hazardous areas

4.4. Case study approach

Our findings are based on an examination of specific practices or cases. Case studies can provide an in-depth understanding of specific social phenomena (Yin, 2005). In addition, they can provide context-dependent knowledge, which is crucial for understanding phenomena that cannot be understood by 'general rules' (Flyvbjerg, 2001). Consequently, case studies are regarded as especially suitable for answering 'how' and 'why' questions (Gray, 2004). A case study approach was therefore used in our study.

Dutch emergency management services are organised regionally. The Netherlands is divided into 25 safety regions, each of which is responsible for emergency response. Each safety region (which includes several municipalities) consists of a police department, fire department, and medical and paramedical services. Our examination of the implementation of safety recommendations focused on two contrasting safety regions: a relatively high-risk region (the Rijnmond, in the western part of the Netherlands) and a lower risk region (Gelderland Midden in the centre of the Netherlands) (Figure 4-3). By selecting these two contrasting regions, comparisons could be made between the two regions and between the different reasons that were found for the conformance and performance of the safety recommendations.

The Rijnmond region can be characterised as an industrial urban area, inhabited by almost 1.2 million people. This region includes the industrial harbour of Rotterdam, one of the largest harbours in the world. In addition, about 22,000 industrial enterprises of above-average size are located within this region. These enterprises are involved in activities such as the production of chemical products, energy production and transport (Kruize & Bouwman, 2004). Furthermore, the region includes an international airport.

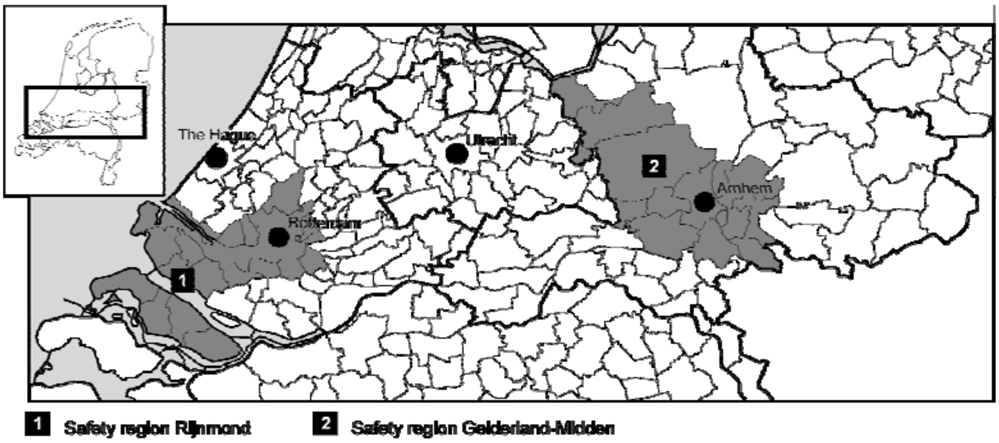

Figure 4-3. The safety regions Rijnmond and Gelderland-Midden

Compared to the Rijnmond region, Gelderland Midden, which is inhabited by 650,000 people, is not only a less densely populated region, it can also be characterised as less hazardous region, since it is less industrialised than the Rijnmond region. Nevertheless, hazardous activities such as the storage or production of chemicals or the transport of hazardous materials also take place in Gelderland Midden. An issue of particular concern is the transport of hazardous materials via the Betuwe Railway line, a new freight rail line that connects the Rijnmond region with the German hinterland.

In consultation with both regional fire departments, ten spatial planning projects were selected: five from each safety region. This allowed comparison both between and within regions. The selection of a limited number of projects allowed a deeper analysis, leading to more understanding of the use and implementation of safety recommendations. Only projects that were related to the development of land allocation plans were selected. It was assumed that respondents would be most familiar with the planning process of recent projects. For that reason, only recent projects, for which the safety recommendations were made no more than two years previously, were selected. As a result, however, not all of the planning processes that we examined had been completed. The analysis therefore represents perceptions of outcomes at a particular point in time in the planning process. The resulting projects represented a wide variety of safety issues, as illustrated in Table 4-2.

Table 4-2. An overview of the examined case projects

		Case project	**Major safety concerns**
Gelderland Midden	C1	De Corridor, Duiven	The proposed extension of catering establishments and retail shops results in an increased SR due to the presence of an LPG station and the transport of hazardous materials on the adjacent motorway.
	C2	De Hoven, Bennekom	The transport of hazardous materials on the adjacent motorway causes safety risks for the proposed assisted living complex.
	C3	Kernhem, Ede	The proposed residential development results in an increased SR through the presence of a gas pipeline and the transport of hazardous materials, especially on the adjacent motorway.
	C4	Groot Holthuizen, Zevenaar	SR is expected to increase due to the proposed development of a residential area and industrial estate and the presence of a gas pipeline and the transport of hazardous materials on the adjacent Betuwe Railway line and motorway.
	C5	Kleefse Waard, Arnhem	The existing hazardous installations on the industrial estate can conflict with the proposed further development of the estate. Through the development of additional industrial buildings, SR can increase.
Rijnmond	C6	Schieveste, Schiedam	A gas pipeline and the transport of hazardous materials on the adjacent motorway cause a safety risk for the plan area. Two alternatives were analysed in the safety recommendations: high and low-density alternatives. In both alternatives, SR will increase, but in the high-density alternative, the SR criteria will be exceeded.
	C7	Terbregge- Oost, Rotterdam	As a result of the high population density around a freight railway line, SR risks were exceeded. In addition, the presence of an LPG station causes a safety risk for the area.
	C8	Schiekamp, Spijkenisse	Two LPG stations are present in the plan area. IR criteria are met. The SR criteria are exceeded and the proposed industrial estates result in a modest increase in the SR. In addition a gas pipeline causes a safety risk.
	C9	Oosteindse polder, Bergschen-hoek	Some existing buildings are situated within the safety distances (IR) of the adjacent airport. There is a proposal to build 50 houses within the sphere of influence of this airport. This development would result in an increase in SR. In addition, risks caused by urban developments in the vicinity of a gas pipeline should be considered.

	C10	Klappolder, Bleiswijk	The extension of some industrial buildings will be allowed, but two gas pipelines are present within the area. The present and proposed land use will not conflict with the IR and SR criteria.

The fire departments and municipalities concerned provided the safety recommendations and relevant planning documents. First, it was determined which measures were suggested in the safety recommendations. Second, the planning documents were examined in the light of their conformance with the safety recommendations. In this respect, we focused mainly on the outcome of the planning process. We evaluated not only the conformance of the land-use plan to the measures suggested in the safety recommendations, but also the conformance of the plan to the general goal of the safety recommendations, which was risk reduction.

The reasons for municipalities to accept or reject safety recommendations were addressed explicitly through additional interviews with representatives of the two regional fire departments and spatial planners of the ten selected case projects. The interviews were semi-structured and took about one hour each. The interview reports have been approved by the respondents. Additional telephone consultations were carried out to discuss questions that could not be fully answered during the interviews. In order to acquire an initial idea of the performance of the recommendations, the respondents were asked how they regarded the role and usefulness of the safety recommendations in the spatial planning process. In addition they were asked why some aspects of the safety recommendations were implemented in the spatial plan while others were not, and what happened with safety recommendations that were not implemented in the spatial plan. The reasons given by the representatives provided insight into the various factors that could explain the conformance and performance of the safety recommendations. The factors, as mentioned in Table 4-1, were used to structure and interpret these reasons.

The following sections discuss the research results. The five cases in the Gelderland Midden region are labelled C1 through C5, the cases in the Rijnmond region are labelled C6 through C10. The labelling of respondents is consistent with the labelling of the cases. For example, respondent 6 (noted as R6) refers to case C6 in the Rijnmond area.

4.5. Content and implementation of safety recommendations

In their safety recommendations, the regional fire departments addressed a wide variety of emergency management issues. The advice given in the safety recommendations is summarised in Table 4-3, together with the number of times a specific piece of advice was found in the analysed safety recommendations (ten in total). Table 4-3 gives an indication of the type of issues that were addressed in the safety recommendations. Most recommendations focused directly on increasing the capacity for emergency response, which we defined as the capacity of the area to respond immediately to an event and the response in the aftermath of an event. Measures to increase the emergency response capacity were mentioned in recommendations 1, 2, 4 and 6. In addition, other risk-reduction measures were suggested which were indirectly related to emergency management. First, the reduction of the hazard, defined as the industrial activity that could cause injury or loss of life, was addressed in recommendations 8 and 11. Second, the limitation of exposure of vulnerable people and objects was addressed in recommendations 7, 10, 12, 13 and 14. Third, increasing the capacity of the area to resist an incident was suggested in recommendations 9 and 15. Finally, some procedural advice was given in recommendations 3 and 5.

Table 4-3. Safety issues addressed in the safety recommendations for the Gelderland Midden (Gld) and Rijnmond (Rnm) cases respectively

	Municipalities should:	Gld	Rnm
1.	Increase the possibilities for self-help through risk communication	5	4
2.	Consider the current and future fire extinguishing water infrastructure	5	4
3.	Explain how societal risks were addressed in the land allocation plan	5	3
4.	Provide escape routes away from the risk object	2	4
5.	Recognise and accept residual risks	5	0
6.	Ensure accessibility for emergency services	2	2
7.	Exclude vulnerable objects from hazard-prone areas	3	1
8.	Consult the owner of the gas pipelines on additional measures to reduce risks	1	3
9.	Take precautionary measures in buildings such as fire prevention measures to create a 'safe haven' for shelter	1	2
10.	Include IR contours in the spatial plan	0	2
11.	Reduce the amount of hazardous materials produced, used, stored or transported	0	2

12.	Control the opening hours of adjacent catering establishments	1	0
13.	Limit population density to reduce SR	1	0
14.	Give explicit attention to the presence of vulnerable people such as elderly or disabled people	1	0
15.	Construct a dam to prevent the inflow of hazardous material	0	1
16.	State the number of people present in the plan area in the spatial plan	1	0

The issues and the number of times an issue was addressed obviously depended on the selected cases. Within our case selection, there were many safety issues related to the pipe transport of hazardous materials and to LPG stations; therefore many recommendations related to these issues were found. It should therefore be noted that the number of times a specific recommendation was given provides information about our case selection, although it can also be regarded as an indication of the kind of emergency management issues that are addressed in the spatial planning process.

Even though the safety recommendations are often part of the procedure for the development or reconsideration of the land allocation plan, only a limited number of issues addressed in the safety recommendations were implemented through the land allocation plan itself. Within the land allocation plan, recommendations on IR contours and safety distances were included. Furthermore, the development of vulnerable objects and the population density within the sphere of influence of the hazard were controlled through regulations within the land allocation plan. This was not surprising, since the IR criteria are legally binding, as discussed in Section 4.2.

The focus of our analysis, however, was on the measures that were suggested to reduce SR. Most measures were implemented through policy instruments other than the land allocation plan, such as environmental licenses, contingency plans, risk communication strategies and private law arrangements with developers, or through more detailed plans in which the project implementation was described. According to our respondents, issues related to the fire extinguishing water infrastructure, for example, were worked out in project plans; access routes were addressed in private law agreements between the municipality and private developers, and risk communication issues were addressed in risk communication and contingency plans.

Sometimes recommendations were implemented in a different way. For example, instead of controlling the opening hours of catering establishments to prevent an overlap with the provisioning of the adjacent LPG station, the provisioning itself was limited and was only allowed in the morning (C1). The recommendation to exclude new vulnerable objects in the vicinity of transport routes of hazardous materials was explicitly rejected in only one of the examined cases (C2). In this case, the municipality decided to allow the proposed complex, a house for assisted living. Nevertheless, additional measures were taken to increase possibilities for emergency management and evacuation.

All municipal respondents said they intended to implement the safety recommendations. Similar to experiences in the UK (Walker, 2000), they believed they were being responsible and regarded the measures as suggested in the safety recommendations as legally compulsory, especially with respect to IR criteria because legal acceptability criteria existed. One respondent (R6) stated that not implementing the safety recommendations implied that the municipality would be responsible in case there was an event. Furthermore, the recommendations were regarded as professional (R9) and, therefore, could not be easily rejected. This does not mean that all recommendations to reduce SR were implemented. When SR criteria were met, additional measures were not necessarily taken, as was found in one of the case projects (C2). In addition, it was argued that trade-offs, such as economic or planning concerns could be a reason to accept an exceedance of the SR criteria (R7, R8).

According to one municipal respondent (R7) who had also dealt with other planning processes in which the SR criteria were exceeded, the municipality tried to find ways to achieve the desired developments even though the SR criteria were exceeded. It was argued that in such cases higher societal risks could be accepted if additional compensation measures, such as improved evacuation or access routes, were implemented or if the desired urban development was very important for the city (e.g. the creation of jobs). Similar reasoning was found in another case project (C8). In the land allocation plan, it was explained why the proposed urban development was required. Additional compensation measures, such as the development of emergency routes, were proposed. Based on these considerations, the municipality regarded the SR as acceptable.

Even though almost all recommendations were adopted by the municipality, measures were hardly implemented through the land allocation plan itself. As explained by the planners we interviewed, the land allocation plan was mainly meant to allow or prohibit specific land-use changes. Other policy instruments were regarded as more suitable for implementing measures. One respondent argued that his municipality (R8) was cautious about implementing the safety recommendations in the land allocation plan, since too many restrictions could cause ‘planning damage’, i.e. negative consequences from land-use changes, which could result in claims from the people affected.

It should be noted, however, that most of the planning processes we studied were still in progress. Even if a final version of the land allocation plan was available, the full implementation of the safety recommendations, for example through arrangements with developers, more detailed project plans or risk communication plans, still had to be undertaken. The municipal planners we interviewed did not have a good overview of the actual implementation of the safety recommendations within their municipality, especially regarding the recommendations that related to emergency management and risk communication. Implementation takes place through many different instruments and departments, which makes monitoring complex.

The regional fire department in Gelderland Midden, for example, wanted more insight into the actual implementation of its recommendations. It assumed that not every suggested measure was implemented. The fire department, however, did not have the capacity in time and resources to study this, since it is not its task to monitor implementation. The province does have a role in monitoring, but is mainly focused on the legal criteria, such as the IR contours and procedural criteria, for example whether or not the SRs are properly explained. In addition, the province monitors the development of contingency plans. The municipalities remain responsible for the implementation of the measures given in the safety recommendations and apparently make use of their discretionary freedom in implementing these measures. Within the municipality, however, people were often responsible for a particular aspect of the safety recommendations. It was hard to identify who was responsible for the implementation of the recommendations as a whole.

4.6. The role and usefulness of the safety recommendations

The studied cases represented two contrasting regions. It was therefore expected that municipalities in the more industrialised Rijnmond region would be more aware of industrial risks or that emergency management issues would be considered more explicitly in planning processes. This expectation, however, was not reflected in our findings. Emergency issues were not addressed differently in the two regions, safety recommendations in the Rijnmond region did not contribute more to the safety of citizens than those in Gelderland Midden, and the reasons found for the conformance and performance did not differ considerably.

In general, spatial planners regarded the safety recommendations as professional and useful for solving planning problems. The recommendations provided more insight into the safety issues that were relevant for the plan area and into possible risk reducing measures. Consequently, the recommendations increased the capacity of planners to deal with these safety risks. Furthermore, the municipalities and fire departments both believed that the safety recommendations increased risk awareness.

The planning process offers the actors involved the opportunity for dialogue, through which risks and risk reduction measures can be addressed. Through this dialogue, for example, the fire department tries to get support for the safety measures and tries to get them implemented. This dialogue takes place not only through written documents, but also through informal communication between emergency managers and spatial planners during regular meetings on safety issues organised by the regional fire departments. In this light, the communicative character of the safety recommendations, through which the active involvement of emergency services in formal and informal planning processes is stimulated, can be regarded as an important strength.

According to our respondents, the safety recommendations seldom resulted in the cancellation of proposed developments. As was also found in our case studies, the safety recommendations resulted in adjustments of the development, such as additional measures to compensate for the increased safety risks. These additional measures could even be used to justify and allow urban development when SR criteria were exceeded. In this respect, the discretionary freedom of the municipality in implementing the recommendations was used to balance local safety and development objectives.

In two cases (R7, R9) the representatives from the fire department and the municipalities concerned stressed that the performance was best when the fire department is consulted at an early stage in the planning process. Although formally required, consultation at an early stage is also regarded as desirable, since the land allocation plan becomes more resistant to change when it comes closer to its final stages. Moreover, consultation at an early stage offers the opportunity to discuss measures informally and explore options for mutual adjustments.

The safety recommendations, however, did not perform well in all researched planning processes. One bottleneck that was experienced was that different authorities made recommendations on external safety (see Section 4.2). Sometimes these recommendations proved to be contradictory (R1). Furthermore, risk analyses and safety recommendations sometimes changed over time. In one of the cases, a recalculation of the transport of hazardous materials resulted in a reduction of SR (C7), which made it easier to meet the SR criteria. The opposite also happened. As experienced by one respondent (R7), the forecasted transport of hazardous materials sometimes increased dramatically. This resulted in an exceedance of SR criteria, conflicting with the intended urban developments. In this respect, it was emphasised that periodic meetings with the authorities involved in external safety risk management were important. The safety recommendations should therefore not be regarded as static advice, but as a process in which safety issues can be discussed during the planning process.

Another difficulty related to the performance of the safety recommendations was that land allocation plans only focused on a limited part of the municipal territory, whereas some safety recommendations were relevant for the municipality as a whole. On the other hand, some municipalities intended to develop, or actually had developed, policy plans which specifically focused on the management of external safety issues within the entire municipal territory (C1, C5, C8), or were developing strategic local plans which included requirements related to external safety (C7). The development of such plans provides the opportunity to guide the consideration of external safety risks beyond the land allocation plan, involving aspects such as the risk-communication plan or contingency plan. Experiences with pre-disaster recovery plans in the USA have shown that a combination of stand-alone plans and comprehensive plans is likely to be most effective for reducing damage (Berke & Campanella, 2006).

The implementation of the safety recommendations was limited even further by the capacity of the municipalities and fire departments. Expertise in external safety was not widely available at every municipality. Some municipalities could not answer our questions because the external safety expert had just left, or had just started in that job, and therefore did not have enough expertise to answer our questions. The representative of the Rijnmond regional fire department also mentioned the lack of expertise at some municipalities as a bottleneck for the implementation of safety recommendations. Some municipalities had a large turnover in staff, which sometimes resulted in a limited availability of expertise on external safety issues. On the other hand, the capacity of the regional fire department itself was limited as well, which sometimes hampered the safety recommendation process. This issue was addressed by the fire departments as well as the municipalities, especially in the Rijnmond region. As a result, the fire departments were not involved intensively in every planning process and did not monitor the implementation of their recommendations. Only the planning processes with the highest impact on SR were followed intensively.

Two municipal respondents questioned whether the spatial claim of external safety on spatial planning in general had become too restrictive (R1, R7). As stated by one them (R7), adapting urban developments to hazardous activities should not be self-evident (as he thought was generally the case), but the production, storage, use and transport of the hazardous materials themselves could be limited as well. Another respondent (R1) had the impression that the safety recommendations had become too strict. In his view, this was due to the fact that the advising authorities did not want to be responsible in case of an incident, especially after a disaster. In such cases, external safety regulations can seriously hamper spatial developments.

4.7. Discussion and conclusions

Our examination of spatial planning practices showed that emergency management concerns were addressed in these practices in a communicative way through the safety advice of the regional fire department. The safety recommendations stimulated dialogues between safety experts of the regional fire department and the municipality, which according to the representatives we interviewed, strengthened the cooperation between these two governmental bodies. It can be argued that this collaboration between spatial planners and emergency managers contributed to risk reduction. Within the cases studied, the safety recommendations were adopted even when risk acceptability criteria were already met. However, in both of the regions that were studied, the adoption of safety recommendations tended to result in relatively modest fine-tuning of spatial plans rather than more substantive changes. Moreover, the implementation of safety measures seldom led to an elimination of industrial risks, because the adopted measures focused mainly on increasing the capacity of an area to deal with these risks (for example, through additional access and evacuation routes) instead of eliminating them. In areas where the SR was exceeded, these measures were even used to justify the increase of the societal risk and to facilitate the proposed development.

These findings are consistent with Ale's (2005) observations that the emphasis in Dutch risk management practices is shifting from eliminating hazards to coping with hazards without really reducing them. As shown in the case studies, this does not mean that measures for reducing hazards or exposure to risks were not considered or implemented at all. In some cases, the storage of LPG at LPG stations was limited and safety distances around hazardous installations were implemented. The limited contribution to risk reduction can be regarded as the result of the absence of strict rules for the acceptance of societal risks. Nevertheless, this absence can also be regarded as a strength, since it allowed spatial planners to balance various spatial claims.

The conformance and performance of the safety recommendations, however, not only depended on the government strategies that were applied. As previously indicated in the conceptual framework, other factors also played an important role. The implementation of safety recommendations depended largely on the expertise and capacity of both the municipal and fire department staff. Moreover, economic interests were mentioned as a factor for not implementing safety measures. Therefore, the theoretical framework clearly provided a useful framework for understanding the found conformance and performance. Nevertheless, one factor (the role of public commitment) was hardly mentioned by the interviewed representatives of the municipalities and regional fire departments. It seemed that public commitment hardly influenced the consideration and implementation of safety recommendations.

Moreover, some important factors were not included in the conceptual framework. First, there was the timing of the safety recommendations. Safety recommendations should be provided at an early stage in the planning process, because the plans are more fluid at that stage and can therefore be changed more easily. Second, there was the quality of the recommendations. Outdated information or contradictory advice could negatively influence the performance and conformance of the safety recommendations. Consequently, these can be regarded as additional factors that influence commitment as mentioned in the conceptual framework.

Our findings confirm the assumption that collaboration between spatial planners and emergency managers can contribute to safety. In the studied cases, however, this contribution went beyond the implementation of safety distances as imposed by the Seveso II Directive. Additional measures for increasing safety, such as evacuation routes or risk communication, were also addressed and implemented through spatial planning and land-use plans. Consequently, spatial planning should also be recognised as an instrument for increasing the possibilities for emergency response. Therefore, collaboration between planners and emergency responders in general should be considered. The inclusion of safety recommendations in the planning process can be regarded as a promising way of organising this collaboration between planners and emergency responders. The communicative character of the safety recommendation process turned out to be an important strength, especially if compared with the Environmental Impact Assessment, which was criticised for its limited contribution to facilitating dialogue (Richardson, 2005). Because this communicative approach fits well into more general collaborative and communicative planning approaches (see Section 4.3), the Dutch experiences with safety recommendations may also be relevant for the integration of spatial planning and emergency management in other countries.

Nevertheless, the measures suggested in the safety recommendations could not always be implemented through land allocation plans. These plans were regarded as regulatory instruments to prohibit specific land-use changes. Consequently, the land allocation plans only made a small contribution to increasing the possibilities for emergency management. However, this does not mean that safety recommendations should be limited to those measures that can be implemented in land allocation plans. Similar to safety recommendations, land allocation plans should not be regarded only as regulatory or coercive instruments. The process of plan development offers opportunities for promoting cooperation and communication, e.g. for addressing safety issues in general and for promoting the adoption and implementation of safety measures through other plans and processes, such as risk communication plans, contingency plans, building regulations or private law arrangements with developers. For these reasons, the integration of spatial planning and emergency management processes deserves further attention.

Our findings have provided insight into the way in which safety recommendations are adopted and implemented, but more of this type of research is needed. More cases should be studied to make the findings more robust. Moreover, comparative studies with other countries are desirable in order to understand the contextual influence on the consideration of emergency management issues. In addition, more attention should be given to the phase before the first draft of the land allocation plan. In this analysis, only formal drafts were analysed. Therefore, it is possible that within these drafts the planners had already anticipated the expected recommendations from the regional fire department. Consequently, the performance of the safety advice may be underestimated. Finally, the planning process should be studied over a longer period of time. Most of the planning projects that were studied had not yet been completed, which made it difficult to evaluate whether or not the measures were actually implemented. Insight into the actual implementation and enforcement of measures is important, because a lack of implementation and enforcement can increase the likelihood and consequences of an incident (Commissie Onderzoek Vuurwerkramp, 2001; Voogd, 2004).

Acknowledgements

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5

Flood Risk Management in Dutch Local Spatial Planning Practices*

Abstract
Spatial planning is increasingly regarded as an important instrument to reduce flood consequences. Nevertheless, there are very few studies that show why local planning authorities do or do not systematically use spatial planning in advance to mitigate flood risks. This paper explores flood reduction strategies in local planning practices in the Netherlands. It also explores why spatial planning was or was not used to reduce flood consequences. The arguments for the use or non-use of planning mainly referred to requirements from other governmental bodies and the perceived role and the related responsibility of local planning authorities, previous disaster experience, and previous experience with spatial planning for flood risk management.

Keywords: spatial planning, flood risk management, the Netherlands

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5.1 Introduction

Many settlements are located on flood-prone areas near rivers or the seacoast. To protect these settlements, dikes have been constructed. These dikes have significantly reduced the probability of flooding. However, settlement expansion, combined with the expected effects of climate change, are increasing the probability and the potential impact of flooding within the areas protected by dikes (Oosterberg *et al.*, 2005). In risk management literature, there is a growing consensus that, in addition to the reduction of the probability of flooding, reduction of flood consequences is needed as well. Spatial planning is increasingly regarded as an important instrument to support flood impact reduction. Through the regulation of land use, for example, vulnerable land uses can be excluded from flood-prone areas and building codes can encourage the elevation of residential areas (Burby, 1998; Godschalk *et al.*, 1999; Hooijer *et al.*, 2004; Mileti, 1999; White & Howe, 2002). In spite of this recognition of spatial planning in relation to flood risk management, several studies have shown that local governments usually neglect to implement flood mitigation measures in spatial planning (Berke *et al.*, 1996; Burby, 1998; May *et al.*, 1996). Moreover, there are only a few studies that show *why* they do not systematically use spatial planning in this respect (Hutter *et al.*, 2007). The studies that are available refer mainly to the North-American and Australian situation (Deyle *et al.*, 2008; Deyle *et al.*, 1998; Godschalk *et al.*, 1999; May & Deyle, 1998; May *et al.*, 1996; Mileti, 1999; Olshansky & Kartez, 1998). Comparable studies have rarely focussed on areas in Europe. Notable exceptions are the study by White and Richards (2007) for the UK and the study by Kamphuis (2007) for the Netherlands. Kamphuis examined the flood management policies and practices of ten municipalities in the western part of the Netherlands. He showed that local governments regard water authorities and project developers as being responsible for the management of flood risks. In addition, he showed that municipalities scarcely use spatial planning to reduce potential flood consequences. Nevertheless, these authors hardly addressed the question of why municipalities did not feel responsible, and thus, why spatial planning was not systematically used.

With this background, this paper explores why spatial planning is used or is not used in the Netherlands at the local level for the implementation of measures to reduce flood consequences. It aims at a better understanding of spatial planning decision-making in relation to flood risk management, i.e. to supplement the insights gained in the USA, Australia and New Zealand. This can contribute to the further development and implementation of flood mitigating measures as a way to deal with the potential effects of climate change. The scientific purpose of this paper, however, is exploratory in character. Even though the findings can be a starting point for research with a more explanatory character, the intention here is to search for factors that can explain the use of spatial planning for flood reduction, rather than making generalisations, as is common in more explanatory research (Grix, 2004). Our main argument is that higher level government policies and psychological factors strongly influence the adoption of spatial planning as an instrument to reduce flood consequences.

The research was conducted by examining local planning practices in three case study areas. First, we explored whether risk reduction measures were implemented in these planning practices, and, if so, which measures were used. Second, we explored the reasoning of the planning authorities when deciding to implement or not to implement these measures. Based on these explorations, we suggest several strategies that could encourage the use of spatial planning for flood mitigation on the local level.

The structure of the paper is as follows. We start with an overview of Dutch national flood management policies, followed by a description of the analytical framework and the research method. Then, we describe and analyse two types of planning practices. In the final section we summarise the conclusions derived from these practices and discuss their implications for planning.

5.2 Dutch flood management policies

In the Netherlands, all three tiers of government – central, provincial and municipal government – have planning powers. Decision-making consistency between these tiers is established through the formal regulations of the Dutch Spatial Planning Act as well as through communication aiming at consensus building and mutual adjustment of planning proposals (Van der Valk, 2002). Consequently, the spatial policies of higher-level authorities influence the spatial policies of lower-level authorities. Local planning practices, however, can only partly be understood from higher level government policies, since municipal governments also have some discretionary freedom in the implementation of provincial or national planning frameworks and guidelines. These frameworks and guidelines can to a certain extent be adapted and reformulated during the implementation process at the local level, mainly because they leave room for interpretation.

Dutch national and regional flood management policies are traditionally aimed at reducing the probability of flooding through the construction and maintenance of dikes. These dikes are intended to protect the hinterland against floods from the sea or major rivers, and to make the Netherlands more resistant to flood hazards. The area that is protected by a dike is referred to as a dike-ring area. This is an area encircled by a contiguous ring of dikes or high areas that will not be flooded, even under the most unlikely circumstances (Eijgenraam, 2006). Dikes that directly protect a dike-ring area against flooding from the sea or major rivers are called primary dikes. Design standards for these primary dikes are legally established in the Dutch Flood Defences Act. They are defined as 'the average exceedance probability – per year – of the highest water level which the primary dike must be capable of withstanding from the outside, while taking into account other factors which determine the water defensive capability'. These standards differ according to the economic value of the assets in the dike-ring area. The regional water boards are responsible for the daily maintenance of most primary dikes. Some dikes, however, such as the Afsluitdijk, are managed by the Rijkswaterstaat, a policy implementation agency of the Ministry of Transport, Public Works and Water Management.

In 1993 and 1995, some areas in the river forelands of the Meuse river were flooded due to high river discharges. Moreover, dike-ring areas along the Meuse and Rhine in the Netherlands were threatened with flooding in 1995. Almost 250,000 people had to be evacuated, since the authorities felt that the dikes would not hold. And in 1994 and 1998, the western part of the Netherlands was particularly affected by water-logging problems due to heavy rainfall, which resulted in damage to crops and to some buildings.

As a reaction to these events, a dike-reinforcement programme was implemented. The flood events, together with the water-logging events, also triggered a new national flood management policy, which addressed the need for more physical space for water. It was argued that the likelihood of a river flood should also be reduced through spatial measures rather than heightening the dikes even further. The latter measure can increase potential flood depths, restrict natural river dynamics and spoil landscape qualities such as cultural heritage and scenery (Vis *et al.*, 2003). These spatial measures were intended to reduce the maximum river water levels and, in combination with the dike reinforcements, reduce the probability of flooding.

Examples of such spatial measures are the removal of obstacles from the floodplains, dike relocation, the restriction of land for construction and commercial activities in the river forelands, the construction of water retention areas and the construction of bypasses or secondary channels to circumvent urban bottlenecks. A new national policy directive, called ‘Room for the River’ (*Ruimte voor de rivier*), and a corresponding implementation programme, provided the basis for the implementation of these measures in a joint effort of the ministry, provinces, municipalities, water boards and non-governmental stakeholders (Van der Most & Wehrung, 2005).

In 2003 a new policy instrument, called the ‘Water Assessment’ (*Watertoets*), was introduced to ensure that water interests were taken into account in spatial plans and decisions. The status of the Water Assessment was established in several policy documents, governmental agreements and in legislation on spatial planning. The Water Assessment was intended to connect the different, sometimes divided, domains of water management and spatial planning (Milieu- en Natuurplanbureau & RIVM, 2004). The Water Assessment can be characterised as a communicative process in which water managers advise on the consequences of land use developments for the water systems and on the spatial claims that may result from water management measures needed now and in the future, such as water retention areas (Van Dijk, 2008). This means that the initiator of new spatial plans (e.g. a municipality or province) is obliged to ask the water manager (usually the water board) to address and advise on the relevant water management issues within the plan area. However, this advice is not binding.

An evaluation of the application of the Water Assessment, which examined 108 instances of such water advice, showed that only 8% of these instances addressed water safety issues. Furthermore, an analysis of 183 spatial plans showed that water safety was only considered in 6% of these plans (Werkgroep Evaluatie Watertoets, 2006). Even allowing for the fact that water safety is not relevant to every spatial plan, e.g. for the one-third of the Netherlands that lies high enough to be safe from flooding, the results suggest that water safety and flood reduction measures are rarely addressed in local spatial planning practices.

However, these established flood management policies are currently being reconsidered. Consistent with other European countries, more attention is being given to measures to reduce flood consequences. These discussions mainly take place within the framework of the so-called ‘Water Safety in the 21st Century’ project. In this project, spatial planning is regarded as an important instrument to implement measures to reduce flood consequences (Ministerie van Verkeer en Waterstaat, 2008b).

5.3 Analytical framework

The first research question is: what kind of flood risk reduction measures were implemented in local spatial planning practices? It should be noted, however, that such measures often focus on specific flood risk aspects only. For example, the construction of dikes mainly aims at improving the defences against superfluous water, the protection of natural flood plains reduces flood hazards and the regulation of land use usually aims at reducing the exposure of people and property to flooding. As a result, risk reduction measures are often complementary. The regulation of land use, for example, can complement dikes. Nevertheless, flood risks still differ spatially within a dike-ring area. In case of a dike failure, for example, water levels will rise quickly and reach high levels in relatively deep areas near the dike. In addition, flow velocities in these areas are often high, whereas water depths and flow velocities in higher areas further away from the dike are often much lower. As a result, ensuring that urban development takes place away from areas with potentially high water depths and flow velocities can effectively reduce the number of casualties (Jonkman, 2007; Pols *et al.*, 2007).

In this paper, we have distinguished different risk components to characterise different risk reduction measures. Risks are generally regarded as a function of a hazard and the vulnerability of the physical and socio-economic system to this hazard. The term ‘hazard’ refers to the events or phenomena that may cause harm to things that human beings value. ‘Vulnerability’ generally refers to the susceptibility to damage from a particular disaster hazard, but there are fundamentally different conceptual interpretations of this concept. Interpretations either emphasise the exposure to hazards, the social responses – i.e. the capacity of society to deal with hazards and exposure – or the physical and social processes that may lead to vulnerability, such as economic or urban development. Although vulnerability is generally regarded as a combination of these points of view (Adger, 2006; Cutter, 1993; Cutter, 1996; De Bruijn, 2005; De Graaf *et al.*, 2007), we have divided the concept of vulnerability into two components: exposure and capacities (Table 5-1). These two components can change over time as the result of physical and social processes. Furthermore, the different risk components are interrelated. For example, a system cannot be vulnerable if it is not exposed to a hazard.

Table 5-1. Different risk components

<table>
<tr><th colspan="3">Risk components</th><th>Definition</th></tr>
<tr><td rowspan="7">Risk</td><td colspan="2">Hazard</td><td>A potentially damaging physical event, phenomenon or human activity that may cause injury or the loss of life, property damage, social and economic disruption, or environmental degradation.</td></tr>
<tr><td rowspan="5">Vulnerability</td><td>Exposure</td><td>The proneness to being affected by a particular hazard, without taking into consideration the capacity to deal with the hazard.</td></tr>
<tr><td>Resistance capacity</td><td>The ability of a system to prevent hazardous events, such as water defences to resist high water levels.</td></tr>
<tr><td>Adaptive capacity</td><td>Capacity of a society to adapt and to adjust to uncertain future developments and hazards.</td></tr>
<tr><td>Coping capacity</td><td>Capacity to respond in the immediate aftermath of an event.</td></tr>
<tr><td>Recovery capacity</td><td>The capacity to return to the pre-disaster status.</td></tr>
<tr><td colspan="2">Processes</td><td>Physical and social processes that affect hazards and vulnerability, such as climate change or urbanization.</td></tr>
</table>

Based on: De Bruijn et al., 2007; Schneiderbauer, 2007; De Graaf et al., 2007

As shown in Table 5-1, a distinction is made between risk reduction measures that focus on the reduction of the probability of flooding and on measures that focus on the reduction of potential flood consequences. The first category contains measures that reduce flood hazards and increase the resistance capacity, such as dike reinforcement or flood plain protection. The second category contains measures that reduce exposure and increase the adaptive, coping and recovery capacity. Processes can affect both flood probability and flood consequences.

The second research question is: what was the reasoning of local planning authorities when implementing or not implementing measures to reduce flood risks? Research in the USA and Oceania in particular, has already revealed a wide variety of factors that may influence the commitment of local planning authorities to the adoption of spatial strategies for risk reduction (Deyle *et al.*, 2008; Godschalk *et al.*, 1999; May & Deyle, 1998; May *et al.*, 1996; Mileti, 1999; Olshansky & Kartez, 1998; White & Richards, 2007). These factors are divided into five groups: higher-tier government policies, psychological factors, trade-offs between other interests, public commitment and capacities of local authorities. These factors are summarised in Table 5-2, together with examples for each factor. We used these factors to structure and analyse the findings of our research.

A distinction can be made in Table 5-2 between factors that mainly influence the adoption of spatial planning, i.e. the explicit consideration of spatial planning as an instrument to reduce flood risks, and factors that mainly influence the implementation of spatial planning measures, such as the actual implementation of land regulations. Higher-tier government policies and psychological factors, for example, mainly influence the adoption of planning, whereas trade-offs and public commitment mainly influence the actual implementation of planning measures in society. Nevertheless, not every factor can explain the adoption and implementation of measures. Moreover, the relative importance of the factors may differ spatially. For example, Olshansky and Kartez (1998) emphasised that the local governments that planned for hazard mitigation had adequate staff, but May et al. (1996) concluded that the capacity of local governments did not seem to constrain the commitment of the authorities they studied.

Table 5-2. Factors that influence commitment of local authorities to spatial planning for flood reduction

Factors that influence commitment
Higher level government policies • The lack of an overarching central policy in clear and realistic guidelines that gives high priority to land use provisions to govern land use and development in flood prone areas • The absence of strong monitoring and enforcement policies, such as through coercive mandates and sanctions for local governments who do not address flood risk issues in spatial planning • The lack of policies to stimulate commitment • The presence of other policies that indirectly encourage developments in hazardous areas such as insurance systems, the construction of dikes or the improvement of infrastructure in flood prone areas, which may limit opportunities for local governments to apply land use management tools • Lack of technical and other forms of assistance to local governments, such as financial assistance
Psychological factors • The lack of experience with floods, which often reduces the sense of urgency for flood mitigation measures • The perceived remoteness in time of low-probability hazards, which leads to sharp discounting of the benefits of avoided costs • The implementation of recurrence intervals, such as the 100-year flood zone, may result in a perception of absolute boundaries between hazardous and non-hazardous areas

Trade-offs between other interests • The allocation of resources to natural hazards has limited visible rewards • Many flood prone areas are already built out and remedial actions are costly to implement • Hazard prone areas are often very valuable locations, e.g. through ocean view or access to water and water based transport and are attractive for urban development • Land use regulations in flood prone areas may lead to urban developments elsewhere which can be undesirable for other reasons such as nature conservation or accessibility
Public commitment • The lack of public recognition of flood risks due to the lack of experience with floods • The lack of public participation in decision-making • Active opposition by other interests such as real estate and property development interests • Existing rights such as property rights and the right of development may be much stronger and therefore it may be difficult to limit developments in hazardous areas • Entitlements based on previous local development plans and measures
Capacities of local authorities • Lack of staff, expertise and resources on hazard mitigation issues • The lack of clear and authoritative risk maps and risk information • There is no hazard free land available for development, e.g. through other regulation policies such as for nature conservation • There is little spatial contrast in levels of hazards, thus it is difficult to define meaningful boundaries between hazardous and non hazardous areas

Based on: Deyle et al., 2008; Deyle et al., 1998; Godschalk et al., 1999; May & Deyle, 1998; May et al., 1996; Mileti, 1999; Olshansky & Kartez, 1998; White & Richards, 2007

5.4 Research method

Data for answering the research questions were collected in three case study areas. Each of these areas can be regarded as relatively high risk since water depths and flow velocities are potentially high. Nevertheless, house construction projects were proposed and implemented in these areas. Therefore, the consideration of additional measures to reduce flood consequences could be expected. The areas are: dike-ring 16, dike-ring 22 and the Westergouwe residential development project (see Figure 5-1).

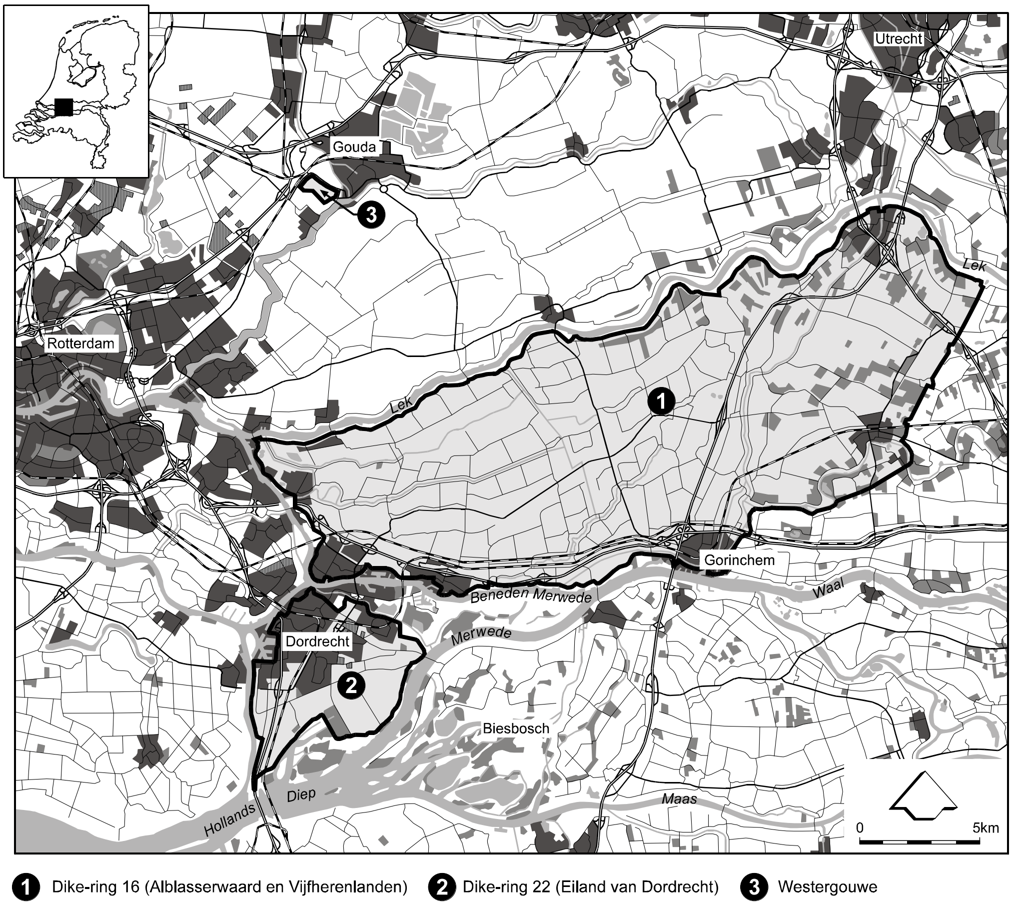

*Figure 5-1***.** Location of the case study areas

Dike-ring area 16, encompassing the polders Alblasserwaard and Vijfheerenlanden, is located to the east of Rotterdam. This dike-ring area of 39,000 hectares consists of 11 municipalities and is inhabited by 197,000 people. The dikes are designed to resist water levels that are expected once in 2,000 years. However, a recent evaluation of these dikes showed some weak sections in the dike ring. The actual likelihood of flooding was estimated at once in 400 years, although the evaluation report stressed that the method used is not yet seen as robust enough and that the results are only an indication and should not be regarded as authoritative (Ministerie van Verkeer en Waterstaat & Inspectie Verkeer en Waterstaat, 2006; Ministry of Transport Public Works and Water Management, 2005). Moreover, the dike-ring area is very flat and water levels can rise quickly, which can lead to a high number of casualties. From a flooding perspective, therefore, the area can be regarded as relatively vulnerable. In the next decade, approximately 2,000 houses will be built within this area.

Dike ring 22 encompasses the city of Dordrecht with 120,000 inhabitants. The city is located on an island in the delta of the rivers Rhine and Meuse. The dikes that protect the city are designed to resist water levels that are expected once in 2,000 years. Nevertheless, some parts of the city are not protected by dikes. New housing has been proposed at locations both inside and outside the dike ring. The third case study area, the Westergouwe area, is located in the Zuidplaspolder, which is one of the deepest polders of the Netherlands. For this area, which is part of the city of Gouda, 3,800 new houses were proposed on a location that lies between 5.60 and 6.13 meters below mean Dutch sea level (Pols *et al.*, 2007). The dikes are designed to resist water levels that are expected once in 10,000 years.

We conducted a desktop study of the spatial planning practices in these areas, and we also interviewed representatives of the local planning authorities and water boards. During the first round of interviews, one representative from each of the three water boards involved was interviewed by phone. These representatives were responsible for spatial planning issues within their water board organisation. Thirteen telephone interviews were conducted with representatives of the local planning authorities, i.e. the municipalities. These representatives were responsible for spatial planning issues within their municipality. They were asked to explain how flood risks, especially from the river, were addressed and dealt with as part of their spatial planning practices. They were also asked to explain why spatial planning was used or not used to address flood risks. The arguments mentioned by the representatives provided insight into the different factors that can explain the use or non use of spatial planning for flood management.

Subsequently, during a second round of interviews, four planning processes were studied more extensively, and three municipal representatives and one provincial representative were interviewed in person. This was done because the telephone interview had revealed that, in the light of flood risk mitigation, spatial planning was used most intensively in these four planning practices. The representatives were selected because they were key actors in these planning practices. By interviewing these representatives face-to-face, we expected to increase the understanding of their reasons to use spatial planning in this way.

Based on the distinction of spatial measures in relation to flood management, the examined practices were divided into two groups. The first group consisted of spatial planning practices which only implemented measures to reduce the probability of flooding. This group of practices, labelled as Established Policy Practices, represented the flood management policies described previously. The second group consisted of practices which implemented or seriously considered additional measures to reduce flood consequences. This group was labelled as Practices to Reduce Flood Consequences.

5.5 Established policy practices

As part of the established policy practices – nine practices used within the dike-ring 16 area – land-use strategies to reduce flood risks were only addressed minimally. Within the dike-ring area, some land-use developments, such as residential development, were regulated to protect the existing dikes and to reserve space to facilitate dike reinforcements in the future. For areas in the river forelands, which are not protected by dikes, changes in land use were also regulated, and spatial measures that affected the dike-ring area, such as river broadening, were facilitated by the local spatial plans. These measures can be characterised as measures focussing on the reduction of the probability of flooding, as discussed in the analytical framework.

Even though flood risks were hardly mentioned in spatial plans, and the water board did not yet advise on flood risks, it cannot be concluded that measures to reduce flood consequences were not considered at all in these established policy practices. For example, one spatial planner explained that civil servants in her region tried to develop ideas about how to deal with residual flood risks, but that they were still searching for appropriate strategies.

Most arguments for not using spatial planning to reduce flood consequences, as given by the respondents, directly or indirectly referred to higher-tier government policies. This can be illustrated by the stories that resulted from the interviews. As explained by one municipal respondent, the national criteria for the design of dikes were met. Flood risks had therefore been reduced to an acceptable level. Consequently, additional risk reduction measures were not considered in spatial planning, despite potentially severe flood consequences. Other respondents in the established policy practices used comparable arguments.

In addition, the local spatial planners did not regard themselves (i.e. their municipalities) as being responsible for additional flood risk reduction measures. However, responsibility can be perceived in many ways and can therefore be regarded as a multi-layered concept (Giddens, 1999). For this reason, Bovens (1999) has identified several types of responsibility. He also made a distinction between passive and active responsibility. Passive responsibility, which we refer to as accountability, is based on external answerability and the potential of being blamed or rewarded. Active responsibility, which we refer to as commitment, is an internalised sense of duty towards particular actions or tasks. In other words, there is a difference between being responsible or being held responsible, and feeling responsible or acting responsibly. Being responsible in a formal sense does not automatically imply responsible behaviour.

The spatial planners representing the established policy practices mainly perceived responsibility in the light of formal tasks or duties. They believed the responsibilities for flood management were held by the water managers, i.e. the water boards and the Rijkswaterstaat. Therefore, these planners argued that the water managers should indicate which additional land use and design strategies were necessary to reduce flood risks, not the municipality: 'The water board should indicate how to deal with flood risks at a proposed building site. They should indicate this in their water advice in which they advise the municipality how to deal with water issues in the municipal spatial plans'. Some planners also argued that the province was partly responsible as well, referring to a causal or liability perception of responsibility. As one of them explained: 'The decision about the location of building sites, which is often made at the provincial level, already implies an acceptance of the flood risks'.

The water managers, however, did not address the need for additional measures. As a result, such measures were not addressed in spatial planning at all. According to the representatives of the water boards, the boards are working to reduce flood risks, but this is mainly done by reinforcing the weak sections in the dike ring. As stated by one representative of the water board: 'We do not advise about how to deal with flood risks in spatial plans in the dike-ring area, since this kind of advice goes ahead of the current flood management policies'. Even though higher-tier government has encouraged cooperation between spatial planners and water managers through the Water Assessment, water managers hardly used this instrument to address the use of spatial planning for the reduction of flood consequences. As a result, spatial planners considered the proposed land-use changes as legitimate in the light of flood risks, and additional land-use strategies were regarded as unnecessary. Consequently, measures to reduce flood consequences were hardly addressed in spatial plans.

Other arguments for not adapting spatial plans to flood risk issues referred to the availability of suitable building locations and to the perception of the seriousness of the flood risk. For example, alternative building locations were not available within the municipality or were not allowed in the provincial spatial plan, e.g. because these areas were protected as part of open space preservation or nature conservation policies. Furthermore, some respondents argued that additional measures were unnecessary in their municipality because their municipality was situated in the highest part of the dike-ring area. Therefore, they perceived the flood risk as relatively low.

5.6 Practices to reduce flood consequences

The Westergouwe and Dordrecht case and two practices in the dike-ring 16 area could be labelled as practices to reduce flood consequences, since measures for the management of exposure and the adaptive, coping and recovery capacity, as discussed in the analytical framework, were considered. In these cases, land-use changes near dikes and in the river forelands were regulated to protect the dikes and to facilitate future dike reinforcements. In addition to these measures to reduce the likelihood of flooding, spatial planning was also used as an instrument to reduce potential flood consequences. At one municipality in the dike-ring 16 area, exposure was limited because the municipality decided to build fewer houses to reduce potential damage. For another proposed residential area, the municipality paid extra attention to artificial hills and evacuation routes, which increased the adaptive and coping capacity. The other municipality in the dike-ring 16 area investigated the elevation of the residential areas to reduce vulnerability. In addition, the configuration of these artificial hills was considered, since this could influence the recovery capacity. The proposed building site was situated in the lowest part of the dike-ring area, near the river and adjacent to a sluice. This sluice would serve as an outlet for the water in case a flood should occur. Urban development near this sluice would hinder the outflow of water. Therefore, special attention was given to the consequences of urban development on the capacity of the sluice.

In the Westergouwe case, spatial planning was also used to implement measures to reduce the exposure of people and properties to flood risks. As a result of the spatial planning process, the proposed residential area will be raised between 1 and 1.5 metres, since it is expected that water levels would most likely reach this height at that location in case of a dike failure (Werkgroep Wateropgave Westergouwe, 2004). In the Dordrecht case, in contrast, the division of the dike-ring area into smaller compartments through secondary dikes was explored. This division could reduce exposure. The secondary dikes could also increase the capacity for evacuation and shelter, and they could provide an access route for emergency services in case of a flood event. As a result, coping capacities would be increased.

The territories of the municipalities that did address flood risks explicitly can be regarded as relatively flood-prone areas. This flood proneness, however, was not the only argument that was mentioned to explain why spatial planning was used to reduce flood consequences. Many other arguments were given as well. These arguments mainly referred to psychological factors and higher-tier government policies and initiatives.

In 1995, only two municipalities in the dike-ring 16 area decided to evacuate some parts of their territory. This decision was prompted, apart from the dangerously high river level, by the existence of a weak dike section. In our case study, these were the same municipalities that considered additional mitigation measures in recent spatial plans. The respondents referred to these events to explain their attention for flood risk. According to one of these respondents, the municipal executive included additional flood reduction measures in the local spatial plan because it felt that flood risks had become a subject of major public concern after the evacuation in 1995.

The respondents in the Dordrecht case also referred to previous flood experience. The historic centre of Dordrecht is situated in the river forelands and is not protected by primary dikes. Therefore, this area has a relatively high probability of flooding, which was regarded as a main reason for the relatively high awareness of flood consequences in Dordrecht. Recent near-flood experiences also affected public commitment, which again played an important role in this municipality. As a result, previous experiences with imminent floods were an important argument to use spatial planning to reduce flood risks.

Nevertheless, the case studies have shown that previous disaster experience is not the only factor that explained the adoption of mitigation measures in local spatial planning practices. The availability and interpretation of authoritative requirements of higher-tier government as well as the acknowledgement of the flood risk issue by the water board also partly explained the attention for additional land-use and design strategies. This was mentioned by two respondents from the dike-ring 16 area and also by the respondents from the Westergouwe area, which was not evacuated in 1995. In these cases, the water managers acknowledged the flood risk issue in their water advice. This advice was worked out in detail and implemented in the spatial plan in order to get approval of higher-tier government.

One of our respondents in the dike-ring 16 area explained that the province must approve local spatial plans. The municipality felt that, in the light of the Water Assessment, additional measures to mitigate flood risks were needed to legitimise the proposed spatial developments and to gain approval, although the province had not yet opposed the developments. As this respondent explained: ‘The province examines whether the municipality has carefully considered the issues addressed in the Water Assessment. To gain the approval of the province, we decided to consult with the water board in advance’.

Within the Westergouwe case, however, the province initially agreed with the proposed development, but the Minister of Housing, Spatial Planning and the Environment ordered the province and the municipality to pay more attention to water issues, and in particular to explain the soundness of the proposed residential development in the light of water management (Werkgroep Wateropgave Westergouwe, 2004). Even though this order mainly focussed on water logging, it also led to the consideration of flood risks. Additional flood mitigation measures were explored and implemented. Comparable arguments were also expressed by the representatives in the dike-ring 16 area.

Finally, experiences and knowledge with previous spatial planning strategies for flood reduction were mentioned as an important reason for the explicit consideration of flood risk issues in spatial planning. This argument referred to the expertise of local authorities. The respondents in the Dordrecht case explained that their experience with land use and design strategies in another project, which focussed on urban development in the river forelands, had changed their notion of flood risk management and planning. This experience had motivated them to consider such strategies within the dike-ring as well. The same applies to the respondents involved in the Westergouwe project. They argued that their experience had motivated them to consider land use strategies to reduce flood consequences. They did this, for example, by reducing flood exposure or by improving the coping capacities in other areas as well.

5.7 Discussion and conclusions

The objective of this paper was to explore how flood risks are addressed in local spatial planning practices in the Netherlands. More specifically, it addressed the question of why spatial planning was or was not used for the reduction of flood consequences. These insights should contribute to discussions on the implementation of flood mitigation measures as a way to deal with the potential effects of climate change on urban development.

Making a distinction between various risk components (see Table 5-1) turned out to be useful to characterise the way in which flood risks were addressed in different planning practices. Based on these various risk components, it can be concluded that most of the planning practices that were examined in this study focussed on the implementation of measures to reduce flood hazards and to increase the resistance capacity of the dike-ring areas. Measures to reduce flood consequences, including measures to increase the coping, adaptive and recovery capacities of dike-ring areas and measures to reduce flood exposure, were only considered in some practices.

Based on research in the USA, New Zealand and Australia, several factors could be distinguished that influence the way local authorities use spatial planning to mitigate flood risks (see Table 5-2). These factors were suitable for explaining the use of spatial planning for flood reduction in the Netherlands. The cases we examined indicate that psychological factors, higher-tier government policies and the local interpretation of these policies explain to a large extent the actual use of spatial planning. National flood management policies do seem to have led to spatial planners assuming that they are not responsible for the further reduction of flood consequences. In this respect, a lack of accountability in combination with a lack of recent flood experiences resulted in a lack of commitment to use spatial planning to reduce flood consequences.

In some of the cases we studied, risks were perceived as relatively low and therefore additional spatial planning measures to further reduce flood risks were not considered. On the other hand, such measures were taken in relatively high risk areas. For these reasons, actual flood risks and risk perceptions can be regarded as important additional factors that can influence commitment to spatial planning for flood reduction. Of course, these factors are interrelated with other factors identified in Table 5-2. The perceived flood risk in an area, for example, can influence perceived trade-offs or public commitment.

Our respondents, however, hardly mentioned trade-offs with other interests as an argument for not using spatial planning to reduce flood consequences. Nevertheless, measures that integrated flood management and urban development interests were applied far more often than measures that only focussed on flood consequences. Instead of reducing the proposed number of houses, for example, the houses themselves were adapted or the building site was elevated. Also issues related to public commitment for the implementation of measures to reduce flood consequences hardly played a role in the ways of reasoning of spatial planners.

When compared to other countries such as the USA and the UK, trade-offs and public commitment seemed less relevant in the cases we examined. A possible explanation is that in the Netherlands, spatial planning is rarely adopted as an instrument to reduce flood consequences. Spatial measures are sometimes considered, but have not yet been implemented. Nevertheless, these factors can become more significant when measures to reduce flood consequences are more actively considered and implemented. It is therefore important to regard the factors presented in Table 5-2 in the light of specific and changing planning contexts.

Recommendations

If the further reduction of flood risk consequences through spatial planning is desirable, existing national planning procedures should be extended. More specifically, the Water Assessment should be expanded by adding a specific flood risk component. An evaluation of the Water Assessment showed that it is an effective instrument to place water interests more at the centre of spatial planning practices, although flood risks are hardly addressed in actual Water Assessment practices. This calls for the inclusion of a specific flood risk component in these practices.

Nevertheless, planning practices cannot entirely be understood from the institutional structures and procedures. Other factors, such as the personality and individual power of the actors involved, also influence the outcome of the planning process (Hajer & Laws, 2006). For that reason, individual spatial planners, as well as water managers, also have an important task. They have the power to organise attention to flood risk issues and risk reduction measures. They can also challenge existing practices, roles, responsibilities and cultures instead of reproducing them naively (Forester, 1989). People in higher-tiers of government should therefore actively coordinate the consideration of flood risks in spatial planning practices, since local governments felt more responsible for the consideration of flood risk issues when higher-tier authorities required them to do so. Subsequently, spatial planners should address flood risks more extensively on the local level and implement actions that can be taken to reduce flood risks.

However, this requires higher-tier governments and local spatial planners to be more aware of the flood risks within their jurisdictions. Water authorities have an important task in supporting them. They should address flood risks and flood risk reduction measures as part of their Water Assessment and provide other authorities with area-specific flood risk information.

Trade-offs with other interests were hardly used as an argument for not using spatial planning. Nevertheless, water and climate change should not be regarded as independent land-use functions, but as creative inputs for integral flood management that involves different interests. If different interests can be integrated, then the implementation is likely to be more successful. In this context, issues related to public commitment for the implementation of measures to reduce flood consequences are important too. Our research showed that these issues hardly play a role. Nevertheless, public commitment is a crucial factor for the implementation of risk reduction measures (Roth & Warner, 2007). Consequently, the experts and authorities involved in the planning process have an important task in broadening the discussion and organising attention to the interests and perspectives of other experts, authorities and the public during both the development and implementation process of flood risk reduction measures.

Even though this research provided insight into the use and non-use of spatial planning to reduce flood risks, further research is needed. The number of cases, for example, could be extended to provide more explanatory insights. Moreover, the planning process should be studied over a longer period of time. As a reaction to previous flooding events and climate change, actual flood risk policies have been reconsidered in the Netherlands (Ministerie van Verkeer en Waterstaat, 2008c) and other European countries, such as the UK (White & Richards, 2007) and Germany (Hutter *et al.*, 2007). Spatial planning is increasingly recognised as an important instrument to implement measures to reduce flood consequences, such as the regulation of land use in flood-prone areas. An evaluation of these spatial planning practices over a longer period of time can provide more insight into the effectiveness of spatial planning for flood risk management and therefore contribute to making the considered flood management strategies operational.

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6

A Spatial Planning Perspective for Measures concerning Flood Risk Management*

Abstract

As a reaction to flooding events, various governments in Europe addressed the need to create more physical space for water. Experiences in the Netherlands have shown, however, that the development and implementation of these measures can result in local opposition. Based on an examination of such conflicts, it is argued that spatial planning should not only be regarded as an instrument for regulating the land required for flood reduction, but also as an important instrument and substantive perspective through which participation can be facilitated and through which water management objectives can be balanced with other spatial claims on the landscape.

Keywords: spatial planning, flood management, space for water, the Netherlands**.**

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6.1 Introduction

In the 1990s, some areas in the Netherlands experienced local flooding or were threatened with flooding near rivers. These events triggered a new national water management strategy which was consistent with other European countries (Bohm *et al.*, 2004; Howe & White, 2004; Johnson & Priest, 2008), and which addressed the need for more physical space for water. First of all, it was suggested that rivers required more space. The elevation of dikes alone was regarded as undesirable, since a further elevation could increase potential flood depths, restrict natural river dynamics and spoil landscape qualities such as cultural heritage and scenery (Vis *et al.*, 2003). For these reasons, it was thought advisable to create more physical space for the rivers by reducing the maximum river water levels and consequently the probability of flooding.

The regional and local water systems, including the secondary rivers and channels, also required more space to prevent problems with local flooding due to heavy rainfall and limited drainage capacity. More physical space for water would increase the drainage and storage capacities in the water system, through which the probability of local flooding would be reduced. Clearly, more physical space needed to be given to water and water-related land uses (Howe & White, 2004; Wolsink, 2006). Examples of measures to reduce peak water levels in the rivers are the removal of obstacles from the floodplains, dike relocation and the construction of bypasses or secondary channels to circumvent urban bottlenecks. Examples of measures to prevent local flooding are the development of local and regional water retention areas, canal broadening and the regulation of land use in areas exposed to local flooding. These physical measures, aimed at providing more space for water to reduce flood risks, are referred to as spatial measures for flood risk management.

The organisation of Dutch water management practices is extensively described in the literature (Wiering & Immink, 2006; Wiering & Arts, 2006; Wolsink, 2006; Woltjer & Al, 2007). Relevant aspects of the current system for the implementation of spatial measures for flood risk management are the strictly functional responsibilities of water authorities for flood defence, water quality and water quantity management, and the hierarchical organisational culture within these authorities. Water managers are accustomed to operating in a rather autonomous, isolated and technocratic way. Spatial measures for flood risk management, for example, are often developed in the domain of water management and from a water-management perspective. Consequently, other regional and local ideas on both plan development procedures and substantive aspects of the plan are neglected. As a result, policy makers encounter strong local opposition, which sometimes results in major project delays, inadequate solutions or even in the cancellation of projects aimed at providing more space for water (Davidse, 2008; Grijzen, 2008; Neuvel, 2004; Roth *et al.*, 2006; Schuwer, 2008).

In this light, it is argued that a spatial planning approach towards the development and implementation of spatial measures can have an added value in dealing with current and potential conflicts. Therefore, the central questions addressed in this paper are: what types of conflicts appear during the development and implementation of spatial measures for flood risk reduction, and what can be the added value of a spatial planning perspective in dealing with these conflicts?

These research questions are answered through studying four Dutch projects in which spatial measures for the reduction of flood risks were developed. These projects are discussed from a spatial planning perspective. First we define what a spatial planning perspective is, and then we translate this perspective into an operational analytical framework. This framework is used to analyse the case study projects and to increase understanding of practices and conflicts related to the development and implementation of spatial measures. In addition, the spatial planning perspective is used to provide suggestions on how things might be done differently.

6.2 Spatial planning perspective

Spatial planning focuses on the physical landscape and the activities that take place in the landscape. Based on the demands and requirements of society, spatial planning tries to position activities such as agriculture, recreation or industry, as well as physical structures such as roads or houses, in the landscape (Tewdwr-Jones, 2001). As a result, the actors involved in spatial planning try to influence current and future land use. For this reason, spatial planning can be characterised as a future-oriented activity (Couclelis, 2005). Based on this point of view, spatial planning can be perceived as a policy-making process through which the actors involved try to define and create desired spatial situations while defining and preventing undesired ones (Van Leeuwen *et al.*, 2007).

Similar objectives can also be encountered in transport planning, flood risk management or urban planning. Spatial planning, however, distinguishes itself from these fields through its holistic, integrative approach: it tries to coordinate different spatial sector claims. Spatial planning, for example, tries to balance and, if possible, integrate spatial claims for water retention with claims for residential development.

In contrast with other disciplines which are aimed at integrating various sector claims, such as integrated water resources management (Biswas, 2008), the starting point of spatial planning is the landscape in general, instead of a specific sub-system in the landscape such as the water system or urban system. Through this interdisciplinary and comprehensive approach, spatial planning strives for a physical organisation of space, which is coherent and desirable from both sector and multi-sector points of view (Hidding & Van den Brink, 2006). For this reason, spatial planning is not only involved with the statutory planning process of development control and development plan preparation, but also with broader concerns such as social, economic and cultural issues (Tewdwr-Jones, 2001).

In addition to these substantive questions, the term 'spatial' also links to procedural aspects, for example, about how spatial planning processes should be designed, how spatial planning decisions should come about or how conflicts about both substantive and procedural aspects should be managed. This includes questions about the involvement of local actors and the role of these local actors in the policy-making process. Of courses, substantive and procedural aspects are interrelated. The actors involved, for example, greatly influence the way a problem is defined.

Within flood risk management, however, spatial planning is often narrowed down to a regulatory instrument through which land use change in flood-prone areas can be regulated (Hutter, 2007). Although similar to participatory water management, spatial planning can also be an important instrument by, for example, facilitating more interactive policy making and can provide an interesting substantive focus.

6.3 Research approach

Many conflicts in spatial planning practices are about incompatible spatial claims. Different actors can have diverse, and often conflicting, spatial claims on the same area. For example, one group might prefer residential use for a particular area, while another group might prefer to prohibit residential development in the same area in favour of ecological interests. Consequently, the analytical framework used in this paper focuses on these conflicting spatial claims.

Based on ideas of how people perceive reality (Kolkman, 2005; Schön & Rein, 1994; Te Velde *et al.*, 2002), it is assumed that spatial claims and ideas about desired current and future landscapes are influenced by specific convictions, values, norms, interests and knowledge (Table 6-1). In this respect, the analysis of conflicts focuses not only on conflicting spatial claims or conflicting ideas regarding current and desired landscapes. These claims and ideas are in turn also based on diverse and often conflicting interests, norms, values, convictions and knowledge, all of which require examination as well.

Table 6-1. Factors that influence desired landscapes

Factor	Definition	Examples
Convictions	Convictions are opinions about the way things are. They are strong beliefs that are not easily called into doubt.	The conviction that one should not kill, or that planet earth is a globe.
Values	Values can be described as worldviews about the way things should be. Values are ethically loaded.	Democracy, social justice, solidarity and equity.
Norms	Norms are the translation of values into tangible rules for behaviour.	Equal risk acceptability criteria, traffic rules.
Interests	Interests can be described as ideas about what is perceived as advantageous for individuals or groups, and is therefore something to be striven for. Interests are induced by convictions and values.	Financial interests: can my company still make a profit? Social interests: can my children grow up in a safe environment?
Knowledge	Knowledge is constructed from experiences, facts, stories and impressions. Knowledge is not only the result of observation, but it also steers observation.	Knowledge about risk, knowledge about the viewpoint and behaviour of other actors.

Based on: Kolkman, 2005; Schön & Rein, 1994; Te Velde *et al.*, 2002

To characterise and analyse the procedural aspect of policy-making processes and to characterise how water management authorities dealt with local actors and local opposition, theories on interactive policy making were used. Interactive policy making is a popular attempt to solve conflicts in policy-making processes and to increase the support of local stakeholders, among others (Edelenbos & Klijn, 2005). It can be regarded as a more collaborative policy-making approach. Within interactive policy making, stakeholders are regarded as knowledgeable actors, and authorities try to cooperate with these stakeholders. Even though interactive approaches are not developed exclusively for spatial planning, these approaches are becoming more prominent in planning practices (Albrechts *et al.*, 2001; Edelenbos & Klijn, 2005; Hajer & Zonneveld, 2000; Van Rooy *et al.*, 2007). This is why this perspective was chosen to analyse the procedural aspects of the policy-making process.

Different types of interactive policy-making can be characterised by varying levels of participation, meaning the degree to which people are offered the opportunity of participating in and determining the final outcome of the policy-making process. In addition, different styles of governance can be distinguished in the way the governmental body deals with the target groups of the proposed policy, the stake-holders and ultimately other initiators of spatial measures (Pröpper & Steenbeek, 1999). Based on the level of participation and the governance style, interactive policy-making processes can be characterised by a participation ladder (Table 6-2). In this regard, planning processes can be seen as strongly interactive if there are many local actors involved and if these actors have the opportunity to determine the planning process.

Governance styles and levels of participation, however, should not be regarded as static, but rather dynamic. They can change over time and co-exist alongside one another. Participation can be defined as consulting during the elaboration of a solution or consulting on specific issues, but can be very limited during the process of agenda setting. Therefore, the level of participation and the governance style should be studied over a longer period of time.

Table 6-2. Characterisation of the participation of local stakeholders

Level of participation	Definition	Governance style
Co-deciding	The development and policy-making process is left to the initiators and stakeholders. This process is facilitated by authorities.	Facilitating
Co-producing	The government authorities and stakeholders are partners. Agenda setting and problem-solving are joint activities. The government commits itself to the results of the process.	Cooperating
Delegating	The authorities give participants the power to make decisions within the decision-making context provided	Delegating

Advising	Citizens have the opportunity to bring up problems and formulate solutions, but the government defines the agenda. The politicians are committed to the results in principle, but can deviate from them.	Participatory
Consulting	Authorities define the problems and possible solutions. Citizens are consulted about the problems and solutions and can give their points of view. The authorities are free to commit to these points of view.	Consultative
Informing	The citizens are informed about the policy process, but are not allowed to have input.	Open-authoritarian
No-participation	The public is not informed about the policy-making process and is not allowed to influence it.	Closed-authoritarian

Based on: Edelenbos & Klijn, 2005; Pröpper & Steenbeek, 1999

The analysis of conflicts, degree of participation and governance styles was done by examining four ‘making space for water’ (MSW) projects (Table 6-3, Figure. 6-1). Two of the selected cases concern projects in which there was strong local opposition, ultimately resulting in the cancellation of the projects. The other two projects are still in progress and have some degree of local support. These projects (with their contrasting processes) were selected to compare and understand conflicts that appear in MSW projects.

Table 6-3. Overview of the projects

Project	Objective	Status	Sources
1. Schardammerkoog	Water retention area	Cancelled	(Neuvel, 2004)
2. Nieuwe Driemanspolder	Water retention area	In progress	(Neuvel, 2004)
3. Ooijpolder	Calamity polder	Cancelled	(Davidse, 2008; Roth & Warner, 2007; Roth *et al.*, 2006; Warner, 2008)
4. Kampen Bypass	River bypass	In progress	(Grijzen, 2007; Grijzen, 2008; Schuwer, 2008)

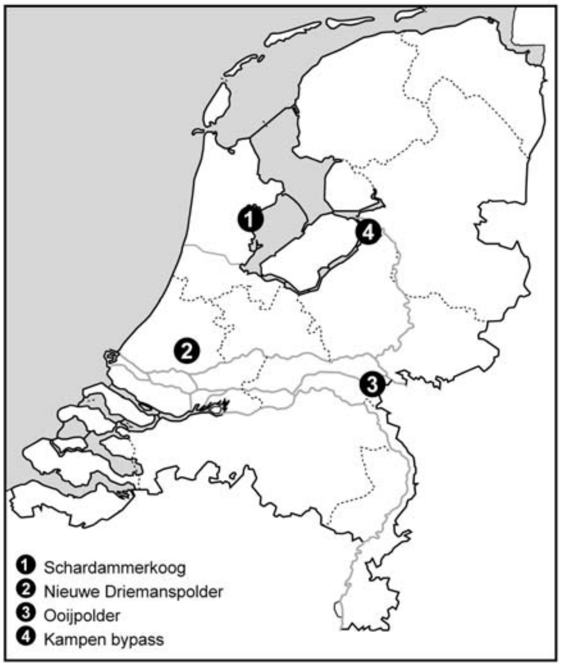

Figure 6-1. Location map of the studied projects

The analytical framework described above was first used for the examination of conflicts that appeared during two projects for the development and implementation of water retention areas (Neuvel, 2004). These two projects were analysed to determine how the policy-making process came about with regard to the level of participation and governance style. In addition, substantive conflicts were examined with regard to conflicting knowledge, interests, values, norms and convictions. The research began with a document analysis involving scientific literature, policy documents, reports, minutes, newspaper articles and other relevant documents. In addition to this first examination, key actors from both governmental and non-governmental organisations such as water boards, municipalities, farmer's groups, and inhabitant and nature conservationist groups were selected and interviewed. The interviews were semi-structured with open-ended questions.

In this paper, we compared the results of this research with experiences from two other studies on 'making space for water' projects in the Netherlands. These studies focused on the development of a 'calamity polder' (Davidse, 2008) and a river bypass (Schuwer, 2008). The studies were carried out as masters thesis projects, supervised by the present authors. Each piece of research focused on conflicting spatial claims and the arguments on which the actors involved based their claims. In addition, the research focused on the level of participation and governance style, and consequently on the way the policy-making process in these projects came about. This was done using an interactive policy-making framework and methodologies similar to those applied during the analysis of the water retention projects.

The results from these masters theses were augmented with experiences from external studies on the same calamity polder project (Roth & Warner, 2007; Roth *et al.*, 2006; Warner, 2008) and the same river bypass project (Grijzen, 2007; 2008). These studies provided additional information on the projects and the conflicts that appeared during the projects. By bringing these case studies together, the empirical findings provided a more robust starting point for reflecting on conflicts that appeared during these 'making space for water' projects. Subsequently, the four case study projects were compared by asking the following sub-questions (which were derived from the analytical framework):

- Which conflicting spatial claims appeared during the policy-making process and how can these conflicting claims be understood in the light of convictions, values, norms, interests and knowledge?
- How did the authorities deal with these conflicts in terms of governance style and the level of participation during the process?

6.4 Case studies

Water retention area Schardammerkoog

In 1994 and 1998, the north-western part of the Netherlands experienced local flooding. After these events, the water board asked a research institute to calculate the current and expected risks of local flooding, taking the discharge and storage capacity of the water system into consideration. According to these studies, the water system met the national guidelines. In the near future, however, the water system could fail more often due to urban development and climate change. For these reasons, the water board began to search for suitable measures to maintain the current level of protection against future water surplus.

In addition to the water board, the province, a regional agricultural group and a nature conservation organisation were involved. They discussed alternative solutions for managing water surplus. This resulted in one preferred solution: a water retention area, to be located in the Schardammerkoog polder, near Lake IJssel. Subsequently, the preferred solution was presented to the local stakeholders in an open authoritarian style. They received a letter in which the proposals for the water retention area were presented.

Both the regional and local actors agreed upon the necessity of additional measures to reduce the probability of local flooding, but they disagreed on the proposed solution. Therefore a local pressure group was established which represented local farmers and inhabitants during official hearings and meetings with the water board, municipality and province.

Many local stakeholders still regarded pumps as the best practice for preventing local flooding and questioned the effectiveness of a water retention area. Moreover, the water retention area conflicted with the interests of local stakeholders. The water retention area required 75 hectares of agricultural land and therefore conflicted with agricultural interests. In addition, the water retention area conflicted with the desire of the municipality and inhabitants to preserve the open landscape.

The representative of the inhabitants in the pressure group also argued that if water retention areas were needed, several smaller areas in different polders were desirable, rather than one large retention area in their polder. This idea was based on a value-rational argument: smaller water retention areas would result in a fairer distribution of the burden. In addition, the local pressure group heavily criticised the style of governance of the water board. The inhabitants of the area wanted to be involved at an earlier stage of the policy-making process.

As a reaction to the local opposition, the water board asked the province to work out the plans in cooperation with local stakeholders, which was a participatory style. Both local representatives and the province regarded this participation as constructive. Nevertheless, this participation did not result in the implementation of the water retention area plan. The strong local opposition caused a decrease in the political support for the water retention area, especially amongst the members of the water board council. As a result, this council cancelled the plan for a water retention area.

This project showed how the scope of problems and solutions can become narrowly defined through the involvement of a limited number of actors in the early stage of the policy-making process. Moreover, the plans that were developed followed a typically technical and sector-based approach. Initial proposals for measures were motivated mainly by technical arguments such as flood probabilities, water level reduction and pumping or storage capacity. Through this technical focus, other values which were based on non-technical or non-scientific arguments or arguments unrelated to water management, such as arguments about distribution of burden, were excluded from the initial debate. As a result of the closed style of governance, adaptation of the initial plan to local views was hardly allowed. Consequently, opportunities to balance the spatial claims of the water authority with the spatial claims of local actors were limited.

The conflicts that appeared in the Schardammerkoog project, however, were not only about the different spatial claims of the actors involved, but also about the values, norms and knowledge underlying the proposal of the water retention area, such as the idea that open landscape should be used for water retention. These values and this knowledge were mainly contested by the actors whose interests conflicted with the proposed spatial measures. Focusing on the values and knowledge underlying the spatial claims instead of the interests involved can be regarded as a way of dealing with the 'dilemma of stake': how to account for interests without being undermined as an interested party (Edwards & Potter, 1992). As a reaction to this dilemma of stake, affected actors can construct their arguments in such a way that they are not regarded as being simply interest-based (Edwards & Potter, 1992; Potter, 1996). For example, local actors brought the proposed water retention area up for discussion based on the value-rational argument that a large-scale water retention area implies an unfair distribution of burden. Of course, opposing views are not necessarily interest-based. Nevertheless, it can be expected that if proposed spatial measures conflict with interests of local actors, then the underlying values and knowledge on which a measure is based will also be contested.

Water retention area – Nieuwe Driemanspolder

In the 1990s, the south-western part of the Netherlands also experienced local flooding. Based on studies of the local water board it was concluded that the water system did not meet the guidelines for local flooding. Consequently, a water retention area was needed and the pumping capacity had to be increased (Hoogheemraadschap van Rijnland, 2000). The Nieuwe Driemanspolder was proposed as the location for this water retention area because this polder was located near the main bottleneck in the water system. In addition, the province already had plans to transform this agricultural area into an area for nature, with agricultural and recreational use. It was argued that since these land uses could be combined with water retention, that the selection of the Nieuwe Driemanspolder would be the most appropriate location for water retention.

Because the province had already started the policy making process on the coordination of various spatial claims in the Nieuwe Driemanspolder, it became the coordinating authority for the further elaboration of the project. The proposed water retention area lay within the territory of two water boards and three municipalities. For that reason, these authorities formed a steering committee for the project. The objective of this steering committee, however, was not only to develop ideas for the development and implementation of the water retention area, but also to develop a spatial plan for the polder which could balance claims for water retention, open space preservation, agriculture, recreation and nature.

Similar to the Schardammerkoog case, local stakeholders were actively consulted only after the choice for a water retention area in the Nieuwe Driemanspolder was made and elaborated on by the steering committee. The participation of these local stakeholders was formalised through the establishment of a sounding board group in which representatives of inhabitants of the polder, land owners, farmers and nature organisations were involved. The task of this group was to ascertain the desires, ideas and objections of the local stakeholders and to advise the steering committee on the further development and implementation of the water retention area in accordance with a participatory style.

In contrast to the Schardammerkoog case, local pressure groups were not established. Moreover, the proposed water retention area was hardly criticised by local stakeholders. Criticism from local stakeholders focused mainly on various technical details regarding the elaboration of the plan rather than on the concept of water retention itself. Some representatives from nature conservation organisations in the sounding board group, for example, worried about the water quality of the water in the retention area during a peak in water storage, and the effect this water quality would have on the desired natural habitats. Local farmers wanted to be compensated for the loss of land or criticised the planned canal for the water retention area, since it would require agricultural land. Inhabitants involved in the sounding board group were concerned about the increase in traffic that was expected from the recreational use of the water retention area. In spite of these concerns, however, the respondents did not reject the water retention plan.

The water retention area seemed to be compatible with the convictions, values, norms, interests and knowledge of local actors representing different sector perspectives such as agriculture, nature conservation or recreation. An important explanation for this 'fit' can be found in the historic development of the policy-making process. In the past, many plans had been developed for this polder. In recent decades numerous new functions had been proposed for the polder such as housing development, a rubbish dump, a forest and even a Chinese theme park. The interviewed inhabitants who were members of the sounding board group explained that they were 'not very happy' with the development of a new water retention area in their backyard. The proposed water retention area conflicted with their values, norms and interests because they preferred to keep the area as it was. In spite of this preference, however, they did not take action to prevent the development of a water retention area. They expected that the area would be transformed in any event, and felt that the development of a water retention area might be 'the best possible development' at the present time and might prevent other, less desirable developments. Farmers in the polder also supported the development of the water retention area, as was explained by the interviewed farmer who was a member of the sounding board group. The local farmers wanted to have clarity about their future. The development of a water retention area might be an opportunity for them to sell their land and to develop a new farm in a region with better prospects.

In contrast with the Schardammerkoog project, the Nieuwe Driemanspolder project focused explicitly on balancing different spatial claims. Through this focus, spatial claims for water retention were integrated with claims for agriculture, nature conservation and recreation. Local stakeholders became involved during the elaboration of the plans and supported the proposal for a water retention area. It should be noted, however, that part of the support for the water retention area was actually the response of stakeholders choosing an option they viewed as less threatening than other, less desirable developments, rather than their involvement in the water retention plan itself.

Calamity polder – Ooijpolder

In February 2000, the Vice Minister presented policy proposals for the national policy 'Room for the River'. These proposals made the national government's intentions for the development of calamity polders public. Calamity polders are existing polders that can be deliberately inundated to store water in case of peak water levels. Through the use of calamity polders, the accidental flooding of other, more densely populated or economically strategic downstream areas could be prevented. Potential locations for the calamity polders had already been selected in the preparation of the National Spatial Policy Document, using an open authoritarian style (Davidse, 2008). The Ooijpolder was one of the selected calamity polders.

Local and regional authorities and interest groups were surprised by the proposals and heavily criticised the proposed calamity polders (Roth *et al.*, 2006; Warner, 2008). As a reaction to this criticism, a state advisory commission was established by the national government to further investigate the need and conditions for calamity polders.

A local bank director in the Ooijpolder invited the chairman of the commission, David Luteijn, to the bank's annual general meeting, to inform citizens in the

Ooijpolder about the calamity polder plans. This meeting can be described as an open authoritative rather than consultative meeting (Warner, 2008).

The presentation caused social turbulence in the Ooijpolder. People were concerned about the consequences of becoming a calamity polder: they were afraid that property values would decline, that desired urban developments would be prohibited and that investments in the area would be reduced (Roth *et al.*, 2006). The presentation triggered local opposition, initially by farmers, but followed by the establishment of a local pressure group (Roth *et al.*, 2006). Similar to the Schardammerkoog group, this pressure group included both farmers and a considerable number of inhabitants. The Ooijpolder group, however, lobbied at both the regional and national level, did additional research on the effectiveness of calamity polders, informed the inhabitants of the polder and used the media to increase public awareness regarding their point of view. Similar to the Schardammerkoog group, the arguments used by the local pressure group did not focus explicitly on interests such as property values. The pressure group focused mainly on the knowledge and technical assumptions underlying controlled flooding (Davidse, 2008; Roth & Warner, 2007). They believed, for example, that the estimate used for peak river discharges was too high, undermining the need for calamity polders. This strategy can be regarded as another strategy for dealing with the dilemma of stake: to focus on the assumptions in the plan instead of the interests held by the members of the local pressure group. This prevents the pressure group from acquiring the label of an NIMBY-driven (Not In My Back Yard) pressure group (Roth *et al.*, 2006).

In 2003 a consultancy bureau submitted a report to the Ministry of Transport, Public Works and Water Management that criticised the research on calamity polders. The Ministry initially denied the existence of this report to the local pressure group, and the report was only made public after the local pressure group announced it would appeal to the government information act. These and other reports raised growing doubts about the effectiveness of calamity polders and the underlying technical facts (Roth *et al.*, 2006).

At this stage, the lobbying of Members of Parliament by the local pressure group turned out to be effective as well. One of the contacts of the pressure group helped propose a resolution, which was voted on in Parliament, to transfer the budgeted funds for the calamity polders to the general budget for the Room for the River Policy. The acceptance of this resolution by Parliament forced the national government to postpone the spatial reservation for the calamity polders in the National Spatial Planning Act. This meant that the plans for the calamity polder in the Ooijpolder were removed from the political agenda (Roth *et al.*, 2006).

As illustrated by the Ooijpolder case study, local actors turned out to be very good at utilising their networks outside the formal policy-making and information meeting process to influence the outcomes (Warner, 2008). Experiences in other planning processes have also shown that actors involved in planning continue to communicate via traditional forms and institutions, but that many activities related to spatial planning such as bargaining, decision-making and influencing activities are taking place outside the formal structures and rules of the planning process (Hillier, 2000). As illustrated by the Ooijpolder project, and to a lesser extent by the Schardammerkoog project, this communication no longer takes place behind closed doors, but in public, involving the media and local stakeholders. Consequently, authorities who are developing spatial water measures that conflict with local ideas on the current and desired future landscape should expect strong local opposition.

Even though the proposed calamity polder conflicted with local interests, such as maintaining property values, local opposition focused mainly on the knowledge underlying the plan for the calamity polder. Consequently, the conflicts were not only about different local and national interests, convictions or values, but also about the technical knowledge on which the proposed calamity polder was based.

The Kampen bypass

In addition to the calamity polders, the national government also explored other possibilities for and consequences of creating more room for the rivers. After this exploration, the national government decided to develop an integral plan for flood management on the main rivers. One of the measures considered in this national plan was the development of a river bypass near Kampen, adjacent to the IJssel River. Consequently, the national government put a claim on this area to enable the development of a river bypass in the future, even though the implementation of the bypass was not planned until between 2050 and 2100. This claim conflicted with the housing objectives of the local government. The municipality of Kampen wanted to build 4,000 to 6,000 houses in this area. In addition, the proposed bypass conflicted with other spatial claims such as a new railway and the upgrading of a main road. Therefore, the province brought the involved authorities together to develop a spatial master plan for the area and to explore, as had been done in the Nieuwe Driemanspolder project, how the different objectives and claims could be integrated.

The regional master plan was developed in cooperation with local, regional and national authorities. These authorities proposed developing a river bypass in the short term and integrating it with the other spatial claims, such as the development of a railway. Five development scenarios were described in the master plan, which was presented using a consultative governance style to the public by means of three information meetings. These meetings were open to all interested parties. The participants were allowed to respond to the various scenarios (Grijzen, 2007; Schuwer, 2008).

The scenario for the bypass as a new secondary river, navigable for recreational boating, was most popular with the participants. During the information sessions, however, inhabitants of Kamperveen, a small village near the city of Kampen, were especially opposed to the proposed scenarios because the bypass would physically split their community. In reaction to this resistance, the province offered to support people in developing alternative scenarios with the aid of the experts involved in the development of the master plan. This governance style can be regarded as a more interactive participatory style, since the authorities did not necessarily commit themselves to the result. Through this more participatory style, province representatives successfully transformed local opposition by inhabitants of Kamperveen into constructive participation (Grijzen, 2008). This resulted in a sixth scenario, which was a variant of the popular secondary river scenario. In this variant, however, the secondary river would divide the Kamperveen community as little as possible. Based on the information meetings, the project group opted for the elaboration of a bypass as a secondary river that would be navigable for recreational boating and for a trajectory that did not divide Kamperveen.

In addition to the inhabitants of Kamperveen, the inhabitants of Noordeinde, a small village in the province of Gelderland, also heavily opposed the plans. The project team was also considering the territory of Noordeinde for the planned route of the bypass. In this village as well, the proposed bypass conflicted with local ideas about the desired landscape. For example, people were afraid that the bypass would attract recreation and would result in new houses, which would disturb the peacefulness of the area (Grijzen, 2008). In addition, the inhabitants claimed that the policy makers had forgotten to inform them about the project. They were not actively informed about the consultation round, and only found out about it three days beforehand (Grijzen, 2008). The people of Noordeinde were able to attract local, regional and national media attention. As a reaction, the project leaders for the project's master plan organised an information evening and promised the inhabitants that the bypass would not cross the territory of Noordeinde. They also extended the consultation round (Grijzen, 2008).

Similar to the Nieuwe Driemanspolder project, the elaboration of the master plan was carried out by a project group which consisted of civil servants from the local and regional authorities and a steering group in which the local and regional governments were represented. Representatives of non-governmental stakeholders were not involved in the consultation rounds as they had been during the presentation of the scenarios, but were invited to participate in a sounding board group. However, the sounding board group did not have any formal decision-making power.

During the elaboration of the plans, ideas for residential development were worked out further. The proposed residential development in the area, which was needed for financing the desired development, amongst other objectives, was still strongly opposed by some inhabitants. Like the group in the Ooijpolder, the local pressure group from Zwartendijk (another village near Kampen) focused on the knowledge underlying the purported housing need. They argued that the housing need was greatly overestimated and proposed building houses at alternative locations, especially within the city itself (Stichting Werkgroep Zwartendijk, 2007). In addition, some farmers were still dissatisfied with the proposed developments because the plans could result in their relocation. As this article went to press, local farmers and the local pressure group from Zwartendijk are still trying to influence the planning process. Like the Ooijpolder group, they are not only using formal methods of resistance, such as formal appeals, but also more informal ones. The Zwartendijk group, for example, is carrying out additional research on housing needs, presenting alternative plans and communicating their ideas through billboards in the fields. Nevertheless, the representatives of local and regional authorities still expect the current plans to be implemented. They regard acquiring sufficient funding for the bypass as one of the main bottlenecks for implementation of the plans (Schuwer, 2008), not the conflicts with local actors.

Similar to the other case study on the development of spatial measures for water management, the proposed bypass near Kampen resulted in conflicts with local actors affected by the bypass. As in the other case study projects, these conflicts were not only about the different interests, but also about the underlying knowledge on which the ideas were based. In the light of the policy-making process, this case study showed how governance styles, and especially adapting governance styles, can contribute to persuading local opposition to engage in more constructive participation (Grijzen, 2008). In addition, the project illustrated that a spatial planning perspective can be used to coordinate various activities that result in spatial claims, such as the development of a bypass, residential areas or new railroad.

6.5 Discussion and conclusions

Spatial measures to reduce flood risks require space, or at least another use of space. In the case studies, the spatial claims resulting from the proposed measures conflicted with other spatial claims and underlying values, norms and interests of actors in the area (Table 6-4). When proposed measures conflict with local views, policy makers can encounter serious opposition organised by the affected local and regional stakeholders. These stakeholders are able to organise strong opposition and make their voices heard, as was found in the Schardammerkoog, Ooijpolder and Kampen Bypass projects.

Table 6-4. Overview of the governance styles and conflicts on plan content

Project	**Governance style (from.. via … to)**	**Conflicting points of view**
Schardammerkoog	closed authoritarian → open authoritarian → consultative	Knowledge: effectiveness and efficiency of water retention versus pumping Interests: use of land and landscape quality versus water retention Values: distribution of burden Norms: one large or numerous smaller retention areas, involvement of local actors
Nieuwe Driemanspolder	closed authoritarian → open authoritarian → consultative	Knowledge: water quality Interests: continuation of agricultural businesses and livability versus land for water retention and recreation Values: openness versus water safety Norms: open landscape, water retention
Ooijpolder	closed authoritarian → open authoritarian	Knowledge: effectiveness and efficiency of calamity polders with respect to alternative flood mitigation measures Interests: land values, development potential, flood protection Values: protection against flooding, effectiveness, efficiency Norms: level of protection of flood prone areas, effective and efficient measures

Kampen Bypass	open authoritarian→ consultative → participatory → consultative	Knowledge: housing needs Interests: river bypass, housing development, infrastructural developments, landscape quality, land ownership, agricultural interests and financial interests Values: openness, peacefulness, social coherence Norms: no bypass through a village, open landscape

Through this opposition, not only the measures themselves, but also the underlying knowledge and values of the proposed measures are contested. In the end, this can result in the cancellation of projects as illustrated by the Schardammerkoog and Ooijpolder projects. .In this light, it can be argued that a more interactive approach to policy-making would be a positive development. This approach, in contrast to an authoritarian top-down approach, allows for discussion about the various spatial claims from various actors or groups of actors. An interactive policy-making process can help involved stakeholders recognize their dependency on other actors and learn about the convictions, values, norms, interests and knowledge of other actors involved. Furthermore, more interactive policy-making can increase trust amongst involved actors, provide additional, area-specific knowledge and creativity and be helpful in identifying potential conflicting values and interests at an early stage (Innes & Booher, 2003; Van Woerkum & Aarts 2002).

Nevertheless, the most appropriate level of interaction or governance style cannot be predefined. They are context dependent. Comparable governance styles in the Schardammerkoog and Nieuwe Driemanspolder led to very different outcomes. The Kampen case study, along with previous studies on interactive decision-making processes (Edelenbos & Klijn, 2005), have shown that policy-making processes are promising if levels of participation and styles of governance are adapted to the conflicts at hand, if the interactions are well prepared and if the voiced preferences are taken seriously.

More interactive policy-making, however, implies that discussions are broadened to introduce additional local spatial claims, such as agriculture or housing. This study of the MSW projects showed that the proposed measures for flood risk reduction not only conflicted with local views on water management, but also with local views on the desired current and future land use. These desires were not only based on water management ambitions, but also on ambitions with respect to agriculture, recreation or housing. Clearly, conflicts were therefore not only about the proposed measure itself, but also about its relationship to other spatial claims and about the underlying knowledge, values and interests. In other words, these conflicts were about the future landscape desired by national and local society and about the coherence of different land uses within this landscape. For this reason, a spatial planning perspective can be of added value if compared to the sectoral water management perspective. A spatial planning perspective implies a substantive focus on the landscape as a whole and on the coherence of and between different land uses and inhabitants. This perspective emphasises a more holistic starting point through which spatial measures for water management can be discussed in relation to other spatial claims. Moreover, the proposed measures and underlying arguments can be confronted with other convictions, values, norms and interests with respect to current and future land use. For these reasons, it can offer an interesting approach for the development of spatial water management measures. As illustrated by the Nieuwe Driemanspolder and the Kampen Bypass project, for example, a more holistic approach offers the opportunity to balance and integrate spatial claims for water management with other claims such as agriculture, housing or transport.

In the introduction, it was argued that the space for water policies could result in a greater priority for water issues within spatial planning practices (Howe & White, 2004; Wolsink, 2006). These case studies, however, have made it clear that in MSW practices, a greater priority for a spatial planning approach and the consistent consideration of other spatial claims, values and interests – such as landscape preservation or agriculture – are required. Within flood risk management, however, spatial planning is often narrowed down to a regulatory instrument through which, for example, land use changes in flood-prone areas can be regulated (Hutter, 2007). However, as this paper has illustrated, there is more to spatial planning than that. In addition to providing an interesting research perspective, spatial planning also provides added value as a substantive focus in interactive policy-making processes. This was shown in the development and implementation of spatial measures for water management, since this type of policy making inherently requires balancing different spatial claims with varying interests, values, norms and convictions with respect to the current and future landscape and its inhabitants and users.

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7

Integrated Flood Management Requires an Integrated Spatial Information Infrastructure*

Abstract
This examination of flood management practices in the Netherlands and the required spatial information in these practices has revealed an increased recognition of the strong interdependence between risk management and emergency response processes. In short, professional actors involved in flood risk management increasingly considered flood mitigation measures in the light of possibilities for emergency response. As a result of this wider conception of flood management, information needs for flood-risk management and flood-emergency response are increasingly overlapping. Consequently, the importance of an integrated spatial information infrastructure that facilitates the process of both risk and emergency management is addressed.

Keywords: flood management, spatial information infrastructure, risk management, emergency management.

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7.1 Introduction

Risk and emergency management activities are often divided into four categories: mitigation, preparation, response and recovery. A considerable part of the requested information before and during a disaster is explicitly geographical, or in other words, the information contains a specific spatial reference, such as hazardous installations, risk contours, vulnerable facilities, shelters, emergency routes, toxic clouds and flooded areas. As a result, geospatial information systems are increasingly seen as indispensable in supporting risk and disaster management activities (Brazier & Greenwood, 1998; Contini *et al.*, 2000; Craciunescu *et al.*, 2006; Greene, 2002; Köhler & Wächter, 2006; Parker *et al.*, 2007). Spatial information systems can support risk and emergency management activities with gathering, storing, retrieving, visualizing, communicating, analysing and modelling geographical and administrative information.

System requirements related to the different activities in risk and emergency management, however, highly differ. For example, as experienced in Dutch risk and emergency management practices in the past, actors involved in emergency response required simple, intuitive interfaces and approaches for communication and information access. The requirements for extended functionality or even intelligence in support of decision-making were minimal. For risk prevention, more extended functionalities were desired to make better arguments for the evaluation of alternative policies. Actors involved in risk management preferred more extended models to estimate the potential number of victims, but more simple applications were also required to communicate with non-experts such as stakeholders or governors (Neuvel & Zlatanova, 2006).

Although risk and emergency management activities have their own characteristics and the actors involved in different activities have their own system requirements, it is still possible to identify at least one common challenge that constrains the ability of risk and emergency management to plan for and manage emergencies effectively and efficiently: the need for better information (Cutter, 2003; Parker *et al.*, 2007; Schneiderbauer, 2007; Zlatanova & Li, 2008). In this paper the spatial informational requirements in risk and emergency management are explored together with their implications for the further development of spatial information systems and especially for the development of spatial information infrastructures. The information needs are explored through two case studies on flood management in the Netherlands. Based on an examination of risk and emergency management activities, the actors involved, and the information needs, we argue that an integrated spatial information infrastructure, which serves all activities in risk and emergency management (mitigation, preparation, response and recovery), should be strived for.

7.2 Conceptualisation of risk and emergency management

Risks, are generally regarded as a function of a hazard and the vulnerability of the physical and socio-economic system to this hazard. The term hazard refers to the events or phenomena that may cause harm to things that human beings value. Vulnerability refers to the susceptibility to damage from a particular disaster hazard. Nevertheless, fundamental conceptual differences related to the concept of vulnerability exist (Cutter, 1996; De Bruijn *et al.*, 2007; De Graaf *et al.*, 2007; Schneiderbauer, 2007). Based on these discussions of conceptual differences, we divided the concept of vulnerability into two components: exposure and capacities (Table 7-1), although the different risk components are interrelated. For example, a system cannot be vulnerable if it is not exposed to a hazard.

Table 7-1. Different risk components

<table>
<tr><th colspan="3">Risk components</th><th>Definition</th></tr>
<tr><td rowspan="6">Risk</td><td colspan="2">Hazard</td><td>A potentially damaging physical event, phenomenon or human activity that may cause injury or the loss of life, property damage, social and economic disruption, or environmental degradation.</td></tr>
<tr><td rowspan="5">Vulnerability</td><td>Exposure</td><td>The proneness to being affected by a particular hazard, without taking into consideration the capacity to deal with the hazard.</td></tr>
<tr><td>Resistance capacity</td><td>The ability of a system to prevent hazardous events, such as water defences to resist high water levels.</td></tr>
<tr><td>Adaptive capacity</td><td>Capacity of a society to adapt and to adjust to uncertain future developments and hazards.</td></tr>
<tr><td>Coping capacity</td><td>Capacity to respond in the (immediate) aftermath of an event.</td></tr>
<tr><td>Recovery capacity</td><td>The capacity to return to the pre-disaster status.</td></tr>
</table>

Based on De Bruijn et al. 2007; Schneiderbauer 2007; De Graaf et al. 2007

Flood management activities are often divided into four categories: mitigation, preparation, response and recovery. Mitigation focuses on minimizing the disaster impact in the event of a disaster. Mitigation activities can take place both during the recovery from a past disaster and during the preparation for a potential disaster. The control of land use, the modification of constructions to create emergency routes or the use of building techniques that help reduce damage are examples of mitigation activities. Within mitigation, prevention is sometimes distinguished as a different category of activities (Schneiderbauer, 2007); prevention deals with the avoidance of unsafe situations such as the regulation of dangerous industrial installation near resident areas, reforestation to reduce flood hazards or landslides, or the regulation of development in flood prone areas. In this light, mitigation activities are referred to as those activities that are undertaken to limit a disaster's potential impact. In this paper, however, mitigation activities also include prevention activities.

Activities and measures taken in advance to ensure an effective response, such as the enhancement of emergency capacities through the development of a contingency plan or through the training of response activities, are considered preparation. Similar to mitigation, preparation activities are pre-event actions.

Response comprises all activities carried out to fight a crisis immediately before or directly after it has taken place, to save lives, to minimize damage to property, and to enhance the effectiveness of recovery (Godschalk, 1991). Examples of response activities immediately before or after an event are the provision of timely and effective warnings, the temporary evacuation of people and property from threatened locations, the coordination of emergency response activities and medical care.

Finally, recovery is related to all measures that are required to return to a normal situation, such as medical and social-psychological aftercare of victims, site clearance and the repair of houses or infrastructure. These measures can be divided into short-term recovery activities and longer term recovery activities (Godschalk, 1991). The former consists of assessing damage, clearing debris and restoring utilities while the later includes reconstruction and evaluation activities such as the reassessment of contingency plans. Post-disaster recovery and reconstruction offers the opportunity to reduce the probability and impact of future disruptions. This focus on preventing re-occurrence connects longer-term recovery activities to mitigation and preparation activities.

Normally, risk and emergency management activities are divided into pre-event activities consisting of mitigation and preparation activities and post-event activities including response and recovery activities. Within the literature on GIS and risk and emergency risk management, however, it has been suggested to merge preparation and response activities since many GIS systems developed in the preparation phase are utilised in the response phase (Cova, 2005). In the light of skills needed, this categorisation partly makes sense. Both emergency training and response call for tactical skills in interagency coordination and decision-making to cope with emergencies under disaster conditions. Like mitigation, emergency planning demands strategic skills in planning, policy design and implementation (Godschalk, 1991). Within the recovery phase, short-term recovery activities are closely linked to response activities. On the other hand, recovery in the longer term is strongly linked to mitigation since longer-term recovery asks for strategic skills whereas short-term recovery puts more emphasis on tactical skills. Consequently, emergency training, response and short-term recovery in this paper are regarded as one related group of activities referred to as *emergency management*. This term refers to all the activities related to directly preparing and providing assistance or intervention immediately before, during or immediately after a disaster. Activities related to mitigation (including prevention), emergency planning and recovery in the longer term are referred to as *risk management* while the term *flood management* is used to refer to both emergency and risk management activities (Figure. 7-1).

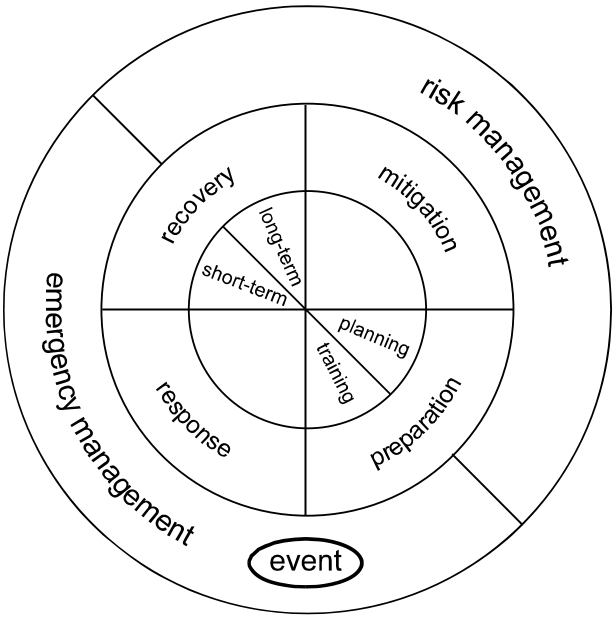

Figure 7-1. Flood risk and emergency management

7.3 Method

To examine the characteristics and informational requirements of flood management, two case studies on flood management in the Netherlands were carried out. Since many actors were involved in flood management, informational requirements were not worked out and discussed for all actors involved. It was decided to work out only the informational requirements for key actors. The first case study focused on the activities, actors and information needs in flood risk management. Land use planners were selected as a key actor in flood risk management since we expect that land use planners will play a prominent role in future flood risk management practices. Consequently, land use planners are regarded as an important target group for future spatial information systems for flood management.

Within the second case, the activities, actors and information needs related to flood emergency management were examined. In this examination, special attention was paid to the information needs of the fire department. The fire department plays a prominent role in emergency response and can be regarded as an important target group for spatial information systems for emergency management. Consequently, the information needs of land use planning and the fire department were worked out in detail.

Within the two cases, spatial information requirements of professional actors involved in flood management were explored through a literature study, interviews and workshops. The literature study aimed to investigate the organisation of Dutch prevention and emergency management and the 'state-of-the-art' in GIS technology used for crisis response and risk prevention. Several workshops were organised to discuss existing problems and to identify where improvements were required and where they could be successfully implemented. Two of the workshops were especially important for this study because they mainly focused on the work and information requirements of the risk and emergency management sector. The first workshop was attended by fire departments, police departments, paramedic teams, provinces, water boards and universities. The second seminar hosted representatives from advisory organisations in risk prevention, such as the Ministry of Transport, Public Works and Water Management and knowledge organisations that focus on public safety and flood management. During these workshops a large number of carefully selected questions were discussed, one of which focussed on the required data for risk and emergency management. The information derived from these workshops was used as starting point for this paper.

More detailed insight into informational requirements came from additional interviews for both case studies. Five interviews were carried out with twelve respondents. The respondents were experts involved in spatial planning, flood risk management, flood risk modelling or a combination of these fields and work at the Ministry of Transport, Public Works and Water Management, the province, the environmental assessment agency and a consultancy bureau respectively. The representatives were asked to define their (mainly spatial) informational requirements for flood risk management activities. Each interview took about 1.5 hours. Previous to the interview the respondents received information about the informational requirements that were derived from the workshops and previous interviews. This document was used as a starting point for the discussion of the respondents' informational requirements. In addition to the informational requirements, different scenarios for flood risk management policies in the Netherlands were also discussed during the interview. In this paper, however, informational requirements are discussed in the light of a flood risk management policy in which land use planning is regarded as an important instrument in implementing measures to reduce flood consequences.

In the flood emergency management case, more detailed insight into informational requirements was gained through a literature study, interviews with experts from the Ministry of Transport, Public Works and Water Management, fire department responders and participants in projects developing software for flood management. Using the interviews, the major actors, the cooperation between the teams, the required information and the systems currently used for both monitoring and simulation of floods and control and coordination during the disaster have been investigated. The analysis focused on the needed spatial information. Finally, the characteristics and informational requirement for the two different flood management activities were compared.

7.4 Changing Perspectives on Flood Management in the Netherlands

The Netherlands is primarily a large delta that is shaped by the rivers Rhine, Meuse and Scheldt. It has a population of over 16 million people living on about 40,000 km^2.

Therefore, the Netherlands is considered a small but densely populated country. Because one fourth of the Netherlands lies below sea level and almost two thirds of the Netherlands would regularly be flooded without levees or dikes protecting it (Van Nes *et al.*, 2001), the country can be regarded as a flood prone area.

Dutch flood management strategies are traditionally aimed at reducing the probability of flooding through more than 3,600 km of primary dikes that directly protect the hinterland from flooding by the sea or major rivers (Ministerie van Verkeer en Waterstaat & Inspectie Verkeer en Waterstaat, 2006). Nevertheless, this flood risk management strategy has been changing since the 1990s. After the flooding of unprotected areas in the river foreland of the Meuse in 1993 and 1995 and a near flooding event of the dike ring areas along the Meuse and Rhine in 1995, flood risk policies were changed and river dikes were raised at various places. This action was supported by a plan which allowed for the largest rivers to be given greater freedom to spill out across some parts of their original floodplains. The plan, which became known as the ‘Room for the River’ Policy, entailed the removal of obstacles from the floodplains, dike relocation, and the creation of retention areas, bypasses and secondary channels to circumvent urban bottlenecks.

In addition to the room-for-the-river measures and dikes, which are mainly focussed on reducing the probability of flooding, the national government and the Ministry of Transport, Public Works and Water Management, in particular, are considering the need for additional mitigation measures to reduce the consequences of flooding (Ministerie van Verkeer en Waterstaat, 2008b). This consideration is taking place in a national project, *Waterveiligheid 21e eeuw*, (Water Safety in the 21st century). Within the discussions on Dutch flood management strategies, flood mitigation measures are increasingly being considered in the light of the reduction of flood consequences, including the possibilities for emergency response. This has resulted in a renewed recognition of the interdependency of flood risk and emergency management. Land use planning is also being seen an important instrument in implementing such mitigation measures.

To reduce flood consequences further, additional attention is being paid to the organisation and preparation of flood emergency management. An evaluation of the organisation and preparation of flood emergency management showed that many improvements can be made in both the organisation and training of flood emergency management. One of the issues raised by this evaluation is the improvement of information exchange and communication within and between operational emergency managers, coordinators, governors and the public (COT *et al.*, 2005). To improve flood emergency management, the Dutch government has established a special task-force. Other initiatives are also being taken to improve flood emergency management. For example, the Ministry of Transport, Public Works and Water Management is continuously working on improving both their flood models and their risk analysis and assessments by developing better terrain models and giving more exact estimates of potential damage and numbers of victims (COT *et al.*, 2005; Ministry of Transport Public Works and Water Management, 2005). In the last decade, various projects were also funded for developing early warning systems (estimating also measurements from water level gauges) and information systems to support the communication between actors involved in emergency response. These improvement efforts also included improving cooperation with neighbouring countries (STOWA, 2008).

7.5 Flood Risk management in the Netherlands

In the first case study, Dutch flood risk management practices are examined. In this section, the performed activities, actors and informational requirements are investigated in the light of the changing perspectives on flood risk management.

Activities and actors

Risk management activities and processes can be grouped into four clusters: 1) identification, 2) risk assessment or evaluation, 3) choice and implementation of risk reduction measures and instruments, 4) monitoring and maintenance of the acceptable risks (Bottelberghs, 2000; Schanze, 2006).

As expected, water authorities play an important role in risk management. The Dutch Ministry of Transport, Public Works and Water Management takes a leading role in the management of flood risks from the sea and major Dutch rivers and lakes. Both regional water boards and the provinces play a prominent role in the flood risk management of other rivers, lakes and canals while the regional board and the Rijkswaterstaat (Ministry of Waterways and Public Works) have an important function in the monitoring and management of Dutch dikes. Land use planning authorities and non-governmental stakeholders such as inhabitants are already involved in the implementation of 'room-for–the-river' measures. These actors, however, still have a limited role in the evaluation an implementation of flood mitigation measures. As mentioned before, perspectives on flood-risk management are changing, though. Consequently, it is expected that land use authorities, including the municipality, the province and the spatial planning ministry will be more instrumental in evaluating and implementing flood risks and flood risk management strategies. Since the national ministry on water management would like emergency response issues to be more influential in future flood risk management practices, we expect that emergency services will be more involved in risk management practices as well. Table 7-2 gives an overview of key actors in Dutch flood risk management practices.

Table 7-2. Key actors involved in risk management

Activities	**Key actors involved**
Identification of flood risks	Ministry of Transport, Public Works and Water Management (V&W), provinces, water boards
Evaluation and assessment of flood risks	V&W, Ministry of Housing Spatial Planning and the Environment (VROM), provinces, municipalities, water boards, emergency services, non-governmental stakeholders
Choice and implementation of risk reduction measures and instruments	V&W, VROM, provinces, municipalities, water boards, emergency services, non-governmental stakeholders
Monitoring and maintenance of the acceptable risks	V&W, water boards.

Informational requirements

The investigation of information needs of spatial planners resulted in a wide variety of information needs related to flood risks. Based on the literature on risk and emergency management, these informational needs have been divided into four categories: hazards, exposure, capacities and processes. Within these categories, static information and simulated information could be distinguished as summarised in Table 7-3. Static information has its time orientation in the present whereas the time focus of the simulated information is in the future. Even though we do not pretend that the information needs derived from the interviews and summarised in this table give a complete overview of the information needs for risk management, the information needs at least give a good indication of the required information related to flood risks.

Table 7-3. Examples of information needed for flood mitigation in land use planning

	Examples of information needs
Hazards	*Static information:* Flood prone areas; Nature of the flood, e.g. flash flood, salt or fresh water. *Simulated information:* Estimates of actual flood probabilities and expected effects and consequences such as potential water depth and velocity.
Exposure	*Static information:* Information about citizens in the area exposed such as total number of inhabitants or people under restrictions such as prisoners; Vulnerable objects such as schools, drinking-water supply or installations with hazardous substances; Buildings characteristics such as high/low-rise building (shelter), building material (strength). *Simulated information:* Damage and number of victims for a particular flooding scenario.
Resistance capacity	*Static information:* Probability of failure of dikes and other hydraulic structures such as sluices. *Simulated information:* Simulation of dike breaches or failure of hydraulic structures.
Adaptive capacity	*Static information:* The extent of flood proofing measures or the flood compatibility of the use of the ground floor of buildings. *Simulated information:* The effect of adaptive measures on potential flood damage and potential number of victims.
Coping capacity	*Static information:* Capacity of people such as the ability of people to get to a safe location; Possibilities for shelter; Infrastructure information such as road capacities. *Simulated information:* Possibilities for evacuation, shelter and capacity of emergency services and hospitals.
Recovery capacity	*Static information:* The extent of insurance, recovery plans *Simulated information*: Potential damage.
Processes	*Static information*: - *Simulated information:* Climate change, urbanization, economic developments.

7.6 Flood emergency management in the Netherlands

In addition to examining flood risk management characteristics and informational requirements, a case study was carried out to study the performed activities, actors and information needs in flood emergency management. The results of this study are summarized below.

Activities and actors

Both emergency training and response activities are focussed on emergency response and its preparation. On the operational level, the activities carried out in emergency management can be divided into four clusters: 1) containment and control of the flood and its effects, 2) medical assistance, 3) public order and traffic management, 4) taking care of the population (Diehl & Van der Heide, 2005; Ministerie van Binnenlandse Zaken, 2002). Table 7-4 gives an overview of the key actors involved in these activities.

Table 7-4. Operational flood emergency activities and key actors involved

Activities	**Key operational actors**
Containment and control of the flood and its effects	Regional fire department; Rijkswaterstaat; Military National Reserve.
Medical assistance	(Para)medical services (GHOR); Red Cross (SIGMA teams) Royal Dutch Water Life Saving Association (KNBRD), Royal Netherlands Sea Rescue Institution (KNRM).
Public order and traffic management	Police department
Taking care of the population	Municipality

As for all other disaster types, the fire response units have an important task in the containing and controlling the hazard and its effects. They are responsible for pumping water out of the streets and other flooded areas, removing blockages, helping evacuate citizens and animals and checking for contamination of water, soil and air. In the event of an emergency, the fire department is also responsible for warning the citizens through the net of stationary sirens. In case of an imminent flood event, the local offices of the Directorate-General for Public Works and Water Management (Rijkswaterstaat) within the Ministry of Transport, Public Works and Water Management are intrinsic to monitoring high water levels. They also give early warnings if necessary (Ministerie van Binnenlandse Zaken, 2002; Rosenthal *et al.*, 1998). The water boards are monitoring and, if necessary, strengthening the dikes in the event of an imminent flood. Several other organisations, such as the Dutch National Reserves, can take a part in the containment and control of the hazard and its effect, if the operational organisations (i.e., first responders) need support (http://www.natres.nl/).

Key actors involved in medical assistance include the ambulance services and hospitals. In addition to these, the SIGMA teams of the Red Cross and special ambulance teams can be formed and included in the medical help operations. However, they are usually involved in large disasters only. In addition to these organisations, the Royal Dutch Water Life Saving Association, KNBRD (http://www.rednet.nl) can be enlisted to save people.

In the event of an emergency, the police are responsible for the processes related to public order and traffic management including the evacuation of threatened or affected areas and the protection of shelters and commando centres. In most cases the police work under the authority of the mayor.

Besides the overall responsibility for disaster management under the authority of the mayor, the municipal structures are responsible for processes related to taking care of the population such as informing citizens, accommodating non-injured people from affected areas and registering casualties.

On the strategic level, the organisation of emergency management response in the Netherlands is divided into a local level (the site of an incident), the regional level, the provincial level and the national level. Most minor emergency incidents are responded to at the local level. Within this operational structure, the local fire officer has the primary operational responsibility for the on-site coordination of local disaster response. If the magnitude of an incident increases and the affected area transcends the incident area, then a regional coordination team will be formed in conjunction with the operational coordination team at site. The regional coordination team is often situated in a regional office remote from the incident (e.g. a joint office of the regional emergency services). If a regional coordination team is formed, then the mayor of the municipality in which the incident occurs takes the administrative lead. On the municipal level, a policy team is formed to support the mayor.

Many more bureaucratic structures will be involved in ‘responding’ to the calamity when the calamity transcends administrative borders, for example, a municipal, provincial or national borders. Moreover, additional coordination teams can be formed up to the international level (Rosenthal *et al.*, 1998). In the event of an imminent flood, experts from the Water Board, the Ministry of Transport, Public Works, and Water Management will be involved in these coordinating teams. As a consequence, numerous actors can be involved in preparation and response; therefore, collaboration is required.

Informational requirements

To compare information needs in flood risk and emergency management, the risk components as discussed in Section 7.2 were used to structure the information needs within flood emergency management. Because many actors are involved in emergency management, only the informational requirements of the fire department are worked out in more detail (Table 7-5). The fire department was selected because they are a central actor in emergency response and can be regarded as an important target group for spatial information systems for emergency management.

The interviewed experts stressed that is very important to have information about the actual situation and actual consequences of the event. They often made a distinction between information that exists prior to the disaster and information that is or should be obtained during the disaster. Based on this time aspect, the information for emergency response was divided into three categories. In addition to the static and simulated information as distinguished in flood risk management, a third category was added: dynamic information. Information created or obtained during the disaster is denoted as dynamic information. Table 7-5 gives an overview of the information needs for the processes which the fire department is responsible for during a flood. A more complete list of information needs of the fire department during an event can be found in Diehl et al. (2006) and Snoeren (2006). Spatial information related to the physical and social processes that can affect hazards and vulnerability were not mentioned by the experts in the interview as information needed. Therefore, this was not mentioned in the overview table.

Table 7-5. Information needs for the fire brigade in case of floods [a]

	Examples of information needs
Hazards	*Static information:* Flood prone areas. *Simulated information:* Estimates of actual flood probabilities and expected effects and consequences such as potential water depths and velocity. *Dynamic information:* Incident information such as scale of the flood and water depths; Meteorological information such as wind direction and speed, precipitation (rain/snow).
Exposure	*Static information:* Information about citizens in the area exposed such as total number of inhabitants or people under restrictions such as prisoners; Vulnerable objects such as schools, drinking-water supply or installations with hazardous substances; Buildings characteristics such as high/low-rise building (shelter), building material (strength), cables and pipes. *Simulated information:* Damage and number of victims for a particular flooding scenario. *Dynamic information:* Victims: trapped people, people in need; Damage: property damage, unstable buildings and infrastructure.

Resistance capacity	*Static information:* Probability of failure of dikes and other hydraulic structures such as sluices. *Simulated information:* Simulation of dike breaches or failure of hydraulic structures. *Dynamic information:* Actual probability of the failure of dikes and other hydraulic structures.
Adaptive capacity	*Static information:* The extent of flood proofing measures or the flood compatibility of building use. *Simulated information:* The effect of adaptive measures on potential flood damage and potential number of victims. *Dynamic information:* The actual extent of adaptive measures taken in an area through temporal flood proofing, sand bags, or preventive evacuation of people, animals and properties, to name a few.
Coping capacity	*Static information:* Capacity of emergency units such as hospitals or the fire brigade units; Capacity of people to get to a safe location; Possibilities for shelter; Infrastructure information such as road capacities and characteristics (paved or un-paved, broad or narrow); Borders such as municipality borders, regional borders, provincial borders; Recourses such as water sources/water collection or sandbags; Information for context and orientation such as aerial photographs, large scale topographic maps, accessibility maps for buildings and industrial terrains. *Simulated information:* Capacity of emergency units, people and resources *Dynamic information:* Actual capacity of emergency units, possibilities for shelter; Accessibility: in- and out-routes, traffic direction, blocked or possibly blocked roads.
Recovery capacity	*Static information*: - *Simulated information*: - *Dynamic information*: Actual damage

[a] To train response activities, the dynamic information is often simulated.

7.7 Discussion

The main lesson derived from the exploration of flood risk and emergency management activities is that even though activities and actors differ, informational requirements overlap considerably. As a result, information has to flow across and between different actors involved in different flood management practices. A spatial information infrastructure that covers both risk and emergency management allows the required exchange of information. Therefore, the development of a spatial information infrastructure that integrated risk and emergency management deserves extra attention. These statements are discussed in more detail in a comparison between the characteristics of flood management and those of informational requirements.

Activities and actors

The exploration of flood management activities has shown that flood risk and emergency management activities profoundly differ. Emergency management activities are often carried out under high time pressure and ask for tactical skills, whereas flood risk management activities are carried out under less time pressure and ask for strategic skills.

Within both flood risk and emergency management, many actors are involved on different levels. As shown in our exploration, emergency preparedness and response is often the domain of emergency units such as medical services, the fire department and police services, while mitigation and recovery are often the domains of the planning, engineering and public works departments.

The exploration, however, has revealed a changing perspective on flood management, especially in the field of flood risk management. Within Dutch flood risk management, more attention is paid to flood consequences and possibilities for emergency management. In this light, flood risks are managed in a more integrated way in which both hazards, exposure, capacities and processes are taken into account. Land use planning is increasingly being considered an important instrument to reduce flood consequences. As a result, flood risk management is expected to become a more important issue in land use planning.

Informational requirements

The informational requirements of two actors involved in two different domains of flood and emergency management have been discussed in detail: the land use planning department and the fire department. Even though the activities of the land use planners and the fire department differed, it was interesting to observe that informational requirement considerably overlapped. The informational requirements with respect to the static and simulated information especially overlapped. Land use planners emphasized the need for information about flood emergency aspects such as the possibilities for emergency response and evacuation. On the other hand, representatives of the fire department mentioned the importance of the spatial data obtained by the land use planners, such as the risk maps. As a consequence, flood risk and emergency management can be seen as activities where informational requirements are increasingly overlapping (Figure 7-2.).

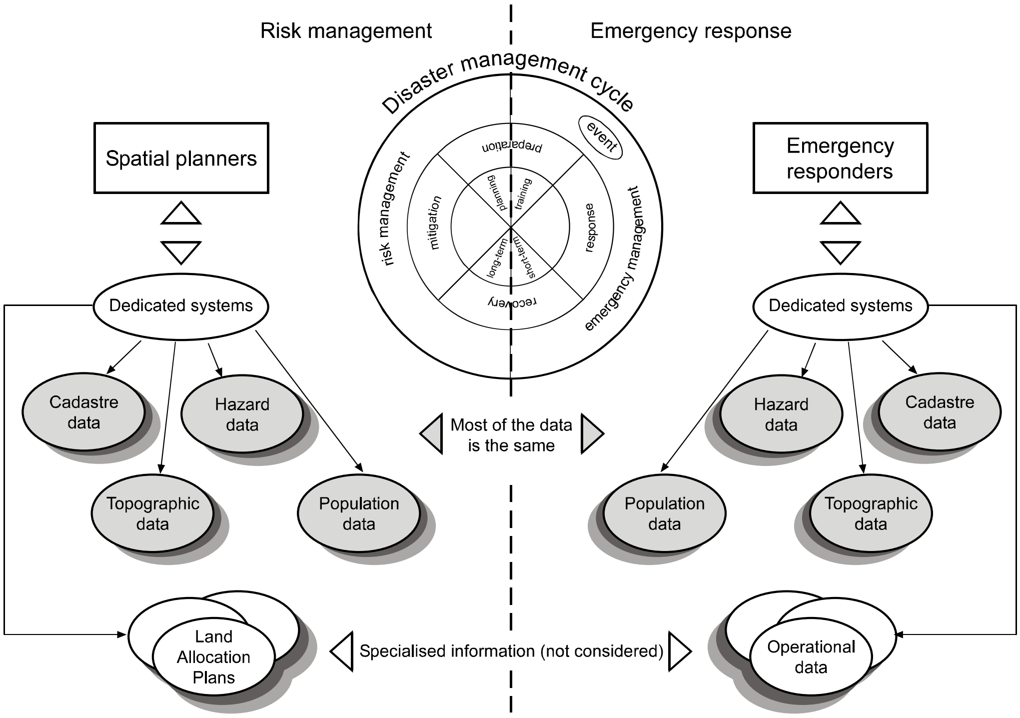

Figure 7-2. Information overlap between risk and emergency management.

Real time dynamic information was mainly required for activities related to flood emergency management. Nevertheless, the real time information obtained during flood emergency activities can be used to improve simulated information in other flood management activities. Dynamic information about the development of a flood wave, for example, can be used to improve flood models for flood risk management and emergency trainings. After a crisis, this dynamic information can, if recorded, also be used to evaluate emergency response.

The need for an integrated spatial information structure

The differences in activities and actors involved in flood management suggest that risk prevention and emergency response should be seen as different kinds of activities with different users and with different requirements for spatial information systems. Flood management, however, is a set of activities that have to be carried out in collaboration with multiple agencies. These agencies should not only cooperate within one activity of flood management, for example, during response activities, but should also work together even if they are involved in different activities. For example, the revealed interest in flood response issues in Dutch flood risk management practices requires the cooperation between land use planners, normally involved in risk management, and emergency response units, normally involved in flood emergency management.

A closer examination of informational requirements shows that it is very likely that informational requirements between flood management activities and the management of other hazards overlap as well. For example, a considerable part of the information about a society's capacity to deal with flood hazards will also be useful to assess the risks of industrial hazards, such as the release of toxic gasses. As a result, information needs to flow across and between agencies and flood risk and emergency management domains.

In this respect, an appropriate spatial information infrastructure that enables the exchange of information is increasingly considered a critical aspect to support risk management activities (Cutter, 2003; Greene, 2002; Grothe *et al.*, 2008; Köhler & Wächter, 2006; Mansourian *et al.*, 2006; Parker *et al.*, 2007). A spatial information infrastructure allows the exchange of information between actors involved in risk and emergency management. Because differences in informational and system requirements exist, the architecture of a spatial information infrastructure should allow room for differentiation in information supply and system requirements. The widely applied Service Oriented Architecture approach offers an interesting concept for such an information infrastructure. Within this concept, the required information for each actor is acquired through the composition of a relevant package of information services. These datasets and services can be acquired from a great variety of available user-specific systems. Through a selection of services, the user is not connected to all available databases for risk management but only to a relevant selection. Furthermore, these services can be presented in different applications, to meet specific user requirements and user interfaces and to enable the implementation of services from one application into another (Figure 7-3).

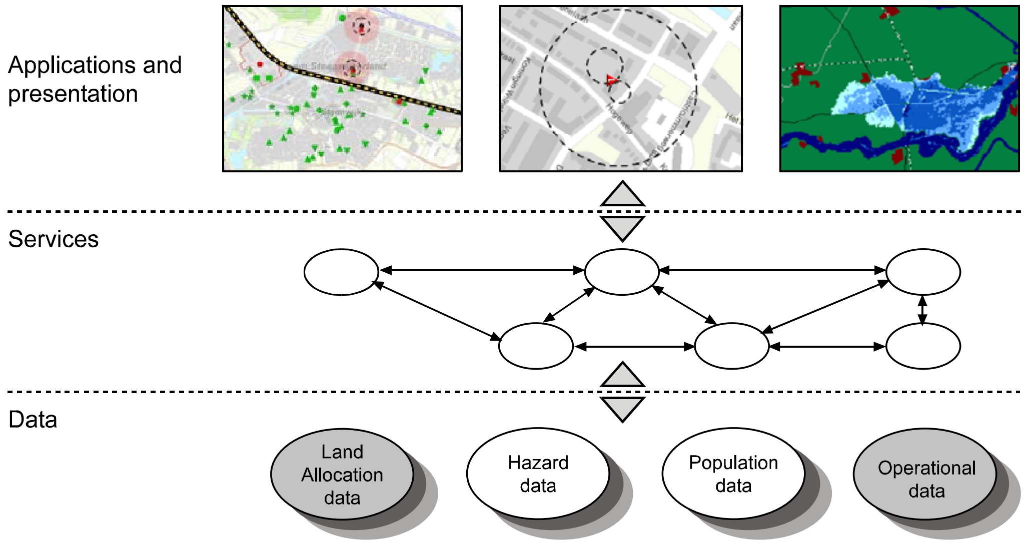

Figure 7-3. A service oriented spatial information infrastructure

In addition to the information, services and application, the spatial information infrastructure requires technical standards such as the ISO standards, access networks such as the internet or through satellites, policies that comprise policies to share information and policies for responsibilities towards information production and maintenance of required spatial data sets, and finally, people who use the spatial information, together with information suppliers and any value-adding agents in between (Mansourian *et al.*, 2006; Williamson & Rajabifard, 2003).

The development and application of open standard by the Open Geospatial Consortium, INSPIRE or GMES, for example, increasingly facilitates the exchange of geographic information and services. Nevertheless, the emergency response sectors and/or other local organisations often maintain much of the information. Access to the information, however, remains a limitation in risk and emergency management decision making (Zerger & Wealands, 2004). Sometimes, it is unclear whether two emergency sectors possess the same information; maps and plans maintained by the police brigade might be not available for ambulances or fire department. This tendency is very strong in the case of spatial information (ACIR, 2005). The different sectors often have individual information systems for management of information, which cannot not communicate with each other and therefore are unable to share information (ACIR, 2005; Scholten *et al.*, 1998). As a result, it is hard to operate together.

A good deal of research on models and services for risk management, however, often concentrate on particular activities within a particular group of actors such as the fire department, police department or medical teams (Diehl & Van der Heide, 2005) a particular phase of risk management (Mansourian *et al.*, 2006) or a particular hazard (Craciunescu *et al.*, 2006). The overlap in informational requirements implies that spatial information systems should allow different actors involved in both flood risk and emergency management to operate together (i.e. to understand each other) before and in any critical situation. These systems should also allow the most appropriate information to be generated, found and delivered in a fast and efficient manner.

In addition to the further development of the physical network, a wide range of arrangements should be made to achieve an integrated spatial information infrastructure, and to enable the exchange of information and services. Experiences on the development of such a structure have already shown that the bottleneck in information exchange is often not really in the technical aspects--technically, these problems can be solved-- but mostly in reaching agreements between different information holders about for example data standards or conditions for data exchange (Diehl & Van der Heide, 2005). Consistently, people involved in mitigation should recognise the benefits of information used for both risk and emergency management.

7.8 Conclusions

The exploration of flood management practices has shown that flood risk and emergency management activities, actors and informational requirements profoundly differ. Nevertheless, the examination of flood risk and emergency management practices also showed a considerable overlap in informational requirements. An examination of the informational requirements of the fire department that is involved in response activities stressed the need for information related to hazards and vulnerability. Interestingly, this information is often collected, used and kept by actors involved in risk management, such as land use planning authorities. On the other hand, actors involved in land use planning and flood risk management stressed the need for information about the possibilities for emergency response in a particular area. Interestingly, actors involved in emergency management and its preparation often collect, use and keep this information.

Consequently, information developed or gathered for one category of risk management activities should be available for other activities and to other actors as well. Given this, an integrated information infrastructure should be strived for. The Service Oriented Architecture approach offers an interesting concept for such an information infrastructure This implies, however, that future spatial information systems should not only be developed in the light of one risk or emergency management activity, one type of actor or one type of hazard, which is often the case in actual risk management practices, but should be based on an integrated information infrastructure that allows the exchange of spatial information between different actors involved in risk and emergency management activities.

Acknowledgements

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8

From Spatial Data to Synchronised Actions*

Abstract
A considerable amount of the required information in risk and emergency management is geographical, but this information does not always reach the right actors at the right time, so how can geographical information be organised in such a way that it supports risk and emergency management more effectively? The answer requires a conceptualisation of risk and emergency management practices resulting in the network-centric concept, which implies that those involved in risk and emergency management are connected and that they have the capability to share and access information. The concept was made operational through the development of an information system and the exchange of geographical information within the system was facilitated by the use of peer-to-peer networking in combination with a client server network. On the application level, the information was presented in both map and text forms to support the exchange of information between actors. This way of organising geographical information and technology leads to improved information and communication, better situational awareness and faster decision making.

Keywords: network-centric, spatial information infrastructures, emergency management, risk management

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8.1 Introduction

Recent emergencies and emergency response exercises have highlighted major information deficiencies in risk management (activities related to the prevention and mitigation of risks) and emergency management (including activities related to emergency training, response and short-term recovery). Important information did not reach the right organisations and people at the right time, resulting in unnecessary loss of life and property (Kevany, 2003; National Research Council, 2007; Van de Ven & Van den Berg, 2007).

The Dutch Bonfire exercise in 2004 illustrated the type of information deficiencies that can appear (COT *et al.*, 2005). This particular exercise dealt with the potential threat of a terrorist attack in the Rotterdam harbour and an attack on the Amsterdam Arena stadium. During the exercises, important individuals such as the National Coordinator for Counterterrorism and the Director-General for Public Safety and Security as well as the ministerial and inter-ministerial policy teams, were not provided with integrated information on time and in a consistent way. Some information was available to other organisations but was not actively requested by organisations in need of this information. The national coordination centre was unable to integrate information from different sources, and thereby unable to get a more complete overview of the current situation. Moreover, the emergency rooms of the police department, fire department and the medical services had only a limited overview of the situation at the scene of the attacks, which also hampered effective decision making. Clearly then, information management is crucial in risk and emergency management, but important information does not always reach the right services and individuals at the right time, thus constraining effective mitigation, preparation, response and recovery.

In addition to the recognition of information in general as crucial element, geospatial information in particular is regarded as indispensable. A considerable part of the information required before and during emergencies contains a specific spatial reference, such as the location of toxic clouds or flooded areas or the location of emergency services. For this reason, much effort is put into the development of geo-information and communications technology (Geo-ICT) or geotechnology for risk and emergency management (Cova, 2005; Greene, 2002; Kevany, 2003; Köhler & Wächter, 2006; MacFarlane, 2005; National Research Council, 2007; Parker *et al.*, 2007). Consequently, the organisation of geographical information and consequently geotechnology requires special attention in addition to the organisation of information in general. This paper focuses on the question of whether geo-information and geotechnology can be organised in such a way that it supports decision-making processes within risk and emergency management more effectively.

The research is based on the idea that the search for an appropriate role for geo-information and geotechnology in risk and emergency management should not start with a particular technology, but with a conception of risk and emergency management activities. This statement follows Klosterman (2001) who argued that the search for an appropriate role for computer-based information and methods must begin with the conception of the activity that should be supported. A technology driven approach can limit our view resulting in a focus on those aspects of risk management and emergency management for which a particular technology or tool is appropriate, but neglecting other vital elements of risk and emergency management activities. As a result, the technologies may not meet the particular needs of the risk and emergency managers. For this reason, the central research objective is to develop a conception of risk and emergency management which can be used as a basis for the organisation of geographical information for decision support in general.

8.2 Research strategy and method

A conception of risk and emergency management can be developed in different ways. On the one hand, this conception can be obtained deductively, implying that knowledge of individual phenomena is derived from universal laws. Consequently, general ideas about emergency response can be applied to individual practices and these general ideas can be used as starting point for the organisation of geo-information and geotechnology in these practices. On the other hand, the conception can be obtained inductively. A conception of risk management can be based on studying particular risk management practices through which more general concepts and mechanisms are highlighted. Abduction can be regarded as a way to mediate between inductive and deductive reasoning. Similar to induction, the starting point of abduction is in the specific rather than the general. The researcher looks at particular situation-specific phenomena; he/she does not only describe these phenomena, but also makes new interpreting links (Danermark *et al.*, 2002). The examined risk and emergency management practices can be interpreted through existing ideas e.g. from the literature or other examined practices. Through this interaction between the individual observations with more general ideas derived from the literature or experiences with previous practices, a specific conceptualisation of the risk and emergency management practices at hand is developed. This strategy reflects the strategy of our conceptualisation of risk and emergency management.

Our conceptualisation of risk and emergency management is based on two different projects: the GeoRisk project (www.georisk.nl) and the Geo-Data Infrastructure for Disaster Management (GDI4DM) project (www.gdi4dm.nl) in the Netherlands in which the authors participated. The GeoRisk project focussed on activities related to risk management in spatial planning. These activities were studied through examining planning practices with respect to the consideration of flood risks and industrial risks in spatial planning. Moreover, information requirements for dealing with risks in planning were considered (Projectconsortium Georisk, 2008). The project consortium included three universities, three research institutes, two consultancy companies, one municipality, one province, the directorate-general for Public Works and Water Management (*Rijkswaterstaat - DWW*) and one safety region. Safety regions are responsible for emergency response. In the Netherlands, emergency management services are organised regionally. The country is divided into 25 safety regions and each safety region, which includes several municipalities, consists of a police department, fire department, and medical and paramedical services.

Within the GDI4DM project, emergency response processes were studied through examining information and system requirements of the actors involved in emergency response (Neuvel & Zlatanova, 2006; Snoeren, 2006). Ideas on risk and emergency management found in external literature were used as an interpreting framework to make links between the different initial conceptualisations of risk and emergency management resulting from the examination of risk and emergency management practices.

Whereas the GeoRisk project mainly focussed on the way spatial planners deal with safety risks and on the requirements for geotechnology in spatial planning, the GDI4DM project also aimed at developing Geo-ICT. Within this project, the conception of emergency management was made operational in principles for spatial information infrastructures (SIIs) for emergency management at the regional level. Based on these principles, an information system was developed to support command and control, referred to as Eagle, which was tested and evaluated in the regional emergency exercise known as Eagle One (Brooijmans, 2008; Geodan, 2008; Riedijk *et al.*, 2008; Van Capelleveen, 2008; Van de Ven, 2008). The project consortium included three universities, one 'safety region', two consultancy companies, one municipality, one province, the cadastre and the directorate-general for Public Works and

Water Management (*Rijkswaterstaat - RWS*). The GDI4DM project can be regarded as one of the leading projects on this topic in the Netherlands, since the Eagle One exercise was awarded the Public Safety Award in 2008. The jury of this award consisted of 11 key figures on public safety from the Government and knowledge institutes including professors, mayors and directors of emergency services and research institutes. The Eagle application, which uses Microsoft technology, was also highlighted by networkworld as an innovative Microsoft research project (www.networkworld.com).

This paper describes and reflects on the findings of these two projects. In the following section, a conception of risk and emergency management is discussed, resulting in the concept of network-centric risk and emergency management which was used as point of departure for the development of Eagle to support emergency management. Subsequently, the added value of geo-information and geotechnology for network-centric risk and emergency management is described. We then discuss the architecture and applications of Eagle and the experiences with Eagle in the Eagle One emergency management exercise. In the concluding section, we reflect on the use of the network-centric approach as concept for the organisation of geo-information and geotechnology in risk and emergency management.

8.3 Risk and emergency management

The conceptualisation of risk and emergency management was a process that took place from the writing of the project proposal at the beginning, until the evaluation of the use of geo-information in the emergency training at the end. The resulting conception of risk and emergency management can be summarised in three key principles, which in the end resulted into the conceptualisation of risk and emergency management as network-centric operations:

- risk management and emergency response is a collaborative process, which implies the connection of all the actors involved;
- collaboration requires a shared situational awareness; and
- collaboration and a shared situation awareness require the sharing of information.

First of all, risk and emergency management was recognised as a *collaborative process.* Collaboration between safety experts and spatial planners was regarded as crucial for the consideration of safety risks in spatial planning (Projectconsortium Georisk, 2008). Through this collaboration, both safety issues and potential ways to deal with the safety issues could be addressed in the planning process and a commitment for the consideration of safety risks could be created. Moreover, during an emergency response, cooperation between actors is required for effective action. During an evacuation, for example, the police department will be responsible for traffic management but the municipalities are responsible for communication with citizens (Diehl & Van der Heide, 2005). Consequently, emergency response has to be carried out by multiple agencies in which both vertical and horizontal coordination is required, requiring the collaboration of all the actors involved. Establishing connections can be regarded as an important challenge, since actors involved in emergency response are often spread out between different organisations which may have different physical locations. Moreover, actors within one organisation may also be spread out in the field or between offices.

In addition, collaboration requires a *shared situational awareness*. When there is a weak section of dike but actor A assumes that it is on the left side of the river bank and actor B believes that it is on the right side, collaboration to deal with the specific weak spot will be confused. Collaboration in spatial planning also requires shared situational awareness. For example, when spatial planners and safety experts have different knowledge about the nature and amount of hazardous materials in a particular installation, they will apply different safety distances for urban developments in the vicinity of the site. Shared situational awareness is located in the mind, rather than being available in an information system or in other media such as a handbook. Shared situational awareness therefore differs from the term Common Operational Picture (COP); for example, when the information system shows that the weak dike section is on the left side, but actor B interprets it as the right side, there is a common operational picture of the situation, but not a shared situational awareness.

Collaboration and shared situation awareness, however, require the *sharing of information*. Information and communication are recognised as central elements in both risk and emergency management. Information is a prerequisite for situational awareness, which allows collaboration and coordination of these actions. The exchange of information is regarded as time critical, especially in emergency response. A common operational picture, as well as a shared situational awareness, requires the exchange of valid and up-to-date information between all the involved actors at the same time. The information that has to be distributed can consist of information that already exists prior to an event such as information about topography or contingency plans but also of information that becomes available during an event, referred to as *in situ* information, such as intelligence about a collapsed dike or on the geographical position of the emergency services.

Ideas about network-centric operations were useful for structuring the principles of risk and emergency management because similar to the presented ideas on risk and emergency management, the concept of network-centric operations has collaboration as point of departure. Moreover, the concept explicitly specifies the role of information in these collaborative processes from which informational and system requirements can be derived, which also fitted in the principles of risk and emergency management that were developed already within the project. For these reasons, 'network-centric risk and emergency management' was used as the interpreting framework through which the different conceptualisations of risk and emergency management can be structured and integrated. The term network-centric is derived from a military context where 'network-centric warfare' is the term used for the US military response to the information age. It implies that military operations are enabled by the networking of the armed forces and this networking takes place in the physical, information and cognitive domains (Alberts *et al.*, 2001). The physical domain is the domain that the military seeks to influence, and includes the activities or events in a particular area that need to be controlled. The information domain is the domain where information is created, manipulated and shared. The cognitive domain is regarded as the domain of the mind of the actors involved in warfare which includes tactics, strategies and techniques. Principles of network-centric warfare can also be applied to other fields so we can speak of network-centric operations that have been applied to emergency management as well (Von Lubitz *et al.*, 2008a; Von Lubitz *et al.*, 2008b). If applied to risk and emergency management activities, we can speak of 'network-centric risk and emergency management' (NCREM) (Table 8-1).

Table 8-1. Characteristics of network-centric emergency response

Domain	Characteristics
Information	The actors involved in risk and emergency management have the capability to share, access, produce and gather information in a network-centric way instead of hierarchically. Of course, this information should be valid, complete, accurate and up to date.
Cognitive	The actors involved in risk and emergency management have developed an awareness and shared understanding about what's going on, what can be done and what should be done.
Physical	The actors involved in risk and emergency management work together to influence the physical domain such as the area that is or can be flooded to reduce both the damage and the number of victims.

The physical domain then involves the area that the risk and emergency managers seek to influence. The information domain includes the information created and needed for effective risk management and response and here a distinction can be made between data and information. Data can be regarded as the basic descriptive characteristics of things and placed in a comparatively raw format such as observations, counts, measurements, locations or attributes, whereas information is regarded as more processed, organised, summarised, selective and user friendly, with the intention of assisting correct interpretation (Parker *et al.*, 2007). The common operational picture, for example, can be regarded as information. The cognitive domain is located in the mind and involves, amongst other things, situational awareness that can be constructed from the information in the information systems but can also result from other information e.g. resulting from face-to-face contact or telephone contact. Moreover, existing cognitions or elements in the cognitive domain shape observations and the interpretation of information. Previous experiences, feelings, intuitions and values can greatly influence the perception of information (see, for example, Te Velde *et al.*, 2002). In this respect, wisdom, referred to as the capacity to make value judgements based on knowledge (Walter, 2005), can be regarded as a factor which influences situational awareness

These different domains are highly connected (Von Lubitz *et al.*, 2008b). Improved information sharing through networks, for example, should result in a common operational picture and subsequently in shared understanding in the cognitive domain and into synchronised actions in the physical domain, which should result in better collaboration and subsequently in better decisions and the reduction of disaster impact, as illustrated in Figure 8-1.

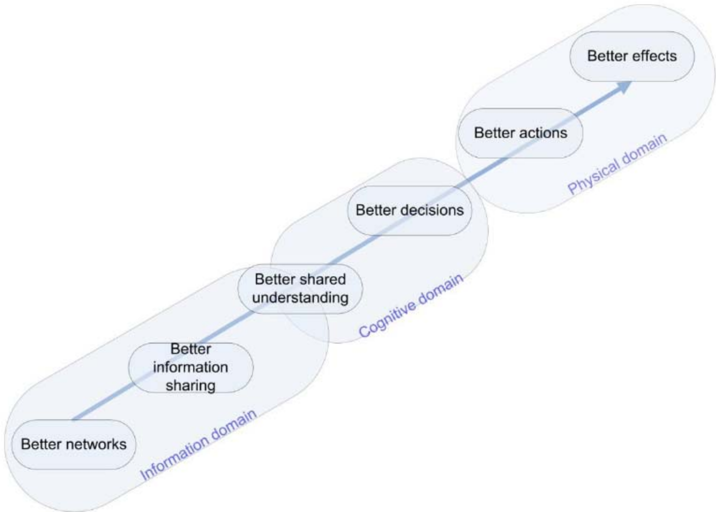

*Figure 8-1***.** The relationship between the information, cognitive and physical domains Source: Brooijmans (2008)

8.4 The added value of geotechnology in NCREM

Within previous evaluations of the use of information in risk and emergency management, it was mentioned that crucial information was either not available or not shared (ACIR, 2005; National Research Council, 2007). Geotechnology can contribute to the organisation of the information domain through its tools for gathering, processing, sharing and presenting information (MacFarlane, 2005). This can be regarded as a prerequisite for creating situational awareness, synchronising actions and, finally, limiting disaster impact effectively. First of all, geotechnology can support the collection and subsequent integration of relevant spatial data, such as population or topographic data, which can be brought together in comprehensive databases. Subsequently, these data can be used for further analytical operations like the selection of areas higher than one metre above sea level or the calculation of the number of people living in a specific area. Through these static operations, a descriptive model of an area can be developed, which can result in an initial operational picture of the area or the event (see, for example, Köhler & Wächter, 2006; MacFarlane, 2005; Van de Ven *et al.*, 2008; Zerger, 2002). Furthermore, modelling functions can be included within geo-tools which can be used for scenario development, e.g. to explore flood patterns resulting from breaches of dikes in different locations. These tools are especially useful when the risk, e.g. the particular location of a dike breach, is not fully known. Assessment tools can be used to identify the consequences of flooding in the light of different objectives, e.g. damage reduction or the reduction of casualties, to explore different alternatives. In addition, geotechnology can support the visualisation of information through maps, charts, graphs, tables, animations or 3D graphics and such images can support actors involved in risk and emergency management (MacFarlane, 2005). Moreover, geotechnology can contribute to the exchange of geographical information through which collaboration can be supported as discussed previously. Spatial information infrastructures (SIIs), also referred to as geo-data infrastructures (GDIs) or spatial data infrastructures (SDIs), can be regarded as the central concept for creating interoperable systems and enabling the exchange of geographical data and information. This exchange requires technical standards such as ISO standards, access networks such as the internet, policies such as those on conditions for data sharing and guidelines on responsibilities towards information production and maintenance of required spatial data sets, and, last but not least, individuals who use the spatial information, together with information suppliers and any value-adding agents in between (Mansourian *et al.*, 2006; Williamson & Rajabifard, 2003). In this respect, an appropriate SII that enables the exchange of information is increasingly considered a critical aspect to support risk and emergency management activities (Cutter, 1996; Greene, 2002; Grothe *et al.*, 2008; Köhler & Wächter, 2006; Mansourian *et al.*, 2006; Parker *et al.*, 2007; Scholten *et al.*, 1998).

It has been argued that major events and crises, even though they seem structured problems in the beginning, will inevitably pass into the unstructured domain in due course (French & Niculae, 2005). This unstructured character can hamper the use of geotechnology since, when it is unclear which problems should be tackled and which objectives should be met, it is also hard to use geo-tools for analysis. Nevertheless, this point was nuanced within the GDI4DM project. Even within these chaotic circumstances, structured working processes can be recognised, such as alerting or source and effect control (Diehl & Van der Heide, 2005; Dilo & Zlatanova, 2008; Fruijtier *et al.*, 2009; Snoeren, 2006). The problems that need to be tackled within these working processes as well as the objectives that should be met can be well defined in advance, i.e. through contingency planning. In addition, a considerable part of the informational requirements could be defined beforehand. Clearly then a chaotic, unstructured event contains both structured, semi-structured and unstructured sub-problems, which can be supported through geotechnology. Moreover, geotechnology can stimulate communication and collaboration between actors, which is regarded as crucial under chaotic circumstances (French & Niculae, 2005). Comparable arguments can be made in the context of risk management. Even though a planning problem, e.g. on the desired land use in the future, can be unstructured, the risk management problem within the planning process can be structured or semi-structured. Moreover, the information derived from the geo-tools can be used in discussions, e.g. as idea or argument to structure problems and objectives (Shulock, 1999; Weiss, 1991).

8.5 Towards an architecture for geo-enabled NCREM

The principles for NCREM have only been made operational through a system for supporting emergency management. Nevertheless, the experiences with these emergency management systems are also relevant for risk management as discussed in the concluding section. Even though massive investments have been made in the development of geo-tools and SIIs, the special needs of emergency management have rarely been addressed (National Research Council, 2007). To meet the requirements for network-centric risk management and emergency response, new geographical systems and especially architectures have had to be developed. One major challenge associated with the architecture for a geo-enabled network-centric software solution lays in the connection of all the people, organisations, services and networks through which existing and *in situ* data were made available and easily accessible when needed. A mobile first responder in a crisis situation, for example, has to be able to get up-to-date geo-information from the disaster management service. Nevertheless, during a disaster, a constant availability and capacity of the network cannot be guaranteed, especially not for field workers. Therefore, peer-to-peer (P2P) networks were used to connect the actors in the field with each other and with the actors in the coordination centres.

While quite common in military command and control systems, the P2P technology is still insufficiently explored in civil applications and especially in emergency response situations (Bortenschlager *et al.*, 2007). A P2P network differs from a more traditional client-server architecture in which a relatively low number of servers provide information to different clients or applications (Figure 8-2). Strictly speaking, a P2P network does not make a distinction between ‘clients’ and ‘servers’, but consists of equal entities, i.e. peers or nodes, which can serve both as clients and servers to other nodes. These nodes can be linked with each other via *ad hoc* connections and allow for sharing of a large number of data, including real-time data. The P2P technology enables systems to be functional when a constant network connectivity with a server could not be guaranteed, since a P2P network allows the exchange of information via other nodes available, either through a wireless local area network (WLAN) or mobile network or using *ad hoc* P2P networks (Bortenschlager *et al.*, 2007).

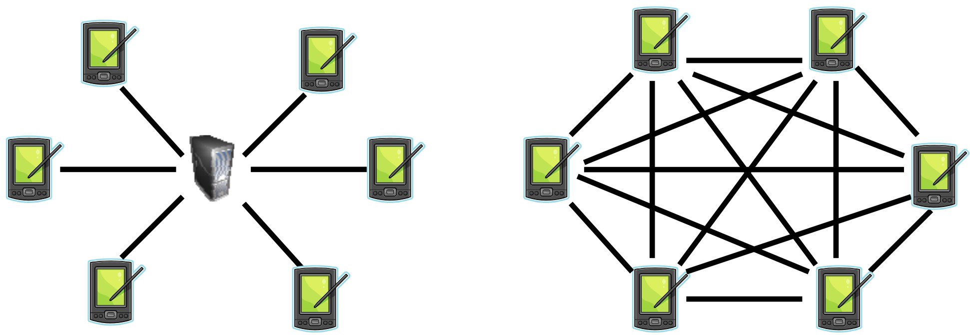

Figure 8-2. A client-server (left) versus peer-to-peer network (right)

Within Eagle, the client-server approach and the P2P technology were integrated into one system architecture as shown in Figure 8-3. The system architecture consisted of clients (P2P, Open GIS Consortium (OGC) and vendor-specific), a central database management system (DBMS), local data copies, a data harvester and external servers and services. The external servers were data repositories of various organisations which could possess valuable geo-information such as citizen and building registers, meteorological and statistical data. The organisations and institutions maintaining these data repositories were supposed to provide 24-7 access to their servers and applications. The Netherlands, for example, has identified approximately 30 of such data sets and the responsible organisations will be obliged to provide OGC services for access. The generated information is retrieved from the P2P network and stored in databases (Dilo & Zlatanova, 2008). Of course, calling the services directly has the main advantage of providing the most recent information. However, if these services are not available or overloaded, the information that was retrieved previously by another P2P client can be used instead. Consequently, data can be distributed either using the P2P network or directly from the system itself.

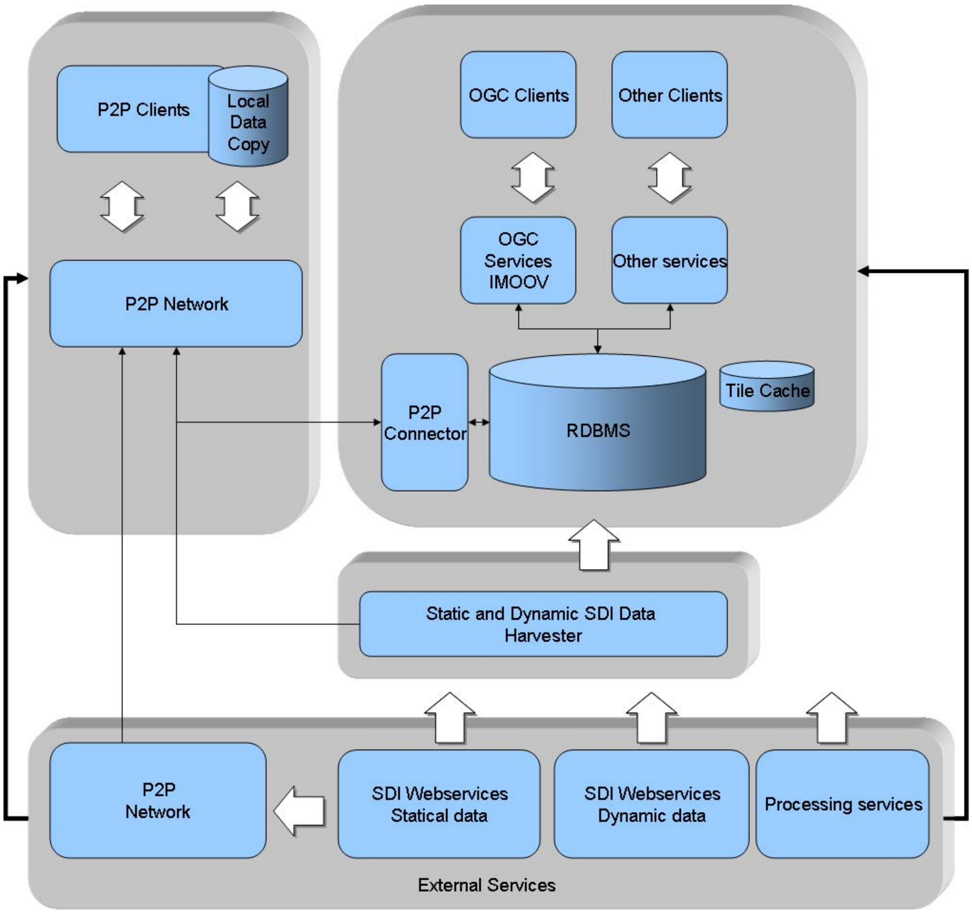

Figure 8-3. The Eagle system architecture

With respect to the information that should be exchanged through the networks, the definition of well-defined standardised services for discovery and exchange of geo-information is required. Geo-information services refer to the processing of geo-data which result in processed information, e.g. the potential water depth at a particular point or the fastest route from A to B (Annoni *et al.*, 2005; Drummond & French, 2008; Scholten *et al.*, 2008). These services can be acquired from a great variety of available user-specific systems and can be presented in different applications, to meet specific user requirements and user interfaces and to enable the implementation of services from one application into another.

Such services are closely related to the development of SIIs. Initiatives for SIIs are in progress at many levels all over the world, e.g. INSPIRE in Europe (www.ec-gis.org/inspire). These have to be further enriched to be able to serve the emergency sector. Large international projects, e.g. ORCHESTRA (www.eu-orchestra.org), OASIS (www.oasis-fp6.org) and WIN (ww.win-eu.org) have been reporting results of their research in this area. Proposals for standards and services developed within these projects are in process of discussion within the Open Geospatial Consortium (OGC, www. opengeospatial.org). However, all these services designed for client-server architecture can be made available within the P2P network. Selecting the relevant data and services required extensive investigations of user requirements and formal specifications of the emergency response processes and the data created and required within each sub-process of emergency response (Dilo & Zlatanova, 2008; Snoeren, 2006). For that reason, a two step approach was applied: (i) the design of a conceptual model of emergency management processes and data requirements, using Unified Modelling Language (UML), and (ii) deriving a data model.

On the visualisation and communication level, special attention was given to the creation and exchange of the COP. Traditionally, this COP was presented and exchanged through situation reports. These reports have been very useful to inform actors involved in emergency response about the actual situation. Nevertheless, three main drawbacks were recognised (Van de Ven *et al.*, 2008). First, it took time for situation reports to arrive at other teams, especially at teams at the higher level. Second, situation reports provided a static view of the dynamic situation. Consequently they were often out-dated. Third, not everybody who needed the information had access to the information. In addition to these drawbacks, it should be mentioned that situation reports often consisted of pages of text, which required time for reading.

To improve visualisation and communication of situation reports, two alternative interfaces were developed and used together: SitPlot and SitText. SitPlot is a geographic interface based on ESRI's ArcGIS that allows its users to view, analyse and generate geographical information that is needed for decision making, such as information on current or potential water depth at a specific location. Figure 8-4 represents a screenshot of the SitPlot application at the beginning of an emergency exercise. It presents the area in which one of the emergency response exercises took place. On the left-hand side, different data layers, including reference and thematic data, can be selected such as topographic maps or maps with information about the population in the area. On the right-hand side, information about the incident can be added such as the location of the incident or the location of emergency services. The shared picture as presented in SitPlot results from the inputs from the different sections within the regional operational team (ROT, see also Section 8.6) and is available on every pc on which Sitplot is installed and activated. Users can add maps to SitPlot, e.g. maps which represent the location of an incident or the accessibility of an area, and these maps then become available as separate map layer in SitPlot. Plotters in the information-section take care of the integration of the added maps. In addition, they can carry out analytical operations within SitPlot in order to meet specific information requirements of various ROT-sections during the exercise, such as an analysis of the number of people that will be affected by a toxic cloud.

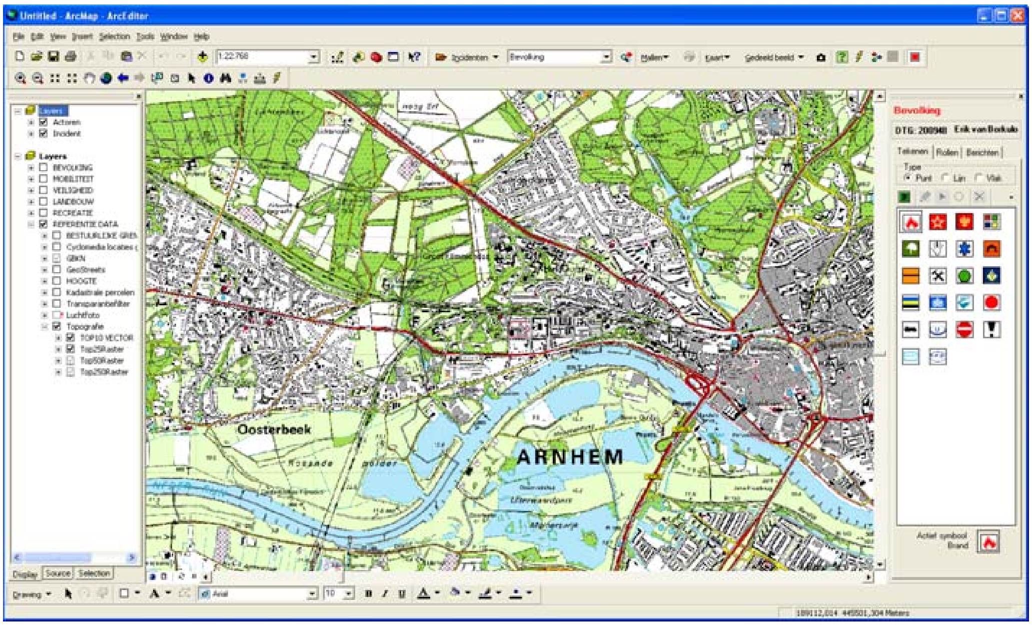

Figure 8-4. SitPlot

SitText (Figure 8-5) is a collective workspace used for storing and exchanging texts. It allows its users to send and receive short text messages. SitText consisted of different tabs for different groups of users such as the fire department of the police department. Figure 8-5 represents an example of SitText, which represents the situational report during one of the exercises. It contains information about various aspects of the emergency such as the weather conditions i.e. temperature 20 degrees, wind, Northeast 5; the nature of the incident, i.e. a train accident; the nature and direction of the released hazardous materials; the possibilities for emergency response i.e. some roads are blocked; the number of people affected together with and indication of the seriousness of their injuries and the actions undertaken i.e. emergency services have entered the train, the water board is warned. On the left-hand side, it is indicated which users are online. On the top, the different tabs can be selected. Through SitPlot and SitText, a more dynamic view of the actual situation could be given, which could be exchanged with the actors involved in emergency management in a fast and efficient way.

*Figure 8-5***.** SitText

8.6 Experiences from the Eagle One exercise

In the Netherlands, most emergency incidents of a minor nature are responded to at the local level by the emergency services including the fire brigade, paramedic teams and the police department. When there is a need for a structured coordination, a coordination team of representatives of the emergency services is formed at the site of an incident. When the magnitude of the emergency increases, other parties at other administrative levels can become involved and a regional coordination team is formed. This coordination team is often situated in the regional emergency operations centre of the safety region remote from the incident and consists of representatives of the emergency services and the municipality. The mayor of the municipality in which the incident is taking place has the administrative lead within the regional coordination team. The nature of a disaster may require the need for the involvement of additional, specialised organisations such as the water board in case of a flooding. When the potential magnitude of an incident leads to a serious threat to a large section of the community in the incident vicinity, to the environment, or to anticipated severe damage to property, emergency officers at provincial or national level are involved (Ministerie van Binnenlandse Zaken, 2003; Scholtens, 2008).

The Eagle One exercise focussed on the regional level and took place in the Safety region Gelderland Midden, in the Gelderland province, located in the east of the Netherlands (Figure 8-6). The central objective of Eagle One was to test and evaluate the use of information and geotechnology through testing the Eagle applicationsystem. Eagle was applied in the regional operational team (ROT) of the regional coordination centre. The regional emergency operations centre consists of a policy team, mainly focussed on decision making, and an operational team, which advises the policy team and executes the strategies developed by the team. The ROT communicates with both the policy team and with the actors in the field on the site of the incident. The ROT itself consists of eight sections: Information management; Fire department; Police department; Paramedics; Logistics; Municipality; Information services; and Third parties, consisting of organisations with specific expertise such as the water board during a flood or electricity companies during a power breakdown. The focus of the exercise was on the ROT. Proposed actions in the ROT were not executed and practiced in the field.

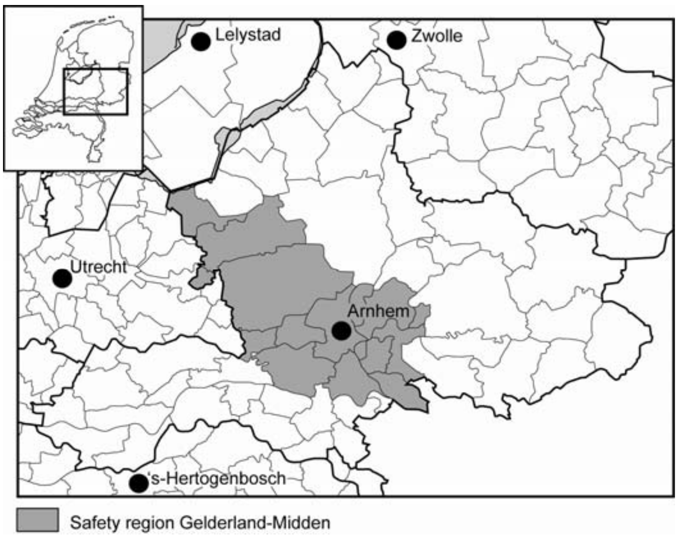

Figure 8-6. Safety region Gelderland Midden

During the exercise, every section of the ROT was observed and particular attention was paid to the information domain in general and the communication process and the use of information and information systems in particular. The exercise was also evaluated in a plenary session with the participants. In addition, participants in the exercise were asked to fill in an online questionnaire. Within this questionnaire a distinction was made between users that used only SitPlot, referred to as SitPlot respondents and users that used both SitPlot and SitText, referred to as SitPlot and SitText respondents (Table 8-2). The observations and evaluations have resulted in two evaluation reports on network-centric sharing of information, the use of information and the Eagle application during Eagle One (Brooijmans, 2008; Van de Ven, 2008), one technical evaluation of the Eagle application (Geodan, 2008) and one evaluation of the emergency management in general during Eagle One (Van Capelleveen, 2008) resulting in an overall evaluation of the use of geo-information and Geo-ICT in the Eagle One exercise (Riedijk *et al.*, 2008). In this section, only the main findings are summarised according to network-centric domain.

*Table 8-2***.** Respondents to the questionnaires

	SitPlot	**SitText+SitPlot**	
Organisation	*Respondents*	*Respondents*	*Total*
Fire brigade	7	8	15
Police	2	3	5
Paramedics	1	2	3
Municipality	1	2	3
Other	3	1	4
Unknown	2	4	6
Total	16	20	36

Source: Brooijmans (2008).

Information domain

Through the information systems, the different units of the ROT were connected and were able to share information directly. Even though decision making still took place in a hierarchical way, the information could be shared more easily. In contrast with the established practices within the ROT, in which information was shared hierarchically from top to bottom or from bottom to top, information from one actor was now shared with other actors immediately. Moreover, more sources of information were available, since the regional actors were also connected to national and local geographical databases. In addition to having access to the information and the COP that was derived from the information, participants could also contribute to the common picture from their own perspective.

Through this way of organising information, the required information was mainly available in the information system as was also illustrated by the response to questions related to the information domain. For example, more than 50% of the SitPlot respondents stated that all information needed was present in SitPlot and 83% stated that this information supported their tasks. Nevertheless, some redundant information was also available in the system, since 64% agreed that some data layers would never be used. There was some variation in the assessment of accuracy of the data in the SitPlot system, however, with 21% agreeing that there was too much detail, 43% desired more detail. In addition, specific attention should be given to the accuracy of data, since 46% of the SitPlot respondents found errors in the data compared with 14% who did not and 40% who did not know or gave a neutral answer. In addition, data should be more up-to-date as was agreed by 54% of the SitPlot respondents although 23% disagreed. Related to this, only 36% of these respondents regarded the information in the system as valid and reliable compared with 14% who did not.

Cognitive domain

It can be concluded that the Eagle system contributed to both a common operational picture and a shared operational awareness. This was best observed during the multidisciplinary meetings. Little time was spent on explaining the situation, but the actors immediately started to plan actions. In addition, the responses to the questionnaires suggested that also the actors themselves perceived an increased situational awareness. Almost three quarters of the SitPlot and SitText respondents (72%) argued that other sections of the ROT had the same operational picture and 94% argued that actors in the same section had the same operational picture. Almost 90% of the SitPlot respondents argued that they had a better overview of what happened because information was shared through maps. Moreover, 86% of the SitText and SitPlot respondents agreed that they had a better operational picture through SitPlot and SitText.

The available information helped greatly to shape the situational awareness of the participants. Even though this contributed to a shared situational awareness, it also caused some problems during the exercise, especially when information was taken for granted. For example, participants focused on vulnerable people from nursing and elderly homes that were available in the database, while neglecting other groups of vulnerable people. Therefore a critical attitude towards the information available and presented in the information system is required.

Physical domain

In the end, improved information and communication should result in a shared situational awareness and to improved collaboration resulting in the reduction of the impact of an incident. It was difficult, however, to judge if the organisation of information and the geotechnology system being tested actually resulted in better actions and effects. The setup of the training did not allow for making a distinction between different but parallel groups through which results of the exercise with the information system could have been compared with groups who worked in a traditional way without the system. Undertaking the exercise with a network-centric approach and the information system was a general objective and, therefore, groups were not excluded from using the system. Nevertheless, results on the collaboration and shared situational awareness already indicated that the information contributed to a reduction of potential effects of an incident through improving the communication, information and, related to that, the situational awareness. In addition, the questionnaire results suggested that the system had contributed positively to decision making in general, since over 70% of the SitPlot and the SitPlot and SitText respondents agreed that the information system improved the quality of their work in general.

8.7 Discussion and conclusions

Conceptualising risk and emergency management as a point of departure for developing information systems may look simple and straightforward in theory. However, it turned out to be difficult to do this in practice. Ideas on what risk management and emergency response is about or how it should be carried out are often implicit and hard to make explicit. It turned out to be useful to switch from particular conceptions derived from project meetings with developers and users within the project to a more general conception in the literature to develop an interpreting framework through which risk and emergency management as a process could be conceptualised. The conceptualisation of risk and emergency management as network-centric operations turned out to be useful to understand risk and emergency management and to develop points of departure for the development of an information infrastructure through which geo-information and geotechnology could be organised. But did it also add anything new to existing ideas on risk and emergency management or geotechnology and SIIs?

At first glance the network-centric concept was useful as an overall concept to structure existing ideas on collaboration, shared situational awareness, information sharing, geotechnology and SIIs. Nevertheless, little was added to existing ideas on risk and emergency management or geotechnology and SII development. Its contribution to geotechnologies, for example, seemed limited, especially with respect to existing ideas on networks and services as developed in the field of SIIs (see, for example, Mansourian *et al.*, 2006). Of course, the network-centric concept was useful in practice to convince the actors involved in emergency response of the need of information sharing and interoperability and consequently to create a shared situational awareness on how geo-information and geotechnology should be organised. In the end, however, we believe that the added value of the network-centric approach goes beyond its value for marketing or structuring ideas.

A critical innovative aspect of the network-centric approach is its philosophy on information sharing. Whereas information was initially shared in an hierarchical way, the implementation of the network-centric approach resulted in a network-centric dissemination of information through which new information on the actual situation of actions of other actors became available immediately to actors involved in emergency response through which actions could be adapted to both the new situation and the actions of other actors. This network-centric way of information sharing instead of a hierarchical way also triggered technological innovations, such as the implementation of a P2P network to guarantee a constant information exchange during emergencies. In addition, network-centric risk and emergency management can be regarded as another way of coordinating activities and of stimulating collaboration in risk and emergency management. Actual emergency management processes in the Netherlands are being criticised for its hierarchical top-down command structure. These commands are regarded as ineffective ways of coordination during emergencies (Scholtens, 2008). Nevertheless, coordination is not necessarily achieved through central commands, but can also be stimulated through information sharing and the development of a common operational picture as assumed in the network-centric approach, which can support self-managing ways of collaboration as an alternative for collaboration through central commands and control (see also Scholtens, 2008).

These principles and lessons as derived from the development of Eagle and the emergency training can also be relevant for risk management processes. Of course, it can be argued that relevant risk information for risk management is already becoming available and shared, e.g. through improved and increased risk assessment or through the worldwide development of spatial data clearinghouses as a main element of SIIs (Crompvoets *et al.*, 2004). These existing information infrastructures, however, do often not meet the specific requirements needed for emergency response such as network stability or the speed of information availability and exchange (National Research Council, 2007). Therefore, the organisation and development of geotechnology and geo-information for risk management should also be considered in the light of the requirements for emergency management so that the information and networks can also be used during an emergency. Moreover, principles of a network-centric dissemination of information in risk management should be considered. In risk management practices, it is not uncommon that information is distributed hierarchically. Changes in the nature and amount of hazardous materials at a particular installation, for example, are often distributed hierarchically, e.g. from the plant operator to a National Health and Safety Executive, who should forward this information to a local planning department (Basta *et al.*, 2007). Even though risk management practices are less time-critical, a network-centric organisation of information dissemination and information systems can still contribute to a more realistic picture of the safety risks of a particular area and consequently to an improved situational awareness which can result in improved collaboration and coordination and subsequently to more effective risk management. Outdated information, for example, can result into inappropriate safety distances or contingency plans.

Even though network-centric warfare has been highly technology driven (Von Lubitz *et al.*, 2008b), we believe that the added value of the network-centric approach for the organisation of geotechnology in risk and emergency response lies in the network-centric organisation of information dissemination, which subsequently requires technology such as the development of services and networks. An exclusive focus on technology is therefore undesirable, since it can derive attention away from crucial organisational aspects. Moreover, the implementation of an information system that can support NCREM does not imply that network-centric emergency response automatically results from it. People should be willing to share information in a network-centric way. In addition, it can be argued that, according to network-centric emergency response principles, people with a better information position should be able to take better decisions. The central command can still give orders to lower level units about the objectives that should be achieved but these operational units do have the freedom to decide on how these objectives should be achieved as is worked out in the Netherlands defence doctrine (Ministry of Defence, 2005). As stated by Von Lubitz *et al.* (2008b: 576),

> *"the net effect of network-centricity is much greater operational and tactical freedom for the individual units that support the most effective execution of 'commander's intent' as*

well as operational coordination of all activities within the entire spectrum of the assigned missions".

Clearly then, the elaboration of network-centric risk and emergency management is about both the organisation of information and about the organisation of risk and emergency management itself. Consequently, the development of geotechnology for risk and emergency management is not only about the information system or technology itself, but also about the way risks or emergencies can or should be addressed and dealt with, which requires a conception of risk and emergency management activities.

Risk and emergency management activities have been portrayed as network-centric operations in which collaboration and information exchange are required. Based on this conceptualisation of risk and emergency management practices, it has been argued that information should no longer be shared in an hierarchical way. Information should be shared and available at all levels at the same moment through information networks. The development and implementation of a spatial information infrastructure is desirable to organise geographical information for emergency management and to facilitate information sharing and integration during emergency preparation and response. Organising geographic information and geotechnology in a network-centric way can lead to improved information; improved communication; better situational awareness; better and faster decision making and more effective risk management and emergency response.

Acknowledgements

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9

Discussion

Spatial planning and Geo-ICT are regarded as important instruments for risk management. Nevertheless, the use of spatial planning for risk reduction and the related use of Geo-ICT for the consideration of safety risks in planning is far from widespread. In the Introduction, various factors that could explain the limited use of Geo-ICT were identified. Similar to studies on spatial literacy, one specific factor was emphasised: the forms of reasoning of actors involved in planning. It was assumed that the forms of reasoning of spatial planners with respect to risk management could – at least to some extent – explain both the use of spatial planning to reduce safety risks and the use of Geo-ICT to support the consideration of safety risks. In line with Klosterman (2001), it was assumed that forms of reasoning about how safety risks can or should be managed could also be used as a point of departure for developing directions for the further application and development of Geo-ICT. With this background, the central research question was discussed:

How are safety issues addressed in spatial planning practices and what contribution can be made by geo-information and Geo-ICT to support the consideration of safety risks in spatial planning?

The resulting research revealed many interesting insights on the conceptual and methodological levels. On the conceptual level, spatial planning activities could be linked more explicitly with the capacity of an area to resist, adapt to, cope with and recover from emergencies. Moreover, factors and conditions were identified which could be used to understand the consideration of safety risks in planning practices. With respect to risk management and Geo-ICT, it was demonstrated how the network-centric approach can contribute to the organisation of geo-information and Geo-ICT in risk and emergency management. On the methodological level, it was illustrated how existing concepts of risk management and spatial planning can enrich inductive interpretative research strategies and results. This chapter brings these results together. In addition, recommendations are given for enhancing spatial planning and Geo-ICT as risk management instruments.

9.1 Spatial planning for risk reduction

As mentioned in Chapter 1, safety risks within an area can be divided into components: the hazards, exposure and the capacities of an area to resist, adapt to, cope with and recover from emergencies. These safety risks were highly influenced by the spatial disposition (*ruimtelijke inrichting)* and consequently by land use and land use changes. Therefore, spatial planning was regarded as an important instrument to reduce safety risks. Spatial planning, for example, was used as an instrument to implement safety distances around hazardous installations, which reduced exposure to industrial hazards.

This distinction between risk aspects was helpful to identify risk reduction measures that can be complementary to the measures that are already considered in spatial planning practices. In spatial planning, land use near dikes can be regulated to facilitate dike improvements, which can increase the resistance capacity of a dike ring area. The regulation of land use in dike-ring areas, however, can also complement dikes, e.g. when exposure is reduced through these land-use regulations. However, the land use in dike-ring areas is rarely regulated for flood risk reduction purposes.

In this respect, it was interesting to observe changes in the way safety risks are considered in Dutch spatial planning and risk management practices, where the capacity of an area to deal with hazards and exposure is taken into account more explicitly. This approach is most prominent in external safety policies, but comparable trends can also be identified in the reconsideration of flood management policies, especially at the national and regional levels (Ministerie van Verkeer en Waterstaat, 2008a; Ministerie van Verkeer en Waterstaat, 2008c). Within these flood management policies, special attention is paid to reducing the potential consequences of a flood. Even though preventing flooding remains the main pillar of these flood risk management policies, the influence of the spatial disposition on flood risks is now being explicitly considered as well. Consequently, flood risks should be considered in spatial planning practices and in decisions on urban development (Ministerie van Verkeer en Waterstaat, 2008c).

This policy is in line with recent European policies on flood management. In November 2007, the European Directive on the assessment and management of flood risks (07/60/EC) came into force. This framework for the assessment and management of flood risks obliges Member States to carry out a flood risk assessment for their territory and to identify areas where, according to these States, potential significant flood risks exist or are likely to occur. Based on this flood risk information, appropriate objectives for the management of flood risks for the identified high-risk areas should be established by the Member States. In addition, Member States should establish flood risk management plans which describe the measures they will take to achieve the flood management objectives. As discussed previously, spatial planning can be an important instrument for implementing measures.

However, if additional risk reduction measures are considered, the contribution of spatial planning to risk reduction should not be narrowed down to the land allocation plans to regulate land use, such as the implementation of safety distances in land allocation plans. Spatial planning has more to offer to the reduction of hazards and vulnerability than land allocation plans alone. Even though many risk reduction measures, such as risk communication or the presence of evacuation routes, could not be implemented through these plans (see Chapter 4), they can be addressed in planning processes. In the planning process, the safety risks as a whole could be addressed and arrangements could be made to implement safety measures and measures both within the land allocation plan itself and outside its scope. Consequently, spatial planning processes can be perceived as actual risk reduction instruments that can be used to make arrangements to implement safety measures. This can result in the implementation of safety measures either in land allocation plans or in other instruments such as private-law arrangements with developers or risk communication plans.

Nevertheless, developing visions on how spatial planning and spatial plans can contribute to risk reduction is one thing, but implementing them is another. Many local governments have avoided using spatial planning to implement mitigation measures, especially with respect to flood risks. Despite the acknowledgement that planning can contribute to risk reduction, the commitment of government bodies in general and spatial planners in particular to mitigate specific hazards through spatial plans or spatial planning was limited. In the studies on planning practices, the interviewed planners gave various reasons for using or not using spatial planning or plans for reducing safety risks. Some reasons were beyond the control of governmental bodies, such as previous disaster experiences. Nevertheless, commitment could also be explained by factors and conditions that are controllable by government, including the availability of clear guidelines for the consideration of safety risks, public commitment and the capacity and skills of actors involved in planning to deal with safety risks. Clearly then, the required commitment for hazard mitigation of actors involved in spatial planning can at least partly be encouraged by governmental bodies, which also offers these bodies opportunities for promoting the consideration of safety risks in spatial planning.

Recommendations

Based on the examination of specific local planning practices and the consideration of both flood risks and industrial risks in these practices, several recommendations can be made for promoting the commitment of spatial planners to risk management on the local level in general and consequently for the implementation of the national flood risk management policies in particular. These recommendations can be relevant to professionals involved in flood risk management and spatial planning, but also to professionals involved in the consideration of other risks in planning, such as the consideration of climate change risks and adaptation measures.

First of all, higher-tier governmental bodies can provide guidelines and requirements for the consideration of safety risks. For example, national or regional governmental bodies can identify areas in which explicit attention for flood risks is required. This attention can be made operational through the involvement of safety experts in spatial planning processes in these areas. These safety experts should address these safety risks and provide recommendations on how to deal with them. Of course, these requirements should not only apply to lower-tier governmental bodies, but also to the higher-tier governmental bodies themselves, if they are considering spatial developments in flood-prone areas.

Even though such coercive strategies can provide a point of departure for encouraging the consideration of safety risks, a strict focus on coercive mechanisms was regarded as undesirable, since it can result in a symbolic consideration of safety risks to meet the formal requirement, rather than an active consideration of safety risks and potential measures to deal with these risks. A combination of cooperative and coercive strategies should therefore be pursued, which was also regarded as an important strength of the safety recommendations on industrial risks. Therefore, the second recommendation for implementing the considered flood risk policies is to encourage cooperation between planners and flood risk experts through an extension of the Water Assessment (WA). Similar to the safety recommendations, the WA has been a successful instrument for bringing spatial planners and water managers together. It has resulted in increased attention for water management issues in spatial planning. Like the safety recommendations, the WA is communicative in character (Van Dijk, 2008). It promotes deliberation between water managers and spatial planners. However, flood risks resulting from the failure of primary dikes are not yet considered in the WA. In this light, the inclusion of these risks in the WA is worth considering if flood risks are to be addressed more explicitly in spatial planning. The advantage of extending existing planning instruments with a hazard component is that relatively minor adjustments have to be made to normal practices in order to be effective (Olshansky & Kartez, 1998). The guidelines on the national or regional levels can provide the coercive safety net if these communicative processes do not result in the consideration or implementation of risk reduction measures.

If flood risks are considered in the WA, then water managers will have an important task in addressing flood risks and giving recommendations for reducing flood risks. Their safety recommendations, however, should not necessarily be limited to those measures that can be implemented in land allocation plans, since the process of plan development also offers opportunities to address safety issues in general and to promote the adoption and implementation of safety measures through other plans and processes, such as risk communication plans, contingency plans, building regulations or private law arrangements with developers.

To promote commitment, of course, other conditions should also be met. The actors involved in the consideration of these risks should have the capacity to deal with them. If risks should be explicitly considered, staff should be capable of taking these risks into account. This implies, for example, that both appropriate risk information and risk management expertise are available. In addition, planners should be made aware of risks e.g. through risk communication. Moreover, trade-offs between other interests should be considered, since risk prevention is sometimes controversial in the light of other interests such as economic development. The management of safety risks should therefore be considered in the light of these various interests.

Finally, special attention should be paid to public commitment. Even though this factor hardly played a role in the studies on the safety recommendations and on flood risk management, it turned out to be crucial during the implementation of safety measures, as illustrated by the ‘making space for water’ projects. For that reason, a more interactive approach should be considered as an alternative for the authoritarian styles of implementing safety measures. This provides alternative ways to manage potential conflicts and to potentially transform these conflicts into more constructive discussions (Fischer, 2003a; Funtowicz & Ravetz, 1993; King, 2008; Klinke & Renn, 2002). Nevertheless, approaches that are more interactive and those that link risk management with spatial planning both require another substantive starting point. The development of risk reduction measures from a safety perspective can be problematic, as was the case in some 'making space for water' projects. The measures that were developed for the reduction of flood risks conflicted with the interests, values, norms, convictions and knowledge of other stakeholders in the specific areas. The resulting conflicts were not only about the flood risks or the measures themselves, but could also be regarded as conflicts about the actual and desired landscape as a whole. For that reason, an area-oriented perspective is recommended. This perspective concentrates on an area as a whole and on the different spatial sector claims on that area. Because implementing risk reduction measures through spatial planning inherently requires balancing different spatial claims with varying interests, values, norms and convictions with respect to the current and future landscape and its inhabitants and users, this area-oriented perspective is also recommended for risk management in spatial planning.

9.2 The contribution, use and further development of Geo-ICT

Ideas on the contribution of geo-information and Geo-ICT to the consideration of safety risks in planning were based on conceptions of spatial planning and the consideration of safety risks in planning. Based on an understanding of how spatial planners deal with safety risks and informational requirements within spatial planning, ideas were developed on how geo-information on risks can contribute to the planning process and how this information should be organised. These ideas were enriched by ideas on emergency management and the role of information and Geo-ICT in emergency management, which resulted in the concept of network-centric risk and emergency management. This concept provided a point of departure for discussions on the contribution of geo-information and Geo-ICT to spatial planning and for the further development of geo-information and Geo-ICT.

Network-centric risk and emergency management implies that actors involved in risk and emergency management have the capability to gather, produce, share and access information in a network-centric way. Information is distributed directly to those individuals and organisations for which the information is relevant, instead of distributing the information step-by-step in a hierarchical way. This network-centric distribution of information should result in a common picture of both the available information about the present situation and the actions that are planned and taken. The immediate availability of this common operational picture should be a basis for a shared situational awareness of the safety risks, and subsequently, a basis for the collaboration and synchronisation of actions through which the impacts (real or potential) of risks and emergencies are reduced.

These ideas on network-centric risk and emergency management in general and on the role and contribution of information in particular are related to ideas on the development of Geo-ICT and spatial information infrastructures (SIIs), respectively. SIIs can play a crucial role in facilitating the dissemination of information. Through networks, the actors involved in risk and emergency management can be connected. Moreover, the required information can be gathered, developed and integrated into a single, common picture of the area. In addition, Geo-ICT can provide tools to analyse this picture, e.g. to develop scenarios of different emergencies and to visualise the integrated information. For these reasons, SIIs and Geo-ICT can contribute to the integration of spatial data and information from different sources in order to develop a common picture of the present safety risks in a specific area.

These ideas can be made operational through the establishment of SIIs; this includes technological developments, such as the development of networks and services, which enable the exchange of data and information. In addition, organisational arrangements should be made, such as arrangements on data use and exchange and arrangements on data standards that enable the exchange of data and information between different systems. As a result, the many actors involved in both risk and emergency management can be connected to each other, and the required information, which was often spread between many different parties, can be exchanged. Moreover, arrangements on standards for data and services are required to facilitate the exchange of information between the different information systems that are used for risk and emergency management.

As illustrated in Chapter 7, the actors involved in risk and emergency management have overlapping information requirements. Nevertheless, some information requirements and system requirements differ. For that reason, the architecture of a spatial information infrastructure should allow room for differentiation in information supply and system requirements. The widely applied Service Oriented Architecture approach offers an interesting concept for such an information infrastructure. Moreover, this information infrastructure point of view promotes thinking beyond a single application developed for a specific type of activity or user. This is because information and services developed for a single risk management activity - such as spatial planning or emergency response - or one group of actors, can be relevant for other actors or activities as well.

Nevertheless, the added value of the network-centric concept – compared to existing ideas on SIIs as presented in Chapter 7 – is its philosophy on information sharing in general. Whereas SIIs can also support hierarchical information dissemination, the implementation of the network-centric approach requires that information about the actual situation or about the actions of other actors becomes available immediately to the actors for whom this information is relevant. Based on this information, actions can be adapted to the new situation as well as to the actions of other actors. Consequently, ideas on network-centric risk and emergency management have enriched accepted ideas on SIIs.

These ideas are not only relevant for emergency response, in which a common operational picture of the present situation is regarded as crucial, but also for spatial planning. Similar to emergency management, it is important that the actors involved in spatial planning have access to up-to-date information. Information about changes in environmental licences for operators of hazardous installations, for example, should also become available to spatial planning, since these changes may increase or decrease the possibilities for spatial development. In addition, changes in the allowed number of buildings or people in an area can affect the approval of applications for environmental licences. Therefore, the principles of network-centric risk and emergency management also deserve attention in spatial planning, especially with respect to the development of information systems to support spatial planning. In addition, organising the geo-information and Geo-ICT used for spatial planning in a network-centric way is not only beneficial for spatial planning, but also for emergency management. A considerable part of the information used in spatial planning is also required by emergency managers. Therefore, a network-centric organisation of geo-information and Geo-ICT for risk management also contributes to the organisation of geo-information for emergency response, since emergency managers require this information as well.

Even though the focus of this research was mainly on geo-information, the focus during the development of geo-information and Geo-ICT for supporting network-centric risk and emergency management should go beyond the information that can be presented on a map. Policy makers or decision makers, for example, also require knowledge and expertise which is not explicitly geographical, such as information on how risks can or should be managed. For that reason, other applications that can be of added value to geographical applications should be considered as well, such as text applications, as was illustrated in Chapter 8.

Moreover, sharing information is not only about the organisation of information in information systems. It is also about the organisation of the information that can be derived from these systems and about the organisation of information and expertise that are not or cannot be included in these systems, such as tacit knowledge and skills. For these reasons, network-centric risk and emergency management requires not only an appropriate organisation of geo-information and Geo-ICT, but also a network-centric organisation of information in general. Therefore, attention should be paid to the organisation of risk and emergency management in general. With respect to risk management in spatial planning, an appropriate organisation of planning processes and of the consideration of safety risks in these processes is needed. The safety recommendations in Dutch planning practices can be regarded as an example of how expertise and information can be brought together in the planning process. Clearly then, ideas on the contribution and further development and application of geo-information and Geo-ICT should be developed hand-in-hand with ideas on how the consideration of safety risks in planning should be organised.

Recommendations

Within the Netherlands, many efforts are being undertaken on the further development and application of Geo-ICT to support risk and emergency management. Relevant risk information is increasingly becoming available, which can enhance the situational awareness of actors involved in risk and emergency management. This information is mainly made available to spatial planning through risk maps. Risk maps are available via the Internet for professionals and, to a lesser extent, the public (as discussed in Chapter 3). In addition to information on hazardous installations, these risks maps are extended with information about other hazards, including potential water depths in case of flooding, and with information about vulnerable objects (www.risicokaart.nl). Moreover, the information is also becoming available for response and recovery activities, because databases of the risks maps are also included in the national SII that was developed to support emergency management (Ministerie van Binnenlandse Zaken *et al.*, 2007). As a result, information can also be shared between the domains of risk and emergency management, resulting in a common picture of the safety risks in an area, which can enhance a shared situational awareness. Consequently, many problems with respect to the availability and accessibility of geo-information are being tackled.

Despite these efforts on the national level, the implementation of these national models and SII initiatives to local and regional practices should be worked out further. Local practices in which geo-information about flood risks was actively used are scarce (see, for example, Steekelenburg *et al.*, 2008; Stone *et al.*, 2008), consistent with the small number of planning practices in which flood risks resulting from primary water defences are actively considered. In addition, a study of the advisory body on hazardous materials (*Adviesraad gevaarlijke stoffen)* revealed that a further development of more local risk models is desirable to support the consideration of external safety risks. The fire departments, for example, do not have quantitative models to calculate the number of wounded people or models to develop insight into the effects of safety measures on self-help or the possibilities for emergency response (Adviesraad gevaarlijke stoffen, 2008). Consequently, the present and future possibilities for emergency response and self-help cannot be assessed effectively. Also, with respect to networks, special attention should be paid to the regional level (as was illustrated in Chapter 8), where peer-to-peer principles were applied to make the national information accessible at both the regional level and in the field. Clearly then, national initiatives are promising in the light of the ideas presented in this study, but the implementation of these ideas at the regional and local levels deserves further attention.

Moreover, issues for the future dissemination of information can be identified. It should be considered which information can be distributed in a network-centric way, and when this information can be distributed in such a way. Direct network-centric dissemination of information can be desirable in relation to the time pressure that is evident in many crisis situations. Users of this information can add their information to the common operational picture, or they can suggest changes if they regard the information as incorrect. Nevertheless, some extent of hierarchical distribution – in order to check and approve the information before disseminating it – can be recommended as well. In addition, it should be defined which type of information can be relevant for which type of actor, since an overly enthusiastic distribution of information easily results in information overloads. Furthermore, some information can be confidential, which makes a broad distribution of this information undesirable. Therefore, the information requirement and the requirements for the distribution of information within both risk and emergency management should be elaborated in greater detail. In addition, more training programmes based on the principles of network-centric risk and emergency management are desirable in order to enhance the skills of risk and emergency managers and the concept of network-centric risk and emergency management itself.

9.3 Suggestions for further research

Similar to other studies, this research not only provided answers to questions, but it also raised new ones. Therefore, some suggestions for further research are given. The suggestions presented here are not all-encompassing, but some directions can be identified. First of all, examining the consideration of safety issues over a longer term is desirable to study the effects of policy changes on both the consideration of safety risks and the implementation of actual safety measures. This study provided useful insights, but the policy context in which spatial planning in the Netherlands is carried out has changed, and the implications of these changes on the consideration of safety risks are unclear. A new national spatial planning act has been in force since July 2008. In addition, flood risk management policies are being reconsidered, which may result in different responsibilities and tasks for spatial planners with respect to risk management. Continuing research on the consideration of safety risks and on the implementation of safety measures can provide insight into the effects and effectiveness of specific policies and policy changes. In addition, more insight can be acquired into the responsibilities of actors involved and how these responsibilities are perceived.

Second, ideas on the integration of spatial planning and emergency management require further elaboration. Spatial planning and emergency management are often regarded as different fields. Nevertheless, they have much to offer to each other. Spatial planning, for example, can be used to address, discuss and implement measures for increasing the possibilities for emergency response, whereas emergency responders can provide valuable knowledge and expertise about increasing the capacity of an area to respond to events. It was previously argued that a combination of coercive and cooperative strategies can encourage the consideration of emergency management concerns in spatial planning. However, few studies have been conducted on the consideration of emergency management concerns in spatial planning, or on the effectiveness of the developed strategies to encourage the consideration of emergency management concerns. Therefore, further research on the effectiveness of such strategies is desirable.

Third, the added value of risk information and Geo-ICT should be studied in more detail. The network-centric approach assumed that better information leads to shared understanding of the actual situation and subsequently to better decisions and synchronised actions, which should ultimately result in the reduction of disaster impact. However, information sharing does not automatically result in risk reduction or reduced losses. Other factors, such as commitment to the consideration of safety risks in general, also play a role. For that reason, the use of geographical risk information and its effects on decision making processes should be studied further. Even though studies on knowledge use are available (see, for example, Boogerd *et al.*, 1997; Hills, 2005; Hisschemöller *et al.*, 1998; In 't Veld, 2000; Macauley, 2006; Shulock, 1999; Stephenson, 2000; Weiss, 1991), it remains important to conduct additional studies that provide insight into the use of information, and specifically in this case, the use of geographical risk information and systems. This will ensure the development and application of these systems and the evaluation of the contribution of network-centric operations.

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Appendix: List of Actors Interviewed

Study on risk maps (Chapter 3)
Mrs. Balmforth, HSE
Mr. Bouwman, Provincie Overijssel
Mr. Manuel, RIVM
Mr. Van der Zande, RIVM

Study on the implementation of safety recommendations (Chapter 4)
Mrs. Gerritsen, Gemeente Arnhem
Mr. Koedam, Gemeente Arnhem
Mr. Meijers, Gemeente Arnhem
Mr. De Wijer, Gemeente Duiven
Mr. Flijling, Gemeente Ede
Mr. Van Beukering, Gemeente Ede
Mrs. Refwutu, Gemeente Lansingerland
Mr. Bakker, Gemeente Rotterdam
Mr. De Rooij, Gemeente Rotterdam
Mr. E.B. Weeder, Gemeente Schiedam
Mr. In ’t Veld, Gemeente Spijkenisse
Mrs. Koenen, Gemeente Zevenaar
Mr. Geurts, Gemeente Zevenaar
Mr. De Boer, Hulpverlening Gelderand Midden
Mrs. Duindam Hulpverlening Gelderand Midden
Mrs. Van Schaijk, Hulpverlening Gelderland Midden
Mr. Anink, Veiligheidsregio Rotterdam Rijnmond
Mr. Buitendijk, Veiligheidsregio Rotterdam Rijnmond

Study on the consideration of flood risks (Chapter 5)
Mrs. Cobio, Gemeente Alblasserdam
Mrs. Bax, Gemeente Dordrecht
Mrs. Van Walwijk Gemeente Dordrecht
Mrs. Shouten, Gemeente Giesenlanden
Mr. Pouw, Gemeente Gorinchem

Mr. Van den Berg, Gemeente Graafstroom
Mr. Ligny, Gemeente Hardinxveld-Giessendam
Mr. Van Gilst, Leerdam
Mrs. Kievit, Gemeente Liesveld
Mrs. Van der Spek, Gemeente Nieuw-Lekkerland
Mr. Van Bracht, Gemeente Papendrecht
Mr. Labee, Gemeente Sliedrecht
Mr. Foppen, Gemeente Vianen
Mr. Hanning, Gemeente Zederik
Mrs. Aalbers, Hoogheemraadschap van Delfland
Mr. Van Bruggen, Hoogheemraadschap Schieland en de Krimpenerwaard
Mrs. Frinking, Provincie Zuid-Holland
Mrs. Somsen, Provincie Zuid-Holland
Mr. Zaalberg, Provincie Zuid-Holland
Mr. Hielen, Waterschap Rivierenland

Study on informational requirements with respect to flood risk management
Mr. Klijn, Deltares
Mr. Beugelink, PBL
Mr. Lightvoet, PBL
Mr. Pieterse, PBL
Mr. Tennekes, PBL
Mr. De Wit, TNO
Mrs. Roos, TNO
Mrs. Frinking, Provincie Zuid-Holland
Mrs. Somsen, Provincie Zuid-Holland
Mr. Zaalberg, Provincie Zuid-Holland
Mr. Piek, Provincie Zuid-Holland
Mr. De Mooij, Ministerie van Verkeer en Waterstaat

Summary

Both spatial planning and Geo-ICT are regarded as important instruments for risk management. Nevertheless, their use is seen as problematic. Spatial planning, despite its potential as an instrument for risk management, is not widely used to mitigate safety risks. The use of Geo-ICT is also far from effective due to the limited availability of geo-information, unsuitable geo-tools or limited possibilities for information exchange. This thesis describes how safety issues are addressed in spatial planning practices and what contributions can be made by geo-information and Geo-ICT to support the consideration of safety risks in these practices.

The first aim of this study was to understand how safety issues are addressed in spatial planning practices and to explore the reasons for the use or non-use of spatial planning for reducing safety risks in advance. Based on the resulting insights, recommendations have been given for stimulating the consideration of safety risks in planning. The resulting insights were also used as a starting point for meeting the second aim, which was to discuss the contribution of Geo-ICT and to give recommendations on the further development and application of geo-information and Geo-ICT for the consideration of safety issues in spatial planning.

Risk management, spatial planning and Geo-ICT

Spatial planning, with its objective of influencing land use, can play an important role in increasing the safety of citizens in both industrial and flood-prone areas. It can contribute to the management of various risk components including hazards, exposure and the capacity of an area to resist, cope with, adapt to and recover from disasters. For example, existing hazardous installations can be reallocated to reduce hazards in a particular area, and development in hazard-prone areas can be regulated to reduce exposure. In addition, spatial planning can facilitate obtaining the space required for the improvement of dikes, through which the resistance capacity of dike-ring areas can be increased. Spatial planners can also stimulate the capacity for disaster response by requiring the presence of evacuation or access routes within an area as a prerequisite for further urban development in hazard-prone areas.

In addition to the examples above, the adaptation of buildings (by flood proofing, for example) can improve the way an area is adapted to potential flooding. Furthermore, critical elements of infrastructure, such as power stations and drinking water facilities, can be located outside hazard-prone areas, thereby increasing the

capacity for recovery after a disaster. To consider both hazards and impacts in spatial planning and to make informed choices between alternative ways of development, spatial planners require information about these safety risks. A considerable part of this information can be regarded as geo-information. Therefore, both geo-information and Geo-ICT are essential for risk management in spatial planning.

Research approach

Many studies on the use of geo-information in spatial planning have geo-tools, technologies or information itself as the object of study. In this light, the limited use of geo-information and Geo-ICT is explored and explained from a system and information characteristics point of view. Within the present study, however, spatial planning practices themselves have been taken as the starting point.

It was assumed that the way spatial planners give meaning to safety risks in spatial planning practices significantly shapes actions and, consequently, the use of risk information in planning. For that reason, the way safety issues are addressed in spatial planning practices and the contributions that could be made by geo-information and Geo-ICT to support the consideration of safety risks in these practices were explored.

The epistemological position taken in this thesis is based on the assumption that realities cannot be discovered objectively, but that they are produced by human thoughts in culture. This approach is referred to as constructivism. This implies that knowledge about reality should be regarded as the result of the interplay between reality and the actors who perceive reality. The consideration of safety risks in planning practices was consistently analysed from an interpretative perspective. The research focussed on how spatial planners attributed meaning to risk in spatial planning practices, which provided a way of understanding how risks are dealt with in these practices. Moreover, it was assumed that the attributed meanings also shape the use of geo-information. For example, if spatial planners do not regard themselves as being responsible for reducing specific risks, it is unlikely that risk-reducing measures will be taken as a result of the information presented on risk maps, even though the risks can be considerable in terms of probabilities or potential consequences. Consistent with interpretative policy analysis methodology, human meaning and social realities were put at the core of the analysis.

Case studies were the main method for studying the way spatial planners attributed meaning to safety risks in spatial planning practices. They provided an in-depth and context-dependent understanding of the reasoning of spatial planners, and were focussed on the consideration of two different types of safety risks in the Netherlands: 1) external safety risks resulting from the production, use, storage and transport of hazardous materials and 2) flood risks from the sea and major rivers. These two risks represent prominent industrial and natural hazards in the Netherlands.

The contribution of geo-information and Geo-ICT to risk management and spatial planning was examined through case studies as well. These studies focussed both on informational requirements and on the use of Geo-ICT in spatial planning. The study on the development of Geo-ICT was based on actual practice. To increase understanding of the context and framework for risk management in the Netherlands, the development of risk maps in the Netherlands was compared with the development of risk maps in the UK. The examination of informational requirements was based on expected changes in flood risk management policies, in which attention for spatial planning and the capacity of an area to deal with floods is increasing. These studies focussed mainly on cases in the Netherlands.

In addition, informational requirements and Geo-ICT developments within emergency management practices were examined, because the cases on spatial planning showed that spatial planners were increasingly interested in emergency management concerns and that informational requirements of spatial planners overlapped with informational requirements of actors involved in emergency management. Moreover, ideas about emergency response and the related organisation of Geo-ICT to support emergency response were also relevant for spatial planning.

The data required for these case studies was collected through desktop studies and interviews. The desktop studies focussed on the policy documents of the selected spatial planning and risk and emergency management practices. The interviews with representatives of the authorities involved in the selected cases provided additional insight into informational requirements and into the reasoning involved in deciding to use or not use spatial planning for risk mitigation.

The consideration of safety risks in spatial planning

The exploration of the management of industrial risks showed that industrial hazards were addressed in planning practices and that the safety recommendations from the regional fire department played an important role in the consideration of these industrial hazards in planning. The safety recommendations stimulated dialogue between safety experts from the regional fire department and the municipality, which strengthened the cooperation between these two governmental bodies and the awareness of spatial planners for risk reduction measures. The communicative character of the safety recommendation process turned out to be an important strength, since it corresponded with the communicative character of spatial planning processes.

In addition, national safety regulations, such as the legally binding risk tolerance thresholds for individual risk *(plaatsgebonden risico)* and the procedures and non-binding thresholds for societal risks (*groepsrisico)* provided a coercive safety net if these communicative processes did not result in the consideration of industrial hazards or in the implementation of risk reduction measures.

Nevertheless, the safety recommendations tended to result in a relatively modest 'fine tuning' of spatial plans rather than more substantive changes. Moreover, the implementation of safety measures seldom led to an elimination of industrial risks, because the adopted measure focussed mainly on increasing the capacity of an area to deal with these risks. In addition, many risk reduction measures, such as risk communication or the presence of evacuation routes, could not be directly implemented through land allocation plans. These plans were regarded as regulatory instruments to prohibit specific land-use changes and not as instruments to implement additional safety measures. In the spatial planning process, however, risk reduction measures could be addressed and arrangements could be made for the implementation of these measures both within the land allocation plan itself and outside its scope. For that reason, the contribution of spatial planning to risk reduction should not be narrowed down to the land allocation plans for regulating land use in hazard-prone areas. The power of planning processes should be recognised in addition to the power of plans. Special attention, however, should be given to the actual implementation of measures that could not be implemented in the land allocation plan, since coordination of the implementation through other instruments is required.

With respect to the consideration of flood risks in spatial planning, the established practices can be characterised as planners focussing on the reduction of the probability of flooding rather than potential flood consequences. Land-use strategies to reduce damage potential were only minimally addressed. Within the dike-ring areas, some land-use development (such as residential development) was regulated to protect the existing dikes and to reserve space for facilitating dike reinforcements or river broadening in the future. For areas in the river forelands, which are not protected by dikes, changes in land use were also regulated by the local land allocation plans.

Most arguments for not using spatial planning to reduce flood consequences, as given by the respondents, directly or indirectly referred to other governmental policies. Floods were regarded as being reduced to an acceptable level through dikes and the legal criteria for dike strength, and therefore additional land-use measures were not needed. In addition, local spatial planners did not regard themselves as being responsible for considering additional flood risk measures. They argued that water managers, such as water boards, should indicate how to deal with flood risks at proposed building sites. However, the water boards did not address the need for additional measures, since they mainly focussed on the maintenance of dikes and the reinforcement of sections of weak dike.

In some of the cases studied, however, additional measures to reduce flood consequences were considered. To reduce damage potential, proposed residential areas were to be elevated or the number of houses decreased. Many respondents referred to previous experiences with flooding or threats of flooding as the argument for considering additional measures. Nevertheless, previous disaster experiences were not the only factor that explained the use or non-use of spatial planning to reduce the consequences of potential flooding.

On the whole, the use or non-use of spatial planning for the reduction of both industrial risks and flood risks could be understood to be a result of the commitment of the actors involved in spatial planning to the consideration and management of safety risks. In addition to previous disaster experiences, this commitment was influenced by government strategies, such as the availability of guidelines. Strict guidelines for the implementation of safety distances, for example, were an important reason for the consideration of safety risks in spatial planning, whereas the absence of guidelines for the consideration of safety risks in planning could result in limited attention for safety risks in local planning practices. The perceived responsibility of planners, however, was not always consistent with the formal responsibility. In some areas, additional measures for reducing flood risk were taken, even though these measures were not formally required.

Furthermore, the perceived trade-offs between other interests (such as economic growth), played an important role. Some planners did not take additional risk reduction measures or allowed urban development in hazard-prone areas because of economic benefits. In addition, capacities of local authorities played an important role. These capacities concerned not only the expertise of staff, which is required for dealing with safety risks, but also the availability of risk information or hazard-free land.

Another important factor, as derived from the planning and risk management literature, was public commitment to risk reduction measures. Even though this issue was hardly mentioned as a reason for using or not using spatial planning to reduce safety risks, our examination of ‘making space for water’ projects showed that public commitment was crucial for a successful implementation of measures. Based on these experiences, it was argued that spatial planning should not only be regarded as an instrument through which safety risks can be addressed. Spatial planning can also provide a valuable substantive perspective for the development of risk reduction measures. Conflicts that appeared during the implementation of measures were not only about the proposed measures for risk reduction, but also about other interests and ambitions, such as ambitions for agriculture or housing. Because a spatial planning perspective implies a substantive focus on the landscape as a whole and on the coherence of and between different land uses, it can offer an interesting approach for implementing safety measures and for integrating and balancing spatial claims for risk reduction with other conflicting spatial claims on an area.

However, it is important to recognise that the way that industrial and flood risks are being dealt with in spatial planning practices in the Netherlands is changing. More attention is being given to emergency response aspects such as the presence of evacuation routes. This could be recognised most explicitly in external safety policies, but was also apparent in flood risk management, especially at the national and regional levels. For that reason, a further integration of both emergency response and spatial planning is worth consideration.

The contribution of geo-information and Geo-ICT

In the Netherlands, risk maps have been developed to inform professionals involved in risk management about external safety risks. Authorities responsible for granting environmental license to operators of a given hazardous installation are obliged to forward all relevant information about the hazardous materials to a central database: the Installations Handling Dangerous Substances database (IHDS). Additional risk information is stored in the ISOR (*Informatie Systeem Overige Ramptypen*) database, such as information about vulnerable objects or information about other hazards such as flood hazards. This database is the result of the cooperation between the twelve Dutch provinces. Based on the information from both the IHDS database and the ISOR database, provincial risk maps have been realised on a GIS platform.

A comparison of the development of risk maps in the Netherlands and the UK showed that in both countries the GIS databases, which store the enormous amount of data regarding industrial risks, only recently came into being. A notable difference between the two countries concerns the possibility of public access to the risk maps. In the Netherlands, a notable amount of risk information is available to the public via the Internet. In the UK, this risk information is also public, but can only be accessed by the public after a specific request. The comparison confirmed the fact that different developments and applications of risks maps are grounded in the political, cultural and historical context in which they are created and that they can only be understood in their context.

Geo-information about safety risks, such as risk maps, has the potential to support spatial planning. Nevertheless, the information is only of added value if the actors involved in planning consider safety risks in general. As a result of the increased attention for safety risks in spatial planning, the need for safety risk information is increasing. The required information could be divided into hazards, exposure, and the resistance, adaptive, coping and recovery capacity of an area.

A comparison of information requirements of emergency responders at the fire department showed that informational requirements of spatial planners and emergency responders considerably overlapped, especially with respect to static and simulated risk information. Real-time information was mainly required for flood emergency management. Nevertheless, the real-time information obtained during flood emergency activities could also be used to improve simulated information in other flood management activities, such as flooding scenarios for spatial planning. Therefore, the future development of Geo-ICT should not only focus on the further development and application of specific systems for supporting only a limited number of activities with respect to risk management, but also on infrastructure and networks through which information from different applications can be exchanged, since informational requirements overlap. For this reason, it is important to think beyond one application for one type of activity or one group of users, since information for one disaster management activity or user can be useful for other activities and users as well.

Because differences in informational and system requirements still exist, the architecture should also allow room for differentiation in information supply and system requirements. The widely applied Service Oriented Architecture approach offers an interesting concept for such an information infrastructure. Within this concept, the required information for each actor is acquired through the composition of a relevant package of information services. These datasets and services can be acquired from a great variety of available user-specific systems. Through a selection of services, the user is not connected to all available databases for risk management, but only to a relevant selection. Furthermore, these services can be presented in different applications to meet specific user requirements and user interfaces and to enable the exchange of services from one application to another.

In addition to the Service Oriented Architecture approach, the organisation of geo-information and Geo-ICT within these networks should be based on principles of Network-Centric Risk and Emergency Management (NCREM). This concept offers a model to describe and understand risk and emergency management processes, as well as a vision for the future role and development of Geo-ICT to support these processes.

NCREM implies that actors involved in risk and emergency management have the capability to gather, produce and share information in a network-centric way. Information is distributed directly to those individuals and organisations for whom the information is relevant, instead of distributing the information step-by-step in a hierarchical way. This network-centric distribution of information should result in a common picture of both the available information about the present situation and the actions that are planned and taken. The immediate availability of this common operational picture should be a basis for a shared situational awareness of the safety risks, and subsequently, a basis for the collaboration and synchronisation of actions through which the impact (real or potential) of risks and emergencies are reduced. In this respect, the main contribution of Geo-ICT is to enable network-centric risk and emergency management.

Recommendations and suggestions for further research

Several factors were identified through which the commitment of spatial planners to the use of spatial planning for risk reduction could be understood. In addition, suggestions for promoting the commitment of spatial planners in the Netherlands to risk management could be derived from these factors. Guidelines from higher-tier governmental bodies in combination with cooperative strategies, such as the safety recommendations, turned out to be crucial for the use of spatial planning for risk reduction. Therefore, it is suggested that the consideration of flood risk in the Netherlands can be encouraged by guidelines from higher-tier governmental bodies in which they indicate areas in which explicit attention for flood risk is required. In addition, cooperation between planners and flood risk experts should be encouraged through an extension of the Water Assessment (WA). The WA has already been a successful instrument for bringing spatial planners and water managers together, but flood risks resulting from the failure of primary dikes are hardly considered in the WA. The inclusion of these risks in the WA is worth considering if flood risks are to be addressed more explicitly in spatial planning. As illustrated by the study on external safety (*externe veiligheid),* recommendations in the WA should not necessarily be limited to those measures that can be implemented in land allocation plans. In addition, other measures such as risk communication and the development of evacuation routes can be addressed. Monitoring the actual consideration and implementation of the suggested measures remains desirable, since the use of spatial planning for increasing the possibilities for emergency response in general, as well as the use of planning to reduce potential flood consequences in particular is, at least in the Netherlands, still in its infancy and the policies on both spatial planning and risk management are still changing.

Geo-information and Geo-ICT have the potential to support the consideration of safety risks, especially now that such risks are increasingly considered in spatial planning practices. Despite major efforts in the development of Spatial Information Infrastructures at the national level and in the development of risk maps on industrial risks, special attention is required for the implementation of such national initiatives to local and regional flood management practices, since local planning practices in which flood risk information is explicitly used are scarce. Moreover, the concept of network-centric risk and emergency response requires further attention. This could take place, for example, through additional studies that provide insight into the informational requirement within network-centric emergency management and response, or through more training or pilot programmes in which the principles of the NCREM can be worked out, evaluated and taught, since this concept is still at an intentional stage.

Samenvatting (Summary in Dutch)

Zowel ruimtelijke ordening als Geo-ICT worden gezien als belangrijke instrumenten voor risicomanagement. Het gebruik van deze instrumenten wordt echter als problematisch gezien. Ruimtelijke planning wordt, ondanks zijn potentieel als instrument voor risicobeheersing, beperkt toegepast voor het verminderen van veiligheidsrisico's. Het gebruik van Geo-ICT is eveneens verre van effectief vanwege de beperkte beschikbaarheid van geo-informatie, ongeschikte geo-tools of beperkte mogelijkheden voor informatie-uitwisseling. Dit proefschrift beschrijft hoe veiligheidsvraagstukken in ruimtelijke planningspraktijken in acht worden genomen en welke bijdrage geo-informatie en Geo-ICT kunnen leveren bij het ondersteunen van de inachtneming van veiligheidsrisico's in deze praktijken.

Het eerste doel van deze studie was om te begrijpen hoe veiligheidsrisico's worden meegenomen in ruimtelijke planningspraktijken en om te verkennen waarom ruimtelijke planning nu wel of niet wordt ingezet om veiligheidsrisico's vroegtijdig aan te pakken. Op basis van deze inzichten zijn aanbevelingen gegeven om de inachtneming van veiligheidsrisico's in de ruimtelijke planning te stimuleren. De verkregen inzichten zijn eveneens gebruikt als vertrekpunt voor het tweede doel van deze studie: het bespreken van de mogelijke bijdrage van Geo-ICT en het geven van suggesties en aanbevelingen voor de verdere ontwikkelingen en toepassing van geo-informatie en Geo-ICT ter ondersteuning van risicomanagement in de ruimtelijke planning.

Risico management, ruimtelijke planning en Geo-ICT

Ruimtelijke planning, met als doel het beïnvloeden van landgebruik, kan een belangrijke rol spelen bij het vergroten van de veiligheid van burgers in zowel industriële als overstromingsgevoelige gebieden. Er kan een bijdrage worden geleverd aan de beheersing van verscheidene risicocomponenten, waaronder de dreiging, blootstelling en de capaciteiten van een gebied om rampen te weerstaan of te bestrijden, zich aan te passen aan potentiële rampen of om te herstellen van een ramp. Bestaande gevaarlijke installaties kunnen bijvoorbeeld worden verplaatst om de dreiging in een specifiek gebied weg te nemen. Daarnaast kan bebouwing in gevaarlijke gebieden gereguleerd worden om de blootstelling te verkleinen. Bovendien kan ruimtelijke planning dijkverbetering faciliteren door de benodigde ruimte te reserveren, waardoor de weerstand van een dijkring kan worden vergroot. Ruimtelijke planners kunnen ook de capaciteit voor rampenbestrijding van een gebied vergroten door de aanwezigheid van toegangsof evacuatieroutes te vereisen als voorwaarde voor verdere verstedelijking in gevaarlijke gebieden.

Naast de voorbeelden hierboven, kan ook de aanpassing van gebouwen (bijvoorbeeld door het overstromingsbestendig maken van gebouwen) de mate van aanpassing van een gebied vergroten. Verder kan vitale infrastructuur, zoals elektriciteit- en drinkwatervoorzieningen buiten de gevaarlijke gebieden worden gesitueerd, waardoor de herstelcapaciteit na een ramp kan worden vergroot.

Om dergelijke gevaren en gevolgen mee te nemen in de ruimtelijke planning en om hierbij geïnformeerde keuzes te maken tussen alternatieve ontwikkelingsrichtingen hebben ruimtelijke planners informatie nodig over deze veiligheidsrisico's. Een aanzienlijk deel van deze informatie kan worden omschreven als geo-informatie. Daarom zijn zowel geo-informatie als Geo-ICT essentieel voor risicomanagement in de ruimtelijke planning.

Onderzoeksbenadering

Veel studies naar het gebruik van geo-informatie in de ruimtelijke planning hebben de geo-tools, technologieën of informatie zelf als object van onderzoek. In dit licht wordt het beperkte gebruik van geo-informatie en Geo-ICT verkend en verklaard vanuit de karakteristieken van de informatie of het informatiesysteem. In deze studie worden ruimtelijke planningspraktijken zelf echter als uitgangspunt genomen.

Hierbij wordt verondersteld dat de manier waarop ruimtelijke planners in ruimtelijke planningspraktijken betekenis geven aan veiligheidsrisico's voor een belangrijk deel hun acties beïnvloedt. De manier waarop zij betekenis geven aan veiligheidsrisico's beïnvloedt daarmee ook het gebruik van risico-informatie in de ruimtelijke planning. Om deze reden is verkend op welke manier veiligheidrisico's in acht worden genomen in ruimtelijke planningspraktijken en op welke manier geo-informatie en Geo-ICT een bijdrage kan leveren aan de inachtneming van veiligheidsrisico's in deze praktijken.

Het onderzoek is uitgevoerd vanuit de epistemologische veronderstelling dat de werkelijkheid niet objectief kan worden ontdekt, maar dat zij het cultuurgebonden product is van menselijk denken. Deze benadering staat bekend als constructivisme. Dit houdt in dat kennis over de werkelijkheid moet worden gezien als het resultaat van een interactie tussen de werkelijkheid en de actoren die deze werkelijkheid waarnemen. De inachtneming van veiligheidsrisico's is geanalyseerd vanuit dit perspectief. Het onderzoek richtte zich op de vraag hoe ruimtelijke planners betekenis toekennen aan risico's in ruimtelijke planningpraktijken. Hiermee kon de manier waarop met deze risico's wordt omgegaan worden begrepen. Bovendien is verondersteld dat de gegeven betekenis ook het gebruik van geo-informatie beïnvloedt. Wanneer ruimtelijke planners zich bijvoorbeeld niet verantwoordelijk achten voor het reduceren van bepaalde risico's is het onwaarschijnlijk dat risicoreducerende maatregelen worden genomen als gevolg van de informatie gepresenteerd op risicokaarten, zelfs wanneer de risico's aanzienlijk zijn in termen van waarschijnlijkheid of potentiële gevolgen. In lijn met de interpretatieve beleidsanalyse vormden menselijke betekenissen en sociale werkelijkheid dan ook de kern van de analyse.

De manier waarop ruimtelijke planners in de ruimtelijke planning betekenis geven aan veiligheidsrisico's is vooral bestudeerd door middel van casestudies. Deze studies verschaften een diepgaand en contextafhankelijk begrip van de redeneringen van ruimtelijke planners. De casestudies hebben zich gericht op de inachtneming van twee verschillende veiligheidsrisico's in Nederland 1) externe veiligheidsrisico's als gevolg van productie, gebruik, opslag en vervoer van gevaarlijke stoffen en 2) overstromingsrisico's vanuit de zee en grote rivieren. Deze twee risico's representeren namelijk prominente technologische en natuurlijke dreigingen in Nederland.

De bijdrage van geo-informatie en Geo-ICT aan risicomanagement en ruimtelijke planning is eveneens door middel van casestudies onderzocht. Deze studies richtten zich op zowel de informatiebehoeften en op het gebruik van Geo-ICT in ruimtelijke planning. Het onderzoek naar de ontwikkeling van Geo-ICT is gebaseerd op huidige praktijken. De ontwikkeling van risicokaarten in Nederland is hierin vergeleken met de ontwikkeling van risicokaarten in het Verenigd Koninkrijk. Achterliggend doel hierbij was om het Nederlandse kader en de Nederlandse context voor risicomanagement beter te begrijpen. Het onderzoek naar informatiebehoeften was gebaseerd op de te verwachten veranderingen in het beleid voor de beheersing van overstromingsrisico's. In dit beleid neemt de aandacht voor ruimtelijke planning en de capaciteit van een gebied om met overstromingsrisico's om te gaan toe . Deze studie heeft zich vooral gericht op cases in Nederland.

Daarnaast zijn ook de behoeften aan informatie en Geo-ICT in de rampenbestrijding onderzocht, omdat uit de cases over ruimtelijke planning naar voren kwam dat ruimtelijke planners in toenemende mate geïnteresseerd zijn in aspecten van rampenbestrijding. Hieruit kwam naar voren dat informatiebehoeften van ruimtelijke planners overlapten met informatiebehoeften van actoren betrokken bij de rampenbestrijding. Bovendien bleken ideeën over rampenbestrijding en de daaraan gerelateerde organisatie van Geo-ICT om de rampenbestrijding te ondersteunen relevant voor de ruimtelijke planning.

Het materiaal dat benodigd was voor de casestudies is verzameld door literatuurstudies en interviews. De literatuurstudies richtten zich op beleidsdocumenten van de geselecteerde praktijken van ruimtelijke planning, risicomanagement en rampenbestrijding. De interviews met vertegenwoordigers van de autoriteiten die betrokken waren bij de geselecteerde cases gaven aanvullende inzichten in de informatiebehoeften en in de argumenten met betrekking tot het wel of niet gebruikten van ruimtelijke planning voor het verminderen van veiligheidsrisico's.

De inachtneming van veiligheidsrisico's in ruimtelijke planning

Het onderzoek naar de beheersing van industriële risico's liet zien dat industriële dreigingen in de ruimtelijke planning in acht werden genomen en dat de veiligheidsadviezen van de regionale brandweer een belangrijke rol speelden bij de inachtneming van deze industriële dreigingen. De veiligheidsadviezen stimuleerden dialoog tussen veiligheidsexperts van de regionale brandweer en de gemeente, waardoor de samenwerking tussen deze twee overheidsorganen werd versterkt en het bewustzijn van ruimtelijke planners voor risicoreducerende maatregelen werd vergroot. Het communicatieve karakter van de veiligheidsadvisering bleek een sterk punt te zijn, omdat dit correspondeerde met het communicatieve karakter van ruimtelijke planningsprocessen.

Daarnaast boden ook nationale veiligheidseisen, zoals wettelijke normen voor het plaatsgebonden risico en de oriënterende waarden en procedures voor het groepsrisico's een dwingende stok achter de deur voor het geval dergelijke communicatieve processen niet resulteerden in de inachtneming van industriële risico's of de uitvoering van risicoreducerende maatregelen.

Desondanks resulteerden de veiligheidsadviezen vooral in kleine aanpassingen in ruimtelijke plannen in plaats van in meer substantiële veranderingen. Bovendien leidde de uitvoering van veiligheidsmaatregelen zelden tot het wegnemen van de industriële risico's. De genomen maatregelen waren vooral gericht op het vergroten van de capaciteiten om binnen een gebied met een ramp om te gaan. Daarbij konden ook veel risicoreducerende maatregelen, zoals risicocommunicatie of de aanwezigheid van vluchtroutes, niet direct via het bestemmingsplan geborgd worden. Bestemmingsplannen werden namelijk vooral gezien als regulerende instrumenten om specifieke vormen van landgebruik toe te laten en niet als instrumenten om aanvullende veiligheidsmaatregelen mee uit te voeren. Het ruimtelijke planningsproces biedt echter wel de mogelijkheid om risicoreducerende maatregelen ter discussie te stellen en biedt mogelijkheden om afspraken te maken over de uitvoering van deze maatregelen zowel binnen het bestemmingsplan als daarbuiten. Om deze reden dient de bijdrage van ruimtelijke planning aan de beheersing van veiligheidsrisico's dan ook niet te worden beperkt tot het bestemmingsplan voor de regulering van landgebruik in gevaarlijke gebieden. De kracht van het planningsproces dient eveneens te worden onderkend.

Bijzondere aandacht voor de daadwerkelijke uitvoering van maatregelen die niet kunnen worden verankerd in het bestemmingsplan is hierbij echter gewenst, omdat hierbij coördinatie tussen verschillende instrumenten vereist is.

De gevestigde praktijken met betrekking tot de inachtneming van overstromingsrisico's in de ruimtelijke planning zijn vooral gericht op het reduceren van de kans op overstroming in plaats van op het reduceren van de potentiële gevolgen. Landgebruikstrategieën om de potentiële schade te beperken werden slechts beperkt meegenomen. Binnen de dijkringgebieden werden sommige vormen van landgebruik, zoals woningbouw, gereguleerd om bestaande dijken te beschermen of om ruimte te reserveren voor toekomstige dijkversterkingen of rivierverbredingen. Voor de uiterwaarden, die niet zijn beschermd door dijken, werd het landgebruik eveneens gereguleerd door bestemmingsplannen.

De meeste argumenten van respondenten voor het niet gebruiken van ruimtelijke planning om de gevolgen van een overstroming te beheersen hadden betrekking op het beleid van andere overheden. De kans op overstromingen werd acceptabel gevonden, omdat het land al wordt beschermd door dijken, waarvan de sterkte aan wettelijke eisen moet voldoen. Om deze reden werden aanvullende maatregelen niet noodzakelijk geacht. Bovendien achtten lokale ruimtelijke planners zichzelf niet verantwoordelijk voor het meenemen van aanvullende maatregelen. Zij stelden dat waterbeheerders, zoals het waterschap, dienen aan te geven hoe bij bouwprojecten met overstromingsrisico´s moet worden omgegaan. Het waterschap stelde dergelijke maatregelen echter niet ter discussie. Zij richtte zich vooral op het dijkonderhoud en op het versterken van de zwakke schakels in de dijken.

In sommige bestudeerde cases werden echter wel aanvullende maatregelen overwogen om de mogelijke gevolgen van een overstroming te reduceren. Voorgestelde bouwlocaties werden bijvoorbeeld opgehoogd of het aantal te bouwen huizen werd verkleind. Veel van de geïnterviewden refereerden hierbij naar eerdere ervaringen met (dreigende) overstromingen als argument voor het overwegen van deze aanvullende maatregelen. Dergelijke eerdere ervaringen waren echter niet de enige factor waarmee de inzet van ruimtelijke planning voor de beheersing van overstromingsschade kon worden verklaard. In het algemeen kan de inzet van ruimtelijke planning voor de reductie van zowel industriële risico's als overstromingsrisico's worden gezien als het resultaat van het commitment van de betrokken actoren voor de inachtneming en beheersing van veiligheidsrisico's. Dit commitment werd, naast eerdere ervaringen met rampen, beïnvloed door strategieën van overheden, zoals de beschikbaarheid van richtlijnen. Strikte richtlijnen voor de overweging van veiligheidsrisico's in ruimtelijke planning waren bijvoorbeeld een belangrijke reden voor de inachtneming van deze risico's in de ruimtelijke planning, terwijl het ontbreken van deze regels kon resulteren in een beperkte aandacht voor veiligheidsrisico's. De gevoelde verantwoordelijkheid van ruimtelijke planners was echter niet altijd in overeenstemming met de formele verantwoordelijkheid. In sommige gebieden werden bijvoorbeeld aanvullende maatregelen genomen, terwijl dit niet formeel noodzakelijk was. Verder speelden ook andere belangen, zoals economische groei, een belangrijke rol. Sommige planners namen geen aanvullende risicoreducerende maatregelen of lieten stedelijke ontwikkelingen toe in gevaarlijke gebieden vanwege de economische baten. Daarnaast speelden ook de capaciteiten van lokale overheden een belangrijke rol. Deze capaciteiten hebben niet alleen betrekking op de noodzakelijke expertise van de medewerkers, maar ook op de beschikbaarheid van bijvoorbeeld risico-informatie of over minder gevaarlijke gronden.

Een andere belangrijke factor die uit de plannings- en risicomanagementliteratuur naar voren is gekomen is het publieke draagvlak voor risicoreducerende maatregelen. Hoewel dit punt in het onderzoek naar de omgang met overstromingsrisico's nauwelijks als reden is genoemd voor het wel of niet gebruiken van ruimtelijke planning voor risicobeheersing heeft het onderzoek naar 'ruimte voor water' projecten laten zien dat publiek draagvlak cruciaal is voor een succesvolle uitvoering van maatregelen. Op basis van deze ervaringen is dan ook gesteld dan ruimtelijke planning niet alleen moet worden gezien als een instrument waarmee veiligheidsrisico's ter discussie kunnen worden gesteld. Ruimtelijke planning kan ook dienen als een waardevolle inhoudelijk perspectief voor de ontwikkeling van risicoreducerende maatregelen. Conflicten die zich voordeden tijdens de uitvoering van maatregelen gingen immers niet alleen over de voorgestelde maatregelen voor risicobeheersing, maar ook over andere belangen en ambities, zoals ambities voor landbouw of woningbouw. Omdat ruimtelijke planning zich inhoudelijk richt op het landschap in zijn geheel en op de samenhang tussen verschillende vormen van landgebruik kan het een interessante benadering zijn voor de uitvoering van veiligheidsmaatregelen en voor het integreren en afwegen van ruimteclaims voor veiligheidsmaatregelen met andere conflicterende ruimteclaims op een gebied.

Het is echter van belang om te erkennen dat de manier waarop in de Nederlandse ruimtelijke planning met externe veiligheidsrisico's en overstromingsrisico's wordt omgegaan aan het veranderen is. Er wordt meer aandacht besteed aan de mogelijkheden voor rampenbestrijding, zoals de aanwezigheid van evacuatieroutes. Deze aandacht is het meest expliciet herkenbaar in het externe veiligheidsbeleid, maar was ook aanwezig in het beleid voor de beheersing van overstromingen en dan in het bijzonder op nationaal en regionaal niveau. Om deze reden is een verdere integratie van ruimtelijke planning en rampenbestrijding het overwegen waard.

De bijdrage van geo-informatie en Geo-ICT

In Nederland zijn risicokaarten ontwikkeld om professionals die betrokken zijn bij risicomanagement te informeren over externe veiligheidsrisico's. De autoriteiten die verantwoordelijk zijn voor het verlenen van de milieuvergunningen voor gevaarlijke installaties zijn verplicht om alle relevante informatie over de gevaarlijke stoffen door te geven aan een centrale database: het Register Risicosituaties Gevaarlijke Stoffen (RRGS). Aanvullende informatie wordt opgeslagen in het Informatie Systeem voor Overige Ramptypen (ISOR), zoals informatie over kwetsbare objecten of informatie over andere dreigingen zoals overstromingsdreiging. Deze database is het resultaat van de samenwerking tussen de twaalf Nederlandse provincies. Op basis van de informatie uit zowel het RRGS en het ISOR zijn via een GIS platform de provinciale risicokaarten tot stand gekomen.

Een vergelijking van de ontwikkeling van risicokaarten in Nederland en het Verenigd Koninkrijk heeft laten zien dan in beide landen dergelijke geografische databases, met een enorme hoeveelheid gegevens over industriële risico's, recent tot stand zijn gekomen. Een noemenswaardig verschil tussen de twee landen is de publieke toegang tot deze risicokaarten. In Nederland is een aanzienlijke hoeveelheid risico-informatie publiek toegankelijk via internet. In het Verenigd Koninkrijk is de risico-informatie eveneens publiek toegankelijk, maar alleen via speciaal verzoek. De vergelijking bevestigt hiermee dat verschillende ontwikkelingen en toepassingen van risicokaarten ingebed zijn in de politieke, culturele en historische contexten waarin zij zijn ontstaan en dat deze ontwikkelingen ook in deze context dienen te worden begrepen.

Geo-informatie over veiligheidsrisico's, zoals risicokaarten, kan ruimtelijke planning ondersteunen. Deze informatie is echter alleen van toegevoegde waarde wanneer de betrokkenen bij ruimtelijke planning veiligheidsrisico's in acht nemen. Als gevolg van de toegenomen aandacht voor veiligheid in ruimtelijke planning neemt de behoefte aan risico-informatie toe. De benodigde informatie kan worden onderverdeeld in informatie over de dreiging, blootstelling en over de capaciteiten van een gebied om een ramp te weerstaan, te bestrijden of om zich aan te passen aan deze dreiging of te herstellen van een mogelijke ramp.

Uit een vergelijking tussen de informatiebehoeften van ruimtelijke planners en rampenbestrijders bij de brandweer kwam naar voren dat informatiebehoeften van deze groepen aanzienlijk overlappen, vooral met bestrekking tot de statische en gesimuleerde risico-informatie. Real-time informatie was vooral vereist voor de bestrijding van overstromingen. De verkregen informatie tijdens een overstroming kan echter ook gebruikt worden om gesimuleerde informatie voor andere activiteiten te verbeteren, zoals overstromingsscenario's voor ruimtelijke planning. De verdere ontwikkeling van Geo-ICT dient zich dan ook niet alleen te richten op de verdere ontwikkeling en toepassing van specifieke systemen voor de ondersteuning van een beperkt aantal activiteiten met betrekking tot risicomanagement, maar ook op de infrastructuur en netwerken waarmee de informatie van de verschillende systemen kan worden uitgewisseld. Het is daarom belangrijk om verder te kijken dan specifieke toepassingen voor één type activiteit of een specifieke groep gebruikers, omdat informatie voor één gebruiker of activiteit van risicobeheersing ook nuttig kan zijn voor andere gebruikers en activiteiten.

Hoewel er een overlap is in informatiebehoeften, bestaan er tussen gebruikers ook nog steeds verschillen in informatiebehoeften en systeemeisen. De systeemarchitectuur dient daarom ook ruimte te bieden voor differentiatie van informatie en systemen. De breed toegepaste service gerichte architectuur biedt hiervoor een interessant concept. Binnen dit concept wordt voor elke gebruiker een specifieke bundel van diensten samengesteld, waarmee de gebruiker van de benodigde informatie wordt voorzien. De benodigde gegevenssets en bewerkingen kunnen worden verkregen uit verschillende, ook gebruikerspecifieke, systemen. Door middel van een selectie van services wordt de gebruiker niet gekoppeld aan alle beschikbare gegevenssets voor risicomanagement, maar alleen aan een relevante selectie. Daarnaast kunnen deze services worden weergegeven in verschillende toepassingen om daarmee te voldoen aan specifieke systeemeisen voor gebruik en interface en om de uitwisseling van diensten tussen de verschillende toepassingen mogelijk te maken.

Naast de service gerichte architectuurbenadering dient de organisatie van geo-informatie en Geo-ICT binnen deze netwerken gebaseerd te worden op de principes van Netcentrische Risicobeheersing en Rampenbestrijding (NCRR). Dit concept biedt een model waarmee risicobeheersings- en rampenbestrijdingsprocessen beschreven en begrepen kunnen worden. Daarnaast biedt dit concept een visie voor de toekomstige rol en ontwikkeling van Geo-ICT voor de ondersteuning van deze processen. NCRR houdt in dat de actoren die betrokken zijn bij risicobeheersing en rampenbestrijding de mogelijkheid hebben om informatie op een netcentrische manier te verzamelen, te produceren en te delen. Informatie wordt direct verspreid naar die individuen en gebruikers voor wie deze relevant is, in plaats van een hiërarchische, stapsgewijze verspreiding van informatie. Deze netcentrische verspreiding van informatie moet resulteren in een gemeenschappelijk beeld van zowel de beschikbare informatie over de huidige situatie als van de acties die worden gepland en ondernomen. De directe beschikbaarheid van dit gemeenschappelijke operationele beeld dient als basis voor een gedeeld bewustzijn van de huidige situatie en veiligheidsrisico's en kan vervolgens aan de basis staan van verdere samenwerking en synchronisatie van acties. Hierdoor kan de werkelijke of potentiële impact van een risico of ramp worden verkleind. In dit perspectief ligt de hoofdbijdrage van Geo-ICT in het mogelijk maken van netcentrische risicobeheersing en rampenbestrijding.

Aanbevelingen en suggesties voor verder onderzoek

Uit dit onderzoek zijn verschillende factoren naar voren gekomen waarmee het commitment van ruimtelijke planners voor het gebruik van ruimtelijke planning voor de beheersing van veiligheidsrisico's kan worden begrepen. Uit deze factoren kunnen ook suggesties ter bevordering van het commitment van Nederlandse ruimtelijke planners worden afgeleid. Richtlijnen van hogere overheden in combinatie met meer op samenwerking gerichte strategieën, zoals veiligheidsadviezen, bleken cruciaal te zijn voor het gebruik van ruimtelijke planning voor de reductie van veiligheidsrisico's. Daarom wordt gesteld dat de inachtneming van overstromingsrisico's in de ruimtelijke planning kan worden bevorderd door het stellen van richtlijnen door hogere overheden. In deze richtlijnen moet worden aangegeven in welke gebieden expliciet aandacht moet worden besteed aan overstromingrisico's. In aanvulling daarop moet de samenwerking tussen ruimtelijke planners en overstromingrisico-experts worden aangemoedigd door een uitbreiding van de watertoets. De watertoets is al een succesvol instrument om ruimtelijke planners en waterbeheerders samen te brengen. Overstromingsrisico's door het falen van primaire keringen worden echter nog nauwelijks meegenomen in de watertoets. Het meenemen van deze risico's in de watertoets is het overwegen waard wanneer overstromingsrisico's meer expliciet meegenomen dienen te worden in de ruimtelijke planning. Zoals ook is geïllustreerd door de studie naar externe veiligheid dienen de adviezen in de watertoets zich niet noodzakelijk te beperken tot maatregelen die direct in het bestemmingsplan kunnen worden opgenomen. Ook andere maatregelen, zoals risicocommunicatie en de ontwikkeling van evacuatieroutes kunnen met de watertoets ter discussie worden gesteld in het planproces. Het monitoren van de doorwerking en uitvoering van maatregelen blijft echter gewenst, omdat in Nederland het gebruik van ruimtelijke planning voor het vergoten van de mogelijkheden voor rampenbestrijding in het algemeen en voor het reduceren van de gevolgen van overstromingen in het bijzonder nog de kinderschoenen staat. Daarnaast is monitoren van belang omdat het ruimtelijke plannings- en risicobeheersingsbeleid verandert.

Geo-informatie en Geo-ICT hebben de potentie om de inachtneming van veiligheidsrisico's te ondersteunen, vooral nu dergelijke risico's in toenemende mate worden meegenomen in de ruimtelijke planning. Ondanks aanzienlijke inspanningen voor de ontwikkeling van Ruimtelijke Informatie Infrastructuren op nationaal niveau en de ontwikkeling van risicokaarten voor industriële risico's en overstromingsrisico's, is bijzondere aandacht voor de doorwerking van dergelijke nationale initiatieven op lokaal en regionaal niveau gewenst. Lokale voorbeelden waarin expliciet gebruik wordt gemaakt van overstromingsrisico-informatie zijn immers schaars. Bovendien verdient het concept van netcentrische risicobeheersing en rampenbestrijding verdere aandacht. Dit kan bijvoorbeeld worden uitgewerkt door middel van aanvullende studies waarin inzicht wordt verkregen in de informatiebehoeften binnen NCRR of door middel van aanvullende trainingen of proefprojecten waarin de principes van NCRR kunnen worden uitgewerkt, geëvalueerd en onderwezen, omdat het concept zich nog in een beginstadium bevindt.

Completed Training and Supervision Plan

Annex to statement

Name J.M.M. Neuvel

PhD student, Mansholt Graduate School of Social Sciences (MG3S)

Description	Institute / Department	Year	ECTS*
Courses:			
Mansholt Introduction Course	Mansholt Graduate School of Social Sciences (MG3S)	2005	1
Qualitative Research Methods	MG3S	2006	3
Scientific Writing	Wageningen Graduate Schools (WGS)	2007	2
Presentation Skills	WGS	2007	2
PhD Competence Assessment	WGS	2007	0.3
Natural Hazards and Disasters	RDS 90406	2007	6
Spatial Modelling	GRS 30306	2008	6
Deliberative Policy Analysis	University of Amsterdam (UvA)	2007	5
Comparative Planning Systems and Open Space Preservation	MG3S	2005	3
Various Teaching and Supervising Activities (Lecturing, Academic Master Cluster, MSc thesis supervision)	Land Use Planning Group (LUP)	2005-2007	4
Presentations at conferences and workshops:			**4.5**
Mansholt Multidisciplinary Seminar		2008	1
AESOP PhD Workshop 2006, Bristol		2006	2.5
11th AESOP Conference, Naples		2007	1
Total (minimum 30 ECTS)			**36.8**

*One ECTS on average is equivalent to 28 hours of course work

Curriculum Vitae

Johannes Martinus Maria (Jeroen) Neuvel was born on 5 July 1981 in Alkmaar, the Netherlands. After graduating from the Bonhoeffer College in Castricum (the Netherlands), he studied Land-use Planning at Wageningen University and received his MSc with honours in 2004. After his graduation, he was employed as a junior researcher at the VU University of Amsterdam and the Netherlands Environmental Agency. From 2005 until 2009, he was employed at the Land-use Planning Group at Wageningen University as a researcher. He was engaged in several projects in the Dutch ‘Space for geo-information’ programme on Geo-ICT and risk and emergency management. Since August 2009, he has worked as a teacher and researcher in Spatial Planning and Safety Risks at the Saxion University of Applied Sciences in Enschede and Deventer (the Netherlands). His main research interests include spatial planning, risk management and Geo-ICT.

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Cover: Mariëlle Neuvel