Knowledge in plan-making processes on flood hazard maps

A research on the influence of types and utilization of knowledge on the depiction of flood risk areas on flood hazard maps in the Zweckverband Großraum Braunschweig

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'Die Zukunft ist nicht planbar, aber wir sollten Sie gestalten'

Dezernat für Ökologie und Planung, Hannover (2010)

Preface

You are about to read my bachelor thesis on the role of knowledge in plan-making processes on flood hazard maps in the Zweckverband Großraum Braunschweig, as a result of the one year bachelor Spatial Planning at the Radboud University Nijmegen.

Now that this bachelor thesis is finished, I would like to thank my supervisors. I was able to do this research as an Erasmus exchange student at the Leibniz University Hannover. During the three months of doing research, my supervisors, Drs. H.W.H.A. Donkers, Prof. Dr. S. Dühr, Dr. M.A. Wiering (Nijmegen) and Dr. F. Scholles (Hannover), helped me whenever needed. Because of my personal interest in flood risks and their spatial impact, I was advised by Dr. Scholles to use the development process of flood hazard maps in the Zweckverband Großraum Braunschweig. This regional spatial planning institute just had developed new spatial maps for their spatial planning region. The information on the case was given me by Mr. A. Menzell, regional planner at the Zweckverband Großraum Braunschweig, who I would like to thank for that.

Due to illness I could not finish this thesis within the time scheduled, what made me to decide to start working at Hoogheemraadschap De Stichtse Rijnlanden, a Dutch waterboard. After two years of working I decided to finish this thesis so I can do my masters in the period 2013-2014. So here it is!

Especially I would like to thank my parents and friends, for supporting me during this period and for giving me helpful feedback on the structure of the thesis.

Enjoy reading!

Frank Wildschut

Nijmegen, 27 August 2013

Abstract

The central question in this research is as follows:

> *What was the influence of different types and uses of knowledge on the depiction of flood risk areas on flood hazard maps during the regional spatial plan-making process in the Zweckverband Großraum Braunschweig?*

To answer this question, the plan-making process on the depiction of flood risk areas on flood hazard maps in the Zweckverband Großraum Braunschweig is explored in practice and used as case. Therefore the following knowledge types, uses and influences are explored in this research:

Knowledge types	Scientific knowledge
	Local knowledge
Uses of knowledge	Instrumental
	Symbolic
	Conceptual
Influence of knowledge	Clear influence
	Partial influence
	Underpinning
	No influence

Source: compiled by the author based on Healy 2008; Failing, Gregory & Harstone 2007; Amara, Ouimet & Landry 2004; ZGB 2007

It seems that the types of knowledge differ in content by the one who uses it. Scientific knowledge is attributed to experts and local knowledge to locals. The use of knowledge differs in the reason why they are used. When knowledge is used instrumentally, it is used for direct action or influence on decisions (Amara et al., 2004, p. 90); symbolic use of knowledge is knowledge being used to underpin predefined decisions (Beyer, 1997, p. 17 in Amara et al., 2004, p. 77). When knowledge is used conceptually it is used for general enlightenment without clearly influencing decisions (Beyer, 1997, p. 17 in Amara et al., Amara et al., 2004, p. 77; Lavis et al., 2003, p. 228). The influence of knowledge is received from a categorization on the basis of an in-depth literature analysis of the Regionales Raumordnungsprogramm 2008 of the Zweckverband Großraum Braunschweig in which this categorization is used to classify the influence of opinions on concept flood hazard maps.

In scientific literature on flood risk management, the depiction of flood risk areas on flood hazard maps is mainly, but not only, based on scientific knowledge (Brown & Damery, 2002, p. 423). This scientific knowledge thus mostly directly influences the designation of flood risk areas. To explore this in practice, the following hypotheses are used in this research:

1. *Both scientific as well as local knowledge are used to influence the depiction of flood risk areas on flood hazard maps;*
2. *Knowledge is used instrumentally, symbolically and conceptually to influence the depiction of flood risk areas on flood hazard maps;*
3. *Scientific knowledge, when used instrumentally, has the greatest influence on the depiction of flood risk areas on flood hazard maps.*

Legislation on flood risk management like the Floods Directive requires to depict flood risk areas on flood hazard maps based on the HQ100, a statistical model (scientific knowledge). This model is used in the Zweckverband Großraum Braunschweig to show the distribution of the water depth within a flooded area based on a hypothetical flood event happening every 100 years, on concept flood hazard maps. Which are developed in collaboration with governmental water management institutions; and distinguish two types of flood risk areas: priority and reserve flood risk areas.

Besides the use of the HQ100, it is also required in legislation to actively involve the general public in the plan-making process (Council, 2007, art. 9), which makes it possible to influence the designation of flood risk areas by both scientific and local knowledge. These opinions contain several values of both knowledge types, which have been used in different ways and influence the designation of flood risk areas differently. Scientific knowledge is used by experts, local knowledge by inhabitants. By analysis of these opinions the influence of the different types and uses of knowledge is explored.

The first hypothesis states that both scientific as well as local knowledge are used to influence the depiction of flood risk areas on flood hazard maps. It may be concluded that indeed both are used; nevertheless scientific knowledge is mostly used: 201 out of 221 opinions were underpinned by scientific knowledge. These consist largely about expert opinions. Only 20 opinions were underpinned by local knowledge and consisted story-tellings about experiences.

In the second hypothesis is stated that knowledge is used instrumentally, symbolically and conceptually to influence the depiction of flood risk areas on flood hazard maps. The results endorse this, although knowledge is mainly used instrumentally, thus to have direct influence. Knowledge is used instrumentally in 189 out of 221 opinions. Only 15 times knowledge is used symbolically and 17 times conceptually.

In the third hypothesis is pointed out that scientific knowledge has, when used instrumentally, the greatest influence on the depiction of flood risk areas on flood hazard maps. The results of this research confirm this hypothesis. 29 opinions, based on scientific knowledge, clearly had influence; none of the opinions based on local knowledge did. Only when used instrumental knowledge had partial influence (10 scientific and 2 local). Knowledge in 48 opinions (43 scientific and 5 local) underpinned decisions. These were used both instrumentally (15 scientific and 4 local), symbolically (14 scientific and 1 local) as well as conceptual (14 scientific). The vast majority of opinions, 132 out of 221 opinions, had no influence at all; comprising a large amount expert opinions (77 opinions).

To give an answer on the research question the research question is repeated below:

> *What was the influence of different types and uses of knowledge on the depiction of flood risk areas on flood hazard maps during the regional spatial plan-making process in the Zweckverband Großraum Braunschweig?*

It was shown in this research that the depiction of flood risk areas on flood hazard maps during the regional spatial plan-making process in the Zweckverband Großraum Braunschweig was mainly based on scientific knowledge, being used instrumentally. These outcomes were in line with the hypotheses. The influence of local knowledge is limited. Both during the development of the concept flood hazard maps as well as during the development of the definitive flood hazard maps, statistical models and requirements in legislation influenced the designation of priority and reserve flood risk areas most. It can be concluded that only opinions underpinned with knowledge which is testable and verifiable can influence the designation of flood risk areas on flood hazard maps.

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Lists of abbreviations, figures and tables

List of abbreviations

Abbreviation	Explanation
EU	European Union
FBC	Federal Building Code (Baugesetzbuch 2004)
FCA	Flood Control Act (Gesetzes zur Verbesserung des vorbeugenden Hochwasserschutzes 2004)
FD	Directive 2007/60/EC on The assessment and management of flood risks (EU Floods Directive)
FRPA	Federal Regional Planning Act (Raumordnungsgesetz) 2009
FWRA	Federal Water Resources Act (Wasserhaushaltsgesetz) 2007
HR	Hannover Region
HQ100	Distribution of the water depth within the flooded area based on a hypothetical flood event happening every 100 years
LROP	Landes Raumordnungsprogramm Niedersachsen 2002
ML	Niedersächsisches Ministerium für den ländlichen Raum, Ernährung, Landwirtschaft und Verbraucherschutz
MS	European Member State (s)
NR	Niedersächsischen Raumordnungsgesetz 2009
NW	Niedersächsischen Wassergesetz 2002
RROP	Regionales Raumordnungsprogramm 2008
RROP A	Abwägungsunterlage Regionales Raumordnungsprogramm Braunschweig 2007
RROP B	Begründung Regionales Raumordnungsprogramm Braunschweig 2008
RROP BD	Beschreibende Darstellung Regionales Raumordnungsprogramm Braunschweig 2008
ZGB	Zweckverband Großraum Braunschweig

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1. Introduction

1.1 The role of knowledge in developing flood hazard maps

Floods are natural phenomena that can have a widespread spatial impact. Nowadays, due to the intensive use of flood prone areas for settlements and industries, the damage potential increases. One way to decrease the flood risk is by spatial planning. As White and Richard (2007, p. 513; in Porter & Demerrit, 2012, p. 2) advocate:

> *‘planning is the most sustainable method to manage flood risk in that not only can it provide for risk management, it can also avoid or even reduce risk (by) influenc(ing) factors such as the location, type, design, and function, of development’*.

In spatial flood risk management, the use of flood hazard maps as a cartographic representation of the territory is commonly used. In Germany, on these maps priority and reserve flood risk areas are depicted. The designation of these areas is underpinned by knowledge. Scientific research in respect to flood risk management focuses on the use of flood hazard maps and the types and uses of knowledge. Nevertheless, a gap in this research exists on the influence of different forms and uses in the designation of flood risk areas on flood hazard maps during regional spatial plan-making processes. In this research is, based on a case study, the influence of the different types and uses of knowledge is explored in practice. In order to do this, the plan-making process on the development of flood hazard maps in the Zweckverband Großraum Braunschweig is studied. This region finished it flood hazard maps in 2008 (see figure 1). This case study can provide the Hannover Region valuable information about the role of knowledge that can be integrated in their new flood hazard maps, which are planned to be finished by the end of 2013.

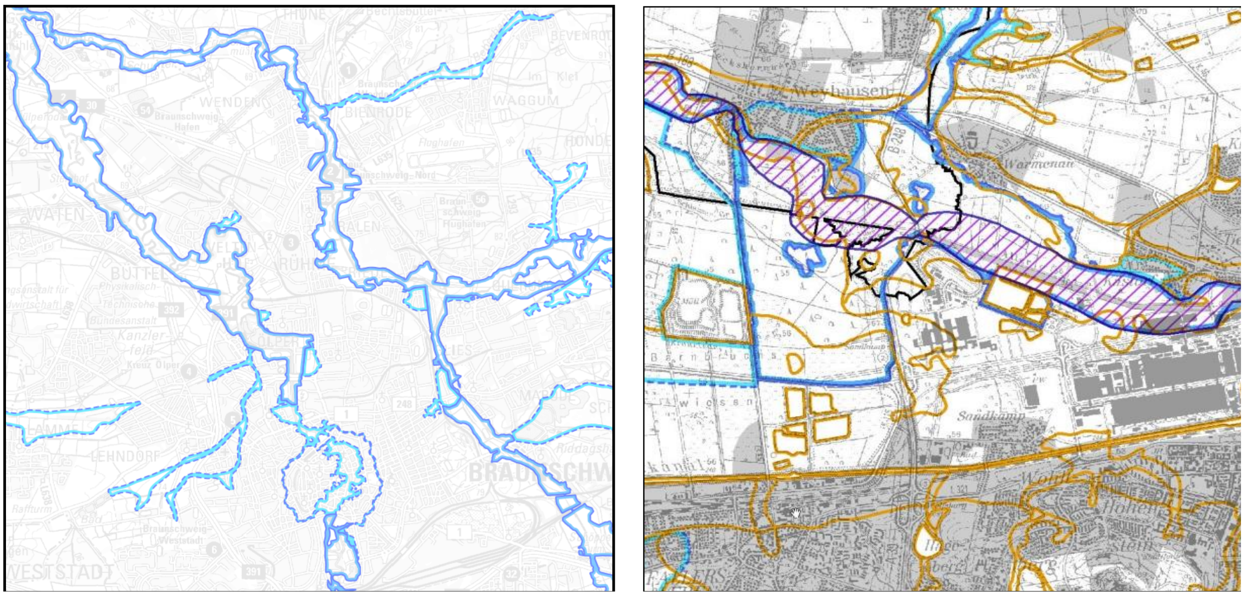

Figure 1: Flood hazard maps Braunschweig city center and Wolfsburg
Source: ZGB, 2008

1.2 Research problem

As part of the plan-making process, knowledge plays an important role to base decisions on. During the plan-making process on the depiction of flood risk areas on flood hazard maps, the use of knowledge by different participants can conflict. In spatial plan-making processes several types (Giorgi and Tandon (2002; in Gudmundsson 2011, p. 152), uses (Lavis, Robertson, Woodside, McLeod, Abelson, 2003; Amara, Ouimet & Landry, 2004) and influences (ZGB, 2007) of knowledge can be distinguished.

Due to the changing role of knowledge in spatial planning, the Hannover Region, a German spatial planning institution, would like to know the influence of the different types and uses of knowledge during plan-making process on the development of flood hazard maps.

Knowing this, the following research problem is distinguished:

> It is not clear what the influence of different types and uses of knowledge is during the plan-making process on the development of flood hazard maps.

By exploring this research problem new knowledge is attributed to the discussion on knowledge in spatial plan-making processes and it can help the Hannover Region in the integration of knowledge in the plan-making processes on the development of flood hazard maps.

1.3 Research goal

In this research two goals can be extracted, an internal and an external goal. An internal goal is 'the knowledge that the research will produce, no less but also no more' (Verschuren & Doorewaard 2007, p. 16). In this research the internal goal is:

> To identify the types, uses of knowledge and their influence in the developing of flood hazard maps by the Zweckverband Groβraum Braunschweig.

This means, that by applying the results of this research, the HR should be in a better position to respond to different types and uses of knowledge so they can all influence the plan-making process on the development of flood hazard maps.

About the external goal, Verschuren en Doorewaard (2007, p. 16) state that an external goal is 'to contribute to something outside the research'. Thus: 'the use of the knowledge produced by this research, not the knowledge itself'. In this research the external goal is:

> To contribute new information about the use of several types and uses of knowledge in plan-making processes on the development of flood hazard maps, to the scientific debate on knowledge and to the HR.

1.4 Research questions

In order to answer the research goals, the following research question is used to explore the types, uses and influence of knowledge in the plan-making process on the development of flood hazard maps in the Zweckverband Großraum Braunschweig:

What was the influence of different types and uses of knowledge on the depiction of flood risk areas on flood hazard maps during the regional spatial plan-making process in the Zweckverband Großraum Braunschweig?

1.4.1 Research sub-questions

Due to the complexity of the research question, the following research sub-questions will be used to answer the different aspects of the research question:

1. Which types of knowledge can influence decisions in plan-making processes on the development of flood hazard maps?
2. How can knowledge be used in plan-making processes on the development of flood hazard maps?
3. What kind of influence can different types and uses of knowledge have in plan-making processes on the development of flood hazard maps?
4. What new knowledge about the influence of different types and utilization in plan-making processes on the development of flood hazard maps learned in the Zweckverband Großraum Braunschweig, can be contributed to the scientific debate and to the HR?

1.5 Research definition

This research focuses on one important subject that influenced the development of flood hazard maps: knowledge in the plan-making process of flood hazard maps in the ZGB. The focus in this research lies on the types, uses and the influence of knowledge in plan-making processes by the development of flood hazard maps. In this paragraph the research is further defined, thus explaining what the precise scope of this research is.

Besides knowledge another related variable is often found in literature on spatial planning: information. Information is 'data arrayed to make a difference as to whether a decision is made and what shape it takes' (Knott & Wildavsky, 1980, p. 548). This variable is not explored in this research because 'knowledge specifies the relationship between variables and consequences' (Knott & Wildavsky, 1980, p. 548). This makes it possible to show the consequences of the different types and uses of knowledge in the flood hazard maps and not only focuses on the data. This implies that this makes it possible to explore the relation between the types, uses and influence of knowledge in plan-making processes on the development of flood hazard maps.

In order to show the types and uses of knowledge in plan-making processes on the development of flood hazard maps, a specific case has been chosen. In 2007 (and finished in 2008) the ZGB, being one of the first regional planning authorities in Germany, developed flood hazard maps which were influenced by the FD and were developed in collaboration with several actors. This makes this region a perfect case for this research.

By focussing on the development of flood hazard maps in the ZGB, the focus in this thesis will be on floods from rivers because this is an inland region. Floods are natural phenomena which cannot fully be prevented. However, 'some human activities, such as increasing human settlements and economic assets in floodplains and the reduction of the natural water retention by land-use contribute to an increase in the likelihood adverse impacts of flood events' (Council, 2007, p. 27). Following the definition as set by the EU, floods are defined as:

> *'the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems' (Council, 2007).*

To define what is needed to prevent floods as much as possible the term 'flood hazard' as defined by the Merz, Thieken & Gocht (2007, p. 235) will be used:

> *'(…) the exceedance probability of potentially damaging flood situations in a given area and within a specified period of time.'*

1.6 Social and scientific relevance

This paragraph describes the social and scientific relevance. In this research, the main scientific relevance is to contribute to the discussion on the types and uses of knowledge in the theoretical spatial planning debate.

In spatial planning, previously performed research has produced knowledge on the types, uses and the influence of knowledge, for example in transport planning (Radaelli, 1995; Lavis et al., 2003; Gudmundsson, 2011). This kind of research on the types, uses and influence of knowledge has also been performed in respect to flood risk management (Enserink, Kamps & Mostert, 2003; Hutter, 2007). The literature research on a combination of these three variables did not reveal studies done before. As far as can be concluded out of the literature research, the application of the ideas on knowledge in the research on a German planning region is also new.

Therefore this research applies new knowledge to the theoretical discussion on the types, uses and influence of knowledge in spatial planning processes. Especially the focus on knowledge in a regional plan-making process is unique. This makes this research useful for regional spatial planners, since the influence of knowledge inserted by actors in the plan-making process on the development of regional flood hazard maps is explored. Using this knowledge gives other regional spatial planning institutes the possibility to integrate knowledge in plan-making processes.

The exploration of the different types, uses and influence of knowledge in the plan-making process of flood hazard maps has a significant social relevance. For all European citizens and especially for inhabitants of the HR and ZGB this research is relevant, having in mind the 2002, 2003 and recent floods in central Europe. During the major floods in 2002 and 2003 the HR and the ZGB suffered by floods from the Weser, Aller and Leine. In line with the paradigm change in flood risk management, the influence of spatial planning in flood risk management also increased. Due to long-term planning, inhabitants will be better protected against floods. To prevent conflicts of spatial uses, it is in their interest to develop maps were all spatial functions are displayed. These maps can then be used for discussion; to make the plan-making process a collaborative process, wherein their knowledge is used. This makes it possible to be sure that all spatial functions are designated, based on knowledge submitted by all interacted actors.

1.7 Research model

Verschuren & Doorewaard (2007, p. 17) describe a research model as a schematic view of the research goal and the steps that have to been taken to reach this goal. The model shows the interdependency of the various steps taken to explore a subject. Besides this, a research model is of interest in determining the theoretical backgrounds (concepts, conceptual model) of the research. Thus the goal of this model is to show the exploration of the plan-making process of flood hazard maps in the ZGB, in order to research the types, uses and influence of knowledge during this process.

The first part of the research consists of building a theoretical framework, based on literature on the types, uses and influence of knowledge in spatial plan-making processes. Hereby is zoomed on spatial plan-making processes on the development of flood risk management plans (A). In addition, these theories are used as a central concept for the creation of a framework (B) to investigate a spatial plan-making process in practice. Analysis of the plan-making processes is done by exploration of a case on the plan-making process on the development of flood hazard maps (C). Then, the empirical evidence is tested to the theories (D), after which an answer to the research question is given and lessons and recommendations will be formulated to reach the purpose of this study (E).

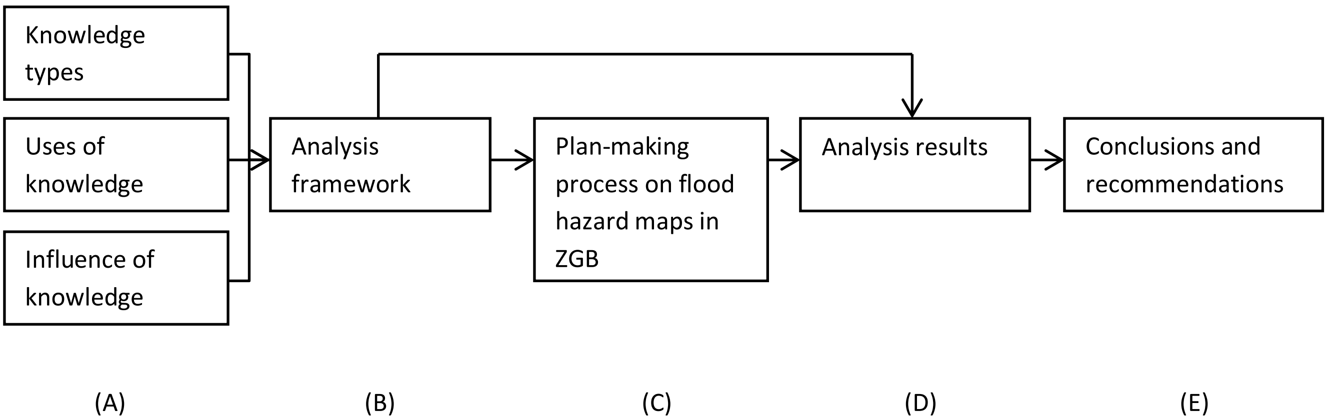

Figure 2: Research model
Source: authors' own

2. Theoretical framework of knowledge

2.1 Introduction

In this chapter a theoretical answer is given on the following research sub-questions:

1. Which types of knowledge can influence decisions in plan-making processes on the development of flood hazard maps?
2. How can knowledge be used in plan-making processes on the development of flood hazard maps?
3. What influence can different types and uses of knowledge have in plan-making processes on the development of flood hazard maps?

The following paragraphs substantiate which aspects of knowledge are explored and which are not, in respect to spatial planning and flood risk management. These are chosen to achieve the intern research goal:

> To identify the types, uses of knowledge and their influence in the developing of flood hazard maps by the Zweckverband Groβraum Braunschweig.

The theoretical framework provides a basis to collect and analyse empirical data in order to answer the research questions. Due to many previous researches on spatial planning practices and methods, theories have been elaborated to explore spatial planning processes and factors that can influence these. These theories can also be applied on the topic of plan-making processes on flood hazard maps. Using a theory makes it possible to make these processes and factors measurable. And when variables are measurable, it is also possible to operationalize them by giving them measurable indicators (see paragraph 3.2).

The theories on knowledge will be used as a framework for the exploration of the empirical data further on in this research. Based on literature analysis, the causal relation between the variables is shown in the conceptual model (figure 3). The information on knowledge provided in this chapter is also used to define hypotheses in this chapter. These hypotheses are in chapter 4 and 5 explored in practice.

2.1.1 Flood risk management: a spatial planning approach

The traditional way of managing floods based on water control by measures like dykes, dams and reservoirs has shifted to holistic approaches to manage the flood risk (Schanze, 2002, DKKV 2003 & Hall et al., 2003, in Hutter, 2006, p. 229) 'within a European perspective on integrated governance and water basin management' (Bresser & Kuks, 2004; in Hutter, 2006, p. 234). This approach to flood risk management underlines the importance of considering policy instruments for flood risk management (Hutter, 2006).

Another changing paradigm in spatial planning is the increasing role of local interest groups in plan-making processes. Whereas traditionally flood risk management was an expert's task based on technical measures, the shift towards management of the catchment area, including for example flood plains, asked for more local knowledge. This change advocated in literature on flood risk management (Brown & Damery, 2002, p. 423; Hooijer, Klijn, Bas, Pedroli, van Os, 2004, p.348; Hutter, 2007, p. 277).

2.1.2 Maps and spatial plan-making processes

Spatial planning, as stated by Faludi (1996, p. 95), is about ‘disposition in space of buildings, infrastructure, and activities, and space is best depicted in diagrammatic forms’. In spatial planning processes ‘cartographic visualisations can help to shape attention for relevant spatial issues, to communicate messages and to stimulate action at lower tiers of government’ (Dühr, 2003, p. 931); and these cartographic visualisations are in spatial planning, important visualisation techniques (Dühr, Colomb & Nadin, 2010, p. 57).

One of these cartographic visualisations are maps, in which the territory and all proposed dispositions can be conceptualised and being placed within their spatial context (Faludi, 1996, p. 96). Maps can be used to resemble the representation of development plans, during a planning process and to communicate decisions to all involved actors. A map does not need to be detailed or a result of a plan binding (Faludi, 1996, p. 96). Both policies and plans can be visualised on maps. Maps can be used to support verbal statements or directly express policies in this (Faludi, 1996, p. 93).

2.1.3 Flood maps

In risk-based decision making, like flood risk management, one of the most important cornerstones is to inform people at risk and responsible authorities and institutions. The results of the risk analysis, depicted spatially, can be communicated through maps showing a cartographic representation of the current or future territory. In respect to flood risk management, ‘maps are indispensable tools to show information about hazards, vulnerabilities and risks in a particular area’ (EXIMAP, 2007, p. 5) and ‘maps give a more direct and stronger impression of the spatial distribution of the flood risk than other forms of presentation’ (Merz, Thieken & Gocht, 2007, p. 231).

Flood maps can be used for several purposes like raising awareness among people at risk and decision makers; providing information for land-use planning and urban development or to land-use regulations, building codes and insurance (EXIMAP, 2007, p. 7). By governments, flood maps are used in spatial planning to serve an advisory purpose or where there is a binding legislation to use flood hazard or risk information (de Moel, van Alphen & Aerts, 2009, p. 231).

2.1.4 Flood hazard maps

Flood maps show the effects of flooding and are represented on two types of maps: flood hazard maps and flood risk maps. Flood risk maps show the potential adverse consequences associated with floods under those scenarios (EXIMAP, 2007, p. 9). The purpose of flood risk maps is: ‘the geographical identification and illustration of areas at different level of risk from flood hazard. In respect to this flood hazard maps need to be designed to meet the end-user needs. ‘This is important in order to convey the complex messages about flooding and flood risk’ (EXIMAP, 2007, p. 9).

In this research is focussed on flood hazard maps because these are mostly linked to spatial plan-making processes: 'flood hazard maps point out areas at risk and necessary for planning' (ASFPM, 2007; in EXIMAP, 2007, p. 6). Flood hazard maps represent the weak points of the flood defence system or indicate a need for action (Plate, 2002, p. 3), showing the different hazard levels (ASFPM, 2007; in EXIMAP, 2007, p. 6). Or as stated by Merz, Thieken & Gocht (2007, p. 239):

> 'A flood hazard map illustrates the flood hazard, i.e. the intensity of flood situations and their associated exceedance probability. Usually flood hazard maps show synthetic events. The most simple example is the inundation area for a scenario with a certain return period. Often, flood intensity is given by the spatial distribution of the water depth.'

Despite of the fact that flood hazard maps should inform about the possible consequences of floods on the society, buildings and natural environment they mostly focus only on hazard aspects (Merz, Thieken & Gocht, 2007, p. 247).

2.2 Definition of knowledge

In this research, knowledge is seen as being conceived of or as derived from objective measurements, verifiable and tested, using distinctive techniques in its generation and based in common sense (Lindblom & Cohen, 1979; in Petts & Brooks, 2006, p. 1046). As mentioned before, this research focuses on the concept of knowledge because:

> *'Knowledge specifies the relationship between variables and consequences; information relates between variables to effects but the relationship remains hypothetical, untested by the results of actual decision* (Knott & Wildavsky, 1980, p. 548).

This implies that knowledge also makes it possible to show the relationship between the influence of different types and uses that they have had in plan-making processes on the development of flood hazard maps. This also implies that decision-makers can use knowledge to make choices and to implement decisions (Radaelli, 1995, p. 162). And other institutions and actors like governments, spatial planning institutions, research institutions, companies, interest groups and inhabitants can use knowledge to underpin their opinion or to show their view on a particular subject.

To research knowledge (in models as a type of knowledge technologies), Gudmundsson (2011, p. 146) defines three elements of which two will partially shape the structure of this research: '(1) *identification* of the use of knowledge (what is used?); (2) *evaluation* of the use of knowledge (how is it used); and (3) *explanation* of use of knowledge (why is it used?)'. The first two elements are used in this research to show what types and uses of knowledge are used by parties during plan-making involved in the plan-making process on the development of flood hazard maps. If also the third element, why is knowledge used, would be researched, the focus would be more on power and interactions between different actors in the plan-making process. Therefore this element is not further explored in this research.

To show the influence of the types and uses of knowledge and to show the relation between these two variables a fourth element is adjusted: (4) the *result* of use of knowledge (what was the influence?). Because 'knowledge' is a rather vague term, the following paragraphs will state the definition of knowledge as used in this research.

2.3 Types of knowledge

The first step as described by Gudmundsson (2011, p. 147) is to identify which knowledge is used. This depends on the users of it and on the context in which it is used. In this paragraph, a selective critical literature review on the knowledge types is given.

In scientific literature, two types of knowledge are distinguished: ‘expert knowledge’ and ‘local knowledge’. It is difficult to define a strict line between expert and local knowledge, although Failing, Gregory & Harstone (2007, p. 49) distinguish expert knowledge as ‘fact-based claims’ and local knowledge as ‘value-laden claims’, they

> *‘(…) use the term ‘fact-based claim’ to refer to descriptive claims about the way the world is or might be (given uncertainty). These claims describe conditions, explain relationships or predict consequences. They could be stated probabilistically, reflecting uncertainty about the truth of the statement. In contrast ‘value-based claims’ offer normative input about how things should be. They provide judgments about priorities, preferences and risk tolerances, and may encompass beliefs about the identity of relevant concerns (...), the relative importance of these different elements, preferences for different outcomes, tolerance to change, tolerance to risk, time preferences, and other factors.’*

In this research the distinction between expert and local knowledge as defined by Lindblom and Cohen (1979; in Petts & Brooks, 2006, p. 1046) will be used:

> *‘Whereas scientific knowledge is conceived of as deriving from objective measurements, verifiable, tested, and using distinctive techniques in its generation, ordinary or lay knowledge is based in common sense - more casual, perhaps even serendipitous, speculative, but still thoughtful.’*

2.3.1 Scientific knowledge

In this research scientific knowledge includes knowledge types known as fact-based, value-based, science, expert, explicit, hard, or systematised knowledge (Te Brömmelstroet & Bertolini, 2010, p. 88; Failing, Gregory & Harstone, 2007, p. 49; Healy, 2008, p. 863). Scientific knowledge is seen as ‘systematised, through categorisation and/or through argumentation which connects concepts about causes and effects, with systematised evidence about experiences’ and is used to be objective (Healey, 2008, p. 863). Failing, Gregory and Harstone (2007, p. 48) state that ‘science inputs are precise, certain and objective’. In line with this view Petts & Brooks (2006, p. 1046) define scientific knowledge as ‘conceived of as deriving from objective measurements, verifiable, tested, and using distinctive techniques in its generation’. These are easily codified knowledge types with a wide validity like data, scientific formulas, general/universal principles, theories, analyses, argumentation and evidence (Te Brömmelstroet & Bertolini, 2010, p. 87) or assessments, models, forecasts and ranking methods (Gudmundsson, 2011, p. 147).

Mostly, the term scientific knowledge implies that knowledge is articulated by professionals, or ‘experts’, and as such, can be validated and is authoritative (Healy, 2008, p. 863), and obtained from conventional scientific expertise (Failing, Gregory & Harstone, 2007, p. 48). It is ‘institutionalised and exclusive and shared through peer-review processes' (Petts & Brooks, 2006, p. 1046). This causes the problem that scientific inputs to decision-making processes are often uncritically accepted (Failing, Gregory and Harstone (2007, p. 48). Scientific knowledge can be used in the field of spatial planning for improved forecasting, modelling and mapping and 'forms a continuum between basic (e.g. definitions of 'floodplain') and advanced (e.g. sophisticated data collection/ modelling for flood prediction) (McEwen & Jones, 2010, p. 1).

Giorgi and Tandon (2002; in Gudmundsson 2011, p. 152) developed table 1, based on their study to knowledge technologies for transport policy evaluation, in which scientific knowledge methods and techniques for data collection and analysis are shown (table 1). In the contend site of transport knowledge three general functions can be distinguish: collection, analysis and assessment (Gudmondsson, 2011, p. 151).

In this thesis the knowledge types represented in this table will be used to identify scientific knowledge in the plan-making process on the designation of flood risk areas on flood hazard maps. Nevertheless, instead of using the term 'scientific knowledge methods and technologies' in this research, this is termed 'scientific knowledge' because this is in line with the terminology used in scientific literature. This classification has not been used before in the field of flood risk management but provides such a clear overview that this will be used in this research.

Comments on this model are given by Gudmundsson (2011, p. 151) by stating that 'the classification itself provides limited guidance to possible success of failure'. A classification for this success or failure is given in paragraph 2.5, in which it is explained what the influence of knowledge can be in spatial-plan making processes on the designation of flood risk areas on flood hazard maps.

Table 1: Types of knowledge technologies for transport policy evaluation

Methods for data collection	Methods for data analysis	Formal assessment techniques/ aggregation
• Surveys • Use of secondary data • Existing information/ databases • Case studies • Focus groups • Natural observations • Expert opinions • Programme documents • Literature reviews	• Statistical analysis • Models ○ Input/ output ○ Micro-economic ○ Macro-economic ○ Statistical • Non-statistical analysis ○ Expert panels ○ SWOT analysis ○ Colour vote ○ Benchmarking ○ Delphi survey ○ Group interviews ○ Meta-analysis	• Cost-benefit analysis • Cost-effectiveness analysis • Multi-criteria analysis • Scenario • Impact assessment • Policy analysis

Source: Giorgi & Tandon, 2002; in: Gudmundsson, 2011, p. 152

2.3.2 Local knowledge

Besides the term local knowledge, this knowledge is known by synonyms as value-laden lay, practical, extended, traditional, implicit, tacit, non-scientific, applied and soft knowledge (Failing, Gregory & Harstone, 2007, p. 48; Healy, 2008, p. 863; Mackinson & Nøttestad, 1998, p. 483; Wisner & Luce, 1995, p. 335). In contradiction to scientific knowledge local knowledge is gained through experience of daily life and task performances (Healey, 2008, p. 863) and 'is deeply rooted in an individual's action and experience as well as in the ideas, values, or emotions he or she embraces' (Nonaka & Konno, 1998, p. 42; in Te Brömmelstroet & Bertolini, 2010, p. 88). This is for example based on practical know-how, intuitions, hunches, feelings and sensibilities (Te Brömmelstroet & Bertolini, 2010, p. 88-89; Healy, 2008, p. 863). The concept of tacit knowledge is introduced 'to conceptualize knowledge that (by definition) cannot be described or talked about (writing it down would make it explicit) (Te Brömmelstroet & Bertolini, 2010, p. 89). In this research this concept is used less strictly to identify the practical know-how, intuitions, hunches, feelings and sensibilities. These can all be articulated by telling about them. Therefore the method of story-telling about experiences can be used, and will be studied in this research.

The local knowledge is attributed to citizens, residents or people with specialized knowledge in a subject (Failing, Gregory & Harstone, 2007, p. 52; Wisner & Luce, 1995, p. 335). These people are motivated to interact in a plan-making process because they want to 'improve their lives and environments' (Wisner & Luce, 1995, p. 344). This is people's knowledge that is hard to formalise (Gibbons et al. 1994; in Te Brömmelstroet & Bertolini, 2010, p. 87). Generating local knowledge is mostly done by 'asking local residents to name or identify hazards, locate them in space and time, and relate their past experiences with, and responses to, these hazards' (Wisner & Luce, 1995, p. 344).

In line with the terming of the scientific knowledge in this research, 'local knowledge types' are termed 'local knowledge' in this research. This term is chosen since this is concurrent with the terminology in scientific literature. Only one type of local knowledge is distinguished above, when mentioned 'local knowledge', is thus referred to 'story-telling about experiences'. When spoken about both 'scientific knowledge' as well as 'local knowledge', the term 'knowledge' or 'type(s) of knowledge' is used.

2.4 Utilization of knowledge

The second step as described by Gudmundsson (2011, p. 147-148) is to identify how knowledge is used. In this research it is assumed that knowledge can be used for problem solving and is neutral, factual and quantitative information to base decisions on (Gudmundsson, 2011, p. 147). Due to the changing influences of different actors in planning processes, the idea of using knowledge has been changed not to only provide an objective input but also to solve a problem (Amara et al., 2004, p. 77). Knowledge can be used in different ways.

To explore how scientific and local knowledge has been used in the designation process of flood hazard maps, three types of 'uses of knowledge' are distinguished (Beyer, 1997, p. 17 in Amara et al., 2004, p. 77; Radaelli, 1995, p. 178) (see for examples paragraph 3.3.1-3.3.3). In this typology 'indirect' knowledge (Gudmundsson, 2001, p. 148) is integrated, showing that knowledge can have very different types in the way that it is used as knowledge. In this, knowledge can be used:

- *Instrumentally*; specifically, direct used knowledge, leading to concrete action or decisions (Amara et al., 2004, p. 90);
- *Symbolically*; knowledge used to legitimise and sustain predetermined positions (Beyer, 1997, p. 17 in Amara et al., p. 77); and
- *Conceptually;* knowledge used for general enlightenment leading to diffuse or indirect influence on actions and decisions (Beyer, 1997, p. 17 in Amara et al., p. 77; Lavis et al., 2003).

2.4.1 Instrumental use

By using knowledge instrumentally, it is used in a specific, direct way, leading to concrete actions or decisions (Amara et al., 2004, p. 90). It is used to solve a predefined or particular problem (Albaek, 1995, p. 85; Lavis et al. 2003, p. 228). This means that there is a lack of knowledge on a problem that has to be solved, for which instance technical data provides the needed knowledge. This makes it possible to make decisions. This is partially in line with the idea of evidence-based planning, which states that evidence leads to decisions and solves clearly predefined problems (Albaek, 1995, p. 85).

2.4.2 Symbolic use

When knowledge is used symbolically, it means that it is used 'to legitimise and sustain predetermined positions' (Beyer, 1997, p. 17 in Amara et al., 2004, p. 77). In contrast to using knowledge instrumental or conceptual, knowledge is used symbolically 'to justify a position or action that has already been taken for other reasons (...) or (...) to justify inaction on other fronts' (Lavis et al., 2003, p. 228).

2.4.3 Conceptual use

The third way to use knowledge is conceptual. When knowledge is used conceptual, it is used for general enlightenment (Beyer, 1997, p. 17 in Amara et al., Amara et al., 2004, p. 77; Lavis et al., 2003, p. 228). Results influence actions and decisions, but in a diffuse and indirect way, in contrary to the instrumentally use (Amara et al., 2004, p. 78). In this way of using knowledge, the influence on the process is not always that strong that it will be able to guide the process (Amara et al., 2004, p. 78).

2.4.4 Discussion on the utilization of knowledge

Despite this classification, the three ways of using knowledge must be considered as complementary, not contradictory (Amara et al, 2004, p. 79), and should thus be combined and confronted, depending on the decision-making situation to get actors involved. Depending on what knowledge is used, how it is used, why it is used and what the influence of it is, the actors in the plan-making process will use it instrumentally, conceptually or symbolically.

Also on the use of the different types of knowledge can be discussion. It is often assumed that scientists, academics and experts use scientific knowledge and for example neighbourhood residents local knowledge (Healy, 2008, p. 863). 'But, in practice, scientists make much use of experiential knowledge (Knorr-Cetina, 1999), and neighbourhood residents may conduct research (Corburn, 2005)' (Healy, 2008, p. 863). Due to the methods and techniques distinguished in paragraph 2.3, in this research a strict division is maintained: scientific knowledge is used by experts, local knowledge by locals.

2.5 Influence of knowledge

Using the different types of knowledge mostly serves at least one goal: to influence a decision in plan-making processes. Rich (1997, p. 15; in Gudmundsson, 2011, p. 148) states: 'Influence, (...) means that information has contributed to a decision, an action, or to a way of thinking about a problem; (...) the user believes that by using information, he/she was aided in a decision or action'. In this research it is assumed that this also applies to knowledge. To have influence in plan-making processes, actors therefore use the knowledge they have in their range.

The influence of knowledge in a plan-making process depends for example on what knowledge types are used and how the knowledge is used (see paragraph 2.3 & paragraph 2.4). This implies that 'the treatment of knowledge claims should be systematic, transparent and equitable, with emphasis on methods for putting different sources on equal footing. (...) There should be consistency in the approach to all claims' (Failing, Gregory & Harstone, 2007, p. 50 & 51). This means that:

> *'policymakers must contend with not only research knowledge but also the (…) opinions of the governing party, its key supporters, interested and affected stakeholders, and the general public* (Lavis et al. 2002; in Lavis et al. 2003, p. 225).

2.6 Knowledge in plan-making processes

In the use of knowledge a paradigm change took place, due to an overall paradigm change in spatial planning. 'The traditional view on knowledge use in policy and planning was the synoptic or instrumentally-rational model' (Innes, 1990, Parsons, 2002; in Gudmundsson, 2011, p. 147). In flood risk management scientific knowledge was used 'in establishing risk and mitigation of fluvial flooding on large water courses, with a limited sense of the historical, anecdotal, qualitative contexts'. In this, knowledge is transferred from expert to public (Petts & Brooks, 2006, p. 1046). McEwen & Jones (2010, p. 1) confirm this by pursing that: 'traditional 'public understanding of science' initiatives have sought to 'transfer' expert science to municipalities and citizens. In this, expert flood knowledge 'is articulated by professionals and as such, can be validated and is authoritative' (McEwen & Jones, 2010, p. 1).

A limitation of the traditional view is that this is a linear model wherein expertise is seen as expert's statements while a decision-making process is a learning process from interactions between different actors (Limoges 1993; in Petts & Brooks, 2006, p. 1046). A consequence of this is that the public is not involved in a plan-making process and thus local knowledge is not used to influence the decisions.

Therefore a change is advocated from the traditional flood protection by quantitative measures, based on mainly scientific knowledge, to long-term flood risk management strategies (Brown & Damery, 2002, p. 413; Schanze, 2002 & DKKV, 2003 & Hall et al., 2003 in in Hutter, 2006, p. 229) grounded in an understanding of exposure to for example the flood hazard and the relationships between different stakeholders. This results in a change from protection against floods, to a more holistic flood risk management approach including spatial planning (Schanze, 2002; DKKV 2003; Hall et al., 2003, in Hutter, 2006, p. 229).

In response to the limitations of the traditional view, since the 21st century the influence of local knowledge grew in which knowledge is exchanged and co-generated (McEwen & Jones, 2010). One of the reasons is that transparency, public access to deliberations and assessment procedures is getting more important (Nowotny, 2003, p. 152). This does not mean that scientific expertise is demotioned or devaluated but originates from an increasingly wish from the lay public to participate in decision-making. Therefore the lay public provide local knowledge and check expert claims (Petts, 1997; in Petts & Brooks, 2006, p. 1046) based on for example 'their experience of floods and their degree of trust' in the expert (Burningham, Fielding & Thrush, 2008, p. 218). This change also implies a change in how knowledge is used from particular instrumental to a combination of instrumentally, conceptually and symbolically. Thus not only the use of knowledge can be viewed as to the synoptic or instrumentally-rational model, but also the garbage-can and bargaining-conflict model of decision-making.

The changing role of knowledge also causes a change in the role of planners (experts) in plan-making processes, also during the development of flood hazard maps. Instead of just transferring knowledge to municipalities and citizens, planners have to cooperate with them. In this cooperation, all available knowledge needs to be synthesised by planners (Nowotny, 2003, p. 152). This means a democratisation of the plan-making process for the spatial planner.

This leads to a common perception of broad stakeholder involvement to develop comprehensive long-term strategies (Hutter, 2007, p. 279). This leads to different insights on what flood risk is. A distinction can be seen between the risks as they really are (as seen by experts) and risks as lay-people perceive them, and making them experts due to the large amount of contextualised and locally embedded information they possess (Irwin & Wynne, 1996; Wynne, 1996; Szerszynski, 1999; in Brown & Damery, 2002, p. 419). Nevertheless, in their article on flood risk management in the UK, Brown & Damery (2002, p. 423) advocate that locally embedded knowledge should be more integrated in hazard management by policymakers, without overlooking the importance of scientific knowledge.

2.7 Knowledge and the development of flood hazard maps

Due to the fact that maps are an effective tool to present hazard zones and communicate spatial planning decisions (Hooijer et al., 2004, p. 351), it is advised to make maps easily readable to ascertain that all actors have the same information (ASFPM, in EXIMAP, 2007, p. 6). This means that knowledge on flood hazards is shared.

Sharing the maps is in line with the changing paradigms (see paragraph 2.6), in which spatial planning is calling for more participatory processes and different stakeholders are involved early in the assessment procedure (Amendola, 2001; in Merz, Thieken & Gocht, 2007, p. 248). A shift in the influence of types and utilization of knowledge in plan-making processes can be expected. Because involving potential users like the public into plan-making processes creates a window for the use of local knowledge. Therefore:

> 'On the one hand, the knowledge of the research community has to be communicated to users and the uptake by end-users has to be facilitated. On the other hand, the expertise, the perspectives and values of the stakeholders need to be taken into account. Following this change, the potential users of flood maps, e.g. land-use planners, emergency managers, the public, infrastructure owners, should be involved in the process of flood mapping (Merz, Thieken & Gocht, 2007, p. 248).'

In their article on their research in flood risk mapping in Vietnam, Tran, Shaw, Chantry and Norton (2009, p. 153) advocate the use of local knowledge in risk management processes, pointed out in two arguments. First they advocate that local knowledge should be integrated in risk management because hazard maps are effective tools in making local knowledge visible, also for locals without specialist knowledge. Using hazard maps is fundamental to collect and display disaster vulnerabilities and risks which should be based on local knowledge. Second, local knowledge is fundamentally spatial and maps are about the disposition of space. Therefore locals should be actively involved in the decision-making process in order to transfer local knowledge from the mind to the map. Local knowledge can provide factual data about the social and physical environment like the indication of flood prone areas. This provides policy makers and practitioners a deeper insight of disaster vulnerabilities and the interrelated role of local people, and makes the risk maps suited to the local situation. Thus to make flood hazard maps more suited to local situations it is argued that local knowledge should be integrated into spatial plan-making processes, including in the development of flood hazard maps. This is in line with changing paradigms in spatial planning calling for the involvement of stakeholders in assessment procedures (Merz, Thieken & Gocht, 2007, p. 248).

2.8 Conceptual model

In order to explore the different factors influencing the plan-making process on the development of flood hazard maps in this research, a conceptual model (figure 3) has been developed. This model shows a conceptual design of the research (Verschuren & Doorewaard, 2007, p.70-72), about what is being investigated. Firstly, the links between the different factors are discussed.

This conceptual model contains two elements: '(a) a collection of concepts that indicate certain phenomena from reality, and (b) a set of relationships between these concepts' (Verschuren & Doorewaard, 2007, p. 280).

These key concepts are variables, differing in modalities and degrees. Between these key concepts causal relationships consist. This means that if one key concept changes, another also changes (Verschuren & Doorewaard, 2007, p. 281). Thus depending on what knowledge is used, and how knowledge is used, the influence in the plan-making process can differ.

This research is focussed on knowledge, on the types, uses and influence of knowledge in spatial plan-making processes. In this the knowledge types and uses of knowledge are independent variables and the influence of knowledge is a dependent variable.

The first dependent variable, the knowledge types, can be separated in scientific and local knowledge. These types differ in the way they represent knowledge, and by whom they are used to involve the plan-making process. The second independent variable in this research is the uses of knowledge. Three ways of how knowledge can be used are distinguished, instrumentally, symbolically and conceptually. When knowledge is used in an instrumental way, it is used in a specific, direct way and leading to action or decisions. Symbolic use of knowledge means that it is used to legitimise and sustain predetermined positions. Using knowledge in a conceptual way can be done for general enlightenment.

The dependent variable, the influence of knowledge, based upon the opinions in the RROP A (ZGB, 2007). In the RROP A (ZGB, 2007), four options are given in order to define the influence in the plan-making process on the development of flood hazard maps, namely: (1) clearly influencing, this is knowledge which directly influences decisions; (2) partially influencing, this means that a part of the knowledge used influences decisions; (3) underpinning, this is knowledge which supports decisions made; and (4) not influencing, this knowledge is not relevant to decision-making.

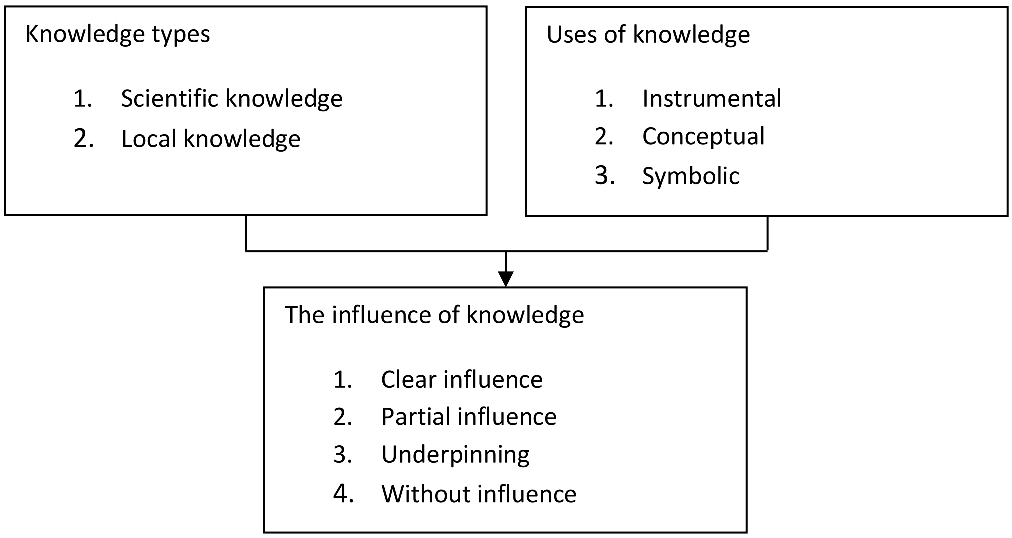

Figure 3: Conceptual model
Source: authors' own

2.9 Hypotheses

In the previous paragraphs the different concepts that are central in this research, are explored and framed on the basis of scientific literature. The concepts of knowledge types, uses of knowledge and influence of knowledge can be seen as variables related somehow to each other. Central in this research is if this relation can be shown. This is shown in the research question:

> *What was the influence of different types and uses of knowledge on the depiction of flood risk areas on flood hazard maps during the regional spatial plan-making process in the Zweckverband Großraum Braunschweig?*

Based on the previous paragraphs a theoretical answer on this research question can be given in the types of research hypotheses, which are follows:

4. *Both scientific as well as local knowledge are used to influence the depiction of flood risk areas on flood hazard maps;*

5. *Knowledge is used instrumentally, symbolically and conceptually to influence the depiction of flood risk areas on flood hazard maps;*
6. *Scientific knowledge, when used instrumentally, has the greatest influence on the depiction of flood risk areas on flood hazard maps.*

2.9.1 Explanation

As shown above, in this research three hypotheses are distinguished, which are explained separately. In the first hypothesis is stated that the depiction of flood risk areas on flood hazard maps is based on both scientific and local knowledge. Due to a paradigm change from traditional flood protection to long-term flood risk management strategies (Brown & Damery, 2002, p. 413; Schanze, 2002 & DKKV, 2003 & Hall et al., 2003 in Hutter, 2006, p. 229) the use of local knowledge grows, without devaluating scientific expertise (Petts, 1997; in Petts & Brooks, 2006, p. 1046).

In the second hypothesis a statement is made on the utilization of knowledge. Herein is stated that knowledge is used instrumentally, symbolically and conceptually to influence the depiction of flood risk areas on flood hazard maps. This is in line with a statement made by Amara et al. (2004, p. 79): 'despite the classification, the three ways of using knowledge must be complementary, not contradictory.' This implies in my opinion that both expert as well as local knowledge can be used in all three possible ways.

The third hypothesis is based on a combination of the previous two aspects. In this hypothesis, it is stated that scientific knowledge, when used instrumentally, has the greatest influence. In the literature on the content and representation of flood hazard maps and on policies (see paragraph 2.7 and Appendix 5) it is shown that mainly scientific knowledge types are used to designate flood risk areas, for example statistical models including the HQ100 and scenarios (maps) (see for example De Moel et al., 2009). Nevertheless, in their article on flood risk management in the UK, Brown & Damery (2002, p. 423) advocate that locally embedded knowledge should be more integrated in hazard management by policymakers, without overlooking the importance of scientific knowledge.

3. Research methodology

3.1 Introduction

In the previous chapter the theory on knowledge is framed and hypotheses are developed in which is focussed on especially three key concepts: (1) what knowledge types is used; (2) how knowledge is used; and (3) what the influence was of the used knowledge in plan-making processes on the depiction of flood risk areas on flood hazard maps. This chapter contains the research approach, operationalization of the research, research strategy, research methods and research materials which are used, in order to show how, where and when the empirical data is collected and explored.

3.2 Research approach

Before considering the research methods, it is important to choose the research approach. In Saunders, Lewis and Thornhill (2008) two methods of research are described: deductive and inductive research. In the deductive method is by means of a hypothesis an existing theory or model tested. In contrast to the deductive method, in the inductive method data is gathered whence a theory is developed. This can subsequently be compared with existing literature (Saunders et al., 2008, p. 31). Creswell distinguishes three practical criteria to choose a research approach, to know: (1) the nature of the research design, (2) the time available, and (3) the demand of the target group (1994 in; Saunders et al., 2008, p. 35-36).

In line with Creswell's criteria's, and in order to choose the research methods, in this research the deductive research approach is chosen because: (1) the subject lends itself more for this approach because there is sufficient literature to types a theory and a hypothesis about knowledge in spatial plan-making processes; (2) it is easier to maintain a strict planning in the three months of research, which is preferred in view of the limited time available; and (3) this approach is generally used in researches to plan-making processes, so the results are easier to adapt on by the HR.

Robson (2002; in Saunders et al., 2008, p. 31) distinguished five stages in a deductive research: (1) a hypothesis is derived from the theory (see paragraph 2.9); (2) operational terms are granted to this hypothesis; before testing it (3) (see paragraph 3.3); (4) the research results are researched to check if the theory can be confirmed or has to be adjusted (see chapter 4 and 5); and (5) the theory is adjusted if necessary on the base of the research results (see chapter 6). The operationalization of the hypotheses is presented in the following paragraph.

3.3 Operationalization

In the conceptual model (figure 3) and the hypotheses (paragraph 2.9) the following variables are distinguished: types, uses and influence of knowledge. To make the conceptual model measurable in practice, the variables are operationalized by assigning indicators (table 5). The assignment of indicators to the variables is based on the literature research in paragraph 2.3, 2.4 and 2.5.

Table 2: Operationalization of the theory

Variable	Indicator	Value
Knowledge types	Scientific knowledge	• Surveys • Use of secondary data • Existing information/ databases • Case studies • Focus groups • Natural observations • Expert opinions • Programme documents • Literature reviews • Statistical analysis • Models (input/output; micro-economic; macro-economic; statistical) • Non-statistical analysis (expert panels; SWOT analysis; colour vote; benchmarking; logical framework; Delphi survey; group interviews; meta-analysis) • Cost-benefit analysis • Cost-effectiveness analysis • Multi-criteria analysis • Scenarios • Impact assessment • Policy analysis
	Local knowledge	• Story-telling about experiences
Uses of knowledge	Instrumental	• Used in a specific, direct way • Leading to concrete action or decisions • Used to solve predefined problems • Based on a rational decision-making process
	Symbolic	• Used to legitimise and sustain predetermined positions or to justify inaction on other fronts • Not used to inform decision making • Assumes that the outcome of the process is already clear • Uses to underpin the outcome
	Conceptual	• Used for general enlightenment • Results influence actions and decisions in a diffuse and indirect way • Inability to guide the process the way one wants it • A decision is made without knowing the results of the research on the subject
Influence of knowledge	Clear influence	• A decision is made on this knowledge
	Partial influence	• Partially influencing a decision, partially denied
	Underpinning	• Influencing indirect a decision
	No influence	• Without influence on a decision

Source: compiled by the author based on Giorgi and Tandon, 2002; in Gudmundsson 2011; Beyer, 1997, p. 17 in Amara et al., 2004, p. 77; Radaelli, 1995, p. 178; Amara et al., 2004, p. 77; Lavis et al., 2003; ZGB, 2007

3.3.1 Operationalization types of knowledge

The different types of knowledge distinguished in the case are based on opinions in the RROP A (ZGB, 2007) and a description of the process in the RROP B (ZGB, 2008). In these documents is explored, based on literature review and an analysis of the opinions on the concept flood hazard maps, what types of knowledge were used in the plan-making process. To get a clear separation in the type of knowledge, scientific or local, the use of scientific knowledge is attributed to 'experts' (professionals in flood management) (Healy, 2008, p. 863) and the use of local knowledge to local citizens (Failing, Gregory & Harstone, 2007, p. 48; Wisner & Luce, 1995, p. 335) of the ZGB. By making this separation, the fact that this separation is not that strict (Knorr-Cetina, 1999 & Corburn, 2005; in Healy, 2008, p. 863) is ignored. This is done to get a clear separation in this research between scientific and local knowledge. More about the consequences of this choice can be found in the reflection (paragraph 6.2).

3.3.2 Operationalization utilization of knowledge

Knowledge can be utilized in three ways: (1) instrumental, (2) symbolic, and (3) conceptual (Beyer, 1997, p. 17 in Amara et al., Amara et al., 2004, p. 77; Lavis et al., 2003, p. 228). Based on the RROP A (ZGB, 2007) and the RROP B (ZGB, 2007) is in chapter 4 and 5 analysed how knowledge is used in the ZGB. The categorization of the uses of knowledge in this research is based on a personal interpretation in the way that opinions have been expressed. This is done because this gives an objective view on this. If in an opinion is stated that something has to be done differently, based on the knowledge supplied, this is categorized as instrumentally used knowledge. Opinion 1716 by Feldintressentschaft Schöppenstedt (ZGB, 2007, p. 683) is an example showing a direct way of using scientific knowledge in an opinion to lead to concrete action (Amara et al., 2004, p. 90):

'The areas for flood protection along the Altenau have to be reduced to a considerable extent.'

An example of local knowledge which is used instrumental is the following (ZGB, 2007, p. 730), wherein a local, Mr. Schreiber, shows on a map where the 'actual' high water line should be in his opinion:

> 'What I see in your design RROP - 2007, is that the area of my farm is affected to a considerable extent. I rise against this. 1 The reservation area G (flood protection) is too broad (light blue line). There are pure arable lands in this area, which could lead to increased requirements. As proposed amendment I have a map of the district Neindorfer settled, wherein my (or actual) "high water line" is marked in blue.'

When knowledge is used symbolically, it is explicitly written in the opinion that the knowledge supplied is to legitimise and sustain predetermined decisions. An example wherein secondary data is used symbolically is opinion 1760 wherein the Velpke community the following states:

> 'Calculated on the basis of a hundred year flood, flood-prone areas in the drawing are defined as "priority flood risk areas". The borders correspond to the formally established floodplain of the Aller.'

Knowledge is used conceptually when knowledge serves for general enlightenment in an opinion. An example of an expert's opinion which is used for general enlightenment is in opinion 1699 (ZGB, 2007, p. 676) wherein the NABU district group Gifhorn states:

> 'We strongly welcome the designation of priority and reservation areas for flood protection. For many decades it has taken until now, the idea took hold that the backup and restore former retention areas is one of the main tasks of preventive flood protection.'

3.3.3 Operationalization of the influence of knowledge

Despite of the in-depth literature research on the influence of knowledge, a scientific qualification could not be found. Therefore in this research the variable 'influence of knowledge' is qualified on the basis of the non-scientifical document RROP A (ZGB, 2007; see paragraph 3.5.1). This document contains the opinions given on the concept flood hazard maps in the ZGB by stakeholders and the general public and is explored and analysed in respectively chapter 4 and 5. In the RROP A (ZGB, 2007) the influence of knowledge in the plan-making process on the development of flood hazard maps is classified into four categories: (1) knowledge that clearly influences decisions; (2) knowledge that partially influence decisions; (3) knowledge that underpins decisions; and (4) knowledge without influence on decisions. This qualification is also used in this research.

In the following figure one page of the RROP A (ZGB, 2007, p. 663) is given, in which from left to right the following for this research relevant categories are distinguished: (1) number opinion (Ziele), (2) the opinion (Stellungnahme bwz. Teilstellungnahme (sachliger Abschnitt)), and (3) the influence (Abwägung) with substantiation of the choice if necessary.

Zeile	**Einwendungsgeber / Stellungnahme -Datum / -Abschnitts-Nr.**	**Textziffer RROP/ Umwelt-bericht (U:)**	**Kate-gorie***	**Stellungnahme bzw. Teilstellungnahme (sachlicher Abschnitt) /** ***Hinweis zu Anlagen oder Verweis auf andere Stellungnahmen***	**Abwägung**
1676	**01.06** Landkreis Peine 25.04.2007 (1 - 44/60)	**III 2.5.4**	H	II b) Unteren Wasserbehörde Hinsichtlich des Hochwasserschutzes hat der ZGB Informationen aus verschiedenen Fachgebieten zusammengetragen und die möglicherweise gefährdeten Flächen durch eine umhüllende Darstellung zeichnerisch festgelegt. Die zur Zeit gesetzlich festgesetzten Überschwemmungsgebiete von 1912 liegen dabei alle innerhalb dieses Bereiches Die gesetzlich festgesetzten Überschwemmungsgebiete der Fuhse, Aue / Erse und Burgdorfer Aue sowie die Nebengewässer 2. Ordnung werden in den kommenden Jahren von mir neu festgesetzt.	**Hinweis wird zur Kenntnis genommen**
1677	**01.07** Landkreis Wolfenbüttel 17.04.2007 (1 - 23/34)	**III 2.5.4**	Z	Kapitel III 2.5.4 Vorbeugender Hochwasserschutz Es ist klarzustellen, unter welche Kategorie (Vorrang oder Vorbehalt Hochwasserschutz) die 50 m breiten „Pufferflächen" fallen bzw. ob sie den Regelungen des vorbeugenden Hochwasserschutzes nicht unterliegen. [...] Begründung In der Begründung wird auf S. 134 ausgeführt, dass aus Darstellungsgründen sämtliche Linien mit einem Abstand von 50 m „gepuffert" und angepasst worden seien. Für die davon betroffenen Randbereiche der Vorrang- und Vorbehaltsgebiete Hochwasserschutz besteht hier Klärungsbedarf.	**Nicht folgen** Die Zeichnerische Darstellung enthält generalisierte Festlegungen im Maßstab 1:50.000. Aus Maßstabsgründen und der Vorgabe von landesweit verbindlichen Planzeichen ist es insbesondere bei flächenhaften, mit einer Umrandung zu versehenen Gebietsfestlegungen unumgänglich, eine "Glättung" von "zackigen" Bereichen vorzunehmen. Dieser Sachverhalt ist mit "Pufferung" umschrieben worden.
1678	**01.07** Landkreis Wolfenbüttel 17.04.2007 (1 - 24/34)	**III 2.5.4** diverse	Z	Weiterhin sind die in der Stellungnahme der Stadt Wolfenbüttel vorgebrachten zeichnerischen Anpassungen vorzunehmen. [...] Begründung Hinsichtlich der zeichnerischen Anpassungen innerhalb der Stadt Wolfenbüttel wird auf die in deren Stellungnahme vorgebrachte Begründung verwiesen.	**Teilweise folgen** s. Abwägungsbegründung in Zeile: 1763

Figure 4: Example page (opinion 1676-1678) RROP A
Source: ZGB 2007

3.4 Research strategy

Verschuren & Doorewaard (2007, p. 159) define a research strategy as an entity of interrelated decisions about the way how to carry out the research in order to gather and assimilate relevant research materials. This is necessary to give valid answers to the research questions. Therefore they call this the most crucial decision by making a technical design for the research. As a reminder therefore first the research question is given where after the research strategy is explored:

> *What was the influence of different types and uses of knowledge on the depiction of flood risk areas on flood hazard maps during the regional spatial plan-making process in the Zweckverband Großraum Braunschweig?*

Several strategies, like the case study, survey, experiment, and desk research can be used to gather and assimilate research materials and to give an answer to the research question (Verschuren & Doorewaard, 2007). These strategies differ from each other by the way they explore the empirical data. When a research is done by a deductive approach, the case study and survey methods can be used. In this research the case study method is chosen to be used.

The research strategy used in this research is called a 'case study'. A case study is a research in which the researcher tries to get an in-depth and comprehensive understanding of one or several time-limited bounded objects or processes. In this a small number of research units are explored. This makes that qualitative, labour intensive, methods are required. This makes it possible to get an integral view of the object as such. This object is explored in its natural environment (Verschuren & Doorewaard, p. 183 - 185). That makes that this method fits on the exploration of types, utilization and influence on the plan-making process on flood hazard maps in the ZGB because this is one time-limited process by which it is possible to obtain an integral view of the object.

The reason not to use the survey method is that this method gives a broad insight in a basically time and spatially extended phenomenon. In a survey a large number of research units should be explored because a large number of interviewees increase the value of the research results (Verschuren & Doorewaard, p. 166). This method is not chosen because this research focusses on one case in depth instead of giving a broad view on several cases. Besides this another reason not to choose this method is the limited time for this research.

3.4.1 Single case study

A variation on the case study-strategy is the single case study method. In this method only one case is studied in-depth. In this, there is focussed on triangulation of different sources to disable coincidences as much as possible. It is possible to distinguish several subcases in one case (Verschuren & Doorewaard, p. 187).

To show the relevance of the chosen case, first the research problem is cited again:

> it is not clear what the influence of different types and uses of knowledge is during the plan-making process on the development of flood hazard maps.

In order to solve this problem, the plan-making process on the development of flood hazard maps in the Zweckverband Großraum Braunschweig is chosen as case in this research. This spatial planning region updated their flood hazard maps in 2008 as part of their 'Regionales Raumordungsprogramm für den Großraum Braunschweig 2008' (after this: RROP). In these maps the latest updates in the field of policy on flood risk management, social needs and spatial developments are processed.

Prior to the development of the flood hazard maps a plan-making process is performed in which several actors used different knowledge types in different ways to influence the development of the flood hazard maps. During this process there is not made a clear distinction in which types or uses were used and what their influence was; this is therefore explored in this research.

3.4.2 Substantiation case

It is possible to state several arguments for choosing the ZGB as the central case, which has been done in consultation with Dr. F Scholles, lecturer in spatial planning and spatial development at the Leibniz University Hannover. Firstly, both the Hannover Region and the ZGB are required to designate flood protection areas (see paragraph 4.3) and operate both at the regional spatial planning level. The flood hazard maps representing the ZGB's territory, include the results of historical flood maps, flood extent maps, flood depth maps (personal comment A. Menzel, 24-06-2010). Since the ZGB already developed the flood hazard maps, lessons can be learned by the HR from this; also in respect to the types, uses and influence of knowledge during the plan-making process on the development of flood hazard maps.

The second reason to choose the ZGB a case is that during the development of the flood hazard maps, current legislation was implemented (like the Floods Directive; see paragraph 4.3), which should also be respected by the Hannover Region in their plan-making process. Due to their role in the development of the Floods Directive, the ZGB was one of the first German regional spatial planning institutions to implement requirements from this Directive in the plan-making process (see paragraph 4.3).

Thirdly, from a scientific perspective, the plan-making process on the development of flood hazard maps in the ZGB can be used to show the relation between the influence of knowledge and different types and uses. In respect to the exploration of knowledge in regional spatial planning plan-making processes on the development of flood hazard maps, only one other research could be found. In their research on expert and local flood knowledge McEwen & Jones (2010) explore the different types of knowledge in building community resilience. In this research the use and influence of knowledge in a plan-making process on the development of flood hazard maps is not included. Therefore, in this research several sources have been used to explore the concepts of knowledge, regional planning and flood hazard maps in practice. This means that none of these papers treats all three concepts simultaneously. In respect to knowledge several papers were found (like: Mackinson & Nøttestad, 1998; Failing, Gregory & Harstone, 2007; Nowotny, 2003; Gudmundsson, 2011; Petts & Brooks, 2006; Te Brömmelstroet & Bertolini, 2010) also in the field of water management (for example: Brown & Damery, 2002; McEwen & Jones, 2010; Petrow, Thieken, Krebich, Bahlburg & Merz, 2006; Plate, 2002); regional planning (for example: Hutter, 2007); and (flood hazard) maps in European Member States, also on local scale (for example: Dühr, 2003; Faludi, 1996; Gierk, 2009; EXIMAP, 2007; Merz, Thieken & Gocht, 2007; Porter & Demeritt, 2012). By combining these three concepts which was possible in this case, it is possible to adjust new knowledge to the scientific debate on knowledge in spatial plan-making processes, which is the external goal of this research.

After an in-depth exploration of the plan-making process as a whole, it was decided, in consultation with Mr. Menzel, spatial planner at the Zweckverband Großraum Braunschweig, to analyse opinions included in the RROP A (ZGB, 2007) to focus on the types, uses and influence of knowledge in the plan-making process on the development of flood hazard maps. This makes it possible to make general descriptive statement about the subject and show relationships between phenomena can be explored (Verschuren & Doorewaard, 2007, p. 280). In this research the results will thus show clearly what types, uses and influences knowledge can have in a spatial plan-making process on the development of flood hazard maps.

3.5 Research methods and materials

Considering the research methods, a characteristic of the case study method is to use labour intensive research methods. In this research is chosen to gather information by doing a content analysis of textual material combined with face-to-face interviews with open questions on location (Verschuren & Doorewaard, 2007, p. 184). In order to show the influence of different types and uses of knowledge in the case, a score table will be developed. This table shows the relationship between these variables (see chapter 7). The results of the literature research, face-to-face interviews and the score table will be combined to answer the research questions. Combining different methods is called method triangulation (Verschuren & Doorewaard, 2007, p. 184).

This paragraph is classified on the basis of the different research methods. For each research method, it is specified what can be done with this, and for each variable (types, use and influence) it will be explained how the method was used and what materials were used for this.

3.5.1 Content analysis

The content analysis method can be used to gather data from literature when it is explored from the research question (Verschuren & Doorewaard, 2007, p. 238). When used as a qualitative method, it's goal is to reduce the for the researcher relevant information by substantive interpretation and understanding (Verschuren & Doorewaard, 2007, p. 239). In this research literature is classified as being books, scientific articles and newspapers. Used literature is gathered by using electronic databases like PiCarta and Google Scholar and electronic databases of regional newspapers.

For general enlightenment on the subject of European, German and regional flood risk management, researches on this subject were explored by using PiCarta and Google Scholar. For in-depth research on the case, the Regionales Raumordnungsprogramm 2008 (ZGB, 2008) developed by the ZGB is used. The RROP (ZGB, 2008) contains a couple of documents including a description of what influenced the plan-making process on flood hazard maps and how this process is processed by the ZGB. The following documents from the RROP (ZGB, 2008) are used:

- Abwägungsunterlage (consideration document; after this RROP A; ZGB 2007); this document contains all consultation responses on the concept flood hazard maps and their influence in the plan-making process. For each consultation response the ZGB substantiated the influence of this in the plan-making process;

- Beschreibende Darstellung (descriptive representation; after this RROP BD; ZGB 2008a); this document contains the objectives and principles of cases including flood protection and is used to explore the influence of legislation in the plan-making process;
- Begründung (foundation; after this RROP B; ZGB 2008b); explains the plan-making process of flood hazard maps and will therefore be used to explore the plan-making process.

These documents are firstly used for general enlightenment about the plan-making process on the development of flood hazard maps in the ZGB. Secondly, and most notably, in combination with the interviews (see paragraph 3.5.2; appendix 1, 2 & 3), scientific literature in respect to flood risk management, the RROP B (ZGB, 2008b) is used in order to explore the role of knowledge in the development of the concept flood hazard maps. In respect to this subject also the RROP BD is used (chapter 4 & 5). Besides, this document is used to define the steps taken by the ZGB in the plan-making process (chapter 6). Thirdly, in combination with interview 2 & 3 (appendix 2 & 3), the RROP A (ZGB, 2007) is used to define the types, uses and influence of knowledge in the plan-making process on the development of flood hazard maps. This document includes opinions on the concept flood hazard maps which are analysed in chapter 4 and 5 and is one of the major sources of empirical data in this research.

3.5.2 Interviews

Another qualitative research method matching with the case study-strategy is to do face-to-face interviews on location (Verschuren & Doorewaard, 2007, p. 184). This is done by using open questions. These are based on the indicators and values of the conceptual framework (figure 2).

In this research two persons are interviewed. Firstly, Mr. M. Herrmann was interviewed. He is spatial planner at the HR charged with the development of flood hazard maps. During this interview, which can be found in appendix 1, the relevance of this research became clear and some general background information was gathered.

The second person interviewed (see appendix 2 & 3), Mr. A. Menzel, is spatial planner at the ZGB. He is responsible for flood risk management in the region. In in a couple interviews with Mr. Menzel firstly was in-depth explored how the plan-making process took place. For more information he referred to the RROP B (ZGB, 2008b) and RROP BD (ZGB, 2007a). Secondly, he highlighted the process of collaboration with other governmental water authorities. Thirdly, the interviews focussed on knowledge during the plan-making process on flood hazard maps. In this respect, there is sought to find examples to analyse the role of types and uses of knowledge by the ZGB and other involved actors in the plan-making process. For this, there for was referred to the RROP A (ZGB, 2007).

3.5.3 Score table

In order to define the types, uses and influence of knowledge in the case, the RROP A (ZGB, 2007) is used. In this document all opinions on the concept flood hazard maps included. These opinions are given during the plan-making process and are submitted by governmental organisations like municipalities, local interest parties and locals. These are based on a knowledge types. Also from these opinions is deduced how this knowledge is used. Besides these opinions, the ZGB also describes for each opinion what the influence of this opinion was. These three variables are scored in the table below (table 3) in order to show the influence of the different types and uses of knowledge in the case.

Table 3: Score table on the types and uses of knowledge and their influence in the plan-making process on flood hazard maps in the ZGB

Use & types / influence	Clear influence (C)	Partial influence (P)	Underpinning (U)	No influence (N)
Scientific / local knowledge				
Instrumental				
Symbolic				
Conceptual				

Source: authors' own

4. Case study on regional level: the plan-making process on the development of flood hazard maps in the Zweckverband Großraum Braunschweig

4.1 Introduction

Hitherto in this research, 'knowledge' in respect to its types, uses and influences is explored in scientific literature, as required to use in plan-making processes on the development of flood hazard maps in European Member States (after this: MS), and on German federal and state administrative level. In this chapter is explored what knowledge influenced the plan-making process on the development of flood hazard maps in a selected case. Therefore in this chapter the following hypotheses are tested:

1. *The type of knowledge mostly used to influence the depiction of flood risk areas on flood hazard maps is scientific knowledge;*
2. *Knowledge is mainly used instrumental to influence the depiction of flood risk areas on flood hazard maps;*
3. *Scientific knowledge, when used instrumentally, has the greatest influence on the depiction of flood risk areas on flood hazard maps.*

To answer these hypotheses, the plan-making process on the development of flood hazard maps in the ZGB is explored in this chapter. As mentioned in paragraph 1.1, because the ZGB was one of the first regional German spatial planning institutes to develop flood hazard maps while implementing the applicable legislation, this case is chosen to do the research on. This legislation includes the Floods Directive (after this: FD), of which more is described in paragraph 4.3.

Firstly, in order to answer the research sub-question, in this chapter are the plan-making process and the depiction of flood areas on maps is explored. Secondly is explored what types, uses and influences of knowledge have been used in the plan-making process on the development of flood hazard maps in the ZGB. In this research 221 opinions are analysed on: (1) scientific knowledge and local knowledge as shown in the operationalization (table 3). When referred to these opinions, a number between 1671 and 1891 is given. These are the numbers given to the opinions in the RROP A (ZGB, 2007); (2) if the knowledge is used instrumentally, symbolically or conceptually. For this the opinions 1671 till 1891 (ZGB, 2007) have been analysed. Depending on what is written in these opinions and how, is derived what the goal of using this knowledge was; and (3) what the influence of the used knowledge was. Therefore the classification as used by the ZGB is acquired in this research. Also here for the opinions 1671-1891 (ZGB, 2007) are used.

4.2 Introduction in the Zweckverband Großraum Braunschweig

Since 1978, the ZGB is the regional spatial planning institution for the municipalities Salzgitter, Wolfsburg, Braunschweig and five other municipalities. The total area of the ZGB covers 5.124 km^2, where in 2005 1.16 million inhabitants lived (personal comment A. Menzel, 24-06-2010; ZGB, 2008b). It is located south-east of the HR, in south Lower Saxony (see figure 4).

Since the establishment of the ZGB, it took over some overall spatial planning issues from the municipalities Gifhorn, Helmstedt, Peine, Wolfenbüttel, Wolfsburg, Braunschweig and Salzgitter. The goal of regional planning in the ZGB is equal to that of the HR, which is: 'no more or less than harmonising the social and economic demands on the land with its ecological functions' (Region Hannover, 2005). This is in line with Dühr, Stead & Zonneveld (2007, p. 43), who state that 'regional planning is primarily concerned with influencing the organisation of the physical spatial structure within a specified region'. By coordinated, sustainable spatial planning for these regional plans, the regional specific development opportunities can be promoted, the high standard infrastructure can be protected and further development and the demographic development adequately met (ZGB, 2008c). In respect to this goal, the ZGB started to develop the spatial planning programmes 2008 in 2005.

Figure 4: Lower Saxonian regions
Source: Nordmedia

4.3 The plan-making process

In 2005, the ZGB started the development of the Regional development plan 2008 (after this: RROP 2008). The RROP 2008 contains spatial plans for the years 2008-2013 for all spatial functions and uses in the ZGB, like for example nature, energy, infrastructure and water management. In Germany, legislation on the development of regional plans is binding (Petrow et al., 2006, p. 723). The RROP 2008 is legally based on the Niedersächsischen Wassergesetz, the Niedersächsischen

Raumordnungsgesetz and the Landes-Raumordnungsprogramm Niedersachsen. These acts and this program are in their turn based on German and EU's legislation like the Floods Directive. In this directive, requirements on the content of flood risk management plans is described, which includes the development of flood hazard maps. In this directive explicitly pointed on the use of statistical models like the HQ100 to depict flood risk areas on flood hazard maps.

In respect to regional plans, the LROP (Lower Saxony, 2002) requires lower governmental authorities to include the following:

1. A descriptive representation of the spatial plans including objectives of regional planning, with for each spatial function a motivation based on scientific evidence, a description of the spatial influence; this is elaborated in the RROP B (ZGB, 2008b);
2. For each subject the legal (EU, federal and state) basis; this is implemented in the RROP BD (ZGB, 2008a) and the RROP B (ZGB, 2008b);
3. A graphic representation with specific spatial rules (the principles and objectives) and a link to the chapter in the descriptive representation; for which maps are used; and
4. A document including all advices and comments on the spatial plans; this became the RROP A (ZGB, 2007).

These four documents together type the RROP. The maps, used as tools for the graphic representation of the principles and objectives, include flood hazard maps and are developed during the plan-making process of the RROP.

The ZGB initiated the plan-making process. In this, is focussed on a flood risk management approach wherein not only was searched for technical measures to prevent floods but also to use former retention areas, outside the current flood prone areas. In order to prevent conflicting use of this space, the German federal government developed the Flood Control Act which was implemented in federal and state legislation (see Appendix 4 for more information on flood risk legislation on European, German federal, state and regional level). During the development of ZGB's flood hazard maps the EU, in collaboration with inter alia German planning institutions, developed the FD. Because the FD was practically equal to the current German legislation its influence was limited (Menzel, interview, 02-12-2010).

During the plan-making process the ZGB found out that the LROP was limited in only requiring 'priority area flood protection'. Besides these areas there were areas which could not be justified being classified as 'priority flood area' because this could not be proved by professional scientific knowledge. In addition, there was the need to specify the so-called flood-prone areas in the descriptive statements and the drawings. This has been implemented in the Federal Water Resources Act (Wasserhaushaltsgesetz; Bundesministerium der Justiz, 2009), which obliges states to identify flood-prone areas and to map them. On request of the ZGB flood-prone areas which could not be classified as 'priority flood areas', the Ministry of Farming Lower Saxony (after this: ML) granted the classification of 'reserve flood protection areas'.

Now that these areas could be classified legally, the ZGB started gathering knowledge on flood areas. In order to clear the gap of knowledge on priority and reserve flood risk areas the ZGB collaborated with the ML and other water authorities. Maps are hereby used as tool for the graphic representation.

4.4 Flood hazard maps

As stated by de Moel et al. (2009, p. 296), governments use flood maps to serve an advisory purpose or where there is a binding legislation to use flood hazard or risk information. In the ZGB, European and German (federal and state) binding legislation requires showing the territory where a certain risk for flooding can be confirmed (for example: ZGB, 2008b; Council, 2007; Bundesministerium der Justiz, 2009). In German legislation these flood risk areas are distinguished to priority and reserve flood areas.

In order to map these areas, the ZGB and the ML started a pilot. In this pilot 800 kilometres of river basins were selected and evaluated by using currently available digital information, such as height and landscape models, raster maps and current flood design values, leading to flood areas based on a HQ100 (ZGB, 2008b, p. 159-160).

In the course of the pilot project is a method has been developed, by a commissioned engineering firm, that allows the identification of potential flood areas using the above basic data and hydraulic principles, without having to perform additional complex survey work. Furthermore, engineering reports that have been created as part of the formal process of fixing flood risk areas have been evaluated and prioritised. Hereby 70-80% of the flood risk areas could be identified. These are areas under risk. Because also flood areas without risk needed to be determined, there was searched for a method to determine these. For this purpose there was no engineering report available and water authorities could give this only sporadically, for example concrete being planned individual measures and technical information available. Therefore the Aue-Lehm-Method (Flood prone area-Clay-Method; after this FCM; ZGB, 2008b) was used. This method shows areas where clay can be found as soil. Comparisons between the results of the FCM and the engineering pilot showed that this method provides results for the unpopulated area that is largely consistent with the appraised flood areas. In this respect the FCM for the level of regional planning provides useful performance to delineate flood-prone areas as defined by the Federal Water Resources Act (Wasserhaushaltsgesetz; after this FWRA) 2007. By this method, the flood areas have been determined exclusively ‘reserved areas for flood protection’.

The priority and reserve areas for flood protection were depicted on concept flood hazard maps, which were developed in cooperation with water and consumer authorities. In respect to this it can be assumed with high probability that the priority and reserve flood risk areas represented the areas as required by the FWRA (ZGB, 2008b, p. 158).

These flood hazard maps are presented for consultation, to all organisations and citizens concerned in the ZGB in line with the FD and German legislation. Hereon 221 opinions were submitted, which all have been collected in the RROP A (ZGB, 2007). After this, these are analysed by the ZGB and the other water authorities involved in the plan-making process. Besides for each view, its motivation is given including the influence of the view in the plan-making process.

4.5 Types of knowledge

As mentioned in paragraph 2.3, two knowledge types are distinguished in this research: scientific and local knowledge. These knowledge types differ in their content and by whom these are used. Scientific knowledge is for example seen as fact-based knowledge (Failing, Gregory & Harstone, 2007, p. 49) used by experts (McEwen & Jones, 2010, p. 1). Local knowledge is for example defined value-laden knowledge (Failing, Gregory & Harstone, 2007, p. 48), used by residents (Wisner & Luce, 1995, p. 335) (see paragraph 2.3 for more information). In the operationalization of the research (Table 3) values have been awarded to the two knowledge types, and are identified in the ZGB's plan-making process on the development of flood hazard maps in the RROP A (ZGB, 2007).

During the development of the flood hazard maps several stages can be distinguished. First the stage wherein the concept flood hazard maps have been developed, second the stage wherein the opinions have been analysed, and third the stage wherein the definitive flood hazard maps were developed (see figure paragraph 5.1). A division can be made on the use of knowledge during these stages. During the development of the concept flood hazard maps (see paragraph 4.4) only scientific knowledge has been used. This includes the FCM to define the HQ100 (statistical model) and the use of the result hereof: the concept flood hazard maps (scenarios).

In respect to public participation, via the submission of opinion statements based on scientific and local knowledge could be submitted. This gives the opportunity to other stakeholders to interact in the plan-making process (Menzel, interview, 02-12-2010). Further on in this paragraph, these opinions are analysed to find out what knowledge is used to influence the designation of flood risk areas. For each value is referred to some of the opinions underpinned with this knowledge, in the RROP A (ZGB, 2007).

4.5.1 Scientific knowledge

In respect to scientific knowledge, based upon the operationalization of the research (table 3), the following values have been identified in the opinions: use of secondary data (34), existing information/ database (1), natural observation (11), expert opinions (89), policy analysis (21), statistical models (29), scenarios (12) and literature review (4) (ZGB, 2007; see table 6). These are identified by direct or indirect reference in the opinions. Users of scientific data are identified as regional governmental (water) institutions and local interest groups representing local residents. Out of 221 opinions, 201 opinions are underpinned with scientific knowledge. In order to show what knowledge is used for each value some examples are described below.

Several opinions are underpinned by the use of secondary data. This has been defined as knowledge being reused by someone else than the developer or commissioner of the development of the knowledge. In this case secondary data consisted mainly of the use of data on the HQ100 and the concept flood hazard maps in the RROP (ZGB, 2007).

Only one opinion is based on existing information/ database. Here in a statement is made by the municipality Seesen in respect to the methods used during and results of the development of the concept flood hazard maps by means of natural observations, the RROP and own models (1695).

Natural observations are done by several municipalities and institutions. This is knowledge gained in the field. The knowledge on which areas were flooded is seen as natural observations, for example during the major floods 2002 and 2003. This is mostly used to underpin an opinion or judgement on the location of flood hazard areas (1781).

The most used knowledge type is the use of an opinion. Experts have used this knowledge in 89 opinions to underpin their statement. In general this has been used to make a statement on the location of flood hazard areas whereby one most times disagreed with the decisions made (1715-1720 & 1879-1818). Also some expert opinions were underpinned by natural observations. Actors stated for example that certain areas could or could not be flooded (1698).

In literature several types of models are found (see table 1; Giorgi & Tandon, in Gudmundsson, 2011). In respect to this case, only statistical models have been identified in the opinions. Two examples will show what kind of statistical models have been used. The first example is on a model used by the Braunschweig community (1671). In respect to flood hazard management in the city centre the community has carried out modelling to the HQ100, which differ from the HQ100 as calculated by the RROP (ZGB, 2008b). Based on this knowledge the community developed maps. More on this specific view can be read in paragraph 6.4.4. A second example is the use of research done by modelling the HQ100 by an extern engineering company commissioned by the municipalities Gifhorn and Wolfsburg (1647, 1680, 1685, 1746-1750, 1752).

In the RROP A only policy analysis on legislation relevant to flood risk management could be defined. This includes statements on federal and state legislation and local spatial plans and local building plans. In these opinions critiques are given on the implementation of this legislation; or this legislation is used to underpin decisions (1678, 1723, 1741, 1763).

Scenarios, in this research identified as maps, are used in several opinions. For example the State Office for Mining, Energy and Geology Hannover developed a map on geology, what had inter alia been implemented in maps showing flood hazard areas (1697). Another example is the use of maps showing flood areas in 2002 and 2003 by the Nature and Biodiversity Conservation Union Germany (1778). These maps are based on statistical models (1697) and natural observations (1778).

4.5.2 Local knowledge

In paragraph 2.3.2 one value of local knowledge is distinguished: story-telling about experience. In this research only 19 out of 221 opinions were underpinned by local knowledge (1721, 1830-1842, 1846, 1847 & 1889-1891). This includes stories about local geographical situations and experiences on the local spatial impact of floods.

Besides, one opinion is classified as being local knowledge because the submitter of this opinion is a citizen of the ZGB. Nevertheless the knowledge used to underpin the opinion is a statistical model on the HQ100.

And three opinions submitted by locals (1889-1891) cannot be defined as story-telling about experiences. In these opinions, statements have been made in respect to the designation of flood risk areas. These lack a foundation by knowledge whatsoever. In respect to scientific knowledge types these would have been classified as expert opinions. Because of the lack of this classification of a method for local knowledge, these opinions are classified as story-telling about experience.

4.6 Uses of knowledge

In this research, three ways of using knowledge are distinguished: instrumental, conceptual and symbolic use (see paragraph 2.4). These 'uses' of knowledge differ in the purpose of the use of knowledge, in respect to decision-making; in this case in the plan-making process on the development of flood hazard maps. In Table 3 values are granted to the different uses to identify these in the RROP A (ZGB, 2007). The instrumental use of knowledge implies that knowledge is used in a specific, direct way, leading to concrete action or decisions (Amara et al., 2004, p. 90). When knowledge is used symbolic it is used to legitimise and sustain predetermined positions or to justify inaction on other fronts (Beyer, 1997, p. 17 in Amara et al., 2004, p. 77; Lavis et al., 2003, p. 228). Conceptually used knowledge is knowledge for general enlightenment influencing actions and decisions in a diffuse and indirect way (Beyer, 1997, p. 17 in Amara et al., Amara et al., 2004, p. 77; Lavis et al., 2003, p. 228; Amara et al., 2004, p. 78).

After analysis of the opinions in the RROP A (ZGB, 2007) is determined how knowledge is used based on the underpinning knowledge and the ZGB's response to the view. The result hereof can be found in table 7. In most opinions both scientific and local knowledge is used instrumental: 189 out of 221. Hereof 18 opinions were underpinned with local knowledge. Only scientific knowledge is used symbolic, in 15 opinions. Also the vast majority of opinions used conceptual was based on scientific knowledge: 16 out of 17 scientific; thus only 1 opinion was based on local knowledge. The results are shown in appendix 6.

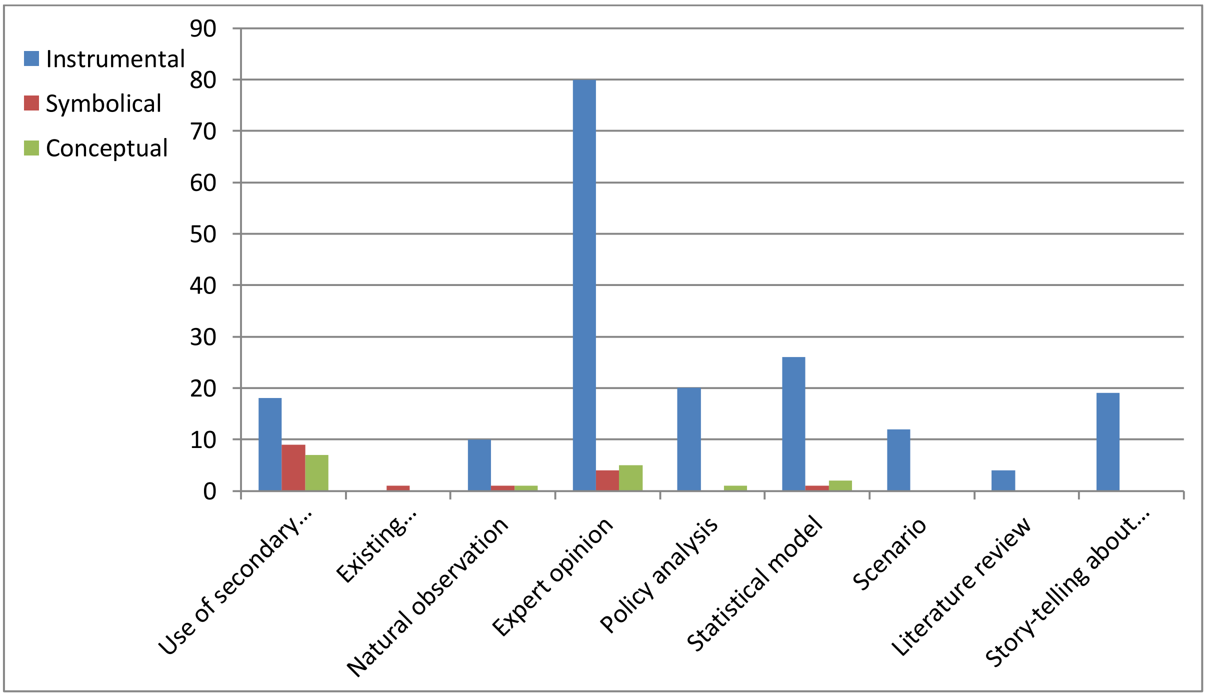

Figure 5: Uses of types of knowledge
Source: compiled by the author based on ZGB 2007

4.6.1 Instrumental

Both scientific as well as local knowledge were mostly used instrumental, as shown in the table above. Some only have been used instrumentally, like scenario (12), literature review (4) and story-telling about experiences (19). Besides, all involved actors have used knowledge instrumentally. This way of using knowledge is used to have direct influence in the plan-making process.

In addition to figure 5 is the instrumental use of the statistical model to designate the priority and reserve flood risk areas on the concept flood hazard maps, which is based on the HQ100. The result, the concept flood hazard map, is also used as scenarios instrumentally to underpin responses on opinions. The designation of the concept priority and reserve flood risk areas is based on the HQ100. This statistical model thus has been used instrumental.

As shown in the table above, expert opinions are used most often to underpin an opinion (89 out of 221). Besides it is thus also mostly used instrumentally (80 out of 89). These opinions contain for example expert opinions on the designation of a flood risk area.

4.6.2 Symbolic

The table above shows that knowledge was rarely used in a symbolic way. In general, knowledge is only used in a relatively large amount while using secondary data (9 out of 34). Besides, also statistical models (1), expert opinions (4) and natural observations (1) have been used symbolically. Knowledge was used this way to underpin the designation of flood risk areas.

4.6.3 Conceptual

Knowledge was also rarely used conceptually. Only in 17 out of 221 opinions knowledge was used conceptually. Knowledge substantiating these opinions was: scientific knowledge like secondary data (7), natural observations (1), statistical models (2), policy analysis (1); and local knowledge, thus story-telling about experiences (1). This type of knowledge is mostly used to give some background information on the subject of flood risk planning.

4.7 Influence of knowledge

As mentioned before, it is expected that the influence of knowledge depends on the types and uses of knowledge used in spatial plan-making processes. Therefore knowledge should be treated systematic, transparent and equitable (Failing, Gregory & Harstone, 2007, p. 50-51) so knowledge can influence a decision, action or a way of thinking about a problem (Rich, 1997, p. 15; in Gudmundsson, 2011, p. 148).

Because in scientific literature there could not be found an appropriate classification of the influence of knowledge in plan-making processes, the influence of knowledge has been categorised into four categories based on the RROP A (ZGB, 2007). The categorization herein is adopted in this research to classify the influence, which is as follows:

1. Knowledge with influence in the plan-making process;
2. Knowledge that partially influences the plan-making process;
3. Knowledge that underpins the plan-making process; and
4. Knowledge without influence on the plan-making process.

In this research knowledge is used during the development of the concept flood hazard maps, whereon opinions (underpinned with knowledge) could be submitted. On the basis of this knowledge the definitive designation of priority and reserve flood risk areas is represented on flood hazard maps. The paragraphs below, 4.8 and 4.9, show the influence of the knowledge used both during the development of the concept flood hazard maps as well as in the opinions.

4.8 Influence of scientific knowledge

In collaboration with other water authorities and in line with applicable policies on flood risk management, the HQ100 is used to depict the priority and reserve flood risk areas on the concept flood hazard maps.

The opinions on the concept flood hazard maps were mainly supported by scientific knowledge. Based on the values as displayed in table 3 the following values have been identified: the use of secondary data (34), existing information/ database (1), natural observation (11), expert opinions (89), policy analysis (21), statistical models (29), scenarios (12) and literature review (4). As mentioned in the third hypothesis (see paragraph 2.9.1), it is expected that there is a relation between the knowledge types and how it is used on the influence of it.

As a result of the analysis of the opinions in the RROP A, it can be concluded that only when scientific knowledge is used instrumentally, it can directly, indirectly or have no influence on the designation of flood risk areas (see table 6). Symbolically and conceptually used scientific knowledge had no influence as well as the vast majority of the opinions used instrumentally.

Table 4: Influence of scientific knowledge on decisions

Use & types / influence	Clear influence (C)	Partial influence (P)	Underpinning (U)	No influence (N)
Scientific knowledge	*29*	*5*	*44*	*119*
Instrumental	29	5	17	115
Symbolic			13	2
Conceptual			14	2

Source: compiled by the author based on ZGB, 2007

In this paragraph is analysed what causes the differences in the influence of different scientific knowledge types on the designation of flood risk areas, based on a literature analysis of the RROP A (ZGB, 2007).

4.8.1 Knowledge with influence in the plan-making process

In collaboration with other water authorities and in line with applicable policies on flood risk management, the HQ100 is used to depict the priority and reserve flood risk areas on the concept flood hazard maps.

In response to the designation of these concept flood areas only 29 opinions clearly influenced the depiction of priority and reserve flood areas on flood hazard maps. These opinions contain knowledge categorised as use of secondary data (1), natural observation (2), policy analysis (10), statistical models (15) and literature review (1). These all have been used instrumentally, knowledge being used symbolic or conceptual could not fully influence a decision. This can be related to the fact that knowledge is used to influence actions or decisions directly (Amara et al., 2004, p. 90).

Opinion 1776 is the only opinion wherein secondary data is used and accepted. Based on the concept flood hazard maps whereon a priority flood protection area has been designated in the district of Celle, the district of Celle states that this decision must be reversed because this is not in the ZGB's planning area. Therefore the ZGB is not authorized to make plans for this area. The ZGB agrees on this so this argument based on secondary data was accepted.

Two opinions were supported by natural observations, to know opinion 1742 and 1743. The district of Peine states that two areas should be designated as priority area because they were flooded in 2002 and 2003. They could prove where exactly this happened so this could be used in the plan-making process.

Statistical models have been used to designate the concept priority and reserve flood areas (HQ100 and FCM). This means that these statistical models are used instrumentally and influence the designation of flood hazard areas during the plan-making process on the development of flood hazard maps. Besides, also in the opinions some uses of statistical models can be distinguished (1671, 1729, 1730, 1733-1739, 1771, 1780, 1849 & 1855). This includes the designation of priority flood hazard areas in Braunschweig's city centre and on the territory of the Volkswagen Factory. This would mean that the use of these areas would be restricted. Both actors disagreed to this designation.

In case of the Braunschweig's city centre the ZGB (1671), water institutions the community of Braunschweig collaborated to find a solution. Statistical models from the community of Braunschweig showed that this area could be designated as precautionary flood risk area because spatial measures had been taken outside the city to increase the flood risk within the city centre.

To change the designation from priority to precautionary flood risk area on the territory of the Volkswagen Factory, the ZGB, water authorities, Volkswagen Ltd. and the Wolfsburg community collaborated (1729, 1730, 1731, 1733-1739, 1780, 1849). During this, Volkswagen Ltd. could approve that they had taken technical measures to reduce the flood risk at the Volkswagen factory (1732). This technical data had not been taken into account during the calculations on the HQ100. Based on comments of the Wolfsburg community and the Volkswagen Ltd. this area was designated as precautionary flood risk area instead of priority flood risk area.

Also some influencing opinions are based on policy analysis (1710, 1713, 1744, 1764-1767, 1850, 1858, 1863). These are based on local developments plans or building plans wherein is stated that measures have been taken to increase the flood risk in order to use these areas as building areas. Therefore these areas should be designated as reserve instead of priority flood risk area.

There is one example of a literature reviews, based on press publishing. In this opinion is stated that an area should be designated as priority flood risk area because this area is regularly flooded (1762).

4.8.2 Knowledge partial influencing the plan-making process

The second category on the influence of knowledge, distinguished in the RROP A (ZGB, 2007) is knowledge that partial influences the plan-making process. These are opinions in which a part of the knowledge is accepted as being relevant and a part is not or in which areas cannot be designated definitive because research is still going on. In this research, all opinions in which knowledge partial influences the plan-making process are used instrumental because these are used to directly influence a decision.

Three participators have used natural observations to influence decisions, and could hereby partial influence decisions. In opinion 1689 it is stated that the designation of a built area as flood risk area should be reversed because this area is flood risk free due to technical measures. Pending on new research of a water institution this opinion is not rejected but also could not directly influence a decision. In the second opinion two arguments are used, whose one has influence and one is not. It is argued on natural observations that an area could not be flooded and that such an area is designated is reproached to an incompatible statistical model. It is agreed that this area cannot be flood risk area and therefore this decision is reversed, however that the model is incompatible is not agreed on. In opinion 1859 is stated that an area should not be designated as flood risk area because there is no flood risk. According to the submitter, this error is attributed to the models used. In response to this opinion the designation as flood risk area is revoked without agreement on the argument. Opinion 1759 (ZGB, 2007) is supported by two knowledge types, to know natural observations and policy analysis. Only the natural observations influence the decision to change the designation of a flood are from reserve to priority.

Opinions based on policy analysis include statements supported by local building plans and interpretations of the FWRA (1678, 1763). These opinions are related to the opinions on policy analysis in paragraph 4.8.1. Because the opinions 1678 and 1763 substantiate decisions made in the other opinions they do have influence. However on the statement about the FWRA is disagreement and is therefore not followed.

There are also some statistical models used to substantiate opinions, to know opinion 1697, 1731 and 1761. In opinion 1697 two knowledge types are used. In a policy analysis a statement is made on the designation of flood risk arias based on the FWRA, RROP B and the NW. This view is not shared and therefore is referenced to the RROP BD. The other argument is on the use of calculations on the HQ100 developed by another engineering company on the designation of flood risk areas. Results of these calculations will be adjusted accordingly if it shows discrepancies with the current HQ100, because it is more specific. In opinion 1731 the community Wolfsburg critiques the procedure of the HQ100. In this opinion is stated that the HQ100 should be used to define reserve flood areas and priority flood risk areas should only be designated after completion of the procedure. In order to designate the right flood risk areas, areas will be designated in collaboration with the water authority in Wolfsburg. In respect to flood hazard in their community the community of Lengede developed a statistical model to check the HQ100 as designated by the ZGB. When the results of this model are clear, the results will be combined with the current HQ100. Until then this opinion has no direct influence whatsoever.

Two opinions based on scenarios are distinguished in the RROP A. Opinion 1732: by collaborating, the ZGB, Volkswagen AG and community Wolfsburg rejected the designation of a priority flood risk area on the territory of the Volkswagen, which conflicted with the designation of priority area industrial plants. This was based on geographical changes. As a result of this change, the substantive contradictions of determination could be eliminated. Opinion 1866 consists two parts: firstly a flood hazard map is used to show where flood risk areas should be designated, based on the HQ100. This map is more specific than the current concept flood hazard maps and therefore this will be adopted in the definitive flood hazard maps. Secondly it is stated that only areas should be flood risk area where this is technically justified. This is underpinning the plan-making process and thus has no clear influence.

4.8.3 Knowledge that underpins decisions in the plan-making process

Also in this research knowledge is distinguished which did not influence the plan-making process directly but supported an already made decision or relates to the designation of flood risk areas in the ZGB. This does not mean that this knowledge always is used symbolically; most times it is used instrumentally to make a decision more supported with knowledge, 20 out of 48 opinions. 14 opinions are used symbolically and 14 are used conceptually. An explanation why knowledge in this category is used symbolically or conceptually is because this knowledge is not always used to influence a decision directly.

In 22 opinions secondary data is used to underpin the statement. There are several sources of knowledge distinguished in these opinions. Firstly, in some of these opinions decisions made in the RROP are supported with results from other sources, like local measures taken to prevent floods which are already taken of will be as a result of the RROP (1672, 1704, 1722, 1728, 1688) or other researches (1684, 1705). Secondly, also is stated that other participants develop flood management plans, in line with the RROP (1673, 1676, 1686, 1760, 1777) or other spatial plans (1693, 1696, 1775, 1861). Thirdly opinions are supported by knowledge from legislation (1691, 1694, 1700, 1851, 1861). Fourthly also opinions contain a motivation to use knowledge to change the designation of flood risk areas in other opinions (1782, 1856).

Two opinions in this category are supported by natural observations (1864, 1878). In opinion 1864 is pointed out for a settling pond system for the treatment of wastewater within the village within a priority flood risk area. This is approved by the statistical model on the HQ100. In opinion 1878 is stated that the designation of a flood risk area in a certain area can be maintained because these are meadows.

There are 12 opinions based on expert opinions (1683, 1698, 1699, 1701, 1702, 1703, 1708, 1709, 1714, 1725, 1726, 1884). This includes opinions about the designation of flood risk areas because these are not yet designated (1683), include requirements or advices made by the participant in respect to flood risk management (1698, 1702, 1709, 1725, 1726), are personal objectives (1699, 1703, 1708); or comments on the designation of flood risk areas (1701, 1714, 1884).

Policy analysis is used in two opinions, to know 1704 and 1711. In these opinions is stated that the designation of flood hazard areas in Saxony-Anhalt are incorrect. This is based on the knowledge substantiating opinion 1858 (see paragraph 1.5.2), an analysis of local building codes.

Four opinions are based on statistical models (1674, 1690, 1697, 1848). Herein is advised to change the location of flood risk areas when this is the outcome of new models. Opinion 1674 can be seen as a part of the collaboration between the ZGB, community of Wolfsburg and the Volkswagen AG as mentioned in paragraph 1.5.2.

To underpin a decision one opinion is based on a scenario, to know 1778. These opinions include explanations of natural observations represented on maps, which are also shown in the concept flood hazard maps which are in line with the current concept designation of flood risk areas.

4.8.4 Knowledge without influence on the plan-making process

The last form of influence distinguished in the RROP A (ZGB, 2007) is the one of knowledge without influence in the plan-making process. This form of influence is only found in the opinions given on the concept flood hazard maps due to the fact that this forms of influence is not noticed during the development of concept flood hazard maps. Most of the opinions given were without influence: 132 out of 221. Hereof 77 are expert opinions, mostly because there is a lack of substantiation by knowledge. Also opinions were distinguished as being having no influence, substantiated on existing information/ databases, statistical models, scenarios and policy analysis.

There are several opinions substantiated by literature reviews. These include communal documents on priority flood risk areas which could not substantiate why particular areas should not be designated as flood risk areas (1754-7156).

There is one opinion without influence based on existing information/ database. This is opinion 1695, wherein is commented on the methods and results on the development of the concept flood hazard maps by means of natural observations, the RROP and own models. This opinion had no influence because the objector has withdrawn his concerns regarding the established flood areas in the meantime.

Also secondary data has been used without leading to concrete action (1677, 1680, 1685, 1692, 1746, 1753, 1768 & 1818, 1853, 1854). These comments are based on the RROP and include comments on the statistical models used to designate the flood risk areas like the HQ100 (1677, 1680, 1685, 1753, 1768, 1783, 1853, 1854); on the implementation of the RROP in communal planning (1745); and on the designation of the flood risk areas because these are not in accordance with the floodplain (1687). Also in these opinions is stated that a particular area could not be designated as priority flood risk area because this is a built area and therefore cannot be designated as flood risk area. The ZGB responded that this area is reserve flood risk area and that it is possible to designate a built area as reserve flood area (1692). And that a particular flood risk area should be reduced because the height conditions do not represent the flood lines as represented on the concept flood hazard maps. To prove the right of these lines reference is made to the HQ100 (1818).

Natural observations are used in four opinions without having influence in the plan-making process. It is used by a group of farmers who collected long-term records of water levels. With this they try to convince the ZGB to reject the flood risk areas as designated in the concept flood hazard maps (1706). Also a hill is pointed out which is designated as flood risk area and therefore cannot be flood risk area. This observation is contradicting to the concept designations and therefore rejected (1707).

Another way to use natural observations is by stating that an area should be designated as reserve flood risk area instead of priority flood risk area because it is not flooded recently. Due to the statistical models used this area remains a priority flood risk area (1757, 1781).

There are 77 opinions based on expert opinions. These are rejected to have influence because they contain neither concrete nor spatially relevant information. In respect to this, an examination of the objection is not possible based on the statistical models which have been used to designate the concept flood hazard areas in collaboration with municipalities and water authorities (1712, 1715, 1716, 1717, 1718, 1719, 1748, 1783, 1787-1828, 1857, 1860, 1865-1888). Also opinions are provided on the use of reservoirs and dams, which should be optimised in the new plans, where in the opinion is stated that these cannot be used better to prevent floods (1724). Besides, opinions have been given on subjects which are no task of regional planning (1727); or to state requirements on the plan-making process in an experts view (1740, 1852); or to advice on the definition of a priority flood risk area (1769). Furthermore, there is stated that it is impossible for local authorities to change their local building codes based on the RROP (1770). In another opinion a participant states that it should be noted that the scale of the flood hazard maps is too much generalizing (1:50.000). This is not agreed on by the ZGB (1779). Also one opinion was given on where flood risk areas should be designated without substantiation why these areas (1865).

Several opinions are given, substantiated by statistical models. These are comments on the outcomes of these models based on own statistical 1 D and 2 D-models (1746-1752). In collaboration with the submitter of this opinion and other water authorities these models are analysed. As long as the results of this analysis are not clear, is held on the current situation.

Also scenarios have been used. Maps have been distinguished as scenarios since they show a flood risk scenario. In the opinions 1681, 1682, 1785 and 1786 arguments have been given to use a different model (2 D) to represent flood risk areas on maps as included by the opinion. This is rejected because this cannot be accepted due to underlying assumptions with the federal and state regulations for flood protection. In other comment maps developed in 1914 are used to prove that an area cannot be designated as flood risk area because on this map this area is excluded as flood risk area and it is stated that the geographical situation has not been changed since (1772, 1773, 1774, 1843).

There were some opinions based on policy analysis without having influence. These include comments on the designation from a legislative view wherein is stated that flood risk areas cannot be designated yet definitive because this has to be done in line with legislative requirements. This interpretation of the legislation is not shared and therefore cannot have influence (1723, 1741). Another example of policy analysis is the use of the RROP 1995 by an actor. This document is used to prevent the designation of flood risk areas. Because these maps are outdated this opinion cannot have influence (1758). The designation of flood risk area conflicts with the current use of this area as reserve area for agriculture. This argument is refuted by referencing to current legislation in respect to flood risk management in the RROP BD (1829). Also is stated in some opinions (1844, 1845) that the designation of flood risk areas cannot interference with other legislation and local building plans. The response hereon is that the textual scheme involves no undue interference with the local planning authority. In opinion 1675 is stated that flood risk management is a task for water authorities only. This statement is contradicting to current policies so cannot influence the plan-making process.

4.9 Influence of local knowledge

As mentioned, besides scientific knowledge also local knowledge can be used in plan-making processes. It is recognised that also this knowledge types should influence the plan-making process on the development of flood hazard maps. Therefore legislation in respect to flood risk management requires active encouraging of the public to participate, for example in the FD (Council, 2007, art. 9).

Therefore it was also possible for the general public to participate in the plan-making process by submitting opinions. This resulted in 20 opinions supported with local knowledge. Hereof two partially influenced, two supported a decision, and 12 had no influence in the plan-making process on the development of flood hazard maps (see table 8). By literature research several values are defined as being local knowledge: practical knowhow; intuitions; hunches; feelings; sensibilities; and story-telling about experiences. In the case only story-telling about experience are identified. All opinions based on local knowledge were used instrumental, except one (1842).

Table 5: Influence of local knowledge

Use & types / influence	Clear influence (C)	Partial influence (P)	Underpinning (U)	No influence (N)
Local knowledge		*2*	*4*	*13*
Instrumental		2	4	13
Symbolic				
Conceptual			1	

Source: compiled by the author on the basis of ZGB 2007

4.9.1 Knowledge with influence in the plan-making process

There was no local knowledge with clear influence in the case.

4.9.2 Knowledge partially influencing the plan-making process

There are two opinions supported with story-telling about experiences which influence the plan-making process partially, to know opinion 1838 and 1840. In these opinions is stated that two areas should be designated as priority flood risk area because these were flooded before. Because this is not shown in the HQ100-calculation, new research on these two areas is started.

4.9.3 Knowledge that emphasizes the plan-making process

Local knowledge is also classified as being emphasizing decisions. Five examples are identified: opinion 1720, 1721, 1842, 1846 and 1847. In opinion 1721 is advocated that a mountain is included in the HQ100. Because this cannot be observed in the statistical models used, there is asked for a spatial clarification. Till this moment this opinion cannot influence the plan-making process. In opinions 1842, 1846 and 1847 story-telling about experiences and policy analysis are combined. Nevertheless this knowledge is classified as local knowledge because it is used by a local. In opinion

1846 and 1847 this has been used for direct influence, thus instrumental. The purpose of opinion 1842 is to inform, knowledge is thus used conceptual.

4.9.4 Knowledge without influence on the plan-making process

Most times the local knowledge had no influence at all, because they were only based on story-telling about experience and could not be supported by any types of scientific knowledge (1830-1836 & 1839 & 1841 & 1889-1891).

4.10 Conclusion

In respect to spatial planning, the regional planning institution ZGB developed the RROP in the period 2005-2008. One of the tasks herein was the development of flood hazard maps for the municipalities represented by the ZGB. Therefore a plan-making process was started, wherein several types and uses of knowledge were used to influence decisions at different stages in the process, as shown in figure 7.

Flood hazard maps have been used as cartographic tool to depict the locations of priority and reserve areas on by the ZGB. In line with legislation on flood risk management like the FD, flood risk areas were defined. Therefore firstly, based on a model, the HQ100 was defined, which shows the priority areas. In combination with the FCM also precautionary areas have been defined.

In response to the concept flood hazard maps, developed by the ZGB and other governmental water authorities, 221 opinions were submitted. This is a type of public participation. Herein mainly scientific knowledge has been used. Local knowledge was used in only 20 of these 221 opinions. Based on the operationalization of scientific and local knowledge the following values were distinguished in the opinions: use of secondary data (34), existing information/ database (1), natural observation (11), expert opinions (89), policy analysis (21), statistical models (29), scenarios (12), literature review (4) (scientific knowledge) and story-telling about experiences (20) (local knowledge). In table 6 the influence of this knowledge is shown for each value.

5. Theory, policy and practice: an analysis of the influence of knowledge in the plan-making process on the development of flood hazard maps in the Zweckverband Großraum Braunschweig

5.1 Introduction

During several stages in the plan-making process on the development of flood hazard maps in the ZGB, step 1 and 2 in figure 6, several types and uses of knowledge are distinguished trough in-depth analysing of the RROP (ZGB, 2008).

But how did this knowledge influence the decisions? In the conceptual model (figure 2) is shown that there can be a relationship between the types and uses of knowledge on the influence. Therefore the ZGB treated knowledge systematic, transparent, equitable and consistent, by analysing and commenting them in the RROP A (ZGB, 2007), in line with what Failing, Gregory & Harstone (2007, p. 50) described about this. After analysing the opinions on the concept flood hazard maps, the ZGB collaborated for the second time with institutions involved in flood risk management, like water authorities and municipalities. This, in order to make decisions that serve the general public, and to develop the definitive flood hazard maps (step 3 in figure 6).

In this chapter the relationship between types, uses and the influence of knowledge is described. Here for policies on flood risk management, the interviews and the RROP (ZGB, 2007; ZGB, 2008a; ZGB, 2008b) are analysed, based on chapter 1 till 4. In the end, this makes it possible to approve or disprove the hypotheses.

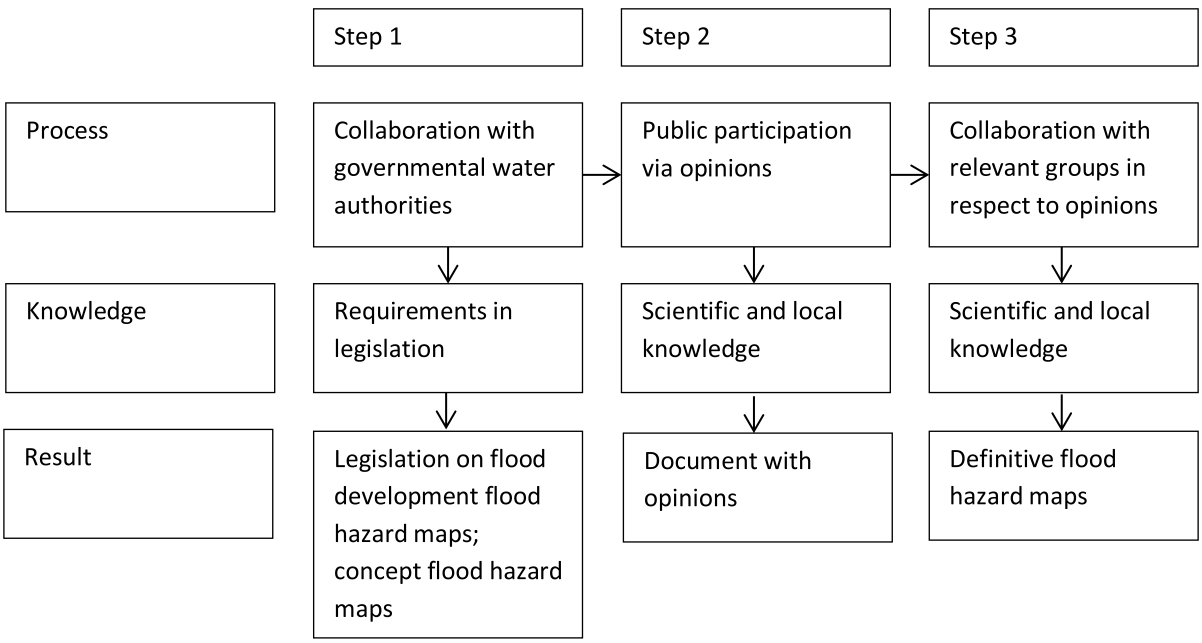

Figure 6: ZGB's plan-making process on the development of flood hazard maps
Source: compiled by the author based on the ZGB 2008b

5.2 Knowledge types

Through literature research, two knowledge types are distinguished in this research, to know scientific knowledge and local knowledge (see paragraph 2.3). The definition of these knowledge types as stated by Lindblom and Cohen (1979; in Petts & Brooks, 2006, p. 1979) is used:

> *'Whereas scientific knowledge is conceived of as deriving from objective measurements, verifiable, tested, and using distinctive techniques in its generation, ordinary or lay knowledge is based in common sense - more casual, perhaps even serendipitous, speculative, but still thoughtful.'*

To identify these two knowledge types, the RROP A (ZGB, 2007) and the RROP B (ZGB, 2008b) are analysed. Hereby the knowledge types are linked to the user to identify the knowledge types used. Scientific knowledge is articulated by professionals (McEwen & Jones, 2010, p. 1) whereas local knowledge is attributed to citizens, residents or people with specialized knowledge in a subject (Failing, Gregory & Harstone, 2007, p. 52; Wisner & Luce, 1995, p. 335).

In spatial planning, a paradigm change occurred from the transfer of knowledge from expert to public, to more public participated forms of planning wherein knowledge is exchanged and co-generated between experts to the lay public (Petts & Brooks, 2006, p. 1046; McEwen & Jones, 2010, p. 1). Also in the field of flood risk management this change occurred (Schanze, 2002; DKKV 2003; Hall et al., 2003, in Hutter, 2006, p. 229).

This change is reflected in policies on flood risk management on European and German level (federal and state). In this, requirements are included on public participation, wherein is stated that active involvement of all interested parties like governments, interested associations and other interest groups determined on a case-by-case basis (Gierk, 2009, p. 8). Involvement of the 'general public' (Council, 2007, art. 9) increases the use of local knowledge in plan-making processes.

Petts (1997; in Petts & Brooks, 2006, p. 1046) states that an increasing influence of local knowledge means that scientific expertise is demotioned or devaluated. This is reflected in the policies mentioned before, wherein for example the use statistical data and flood scenario's is required (Council, 2007; Appendix 5). Knowledge described to use are categorised as statistical models and scenarios, according to Giorgi and Tandon (2002; in Gudmundsson, 2011, p. 152). German and Lower Saxonian legislation are more specific in requiring modelling of the HQ100 and a cost-effect analysis, which can be seen as statistical models and cost-effectiveness analysis (Giorgi and Tandon, 2002; in Gudmundsson, 2011, p. 152).

In order to identify scientific knowledge and local knowledge in the plan-making process on the development of flood hazard maps in the ZGB, values are awarded (see table 3). Several of these values have been identified in the case, to know: the use of secondary data; existing information/ databases; natural observations; expert opinions; policy analysis; statistical models; scenarios (scientific knowledge); and story-telling about experiences (local knowledge).

As shown in the previous chapter, during the plan-making process on the development of flood hazard maps in the ZGB, mainly scientific knowledge was used, both by the ZGB as well as by other participants. The depiction of priority and reserve flood risk areas, based on statistical models like the HQ100 and the FCM (ZGB, 2008b) on the concept flood hazard maps, was based on policy analysis of European, German federal and German state legislation (see paragraph 4.3 and annex 5).

In order to involve the general public as required in legislation, opinions could be given on the concept flood hazard maps. This is in line with a statement by Wisner & Luce (1995, p. 344):

> *'generating local knowledge is mostly done by 'asking local residents to name or identify hazards, locate them in space and time, and relate their past experiences with, and responses to, these hazards''.*

The use of knowledge is reflected in the knowledge identified in the plan-making process on the development of flood hazard maps in the ZGB: besides scientific knowledge also local knowledge is used. Nevertheless 201 out of 221 opinions were supported by scientific knowledge. These could be identified as use of secondary data (34), existing information/ database (1), natural observation (11), expert opinions (89), policy analysis (21), statistical models (29), scenarios (12) and literature reviews (4). The 20 opinions containing local knowledge could be identified as being using story telling about experience (ZGB, 2007).

5.3 Utilization of knowledge

Knowledge can be used for problem solving and to base decisions on (Gudmundsson, 2011, p. 147). In this research three ways of using knowledge are identified: instrumentally, symbolically and conceptually. These uses are all identified in the case (see paragraph 4.6). In the case, both during the development of the concept flood hazard maps as well as during the development of the definitive flood hazard maps knowledge has most commonly been used instrumental.

In policies on both European as well as German federal and state level is a lack of direct requirements on how to use knowledge. Nevertheless it can be stated that knowledge on the HQ100, required in the FD (Council, 2007, art 6.3.b), NW (Lower Saxony, 2002, art. 92.2) and the LROP (Lower Saxony, 2002, art. 3.2.4.12.1), should be used instrumental during the development of plans because the priority and reserve areas should be designated on this knowledge.

During the plan-making process, the statistical models on the HQ100 and the FCM have been used instrumentally to depict priority and reserve flood risk areas on the concept flood hazard maps. Also in the opinions, in response to these concept maps, knowledge is commonly used instrumentally. Out of 221 opinions, in 189 of these knowledge is used instrumentally. This implies that most participants wanted their knowledge to be used for concrete actions or decisions (Amara et al., 2004, p. 90). This is reflected in the analysis of the opinions (see appendix 6), wherein all values from table 3 are used instrumental. Especially expert opinions have been used instrumentally. Besides, all opinions based on local knowledge are used instrumental.

Knowledge is only used 15 times to legitimise and sustain predetermined positions, thus symbolically (Beyer, 1997, p. 17; in Amara et al., p. 77). It can be stated that only secondary data was significantly used conceptual. This was mainly to substantiate the idea to develop flood hazard maps or to substantiate the designation of flood hazard areas.

In the remainder 17 opinions, knowledge is used conceptually, for general enlightenment (Beyer, 1997). This is mainly when secondary data has been used and in expert opinions.

A possible explanation for the overwhelming instrumental use of knowledge is that one submits an opinion to confirm his opinion and thus would like to influence the depiction of priority and reserve flood hazard areas on flood hazard maps directly.

5.4 Influence of knowledge

Based on the categorization used in the RROP A, the influence of knowledge is divided into four categories: clear influence, partial influence, underpinning and no influence. Besides the opinions in the RROP A (ZGB, 2007), also knowledge as required in legislation are categorized. The influence of knowledge is visualised in figure 7, wherein the influence of the different types of knowledge is represented. What in figure 7 is shown is explained afterwards.

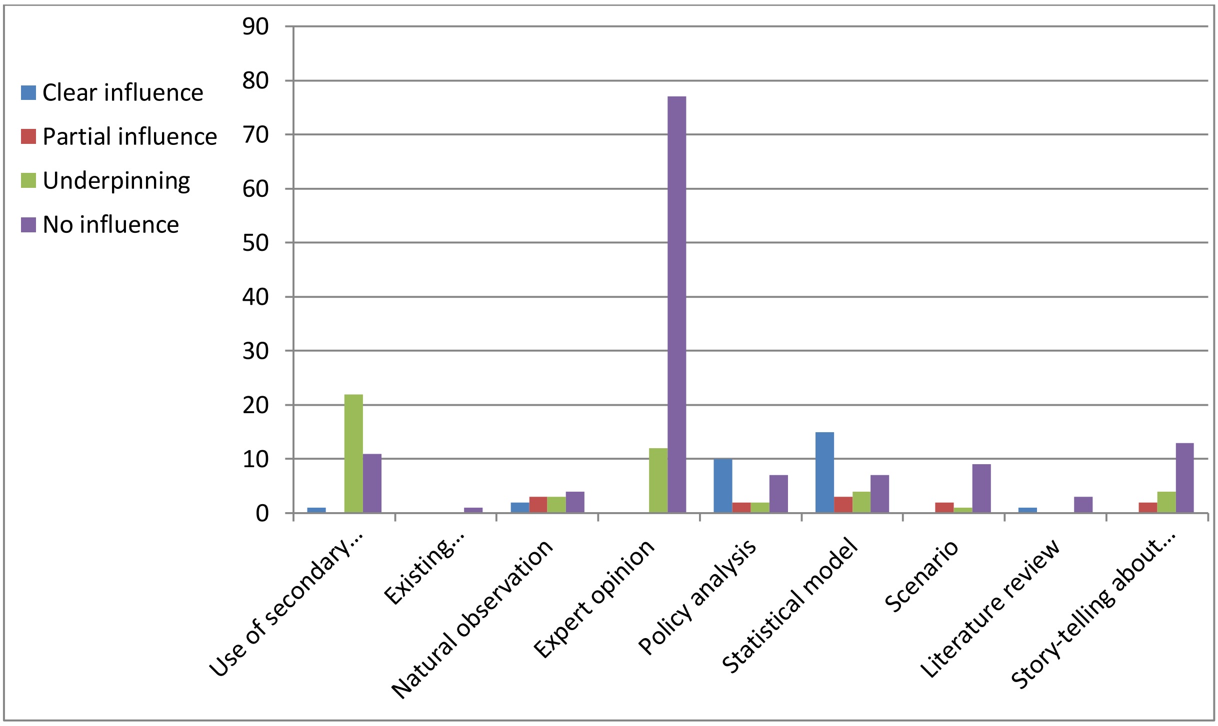

Figure 7: Influence of knowledge used in opinions
Source: authors' own based on the RROP A (ZGB, 2007)

In legislation with respect to flood risk management, the FD requires MS to use predictive models on the flood risk. This is adopted in legislation on federal and state level, leading to the designation of priority and reserve flood risk areas based on the HQ100. These should be represented on flood hazard maps, whereby several actors like governmental institutions and the general public are involved during the plan-making process. The legislative requirements thus influenced the plan-making process instrumentally.

The involvement of the general public in the plan-making process was made possible by submitting opinions. Only policy analysis and statistical models had significant influence (see table 6). These are the same types as required for in flood risk legislation. In table 6 is shown that only when used instrumentally, opinions could have influence.

Only 29 opinions clearly influenced the plan-making process, whereof 29 were underpinned by scientific knowledge. These were mostly statistical models and policy analyses on legislation in respect to flood risk management, which is in line with the knowledge required to use by legislation. Also most of the partially influencing opinions were based on this knowledge. Mostly secondary data influenced the plan-making process by underpinning already made decisions. These were mostly based on the RROP (see paragraph 4.3). Opinions were mostly rejected of having influence because there was a lack of knowledge used to underpin the statement made in these opinions. These were mostly expert opinions.

The categorization of the knowledge shows that the influence of knowledge required in legislation is significant. Almost all opinions which influenced the plan-making process were based on scientific knowledge like statistical models and scenarios. By this, opinions without underpinning of knowledge could not be accepted to influence the plan-making process.

5.5 Testing the hypotheses

In paragraph 2.9, as a theoretical answer on the first three research sub-questions, the following three hypotheses are named:

1. *both scientific as well as local knowledge are used to influence the depiction of flood risk areas on flood hazard maps;*
2. *knowledge is mainly used instrumental to influence the depiction of flood risk areas on flood hazard maps;*
3. *scientific knowledge, when used instrumentally, has the greatest influence on the depiction of flood risk areas on flood hazard maps.*

In this paragraph these hypotheses are tested to practice, by comparing them to the results of the exploration of the depiction of flood risk areas on flood hazard maps in the ZGB.

5.5.1 Testing the hypotheses to practice

In the hypotheses three variables are distinguished: the types, uses and influence of knowledge used in the plan-making process on the development of flood hazard maps in the ZGB. Firstly, therefore it is explored if the theoretical answer on the types of knowledge can be confirmed or has to be denied. Secondly, it is explored whether or not knowledge is mainly used instrumental. And thirdly, it is explored if scientific knowledge, when used instrumentally, does in practice haves the greatest influence. This is based on the exploration of the RROP A (ZGB, 2007), the RROP BD (ZGB, 2008a) and the RROP B (ZGB, 2008b) in the previous paragraphs of this chapter.

Hypothesis 1

The first hypothesis can be confirmed, both scientific as well as local knowledge were used to influence the depiction of flood risk areas on flood hazard maps. During the development of the concept flood hazard maps, only scientific knowledge was used (for example models like the HQ100).

This changed during the plan-making process, herein both scientific and local knowledge were used. This is in line with legislation in respect to flood risk management, wherein is required that scientific knowledge is used, for example in the FD (Council, 2007), and wherein is stated that the 'general public' (Council, 2007, art. 9) should be interacted in the plan-making process. Nevertheless, it should be noted that 191 out of 221 opinions, given on the concept flood hazard maps during the consultation process, were supported by scientific knowledge and that 175 of these were used instrumental. Out of 20 opinions based on local knowledge, 19 were used instrumentally and one conceptually. This shows that mainly experts interacted in the development of the definitive flood hazard maps.

Hypothesis 2

The second hypothesis can also be confirmed, because most knowledge was used to have direct influence on a decision, in this case the depiction of flood risk areas on flood hazard maps. Nevertheless, both types of knowledge (scientific and local) were used instrumentally, symbolically and conceptually. As mentioned, knowledge in the opinions was mainly used instrumentally: 189 out of 221 (175 out of 191 scientific; 19 out of 20 local). In only 15 opinions knowledge was used symbolically; in 17 opinions knowledge was used conceptually.

Hypothesis 3

The third hypothesis can also be confirmed. Scientific knowledge, when used instrumentally, had the greatest influence on the depiction of flood risk areas on flood hazard maps. It can even be stated that only scientific knowledge directly influenced the designation of priority and reserve flood risk areas in the case (see: table 6). Most of the knowledge used to substantiate statements in the opinions had no influence, 132 out of 221, whereof 13 were based on local knowledge out of 20 opinions underpinned by local knowledge (see: table 6). This means that also this part of the hypothesis can be confirmed; scientific had a greater influence in the plan-making process on the development of flood hazard maps in the ZGB.

The results of this research underpin the hypotheses, as shown above. In the plan-making process on the depiction of flood risk areas on flood hazard maps, both scientific and local knowledge are used to influence the depiction. Nevertheless only scientific knowledge could clearly influence decisions.

6. Conclusion and recommendations

This research has contributed to the theory of the possible link between the types, uses and influence of knowledge in spatial plan-making processes on the depiction of flood risk areas on flood hazard maps. The research question in this study was:

> *What was the influence of different types and uses of knowledge on the depiction of flood risk areas on flood hazard maps during the regional spatial plan-making process in the Zweckverband Großraum Braunschweig?*

Herein a distinction is made in the role of the types, uses and influence in spatial plan-making processes as described in scientific literature and in the case of the plan-making process on flood hazard maps in the ZGB.

To answer the research question the following research sub-questions were used:

1. What knowledge types can influence decisions in plan-making processes on the development of flood hazard maps?
2. How can knowledge be used in plan-making processes on the development of flood hazard maps?
3. What kind of influence can different types and uses of knowledge have in plan-making processes on the development of flood hazard maps?
4. What new knowledge about the influence of different types and utilization in plan-making processes on the development of flood hazard maps learned in the Zweckverband Großraum Braunschweig, can be contributed to the scientific debate and to the HR?

This research is done to perform one of the research goals: to identify the influence of the different types and uses of knowledge in the ZGB. After analysing theory and legislation in respect to these variables and flood risk management it is expected that there is a relationship between the types and uses of knowledge and their influence in the plan-making process. In chapter two, this is expressed in theoretical answers on these questions, based on literature research of scientific literature, by the following hypotheses:

1. *Both scientific as well as local knowledge are used to influence the depiction of flood risk areas on flood hazard maps;*
2. *Knowledge is mainly used instrumental to influence the depiction of flood risk areas on flood hazard maps;*
3. *Scientific knowledge, when used instrumentally, has the greatest influence on the depiction of flood risk areas on flood hazard maps.*

6.1 Conclusions

The conclusions in this paragraph are structured by answering the research (sub) questions.

1. Which types of knowledge can influence decisions in plan-making processes on the development of flood hazard maps?

By answering the research questions, firstly is shown that two knowledge types could be distinguished, to know scientific and local knowledge. An important difference between these types is that scientific knowledge is used by experts (McEwen & Jones, 2010, p. 1; Healy, 2008, p. 863) and local knowledge by citizens (Wisner & Luce, 1995, p. 344). Secondly three uses of knowledge have been distinguished, to know the instrumental, conceptual and symbolical use. Knowledge is used instrumentally when it should lead to concrete action or decisions (Amara et al., 2004, p. 90). If knowledge is used symbolically this is to legitimise and sustain predetermined positions (Beyer, 1997, p. 17; in Amara et al., 2004, p. 78). Using knowledge conceptually means that it is used for general enlightenment (Beyer, 1997, p. 17; in Amara et al., 2004, p. 78). Thirdly four forms of influence have been distinguished, to know: clear influence, partial influence, underpinning and without influence.

Based on interviews and literature research, the types, uses and influence of these are identified in the plan-making process on the development of flood hazard maps in the Zweckverband Großraum Braunschweig, a spatial planning region in Lower Saxony, Germany. This is based on values awarded to these variables and set forth in the operationalization of these. Results of this exploration are shown in chapter three and four. From this can be drawn up that in this particular research scientific knowledge, when used instrumental, had the most influence in the plan-making process.

This research has focussed on two stages of the plan-making process because during these, knowledge is used to influence the depiction of flood risk areas on flood hazard maps. Herein a rough distinction can be found due to the users of knowledge. During the first stage, knowledge is used by the ZGB and other governmental institutions in the development of concept flood hazard maps. During the second stage, knowledge used in opinions, is integrated in the process in order to designate the flood risk areas on the final flood hazard maps. This knowledge is submitted by numerous actors like municipalities, interest groups and citizens of the ZGB.

2. How can knowledge be used in plan-making processes on the development of flood hazard maps?

As revealed by literature analysis, the development of the concept flood hazard maps is influenced by scientific knowledge, used instrumentally, as required in legislation on flood risk management. This legislation requires developing flood hazard maps. This tool should be used for the graphic representation of priority and reserve flood risk areas. This categorization is based on the restrictions on other spatial functions in flood risk areas. In priority flood risk areas only functions are allowed as long as these do not increase the flood risk. Other spatial functions are tolerated in reserve flood risk areas as long as they serve a more general interest and if at a different locations measures have been taken to promote the reduction of the flood risk. The designation of these flood risk areas should be based on statistical models showing the HQ100, which are areas with risk on flooding during floods that normally occur only once every 100 years. In line with these requirements, the priority and reserve flood risk areas on the concept flood hazard maps are designated based on the HQ100. Here for statistical models have been used. This is done in accordance with several governmental institutions responsible for flood risk management in Lower Saxony.

Another requirement in legislation is to actively involve the general public in the plan-making process. Therefore the opportunity to interact is given to other interested actors by submission of opinions. These opinions contain several values of both knowledge types, which have been used in different ways and influence the designation of flood risk areas differently. In the case the following values of scientific knowledge are found: the use of secondary data (34 opinions), existing information/ database (1), natural observation (11), expert opinions (89), policy analysis (21), statistical models (29), scenarios (12), literature review (4). Only one value of local is found: story-telling about experiences (20) (see table 6).

Table 6: Type, utilization and influence of knowledge used in opinions during the plan-making process on the development of flood hazard maps

Type of knowledge	Number of opinions	Use			Influence			
		Instrumental	Symbolic	Conceptual	Clear	Partial	Underpinning	No
Scientific knowledge		201						
Use of secondary data	34	18			1		6	11
			9				9	
				7			7	
Existing information/ database	1	1						1
Natural observation	11	9			2	3		4
			1				1	
				1			1	
Expert opinion	89	80					6	74
			4				2	2
				5			4	1
Policy analysis	21	20			10	2	2	6
				1				1
Statistical model	29	26			15	3	1	7
			1				1	
				2			2	
Scenario	12	12				2	1	9
Literature review	4	4			1			3
Local knowledge		20						
Story-telling about experiences	20	19				2	4	13
				1			1	
Total	221	189	15	17	29	12	48	132

Source: compiled by the author based on ZGB 2007

These different values in the opinions have been used instrumentally, symbolically and conceptually. Knowledge is used instrumentally in 189 out of 221 opinions. This shows that most opinions are submitted to have direct influence in the plan-making process. In only 15 opinions knowledge is used symbolically, thus to legitimise and sustain predetermined positions. The remainder 17 opinions show that knowledge also is used for general enlightenment, thus conceptually, in this research.

In the second hypothesis is stated that both scientific as well as local knowledge can be used instrumentally, symbolically and conceptually. After literature analysis on the case it can be concluded that this is also during the plan-making process on the development of flood hazard maps in the ZGB, as described above. Now that the types and uses of knowledge are distinguished, we come to the question what the influence of knowledge was. The results of the literature research are described below, whereby separately the influence of scientific and local knowledge is discussed.

3. What kind of influence can different types and uses of knowledge have in plan-making processes on the development of flood hazard maps?

As shown in table 6, only when scientific knowledge is used instrumentally it influenced the designation of flood risk areas. This can be related to the fact that knowledge is used to influence actions or decisions directly (Amara et al., 2004, p. 90). When knowledge is used in another way it is not meant for direct influence but for example to underpin a decision. Most opinions with clear influence are based on statistical models or policy analysis. These describe situations wherein technical measures have been taken to reduce the flood risk or other spatial functions are more important, whereby the designation should be changed from priority to reserve flood risk area. This is in line with the development of the concept flood hazard maps, wherein also only these values are used. Besides statistical models and policy analysis also natural observations, literature review, and secondary data is used.

Another conclusion is that only 12 opinions have partial influence (see table 6). In these opinions two values of knowledge were used, whereof only one had influence and one was not. This does not mean that the opinion directly had influence but can also mean that pending on new research; a decision is made later on. All knowledge in these opinions is used instrumental, because this is used to have influence in the plan-making process. Knowledge used in this form of influence is quite diverse and contains the use of policy analysis, statistical models, natural observations and scenarios.

Underpinning knowledge can be found in 48 opinions. Values of knowledge found in this category are: use of secondary data, natural observations, expert opinions, statistical models, scenarios and policy analysis. The use of knowledge to substantiate an opinion is almost equally divided between instrumentally, symbolically and conceptually. Symbolically or conceptually used knowledge is not used to directly influence decisions, which explains why these are mostly placed in this category. Most of these opinions are based on the use of secondary knowledge, 22. In the latter these are based on other policies like decisions made in the RROP, local building plans or flood management plans. Also striking is that 12 opinions are based on expert opinions. These contain mainly advices in respect to flood risk management.

Most of the opinions submitted were without influence, 132 out of 221. And almost all these opinions are based on knowledge which is used instrumental. This can be explained by the large number (77) of opinions wherein an expert's opinion is given, without substantiation of any knowledge relevant to flood risk management. Also many of these opinions are based on critiques on the statistical models used in the RROP. Herein misses a good explanation why these critiques are right.

In comparison with scientific knowledge rather little local knowledge is used, nevertheless citizens could also submit an opinion. In almost all opinions local knowledge is used instrumentally, except for one opinion in which knowledge was used conceptually. This can be explained by the fact that all these opinions are submitted because the submitter is involved personally, positive or negative and therefore would like to have influence in the plan-making process. As shown in the table below, most opinions had no influence. This is because they were not underpinned by knowledge; only a statement was made in these opinions.

4. What new knowledge about the influence of different types and utilization in plan-making processes on the development of flood hazard maps learned in the Zweckverband Großraum Braunschweig, can be contributed to the scientific debate and to the HR?

This research also provides some new knowledge for the scientific debate. In the scientific debate several statements on the use of types, uses and influence of knowledge are made. On the use of knowledge is for example stated that the three ways of using knowledge should be combined. The results of this research shows that this has been done; but to have clear influence on a decision knowledge can best be scientific and used instrumental, despite of the systematic treatment of the knowledge. There is a reason for this, only well-founded opinions have been accepted and scientific knowledge is controllable. Also local knowledge is accepted, as long as it is controllable and serves the public interest. This makes the flood hazard maps more locally suited.

The use of knowledge like the statistical models to define the HQ100 prove that the change in flood risk management from traditional to holistic flood risk management is not going on; long-term flood risk management strategies including spatial planning, are used. The participation of the ZGB with different stakeholders during the development of the flood hazard maps is in line with this change because hereby knowledge is exchanged and co-generated, which is advocated in literature.

4.1.1 Central conclusion

In this research the role of knowledge in the depiction of flood risk areas on flood is researched, based on the following research question:

> *What was the influence of different types and uses of knowledge on the depiction of flood risk areas on flood hazard maps during the regional spatial plan-making process in the Zweckverband Großraum Braunschweig?*

The exploration of this research question shows important conclusions, which underpin the hypotheses mentioned before. The first conclusion is that the designation of priority and reserve flood risk areas mainly is based on scientific knowledge when used instrumentally. Generally the influence of local knowledge can be neglected in this process. Both during the development of the concept flood hazard maps as well as during the development of the definitive flood hazard maps, statistical models and requirements in legislation influenced the designation of priority and reserve flood risk areas most. It can be concluded that only opinions underpinned with knowledge which is testable and verifiable can influence the designation of flood risk areas on flood hazard maps.

4.2 Reflection and recommendations

By the contribution of new knowledge to theories on the types, uses and influence of knowledge in the plan-making process on the development of flood hazard maps the purpose of this study is achieved. Nevertheless some aspects of this research could be done better and differently. In this paragraph is reflected on the research process and subsequent recommendations for future research.

4.2.1 Process and methods

Due to the short time of this research is chosen to base most of the research on a literature research of the empirical data. A comment on this research is therefore that also the conclusions in this research are mainly based on this literature research. Between this analysis and the reality could possibly be a discrepancy. Therefore it is advised for further research to interview several participants, who used different types and uses of knowledge, during or after the plan-making process. This makes it possible to check and compare the conclusions of the literature research with the practice.

4.2.2 Theory and operationalization

Types

In chapter two, the values of scientific knowledge are based on categorization types of knowledge technologies for transport evaluation. This table is developed for another field of spatial planning but is chosen because it shows a clear representation of scientific knowledge. As far as literature analysis showed the combination of this particular scheme has not been used before in the field of spatial flood risk management. In reflection, it has seemed to fit well to the scientific knowledge used in this research, all opinions based on scientific knowledge could be defined to one of the types of knowledge stated in this. In order to check whether this table fits other cases or could be otherwise classified, further research is advised.

Utilization

Secondly, in this research is decided to clearly separate the different types of knowledge. Scientific knowledge is identified by being used by experts and local knowledge is identified by being used by local inhabitants. As shown in paragraph ?? this categorization is not entirely consistent with the practice. Four opinions underpinned by local knowledge should be classified as opinions and one as statistical model, which is a type of scientific knowledge. Because such categories were not defined for local knowledge, these four opinions are classified as story-telling about experience. This proves the statements as made Knorr-Cettina (1999; in Healy, 2008, p. 863) and Corburn (2005; in Healy, 2008, p. 863) that scientists use local knowledge and locals use scientific knowledge. In further research it is advised to make it possible to classify this knowledge also in local opinions.

Another point of critique is on the way the use of knowledge is explored in the case. This has been done by exploration of the opinions included in the RROP A (ZGB, 2007). On the basis of how the goal of using knowledge is expressed is determined how this knowledge is used. This is a personal interpretation which is not controlled in practice, by for example interviews. The categorization of the uses of knowledge in this research is based on a personal interpretation in the way that opinions have been expressed. This is done because this gives an objective view on this. The results of this exploration on the utilization of knowledge would be more generalized is other researchers also qualified the opinions, after which the results would be compared to each other.

Influence

A second point of commentary is that the classification of the influence of knowledge, is based on the classification used to judge on the influence of an opinion in the RROP A (ZGB, 2007). In paragraph 2.5, it is explained that notwithstanding in-depth literature research, no other classification could be found. Therefore this categorisation did fit this research but further research on other cases is advised to find out whether or not this also can be used more often in research on the development of flood hazard maps.

4.2.3 Generalizability

As mentioned in the first chapter, one of the reasons to do this research is to inform the HR in respect to the role of knowledge in the plan-making process on the development of flood hazard maps. Besides the conclusions as described above, and in line with the shift in spatial plan-making processes, the HR could try to interact earlier in the process with local citizens to make the maps more locally suited. This makes it easier for citizens, on whose behalf the flood hazard maps are made, to interact and maybe causes a greater influence of local knowledge in the designation of priority and reserve flood risk areas.

In the event of further studies on the types, uses and influence of knowledge it should be noted that due to for example different spatial circumstances, changing paradigms in spatial planning, other compositions of stakeholders and changing legislation, for each casus should be pre-conceived if the theory and methods used in this research also fit in new researches. If these are still comparable, the results of these researches should be compared to the results in this research, to make the results more generalized.

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Appendixes

Appendix 1: Interview Region Hannover

Region Hannover, Hannover, 30 April 2010
Mark Herrmann
Frank Scholles
Frank Wildschut

Question 1: On which spatial plan is the RROP 2005 based?
On the Landes Raumordnungsprogramm Niedersachsen 2008. The explanation is not binding, the plan itself is.

Question 2: What types of flood areas are designated in the RROP 2005?
Vorranggebieten für Hochwasserschutz: these are binding, based on the HQ100. Vorsorggebieten für Hochwasserschutz: these are not binding, not based on HQ100. The problem is: two floods made flood prevention a hot issue. After this the public interest declined: too expensive, conflicting with other spatial designations. Therefore only research to the HQ100 was done for the Leine.

Question 3: When does the new RROP take into force?
Once per 10 years the RROP is changed. Next time all waters will be researched because the state (Lower Saxony) ordered that to do in 2007. This has already been done in

Question 4: Do you think that the floods directive will cause major shifts?
No, the implementation has been done in the Wassergesetz (German government, 2005). The main problem will be the lack of data on former flood plains.

Question 5: Why are the Vorsorggebieten für Hochwasserschutz not binding?
Because this was not mentioned in the Landes Raumordnungsprogramm Niedersachsen. In the 2008 version this is binding, so this will be changed.

Appendix 2: Interview 1 ZGB

Zweckverband Großraum ZGB, ZGB, 24-06-2010
Andre Menzel
Frank Wildschut

Question 1: What type of information has been used by the development of flood hazard maps?

Technical data from own research. The Aue-Lehm-Method has been used, giving graphical information on the location on current and former flood plains. This has been used to designate the Vorranggebieten für Hochwasserschutz: and Vorbehaltsgebieten für Hochwasserschutz. Our own HQ100 has been compared to the HQ100 as calculated by the Lower Saxony government. This was quite similar. These were the already existing Vorranggebieten für Hochwasserschutz. This has been combined with personal knowledge about flood plains of persons working at the Landkreises. Hereby the final Vorranggebieten für Hochwasserschutz were designated based on maps (12,5m x 12,5m).

Problem was that Germany had not set Vorbehaltsgebieten für Hochwasserschutz legal. In 2005 this has been requested.

The flood areas have been designated as Vorbehaltsgebieten für Hochwasserschutz.

Question 2: How has this information been used in making decisions?

Was leading in making decisions. When comments based on other (technical) information are compared with our own research. Comments can change the decision sometimes when it is based on good information.

Question 3: Who made the decision of designation?

The ZGB, sometimes in cooperation with other actors. These other actors could show the ZGB that there help could be useful to make the good decisions. For example the ZGB and Wolfsburg municipalities.

Question 4: Was money, information or property from influence?

Only information.

Question 5: Was the media used to influence the public opinion?

No, only to inform.

Personal comment A. Menzel: you could use the problems in ZGB's city centre and of the VW factory as examples of designation problems. ZGB → problems with city centre designated as Vorranggebiet. After discussion with community decided to change this to Vorbehaltsgebiet based on technical data. This showed that the problems of flooding could be solved somewhere else. VW → regional important employer. Part of it designated as Vorranggebiet, making it impossible to work there longer. Based on VW-research was shown this area has changed and measures have been taken to prevent floods there.

Appendix 3: Interview 2 ZGB

Zweckverband Großraum ZGB, ZGB, 02-12-2010
Andre Menzel
Frank Wildschut

1. Were targets set by the ZGB before the planning process followed by research or vice versa; were these targets made in agreement with other actors; and what are these targets?

The target set by the ZGB in agreement with other water authorities was that in line with the legislation on flood risk management like the FD, spatial flood hazard maps had to be developed, based on the best available techniques.

2. Was there a possibility to change the targets following the conclusions of research done by the ZGB, and what did really change?

No, the targets did not change, but the results from the research, the HQ100, could be influenced by other actors because after the calculations on the HQ100, we started a collaboration process and consultation wherein everyone interested in the subject could response.

3. Did research done by other actors than the principal influence the targets of question two; in case that, what did change?

Yes it did, the results can be found in the Regionales Raumordnungsprogramm 2008 Abwagung. Most of the changes were small, like the HQ100 crossed a house and therefore had to be changed, because the resident cannot live in a priority flood risk area. If necessary, the resident had to change the surroundings of his house for example.

4. Was research by other actors done following the targets of the ZGB, did they follow their own targets, or was there an agreement about targets between the ZGB and the other actors about the targets?

The research done by the other actors did not follow the targets as set by the ZGB. But, because they responded to the concept flood hazard maps, the research was quite in line with the research done by the ZGB. Besides the research, we also listened to experiences of persons working at a water authority, because they have valuable knowledge about where floods occur in addition to the HQ100.

5. Was there some agreement as to what counts as evidence in what circumstances?

The HQ100 was the main evidence. People who wanted to influence, thus change, the HQ100 had to show their evidence. What was seen as evidence differed from time to time. In the end there was on most parts agreement on what was evidence.

6. Was there a strategy of creating evidence in priority areas, with concomitant systematic efforts to accumulate evidence in the types of robust bodies of knowledge; and what was this strategy?

No, there were no strategies. Only the HQ100, flood maps from 1913 and personal experiences were used as evidence.

7. How was such evidence actively disseminated to where it is most needed, and made available for the widest possible use in the planning process?

The evidence was available for everyone.

8. Were the strategies from question seven put in place to ensure the integration of evidence into policy and encourage the utilisation of evidence in practice?

No the HQ100 was a result of the European, German and Lower Saxony legislation, not that the evidence influenced policy on this subject. We only discussed with higher water authorities about the *splitting the flood risk areas in priority and precautionary flood risk areas because there would otherwise be large areas where no other spatial function was allowed than flood risk area. Thus yes, this influenced the legislation, due to the collaboration between the different governmental water authorities.*

9. How have inhabitants of the ZGB been involved in the plan-making process on the development of flood maps?

They have had the possibility to give their vision on the concept depiction of flood hazard areas, which have been included in the 'Abwächungsunterlage RROP 2008'. Besides, in this document the visions and our view on the relevance of this knowledge are included, and we described if the knowledge influenced the definitive designation of flood hazard areas and thus the depiction on the flood hazard maps.

Appendix 4: Information about flood hazard maps

To dispose hazard zones on maps, several factors need to be understood which can be shown on different maps like flood extent and flood depth (figure 1). Several types of flood hazard maps can be named like historical flood maps, flood extend maps, flood depth maps, flood danger maps, qualitative risk maps quantitative risk (damage) maps (de Moel et al., 2009, p. 292-294). These maps differ in the way that information is shown.

Except the historical flood map, on which flooded locations are represented as points, the flood hazard maps are highlighted locations by the use of patterns. Historical flood maps show extents of historical floods. Using remote sensing imagery flood extents of current or very recent floods can be determined. This can be used in statistical and modelling tools to calibrate or validate flood extents and calculate the hazard of hypothetical floods. By this, several parameters can be used to denote the flood hazard like the flood extend, water depth, flow velocity, duration, propagation of water front and the rate at which the water rises (de Moel et al., 2009, p. 291).

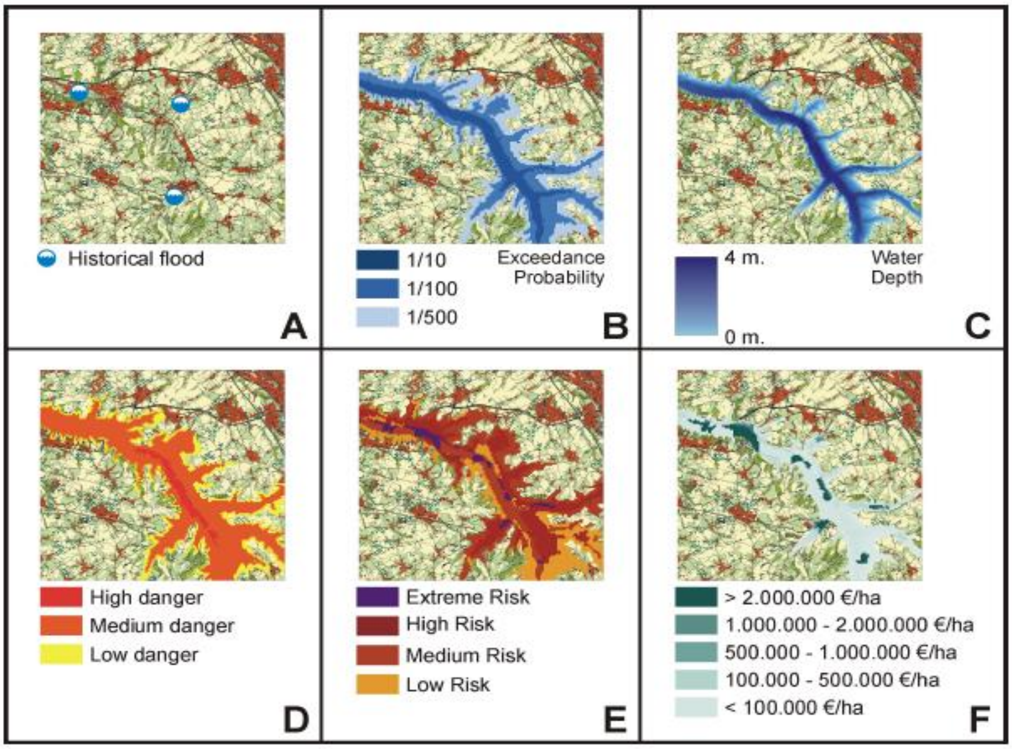

Figure 8: Different flood map types: (A) historical flood map; (B) flood extend map; (C) flood depth map; (D) flood danger map; (E) qualitative risk map; (F) quantitative risk (damage) map
Source: de Moel et al., 2009, p. 293

Flood extent maps are the most common flood hazard maps disposing inundated areas at a specific moment. These are mostly based on two-dimensional models showing the HQ100, showing the distribution of the water depth within the flooded area based on a hypothetical flood event happening every 100 years. Flood depth maps depict the water depths during specific returning periods. These are mostly based on the HQ100. These two types of maps are usually considered the most important parameters to depend flood hazard maps on. Depending on the situation and the purpose of the flood hazard map, the other parameters of which maps are shown in figure 1 can be important and show a single return period because it is impossible to depict several return periods on a single map (de Moel et al., 2009, p. 292).

Appendix 5: European, German and Lower Saxonian policies on flood risk management

European legislation on flood risk management

In Member States (after this: MS) of the European Union (after this: EU), several governmental levels influence the organization of space, and thus also flood risk management. For a comprehensive coordination of flood management within its MS, from the European level two directives were developed to influence the management of flood risks. These are the 'Directive 2000/60/EC establishing a framework for the Community action in the field of water policy', also known as the Water Framework Directive (Council, 2000; after this: WFD) and the 'Directive 2007/60/EC on the assessment and management of flood risks', also known as the Floods Directive (Council, 2007; after this FD). The FD describes that:

> 'in order to have available an effective tool for information, as well as a valuable basis for priority setting and further technical, financial and political decisions regarding flood risk management, it is necessary to provide for the establishing of flood hazard maps and flood risk maps showing the potential adverse consequences associated with different flood scenarios (…) In this context, Member States should assess activities that have the effect of increasing flood risks' (Council, 2007, art. 12).

Named above are flood hazard and flood risk maps. In spatial planning, maps are commonly used as tools to present the result of plan-making processes. Also during these plan-making processes on the development of flood maps, public participation is required by the WFD and FD (Council, 2007, art. 9 & 10). The focus in this research is on flood hazard maps since flood hazard maps present the spatial impact of flood management plans and are thus more relevant to spatial planning than flood risk maps which show more detailed qualitative interpretation.

One of the governmental levels influenced by the European and federal directives and legislation on flood risk management is the region. Their task, regional planning, 'is primarily concerned with influencing the organization of the physical spatial structure within a region' (Dühr et al., 2010, p.32).

Requirements on the development of maps

Both the WFD and the FD require MS to visualise the current spatial situations and measures taken by maps. Requirements about what to show on these maps influence possibly influences the results of what is disposed on federal, state and regional maps.

Since the focus in the WFD is on the quality of surface waters it requires MS to map the following issues in their river basin management plans, without taking notice of flood risks:

- the location and boundaries of water bodies (for surface waters);
- the ecoregions and surface water body types within the river basin (for surface waters);
- the location and boundaries of the groundwater bodies;
- protected areas (…); and
- the monitoring networks, and the results of the monitoring programmes (…) (Council, 2000, annex VII A 1.1).

As part of the flood risk management plans, the FD requires MS to develop two types of maps: flood hazard maps and flood risk maps (Council, 2007, art 6.1). These maps cover areas with an existing potential significant flood risk or where it is likely to occur (Council, 2007, art. 5.1). Since in this research only is focussed on flood hazard maps, the flood risk maps will not be discussed here.

Flood hazard maps ‘cover the geographical areas which could be flooded according to the following scenarios:

- floods with a low probability, or extreme event scenarios;
- floods with a medium probability (likely return period ≥ 100 years);
- floods with a high probability, where appropriate’ (Council, 2007, art. 6.3).

These flood hazard maps have to show for every scenario from article 6.3:

- the flood extent;
- water depths or water level, as appropriate;
- where appropriate, the flow velocity or the relevant water flow (Council, 2007, art. 6.4).

The requirements described above results per MS in several types of flood hazard maps, like for example: flood extent maps, water depths maps and flow velocity maps. Besides, these flood hazard maps include flood danger maps and flood event maps like historical maps (EXIMAP, 2007, p. 15). In MS, most commonly used are flood extent maps, about 80% of the MS developed them already, and thence partial complying with the FD (de Moel et al., 2009, 298).

German and Lower Saxonian legislation on flood risk management

After the flood in August 2002 in the Elbe and the Danube catchment areas, on the federal administrative level it was recognised that a change in flood risk management was required. This marked a paradigm change, which is represented in legislation on flood risk management. Management of the flood risk shifted away from only protection to holistic risk management by including spatial planning. Due to the federal structure of planning, this resulted in flood risk management plans on the governmental levels, including the development of flood maps (Samuels, Klijn & Dijkman, 2006, p. 313), as shown in appendix 4. In this paragraph will be shown what current federal and state legislation require in respect to the development of flood risk management plans and flood hazard maps.

Federal legislation on flood risk management

In response to the 2002 flood, therefore in May 2005 the Flood Control Act (Bundesministirum fur Justitz, 2005) was adopted by the German cabinet. The FCA introduces a nation-wide standard for defining flood hazard and relates 100-year flood zones to land use regulations by demanding amendments in laws like the FWRA, the Federal Building Code (Bundesministerium der Justiz, 2011; herafter: FBC) and the Federal Regional Planning Act (Bundesministerium der Justiz, 2009; after this: FRPA) (Petrow et al., 2006, p. 723). This FWRA (Bundesministerium der Justiz, 2007, art. 74.2) requires in respect to mapping the following:

- country-wide mapping of inundation zones, defined as the 100-year flood area; and
- mapping of flood-prone zones, defined as the area that would be inundated by the 100-year event if flood protection would fail.

In comparison to the FD, this law is far more restrictive on the use and spatial planning in flood prone areas, while requiring almost the same. The implementation of the FD in German federal legislation was therefore not really problematic (Reinhardt, 2008, p. 473). At 31 May 2009, the FD was transposed by an amendment into the FWRA (Gierk, 2009, p. 1). As mentioned, besides the FWRA also the FBC and the FRPA contain requirements about flood risk management and the development of flood hazard maps (Petrow et al., 2006, p. 723). Therefore these three laws will be discussed.

The FWRA (Bundesministerium der Justiz, 2009) requires to set up objectives in regard to the protected interests: a survey of the river basins; an assessment of the flood risk (flood risk management plans), and flood hazard/ flood risk maps in order to protect the human health, the environment, cultural heritage and economic activity and considerable material assets. Based on the WFD and the FD (Council, 2007, art. 4 & 5), the flood risk management plans must document inter alia:

- ‘the flood hazard maps and flood risk maps;
- the conclusion resulting from the evaluation of the flood risk and the result of the analysis of deficits;
- the appropriate objectives;
- measures to achieve the objectives and their priorisation,
- co-operation in shared river basin districts, for example with regard to the methodology applied to the cost-benefit analysis, as well as the assessment of measures with transnational impacts; and
- details regarding the implementation of the flood risk management plan, for example monitoring, information and public consultations, documentation of the responsibilities determined and coordination with the WFD’ (Gierk, 2009, p. 6-7).

In respect to the areas affected by floods, depicted on the HQ100 (see paragraph 4.3.1), it is inter alia forbidden to develop new buildings like settlements (Bundesministerium der Justiz, 2007, art. 78.1) unless there is no other option (Bundesministerium der Justiz, 2007, art. 78.2-78.4). This is further described in the FBC (Bundesministerium der Justiz, 2011, art. 30 & 33-35). The FRPA 2009 (Bundesministerium der Justiz, 2009) requires the development of spatial plans, which inter alia contain provisions for spatial structure including opens spaces to ensure the preventive flood protection (Bundesministerium der Justiz, 2009, art. 8.5). This space is in the FRPA classified into priority (Bundesministerium der Justiz, 2009, art. 8.7.1) and reserve areas (Bundesministerium der Justiz, 2009, art. 8.7.2).

The difference between priority areas and reserve areas is that priority areas intended for certain regionally significant functions or uses and exclude other regionally significant uses in the area, where these are not incompatible with the functions or uses priority. Reserve flood risk areas are areas where certain regionally significant functions or uses in balancing is to be attached with competing regionally significant uses of particular importance (Bundesministerium der Justiz, 2009, art. 8.7.1 & 8.7.2). If this social value is not actual anymore, the type of the area can be changed from priority to reserve area (Menzel, interview, 02-12-2010).

State legislation on flood risk management

In Germany, each state has its own legislation on land-use planning within the federal framework, being the most important formal institution in respect to land use planning; this includes the management of flood risks (Böhm et al., 2004; in Petrow et al., 2006, p. 723). In respect to flood risk management relevant legislation in Lower Saxony are the Lower Saxonian Law on Spatial and Country Planning, the Lower Saxonian Water Act 2002 (after this: NW) and the Lower Saxonian Building Code. In German states, flood risk management is inter alia based on a combination of technical flood protection using such as dykes and retention basins and area-wide water retention (Reinhardt et al., 2011, p. 471).

In line with the WFD, FD and federal legislation also the state laws require the assessment of a flood risk management plan including flood hazard maps and flood risk maps. The NW 2002 requires in art. 92.2 (Lower Saxony, 2002) that water boards have to locate the priority and reserve flood areas. Also prescribed in this law is that areas, flooded before, have to be restored as flood plains, if not in conflict with the public interest (Lower Saxony, 2002, art. 93.1). And without authorisation of the water board it is forbidden to use flood plains for agriculture, to increase or deepen Earth's surface, manufacture or change buildings, built tree or shrub plantings and store substances that prevent the flood discharge (earth, wood, sand, stones etc.) (Lower Saxony, 2002, art. 93.2). In other words: this means that any other activity without authorisation of the water board is forbidden in flood plains.

The Lower Saxonian Law on Spatial and Country Planning 2009 (Lower Saxony, 2009; after this NR) and the State Spatial Planning Program Lower Saxony 2002 (Lower Saxony, 2002; after this: LROP) provide a framework to classify flood plains into priority and reserve flood protection areas. The NR requires that in priority flood protection areas all spatial plans and measures have to be compatible with its intended purpose (Lower Saxony, 2009, art. 3.4.1). These are areas where it can statistically be expected that they will be flooded once in 100 years (the HQ100), should be designated as priority flood risk areas (Lower Saxony, 2012, art. 3.2.4.12.1). Only if there is no other possibility, regionally significant plans and measures are permitted to be located in flood risk areas. These areas will be designated as precautionary flood risk areas (Lower Saxony, 2012, art. 3.2.4.12.3).

Before 22 December 2013 the flood hazard maps have to be developed and after this every six years being reviewed (Lower Saxony, 2012, art. 74.6). What is deposed on these maps is exactly the same as in the FD (Council, 2007, art. 6.3 & 6.4), only then on federal or state administrative level.

Consequently, flood risk management is an important assignment for the Hannover Region (after this: HR) and the Zweckverband Groβraum Braunschweig (after this: ZGB) (see figure ?? for their location), two adjacent German regional spatial planning institutions in Lower Saxony (see figure ??, page ??). Both regions include a major city and several surrounding cities (e.g.: Hannover, Braunschweig, Wolfsburg), and suffer from floods caused by heavy rainfall and melting snow in mountain areas within these regions. In order to organise the physical spatial structure within their regions, they both look for methods to develop flood risk management plans. As part of this, and as described in legislation on this subject, regions are required to develop flood hazard maps. Therefore plan-making processes are undertaken. Influenced by the latest policies and developments in spatial planning, the ZGB developed flood hazard maps in 2008. In 2010 the HR started with this process, hoping to be able to use lessons learnt by the ZGB. Therefore this research explores the influence of knowledge in the plan-making process on the development of flood hazard maps by the ZGB.

Requirements on the use of knowledge in legislation

In order to represent the effects of floods on flood hazard maps several methods are prescribed and required to carry out by MS. This gives a certain value to the flood hazard maps, equal in all MS. In paragraph 3.2 these methods are represented as being types of scientific or local knowledge. In this paragraph is explored which are required to use according to the WFD and the FD.

The Water Framework Directive

In the table below the values as prescribed to use in the WFD in order to develop maps are shown. These are all methods which should be carried out by experts. This represents the values in table 5, which are all related to scientific knowledge. This makes that for example the (preliminary) designation of water bodies often is seen as 'technical' and not likely subject for public participation, and thus for the use of local knowledge (Enserink, Kamp & Mostert, 2003).

Table 7: Knowledge types in the Water Framework Directive

Indicator	Value
Scientific knowledge	Cost-effect analysis Technical elements to technical development and the standardisation of monitoring, sampling and analysis methods Technical knowledge Expert judgement Risk-based assessments Modelling (e.g. predictive models) Historical data
Local knowledge	

Source: Council, 2000

Nevertheless the WFD states that interested parties, including users of water, should be participating by being informed, consulted and involved in the establishment and updating of river basin management plans. Public involvement in plan-making processes should increase the integration of local knowledge in plan-making processes due to submission of this into the process. About this subject, the WFD requires MS the following:

- 'it is necessary to provide proper information of planned measures and to report on progress with their implementation with a view to the involvement of the general public before final decisions on the necessary measures are adopted (Council, 2000, p. 7); and
- Member states shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the

river basin management plans by making them available for comments of the public (Council, 2000, art. 14).

In research, there is inter alia critique on the definition of 'active involvement' and the concept of the 'general public'. It is advocated that these terms can be interpreted in multiple ways, because they are not clearly defined. 'Active involvement' implies that the public gets real influence, although not necessarily decision-making powers. In their opinion this leads to less active involvement of the public. The concept '(general) public' should be clarified because for example in the Netherlands this leads to involvement of well-known organised stakeholders without active involvement of the 'broad public' (Enserink, Kamp & Mostert, 2003, p. 40).

The Floods Directive

In the description of what knowledge types should be used the FD does not differ that much from the WFD. The FD specifies a host of technical details about the information flood maps must include (Porter & Demerrit, 2012), implying the use of methods classifiable as scientific knowledge, in the development of flood risk management plans, what is shown in the following table. This includes technical criteria about the development and compilation of data on hydrology, topography and the positions of watercourses (FD, 2007, art. 4.2.d).

Table 8: Knowledge in the Flood Risk Directive

Indicator	Value
Scientific knowledge	Statistical and cartographic data Cost-benefit analysis used to assess measures with transnational effects Preliminary flood risk assessment Flood scenario's Information of environmental pollution as a consequence of floods 'Best available technologies' 'Best practice' (expert)
Local knowledge	

Source: Council, 2007

Nevertheless flood risk management implies attention to community involvement, compared to the WFD, the view on this has not been changed. In retro perspective, MS have to organise public participation and coordinate the implementation of the FD with the implementation of the WFD (Council, 2007, art. 9 & 10). Still the tasks, the preliminary flood risk assessment, the flood hazard maps, the flood risk maps and the flood risk management plans have to made available to the public (Council, 2007, art. 10).

German and Lower Saxonian legislation

As mentioned before as one of the MS, in 'German federal states, the flood management strategy (…) is based on a combination of (1) technical flood protection using dykes and dams, retention basins, reservoirs, etc. and (2) area-wide water retention by a restoration and improvement of soil infiltration capacities' (Reinhardt et al., 2011, p. 309). This implies that solutions to prevent floods are mostly found in technical measures and spatial solutions based on scientific knowledge, what is represented in the following table.

Equal to the WFD and the FD, there are no requirements about the use of local knowledge in federal or state legislation. Also this legislation requires that flood hazard maps need to be published and interested parties must be involved in the process of drawing up, reviewing and updating, in line with the FD (Council, 2007, art. 9 & 10). These interested parties are specified as besides governments, recognised, interested associations and other interest groups determined on a case-by-case basis (Gierk, 2009, p. 8).

Table 9: Knowledge types in German and Lower Saxonian legislation

Indicator	Value
Scientific knowledge	Survey of the river basin Technical flood protection Modelling of the HQ100 Cost-effect analysis Restoration of historic flood plains
Local knowledge	

Source: Lower Saxony, 2009

Introduction

As mentioned in paragraph 4.3, governments use flood maps in spatial planning to serve an advisory purpose or where there is a binding legislation to use flood hazard or risk information (de Moel et al., 2009, p.??). Since the European Union represents 27 MS, like Germany, its legislation influences flood risk management on federal, state and regional level. This is partial due to idea of subsidiarity in this legislation (Kallis & Butler, 2001). Since in European flood legislation prescriptions about the use of flood hazard maps are assimilated, it is relevant to explore the role of knowledge as described in this.

Therefore the first step in this chapter is to explore European legislation related to spatial planning before zooming in on flood risk management and flood hazard maps. Herein the role of types, uses and influence of knowledge in EU legislation is highlighted.

European legislation on flood risk management

With respect to the management of inland surface, ground-, transitional and coastal waters in EU MS two directives are currently into force, influencing the plan-making process on the development of flood hazard maps in the ZGB (ZGB, 2008a). At 30 June 2000 the 'Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy, also known as the Water Framework Directive (Council, 2000) took into force. In addition to this framework, and especially because of the lack of regulation on flood risk management, at 23 October 2007 'Directive 2007/60/EC of the European Parliament and the Council on the assessment and management of flood risks', also known as the Floods Directive (Council, 2007). These directives are operational tools, setting the objectives for improvement of the water quality and the reducing of the impact of future floods.

The Water Framework Directive

This directive has inter alia been developed 'to establish a framework for the protection of inland surface waters, transnational waters, coastal waters and groundwater which (…) contributes to mitigating the effects of floods (…) (Council, 2000, art.1). This directive frames approaches, objectives, principals, definitions and measures for water management (Grindlay et al., 2001), and institutionalises ecosystem-based objectives and planning processes at the level of the hydrographic basin. Fulfilment of the objective should lead to an overall 'good' ecological and water quality and non-deteriorating statues of all waters (Kallis & Butler, 2001).

In order to achieve an overall 'good' ecological and chemical water quality, MS first have to designate river basins within their territory or in co-ordination with other MS for international waters. Second, MS have to prepare, implement and review river basin management plans every six years on from 2000 (Council, 2000). These plans include inter alia:

- a general description of the characteristics of the district illustrated by a series of maps;
- identification and mapping of protected areas;
- identification and mapping of the monitoring network;
- identification and assessment of the significant pressures on the aquatic environment (including estimation of point and diffuse pollution, a summary of land-uses and estimation of abstractions and quantity stresses);
- an economic analysis of the costs of water; and
- summary information on all measures taken to achieve goals and comply with existing legislation and the directive (Directly copied from Kallis & Butler, 2001; hoe te verwijzen?).

Due to its ecosystem-based approach (Kallis & Butler, 2001) no requirements in respect of flood risk management are included into this directive. Nevertheless basis measures need to developed in order 'to prevent and/or to reduce the impact of accidental pollution incidents for example as a result of floods (…) to reduce the risk to aquatic ecosystems' (Council, 2000, art. 11.3 (I)). This shows the focus on ecological targets for waters (Grindlay et al., 2011).

The Floods Directive

After the 2002 floods in the Danube and Elbe the Council of Ministers started a process for the development of a directive in flood risk management (Mostert & Junier, 2009). This resulted in the Floods directive, which was officially adopted on 23 October 2007. This types an addition to the WFD, wherein '(…) reducing the risk of floods is not one of the principal objectives' (Council, 2007, art.4). Therefore, the FD's purpose is to:

> '(…) establish a framework for the assessment and management of flood risks, aiming at the reducing of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in the Community' (Council, 2007, art.1.1).

This directive requires MS to:

- 'to assess whether watercourses and coastlines are at risk from flooding;
- to map the flood extent to assets and the populations at risk in these areas; and
- to take adequate and coordinated measures to reduce flood risk. In addition, this Directive reinforces the public's right to access this information and to have a say in the planning process (United Nations, 2009, p. 17).

Therefore MS are required to prepare a preliminary flood risk assessment by 22 December 2011 (Council, 2007, art. 4-5), to develop flood hazard and flood risk maps by 22 December 2013 (Council, 2007, art. 6), and to draw up flood risk management plans by 22 December 2015 (Council, 2007, art. 7-8). Flood risk management plans should include:

- 'the conclusions of the preliminary flood risk assessment (…) in the types of a summary map of the river basin district (…);
- flood hazard maps and flood risk maps, (…) and the conclusions that can be drawn from those maps;
- a description of the appropriate objectives of flood risk management (…);
- a summary of the measures and their prioritization aiming to achieve the appropriate objectives of flood risk management (…)' (Council, 2007, Appendix A I).

Because of the similarities of the FD and the WFD, the implementation of both directives should be combined, using the mutual potential for common synergies and benefits (Council, 2007, (16), art. 9). For example the development of flood hazard and flood risk maps (FD) and the first review of the characterization of the river basin district (WFD) could be integrated because their similar deadline (22 December 2013).

This directive shows a move towards a risk based approach. This approach advocates reducing the overall risk through limiting the magnitude and probability of the flood, the damage potential and/or the way flood events are dealt with (de Moel et al., 2009, p. ??). This changed the focus from protection against floods to managing the risk of floods (Mostert & Junier, 2009).

Nevertheless there is also discussion about this directive. One of the points is that the FD could be implemented in two different ways: as a procedural requirement that has to be met in order to prevent problems with the European Commission and the European Court of Justice, or as an opportunity to introduce or improve flood risk management. This could influence the benefits of this directive both positive and negative (Mostert & Junier, 2009).

Conclusion

In respect to spatial planning, EU's legislation influences the field of flood risk management in 27 MS. Two directives are relevant to the development of flood hazard maps in the ZGB, the WFD and the FD. By comparing these two legislative tools, some similarities can be found: (1) both these directives prescribe MS to develop plans, river basin management plans (WFD) respectively flood risk management plans (FD); (2) these plans contain the requirement to develop hazard maps in order to represent the spatial impact of these plans; (3) they all require to use scientific knowledge in the development of the maps; and (4) in respect to the use of local knowledge there is a lack of requirements, although MS are required to actively involve the general public without being clear what this means for the MS and plan-making processes.

Policy on federal and state level: German and Lower Saxonian legislation on flood risk management

The following table (table ??) shows the administrative levels mentioned above and their scope of functions and tools therefore used. This table includes per administrative level influencing floor risk management in Germany the scope of functions, the binding legal basis for comprehensive land use planning and the and the legal basis for sectoral planning, in this case water and flood management.

Table 10: *Adminstrative levels, legislation, and scope of functions within the German spatial planning system*

Administrative level	Scope of functions	Comprehensive planning/ legal basis Land use planning	Sectoral planning/ legal basis Water & flood management
European Union	Overall principles and regulations	European Spatial Development Perspective (ESDP) (not binding)	European Water Framework Directive (WFD) (binding) and Floods Directive (FD) (binding)
Federal (national) level	Principles, aims, general and obligatory regulations	Federal Spatial Planning Act (ROG) and Minister's Conference of Regional Policy/Federal Building Code (BauGB)	Federal Water Resources Act (WHG)
State level (16 German *Länder)*	Comprehensive planning for every state	16 State Planning Acts and respective State development plans (LROP)	16 Water Resources Acts
Subregional level	Comprehensive planning for every subregion	(Sub-) Regional development plans (RROP)	
Communcal level	Mandatory regulations	Local development plans for every community	Local water and flood protection plans

Source: Petrow et al., 2006, p. 723

The legal basis of the European Union has been explored in the previous chapter (chapter 5). The implementation of the FD will be shown in Germany, as one of the 27 MS. After this is focussed on the state level, Lower Saxony, in which the HR and ZGB are located. An important requirement in the

FD was on the development of flood hazard maps. This has been implemented in federal and federal state legislation, in this research Germany and Lower Saxony.

In this chapter are therefore two things explored. First is explored what federal and state legislation states about flood risk management and in particular the development of flood hazard maps. Second is explored what knowledge types are required to use, and how this matches with requirements on this in the FD (see paragraph 5.4.2). On two things mentioned in table ?? is not focussed in this research, to know the ESDP, because this is not binding for MS and on the communal administrative level because the task of flood risk management in the HR and ZGB is adopted by the regional planning authorities.

In comparison with requirements on flood risk management in the WFD and FD, there are no major differences in German federal and Lower Saxony legislation. Requirements on the development of flood hazard maps in flood risk management plans are equal and this is also almost the case in the knowledge types required to use. Legislation on both administrative levels describe to involve interested parties the plan-making process on the development of flood hazard maps. The major difference in this legislation can be found on the classification of flood areas. Where in European legislation is spoken about ‘ flood areas’, in German federal and state legislation this is divided in priority and reserve flood areas, both based on models based on the HQ100. These areas differ in what is legally allowed qua spatial functions in these areas. In priority areas only functions without a negative impact on the flood risks can be depicted, in reserve areas other spatial functions are tolerated when there is no alternative.

Appendix 6: Categorisation of knowledge in opinions

Opinion nr & influence (clearly influencing (C); party influencing (P); underpinning a decision (U); not influencing (N)) & knowledge types & use of knowledge (instrumental (I), symbolic (S), conceptual (C))				
Total amount opinions: 221				
	Nr. view	Influence	Types	Use
Scientific knowledge	1671	C	Statistical model	I
Scientific knowledge	1672	U	Use of secondary data	C
Scientific knowledge	1673	U	Use of secondary data	C
Scientific knowledge	1674	U	Statistical model	C
Scientific knowledge	1675	N	Policy analysis	I
Scientific knowledge	1676	U	Use of secondary data	C
Scientific knowledge	1677	N	Use of secondary data	I
Scientific knowledge	1678	P	Policy analysis	I
Scientific knowledge	1679	P	Statistical model	I
Scientific knowledge	1680	N	Use of secondary data	I
Scientific knowledge	1681	N	Scenario	I
Scientific knowledge	1682	N	Scenario	I
Scientific knowledge	1683	U	Expert opinion	I
Scientific knowledge	1684	U	Use of secondary data	I
Scientific knowledge	1685	N	Use of secondary data	I
Scientific knowledge	1686	U	Use of secondary data	S
Scientific knowledge	1687	N	Use of secondary data	I
Scientific knowledge	1688	U	Use of secondary data	I
Scientific knowledge	1689	P	Natural observation	I
Scientific knowledge	1690	U	Statistical model	C
Scientific knowledge	1691	U	Use of secondary data	S
Scientific knowledge	1692	N	Use of secondary data	I
Scientific knowledge	1693	U	Use of secondary data	C
Scientific knowledge	1694	U	Use of secondary data	C
Scientific knowledge	1695	N	Existing information/ database	I
Scientific knowledge	1696	U	Use of secondary data	S
Scientific knowledge	1697	U	Statistical model	S
Scientific knowledge	1698	U	Expert opinion	S
Scientific knowledge	1699	U	Expert opinion	C
Scientific knowledge	1700	U	Use of secondary data	S
Scientific knowledge	1701	U	Expert opinion	I
Scientific knowledge	1702	U	Expert opinion	I
Scientific knowledge	1703	U	Expert opinion	I
Scientific knowledge	1704	U	Policy analysis	I
Scientific knowledge	1705	U	Use of secondary data	I

Scientific knowledge	1706	N	Natural observation	I
Scientific knowledge	1707	N	Natural observation	I
Scientific knowledge	1708	U	Expert opinion	C
Scientific knowledge	1709	U	Expert opinion	S
Scientific knowledge	1710	C	Policy analysis	I
Scientific knowledge	1711	U	Policy analysis	I
Scientific knowledge	1712	N	Expert opinion	I
Scientific knowledge	1713	C	Policy analysis	I
Scientific knowledge	1714	U	Expert opinion	I
Scientific knowledge	1715	N	Expert opinion	I
Scientific knowledge	1716	N	Expert opinion	I
Scientific knowledge	1717	N	Expert opinion	I
Scientific knowledge	1718	N	Expert opinion	I
Scientific knowledge	1719	N	Expert opinion	I
Scientific knowledge	1720	U	Story-telling about experience	I
Local knowledge	1721	U	Story-telling about experience	I
Scientific knowledge	1722	U	Use of secondary data	I
Scientific knowledge	1723	N	Policy analysis	I
Scientific knowledge	1724	N	Expert opinion	I
Scientific knowledge	1725	U	Expert opinion	C
Scientific knowledge	1726	U	Expert opinion	C
Scientific knowledge	1727	N	Expert opinion	C
Scientific knowledge	1728	U	Use of secondary data	C
Scientific knowledge	1729	C	Statistical model	I
Scientific knowledge	1730	C	Statistical model	I
Scientific knowledge	1731	P	Statistical model	I
Scientific knowledge	1732	P	Scenario	I
Scientific knowledge	1733	C	Statistical model	I
Scientific knowledge	1734	C	Statistical model	I
Scientific knowledge	1735	C	Statistical model	I
Scientific knowledge	1736	C	Statistical model	I
Scientific knowledge	1737	C	Statistical model	I
Scientific knowledge	1738	C	Statistical model	I
Scientific knowledge	1739	C	Statistical model	I
Scientific knowledge	1740	N	Expert opinion	S
Scientific knowledge	1741	N	Policy analysis	I
Scientific knowledge	1742	C	Natural observation	I
Scientific knowledge	1743	C	Natural observation	I
Scientific knowledge	1744	C	Policy analysis	I
Scientific knowledge	1745	N	Use of secondary data	I
Scientific knowledge	1746	N	Statistical model	I
Scientific knowledge	1747	N	Statistical model	I

Scientific knowledge	1748	N	Statistical model	I
Scientific knowledge	1749	N	Statistical model	I
Scientific knowledge	1750	N	Statistical model	I
Scientific knowledge	1751	N	Statistical model	I
Scientific knowledge	1752	N	Statistical model	I
Scientific knowledge	1753	N	Use of secondary data	I
Scientific knowledge	1754	N	Literature review	I
Scientific knowledge	1755	N	Literature review	I
Scientific knowledge	1756	N	Literature review	I
Scientific knowledge	1757	N	Natural observation	I
Scientific knowledge	1758	N	Policy analysis	C
Scientific knowledge	1759	P	Natural observation	I
Scientific knowledge	1760	U	Use of secondary data	S
Scientific knowledge	1761	P	Statistical model	I
Scientific knowledge	1762	C	Literature review	I
Scientific knowledge	1763	P	Policy analysis	I
Scientific knowledge	1764	C	Policy analysis	I
Scientific knowledge	1765	C	Policy analysis	I
Scientific knowledge	1766	C	Policy analysis	I
Scientific knowledge	1767	C	Policy analysis	I
Scientific knowledge	1768	N	Use of secondary data	I
Scientific knowledge	1769	N	Expert opinion	I
Scientific knowledge	1770	N	Expert opinion	I
Scientific knowledge	1771	C	Statistical model	I
Scientific knowledge	1772	N	Scenario	I
Scientific knowledge	1773	N	Scenario	I
Scientific knowledge	1774	N	Scenario	I
Scientific knowledge	1775	U	Use of secondary data	S
Scientific knowledge	1776	C	Use of secondary data	I
Scientific knowledge	1777	U	Use of secondary data	S
Scientific knowledge	1778	U	Scenario	I
Scientific knowledge	1779	N	Expert opinion	S
Scientific knowledge	1780	C	Statistical model	I
Scientific knowledge	1781	N	Natural observation	I
Scientific knowledge	1782	U	Use of secondary data	I
Scientific knowledge	1783	N	Expert opinion	I
Scientific knowledge	1784	N	Expert opinion	I
Scientific knowledge	1785	N	Scenario	I
Scientific knowledge	1786	N	Scenario	I
Scientific knowledge	1787	N	Expert opinion	I
Scientific knowledge	1788	N	Expert opinion	I

Scientific knowledge	1789	N	Expert opinion	I
Scientific knowledge	1790	N	Expert opinion	I
Scientific knowledge	1791	N	Expert opinion	I
Scientific knowledge	1792	N	Expert opinion	I
Scientific knowledge	1793	N	Expert opinion	I
Scientific knowledge	1794	N	Expert opinion	I
Scientific knowledge	1795	N	Expert opinion	I
Scientific knowledge	1796	N	Expert opinion	I
Scientific knowledge	1797	N	Expert opinion	I
Scientific knowledge	1798	N	Expert opinion	I
Scientific knowledge	1799	N	Expert opinion	I
Scientific knowledge	1800	N	Expert opinion	I
Scientific knowledge	1801	N	Expert opinion	I
Scientific knowledge	1802	N	Expert opinion	I
Scientific knowledge	1803	N	Expert opinion	I
Scientific knowledge	1804	N	Expert opinion	I
Scientific knowledge	1805	N	Expert opinion	I
Scientific knowledge	1806	N	Expert opinion	I
Scientific knowledge	1807	N	Expert opinion	I
Scientific knowledge	1808	N	Expert opinion	I
Scientific knowledge	1809	N	Expert opinion	I
Scientific knowledge	1810	N	Expert opinion	I
Scientific knowledge	1811	N	Expert opinion	I
Scientific knowledge	1812	N	Expert opinion	I
Scientific knowledge	1813	N	Expert opinion	I
Scientific knowledge	1814	N	Expert opinion	I
Scientific knowledge	1815	N	Expert opinion	I
Scientific knowledge	1816	N	Expert opinion	I
Scientific knowledge	1817	N	Expert opinion	I
Scientific knowledge	1818	N	Use of secondary data	I
Scientific knowledge	1819	N	Expert opinion	I
Scientific knowledge	1820	N	Expert opinion	I
Scientific knowledge	1821	N	Expert opinion	I
Scientific knowledge	1822	N	Expert opinion	I
Scientific knowledge	1823	N	Expert opinion	I
Scientific knowledge	1824	N	Expert opinion	I
Scientific knowledge	1825	N	Expert opinion	I
Scientific knowledge	1826	N	Expert opinion	I
Scientific knowledge	1827	N	Scenario	I
Scientific knowledge	1828	N	Expert opinion	I
Scientific knowledge	1829	N	Policy analysis	I
Local knowledge	1830	N	Story-telling about experience	I

Local knowledge	1831	N	Story-telling about experience	I
Local knowledge	1832	N	Story-telling about experience	I
Local knowledge	1833	N	Story-telling about experience	I
Local knowledge	1834	N	Story-telling about experience	I
Local knowledge	1835	N	Story-telling about experience	I
Local knowledge	1836	N	Story-telling about experience	I
Local knowledge	1837	N	Story-telling about experience	I
Local knowledge	1838	P	Story-telling about experience	I
Local knowledge	1839	N	Story-telling about experience	I
Local knowledge	1840	P	Story-telling about experience	I
Local knowledge	1841	N	Story-telling about experience	I
Local knowledge	1842	U	Story-telling about experience	C
Scientific knowledge	1843	N	Scenario	I
Scientific knowledge	1844	N	Policy analysis	I
Scientific knowledge	1845	N	Policy analysis	I
Local knowledge	1846	U	Story-telling about experience	I
Local knowledge	1847	U	Story-telling about experience	I
Scientific knowledge	1848	U	Statistical model	I
Scientific knowledge	1849	C	Statistical model	I
Scientific knowledge	1850	C	Policy analysis	I
Scientific knowledge	1851	U	Use of secondary data	S
Scientific knowledge	1852	N	Expert opinion	I
Scientific knowledge	1853	N	Use of secondary data	I
Scientific knowledge	1854	N	Use of secondary data	I
Scientific knowledge	1855	C	Statistical model	I
Scientific knowledge	1856	U	Use of secondary data	I
Scientific knowledge	1857	N	Expert opinion	I
Scientific knowledge	1858	C	Policy analysis	I
Scientific knowledge	1859	P	Natural observation	I
Scientific knowledge	1860	N	Expert opinion	I
Scientific knowledge	1861	U	Use of secondary data	S
Scientific knowledge	1862	U	Use of secondary data	C
Scientific knowledge	1863	C	Policy analysis	I
Scientific knowledge	1864	U	Natural observation	C
Scientific knowledge	1865	N	Expert opinion	I
Scientific knowledge	1866	P	Scenario	I
Scientific knowledge	1867	N	Expert opinion	I
Scientific knowledge	1868	N	Expert opinion	I
Scientific knowledge	1869	N	Expert opinion	I
Scientific knowledge	1870	N	Expert opinion	I
Scientific knowledge	1871	N	Expert opinion	I

Scientific knowledge	1872	N	Expert opinion	I
Scientific knowledge	1873	N	Expert opinion	I
Scientific knowledge	1874	N	Expert opinion	I
Scientific knowledge	1875	N	Expert opinion	I
Scientific knowledge	1876	N	Expert opinion	I
Scientific knowledge	1877	N	Expert opinion	I
Scientific knowledge	1878	U	Natural observation	S
Scientific knowledge	1879	N	Expert opinion	I
Scientific knowledge	1880	N	Expert opinion	I
Scientific knowledge	1881	N	Expert opinion	I
Scientific knowledge	1882	N	Expert opinion	I
Scientific knowledge	1883	N	Expert opinion	I
Scientific knowledge	1884	U	Expert opinion	I
Scientific knowledge	1885	C	Statistical model	I
Scientific knowledge	1886	N	Expert opinion	I
Scientific knowledge	1887	N	Expert opinion	I
Scientific knowledge	1888	N	Expert opinion	I
Local knowledge	1889	N	Story-telling about experience	I
Local knowledge	1890	N	Story-telling about experience	I
Local knowledge	1891	N	Story-telling about experience	I

Source: compiled by the author based on the ZGB 2007