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SDSS and the Technical-Communicative Rationale: Communicating Flood Risk Information to Laymen that have Plural Perspectives

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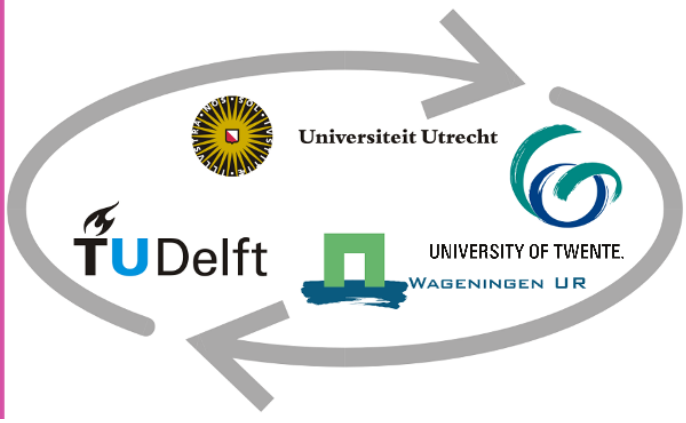

Abstract

This research investigates how a Spatial Decision Support System (SDSS) that is dedicated to communicate flood risk information can be analytically and communicatively supportive for laymen in flood prone areas that have varying preferences for communication methods. To divide residents into groups, the cultural theory of risk is used, by which residents' perspectives can be classified into fatalist, hierarchist, individualist and egalitarian. Floodlabel.net, a prototype SDSS that aims to inform residents about their personal flood risk, is used as a case. Residents from Zwolle, Venlo and Dordrecht in the Netherlands are interviewed to get insights into the analytical support, communicative support and task-technology fit of floodlabel.net from a resident's perspective. Since the four groups of cultural theory are mutually exclusive, it is impossible to develop one communication method that appeals all types of residents. However, this research concluded that improvements for floodlabel.net regarding the analytical and communicative support could be beneficial for bringing residents in general and residents from a specific group of cultural theory to action. Yet, a platform such as floodlabel.net should always be assisted by other communication methods for an optimal flood risk communication.

List of abbreviations

CT perspectives:	Cultural theory of risk perspectives
CT groups:	Cultural theory of risk groups
DSS:	Decision Support Systems
EU:	European Union
GIS:	Geographical Information Systems
IPCC:	Intergovernmental Panel on Climate Change
PSS:	Planning Support Systems
RO:	Research objective
RQ:	Research question
SDSS:	Spatial Decision Support Systems

Keywords

Spatial Decision Support Systems, Flood Risk Management, Cultural Theory of Risk, Spatial Planning

Contents

1. Introduction

1.1. Background

Spatial planning and decision making are characterised by complexity and ill-structured problems. It is difficult for individuals to process all information that is needed for such a complex process. In the light of these cognitive deficiencies of humans, a computer support system is a very helpful solution in dealing with complex spatial decision problems. An example of such a complex spatial decision problem is the spatial adaptation to climate change induced floods, for which flood risk information needs to be communicated among different actors. Flood risk management is essential since the chance of flooding is increasing due to climate change and will have severe impacts if adaptation measures are not implemented properly (IPCC, 2019; 2014). Computer systems are able to provide involved actors with geographical information about the situation at hand (e.g. within flood prone areas) and inform them about the possible actions to undertake and its consequences (Pelzer et al., 2015; Sugumaran and DeGroote, 2010).

One can create a long list of (spatial) planning and decision making tools that are useful for assisting in decision making, for example within flood risk communication. These can be categorised into several types, of which most important are: Planning Support Systems (PSS), Decision Support Systems (DSS), Spatial Decision Support Systems (SDSS), Geographical Information Systems (GIS), and Remote Sensing (RS) technologies (Pelzer et al., 2015; Sugumaran and DeGroote, 2010). Of these systems, it should be noted that they are not systems working on their own. They do overlap and work together in many cases, and PSS is often seen as the umbrella concept for many of these technologies (Pelzer et al., 2015). The focus of this research is on SDSS.

This research examines how SDSS work both technically and communicatively. This is done by using an SDSS as case study. Currently, FLOODLABEL, an EU collaboration with several universities, is developing a website (www.floodlabel.net) which aims to inform residents of flood prone areas about floods and potential measures to take in and around their dwellings. This is a perfect case for this research, as the website is an SDSS, while it is directed to laymen and therefore its communicative value can be tested in practice.

About SDSS it has been written that the current challenge lies in the inclusion of knowledge resulting from the *communicative turn*. The communicative turn arises from the planning theory debate of the technical rationale and the communicative rationale, which can be visualised in a spectrum with two extremes. In the technical rationale, clear, scientific, and objective knowledge are important and the main input for planning. In the communicative rationale this solid knowledge is put aside and communication and interaction between all planning actors are considered essential (Allmendinger, 2017; Pelzer et al., 2015; De Roo, 2003). This shift from technical to communicative, i.e. the communicative turn, is also what the challenge is for SDSS. A successful implementation of SDSS would fulfil both technical and communicative tasks.

From the technical-communicative rationale spectrum, it is only a small step towards the discussion on expert knowledge and lay knowledge. Experts in this sense are the planners and decision-makers, but more specifically, in flood risk management, experts are the flood experts that aim to communicate flood risk information to residents, and the ones that develop tools to facilitate this communication. The residents are laymen, that generally lack specific technical knowledge, which often creates a misunderstanding of what experts try to communicate (Hansen et al, 2003). In fact, the communicative rationale can be seen as the opening from experts to laymen. Without taking the communicative value into account, expert information remains information directed at experts. The communicative area opens up and provides a point for dialogue between experts and the wider society, which are laymen in most cases (Gastil & Levine, 2005; Dryzek, 1990, 2002).

For this study, the discussion around expert-laymen communication can be juxtaposed with the technical and communicative rationale spectrum. Expert knowledge correlates with the technical rationale, since experts have knowledge about the details in a spatial planning case, in the case of floodlabel.net flood risk management at the local home level. Their way of thinking is different from the residents' way of thinking.

Lay knowledge correlates with the communicative rationale, since the information from floodlabel.net experts (flood risk and potential measures) needs to be communicated to laymen who have no technical knowledge about the case. It should be noted that laymen are not ignorant on cases specifically. They even often have better local knowledge than experts. For example, a resident that experienced a flood before has experiential knowledge which the expert lacks. The challenge is to bridge the gap between these two different types of knowledge between experts and laymen, in a communicative setting (Snel et al., 2019; Natarajan, 2017).

Flood risks experts have to deal with a similar challenge, where expert knowledge is not received by laymen as intended by the experts. This is striking since flood risk information and subsequent possible adaptation measures are available in abundance. Still, residents in flood prone areas do not implement these measures accordingly (Mees et al., 2018; Fournier et al., 2016), which leads to unnecessary consequences. There are several reasons for why this implementation gap is still there, of which the miscommunication between experts and the general public by using SDSS is of particular interest to this study. The flood risk communication is mostly done from the perspective of experts, while the general public (i.e. residents) does not have the right knowledge to interpret this information correctly (Patt and Jüpner, 2013; Hansen et al., 2003).

To measure whether SDSS work in practice both technically and communicatively (i.e. address the technical rationale and the communicative rationale), one can measure their analytical support and their communicative support. The analytical support indicates whether SDSS assist in enhancing the understanding of a planning issue, e.g. by showing future scenarios based on input data. The communicative support indicates whether SDSS are beneficial for the communication of information between all actors involved, which include both experts and laymen (Pelzer, 2017; Hopkins, 2001; Vonk, 2006). Lastly, to simply measure whether task (spatial planning tasks to be executed) and technology (SDSS) match, one can look at the *task-technology fit*. This simply examines whether predetermined tasks are fulfilled through the used technology (Goodhue and Thompson, 1995). In the case of floodlabel.net, the task to be performed is informing residents about their flood risk and stimulate taking action.

The challenge lies at the communicative side of the spectrum, thus addressing the perspective of residents of flood prone areas (laymen) on flood risk communication. The cultural theory of risk provides a framework in which four categories are distinguished regarding people's perception of the world: fatalism, hierarchism, individualism and egalitarianism (Douglas, 1970; Douglas and Wildavsky, 1992). These four 'perspectives' are mutually exclusive and therefore each resident can be assigned to one perspective. In section 2.6.1 the cultural theory of risk in general and in relation to flood risk communication is discussed in more detail.

Thus, the cultural theory of risk can be used as a theoretical framework to categorise perspectives on flood risk communication into four groups. This is done in the research of Snel et al. (2019), which also focuses on laymen's perspectives on flood risk communication, and concluded that the four groups they created after the empirical research are one-to-one connected to the four perspectives of cultural theory (hereafter referred to as 'CT perspectives'). It is interesting to see whether these perspectives are still observable among laymen for this research, and whether their perspectives on the prototype SDSS (floodlabel.net) differ. To investigate this, it is tested whether these perspectives are still present while simultaneously focusing on the communicative and analytical support of floodlabel.net for all four CT perspectives. Since the four perspectives are mutually exclusive, it is not possible to entirely include preferences of all CT perspectives into floodlabel.net. Therefore, an optimal form of an SDSS for communicating flood risk information can be searched for. This optimal form then addresses all four perspectives as most as possible in practice. Suggestions on how to come as close as possible to this optimal form, regarding the analytical and communicative support, are to be made in this research.

1.2. Research rationale

This study focuses on what SDSS can mean in the communicative practice, while using rather technical tools. SDSS is chosen over PSS because SDSS, in contrast to PSS, focus on short term decision making and may

therefore lead to a higher effectiveness on the short term specifically. This is not the case for PSS which focus on long term strategic decision making to be performed by planners (Geertman and Stillwell, 2009). SDSS is important in spatial planning since spatial decisions are often correlated with geographical information and therefore benefit from the use of SDSS.

In scientific studies about the use of SDSS in planning, the focus primarily lies on the usefulness and their added value to planning practice regarding technical aspects (Pelzer et al., 2015[a], 2014; Smith et al., 2013; Te Brömmelstroet, 2013). However, it is often not mentioned that these tools can also have a negative effect on planning practice, i.e. hindering a task to be executed rather than supporting it, especially around the communication among actors. This phenomena, where SDSS do negatively contribute to the success of a planning task, is previously found in studies of Pelzer et al. (2015[a]) and Smith et al. (2013). It is stated that the technical role of SDSS can become leading in the planning and decision-making process instead of only supporting, while the communicative effect is ignored.

Although SDSS can undergo a superb technological development, this is only a small step. There is still a giant leap to be made from this towards successful implementation in a communicative practice. Therefore, the aim of this research is to examine the support provided by SDSS in both the technical rationale and the communicative rationale. Thereby, it is tested whether laymen are supported in the process of understanding information about their individual flood risk and potential adaptation measures, due to effective SDSS both technically and communicatively (analytical support and communicative support). To fulfil the communicative side optimally, different laymen perspectives need to be observed and taken into account, as described by cultural theory (Douglas, 1970; Douglas and Wildavsky, 1992) and Snel et al. (2019). Besides the support levels themselves, SDSS also have certain aims in mind of their developers. To test whether the SDSS fits the goal it needs to reach, the *task-technology fit* is tested as well. The following research objectives are to be fulfilled in this research:

1. Test the analytical support of floodlabel.net in practice based on residents' perspectives.
2. Test the communicative support of floodlabel.net in practice based on residents' perspectives.
3. Examine the task-technology fit of floodlabel.net based on residents' perspectives.
4. Examine the flood risk communication preferences of residents.
5. Categorise the perspectives of users on SDSS usage in flood risk management into the four groups of cultural theory.

The following main research question is developed for this research:

How can an SDSS that is dedicated to communicate flood risk information be analytically and communicatively supportive for laymen that have varying preferences?

As discussed before, analytical support, communicative support and task-technology fit are ways to measure whether SDSS foster planning tasks. What these three principles entail and how these are measured is discussed in detail in the theoretical framework of this research (chapter 2). The following three sub questions are asked in order to come to a comprehensive answer to the main question:

1. What is the analytical support of floodlabel.net when communicating flood risk information according to laymen?
2. What is the communicative support of floodlabel.net when communication flood risk information according to laymen?
3. To what extent is there a task-technology fit when using floodlabel.net in flood risk communication according to laymen?

As mentioned before, the EU project FLOODLABEL aims to address the issue of implementing flood adaptation measures by residents. This is done by creating a smart tool in the form of a website (floodlabel.net), in order to help experts and residents prepare for and adapt to future floods in the Netherlands, Belgium, and Austria (FLOODLABEL, 2017). The website focuses on the impact of floods, not the probability. Although flood risks are calculated by impact x probability, one should thus take notice that a flood with a low probability and a high impact is not shown differently on the website than a flood with a high probability and a high impact. This website is being tested in practice, of which this research obtains

knowledge to get an in-depth view of the perspectives and opinions of users on the usage of the website in practice.

This research is scientifically relevant because it fills the gap of knowledge on the role of SDSS within a communicative planning setting. Although one might state that SDSS have a positive effect on the outcome of spatial planning and decision making processes, there is also a chance that the effect is only negative or not present (Pelzer et al., 2015[a]; Smith et al., 2013). Furthermore, while most studies focus on the technical side of SDSS and on the perspective of experts, this study aims to respond to the laymen perspective, i.e. what are their wishes and demands regarding SDSS? Besides just focusing on communicative values as written in scientific theories, this research also looks at different perspectives within those laymen: the CT perspectives. By taking varying perspectives, a comprehensive overview is obtained of how SDSS works best technically as well as communicatively.

This research is societally relevant as it contributes to a better uptake of SDSS communication methods in flood risk management practice. Flood risk communication needs to be tailored to the preferences of residents in flood prone areas in order to be successful. This research contributes to developing a flood risk communication method that is more tailored to the needs of residents. A flood risk communication method that is more tailored to the needs of resident potentially leads those residents to have more awareness about flood risks in general, their own flood risks and what potential measures they can take. Afterwards, it might also stimulate them to take these measures. In other words, floodlabel.net itself, but also knowledge from this study in particular can lead to a better climate adaptation across the world.

To demarcate this research it is important to note that this research is not about the development of any SDSS or GIS tools, but rather the applications of them in practice and the perspectives of users on these tools in combination with flood risk communication.

2. Theoretical Framework

This chapter examines several aspects, starting off with the technical communicative rationale spectrum (section 2.1). Thereafter, the theoretical and practical meaning of SDSS are described (2.2), just as how to measure the effectiveness and usefulness of SDSS (2.3). From section 2.4 onwards, the focus shifts from technical-expert to communicative-laymen, in which also flood risk management and communication is discussed. Thus, the use of SDSS is discussed first, after which flood risk management and cultural theory in combination with SDSS (2.6) is discussed. Lastly, a measurement framework containing the task-technology fit, analytical support and the communicative support is shown in section 2.8.

2.1. Planning Theory: A short introduction to the technical - communicative rationale spectrum

The technical - communicative rationale spectrum pictures the degrees of complexity and its associated actions. Throughout the last century, several paradigm shifts have occurred in planning theory and practice within this spectrum, of which the communicative turn is the most well-known (De Roo, 2010; Healey, 1992). Figure 1 pictures the technical and communicative rationale on a spectrum.

2.1.1. Technical Rationale

The technical rationale (also referred to as *instrumental* (Dryzek, 1990) or *procedural* (Faludi, 1987) rationality) is based in modernism thinking and was mostly popular in the 1960s and 1970s, but still plays a major role in planning today. It assumes that rational choices can be made based on clear, scientific and objective knowledge. The technical rationale is based in rational thinking, which typically involve the clarification of solid policy goals, systematic analysis, logical generation of policy alternatives, systematic evaluation of these alternatives and the monitoring of their performance. In this part of the spectrum, uncertainty is low, just as complexity. Typical decision-making approaches in this are routinisation, sequential decision-making and mixed scanning (Allmendinger, 2017; Etzioni, 1967; Faludi, 1987). Therefore, this rationale assumes that decisions are easily made by humans when they are provided with all kinds of information and tools (Allmendinger, 2017; De Roo and Porter, 2006). In this, GIS could be a perfect example of a system that provides that kind of 'scientific knowledge' in a situation with low complexity and uncertainty, for example in the form of numbers and facts presented in any geographical format. Also a platform showing flood probabilities per area fits perfectly under the technical rationale.

2.1.2. Communicative Rationale

The communicative rationale is based in post-modernist thinking. Instead of using certain facts and objective knowledge as main input, the communicative rationale is based on interaction, behaviour, and the human factor. Complexity and uncertainty are high, which cannot be addressed by only 'hard facts', but need more open-ended exercises (De Roo, 2003). This so-called *communicative turn*, which started during the 1990s, brought with it some interesting challenges. Instead of only clear objective and scientific knowledge, by then opinions, debates, and consensuses became an input for planning as well (Geertman, 2006). Within flood risk management, a platform that enables the communication between municipalities and residents regarding flood would fit under the communicative rationale. The planning institutions and its associated SDSS need to facilitate the change from technical to communicative. Section 2.2 describes what SDSS entail in detail and have as their aim to support practice.

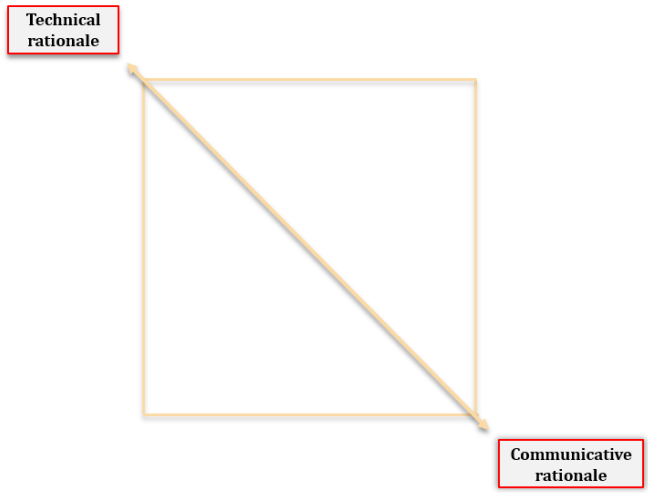

FIGURE 1: VISUALISATION OF THE TECHNICAL - COMMUNICATIVE RATIONALE SPECTRUM (ADAPTED FROM DE ROO, 2014)

2.2. Spatial Decision Support Systems

As discussed, SDSS assist in performing spatial planning tasks, which is for example adapting flood prone areas to future flood scenarios. Flood risk management is part of spatial planning, which is defined as the handling and coordination of policies, interventions, practices that influence the geographical spreading and organisation (Van Assche et al., 2013). Of spatial planning, planning tasks are the "combinations of planning behaviours that accomplish particular functions or purposes" (Hopkins, 2001, p. 187). According to Dennis et al. (2002), there are two kinds of planning tasks: generation tasks and decision making tasks. Generation tasks regard the exploration phase where problems are formulated and solutions to those problems are explored. Decision making tasks are about the identification of problems that are highlighted in the problem identification phase, and thereby selecting a particular planning intervention (Dennis et al., 2002). Decision making tasks are especially important for flood risk management from the perspective of residents. Information about flood risk is directed to residents, from which a problem identification is to be developed, and a solution is to be found. Therefore, SDSS are developed to assist residents in making such a decision in and around their dwelling. This section further describes the compartments of SDSS, and its relation to GIS, DSS, PSS and flood risk communication.

2.2.1. Defining SDSS

Before examining SDSS in detail, it is important to make clear what differentiates SDSS from PSS, and what they have in common. SDSS and PSS are both making use of participatory GIS and decision support tools (e.g. Multi Criteria Analysis) (Arciniegas et al., 2013). According to Geertman and Stillwell (2009), the differences lie in the time-scale and the focus of the actions concerned. PSS are more concerned with long-term issues, while SDSS focus on shorter-term issues, which can also be performed by individuals.

To define SDSS precisely, several articles provide us with definitions, ranging from narrowly to broadly defined versions. To start off, Malczewski defined SDSS in 1999 (p. 281) as: "SDSS is an interactive computer based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial decision problem." In here, the individual comes back again, as noted as a difference with PSS by Geertman and Stillwell (2009). Important to note is that the computer system is interactive, thus be able to in- and output information provided by humans. Secondly, its aim is to achieve a 'higher effectiveness of decision-making', so decision-making should not specifically be less time consuming and less costly, but produce better outcomes. And thirdly, logically, spatial is an important element in SDSS: there needs to be some geographical component active.

The decision-making element by using geographical information is found back in the definition of Densham (1993, p. 405): "SDSS are explicitly designed to provide the user with a decision-making environment that enables the analysis of geographical information to be carried out in a flexible manner." Leipnik et al. (1993,

p. 1) adds that not only spatial but also non-spatial information can be involved: "SDSS are integrated environments, which utilize the databases that are both spatial and non-spatial models, decision support tools like expert systems, statistical packages, optimization packages, and enhanced graphics to offer the decision makers a new paradigm for analysis and problem solving." Thus, SDSS are, according to Densham (1993) and Leipnik et al. (1993), support systems that assist in making decisions that can have spatial as well as non-spatial components.

Janssen (1992) came up with a definition that entails quite some aspects mentioned in the definitions above. An SDSS is a computer program that: (1) helps both individuals and groups making a decision; (2) supports (and does not replace) individuals' thoughts; and (3) enhances the effectiveness (instead of efficiency) of decision-making. This definition comprises essential parts of the definitions of Densham (1993), Leipnik et al. (1993) and Malczewski (1999), making it the most suitable one for this research. It should be added that a spatial component should be active, but this is already incorporated in the term 'SDSS' itself. How spatial and non-spatial elements constitute SDSS is discussed in the next section.

2.2.2. SDSS characteristics

Defining SDSS is one step, analysing what SDSS consist of and what elements make SDSS qualify as SDSS is just as important. Kemp (2008) for example mentions that SDSS combine analytical tools, GIS tools, evaluation models, multi criteria evaluation tools, and sensitivity analyses. Furthermore, SDSS must be able to represent the entire spatial problem, with spatial information, and structures and functionalities that are able to address the logical view of the problem (Keenan, 2003).

To come with a list of specific characteristics of what DSS entail (non-spatial), a publication by Geoffrion (1983), which is recently used by Gray et al. (2013) and Cromley and McLafferty (2011), is very helpful in this. He characterises DSS by using six elements:

1. DSS are purely designed to address ill-structured problems (problems which have no clear origin, and there are no clear goals set by the decision-maker).
2. DSS have a powerful and easy-to-use user interface.
3. DSS enable their users to combine analytical models and data in a flexible way.
4. DSS help the user explore the range of options by using those models in the system to generate sufficient possible and feasible alternatives.
5. DSS support several different decision-making techniques and they are highly adaptive in order to fulfil the ever changing needs of the user.
6. DSS allow interactive and recursive problem solving, thus not following a predefined path, but being able to use different 'routes'.

The elements mentioned above are typical characteristics of DSS. To turn DSS into SDSS, logically the spatial factor needs to be added, which is done by (1) providing mechanisms for spatial data input; (2) allowing representation of complex spatial relations and structures; (3) including analytical techniques that are unique to both spatial and geographical analysis; and (4) providing output in a variety of spatial forms including maps and other more specialised types (Densham, 1993, p. 406).

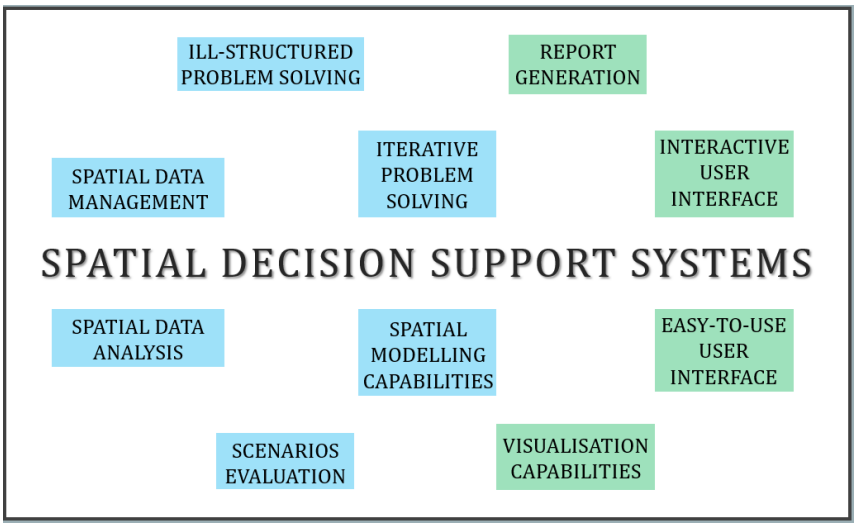

FIGURE 2: CHARACTERISTICS OF SPATIAL DECISION SUPPORT SYSTEMS (ADAPTED FROM SUGUMARAN AND DEGROOTE, 2010)

To conclude, SDSS must have enough capabilities to process stakeholders' preferences, but also have an easy-to-use user interface, thus communicative rationality capabilities are also part of the requirements. Further, it needs to have sufficient user interaction options in an iterative problem solving environment. It is necessary to have custom software that is easy in use, with an understandable graphical user interface and visualisation, and, logically, functionalities for spatial database management and analysis, scenario evaluation and modelling, and the ability to produce concluding reports (Sugumaran and DeGroote, 2010). Also here, communication is considered important since 'understandable graphical user interface and visualisation' entails a software that is able to communicate information about a particular case to laymen. From all these requirements we can conclude that SDSS is made up of a lot of different elements. Therefore, an overview of all SDSS characteristics is shown in figure 2. This figure shows all characteristics named in this section and provided by Sugumaran and DeGroote (2010). The blue boxes show technical elements, the green boxes show communicative elements, corresponding to the technical rationale and communicative rationale as described in section 2.1.

2.2.3. The roles of GIS within SDSS

For this research, GIS are considered "computer systems for capturing, storing, querying, analysing, and displaying geospatial data" (Chang, 2009, p. 1) and thus focuses on spatial information rather than non-spatial information. However this does not mean GIS are not able at all to fulfil the tasks that are less spatial. Often, in GIS, spatial data are integrated with non-spatial attributes. The website floodlabel.net is an example of integrating spatial with non-spatial elements, i.e. the website uses locational data as well as data about specific dwellings that is to be entered by residents themselves (FLOODLABEL, 2020). The role that GIS can fulfil are presented in figure 3.

Roles that GIS cannot fulfil, or at least not entirely, are the following. First of all, complex spatial decision problems mostly have spatial and non-spatial aspects. Some non-spatial aspects are not incorporated in GIS' modelling capabilities, such as the costs of solutions. This needs to be included by the GIS user or this needs to be incorporated in SDSS additionally. Regarding the iterative and interactive problem solving that needs to be part of SDSS, GIS is usually not flexible enough to cater this. Also the unstructuredness of spatial decision problems is sometimes difficult to handle in GIS (Sugumaran and DeGroote, 2010). Also GIS distinguishes itself from SDSS as being a general toolbox, while SDSS are considered more specific and dedicated to a particular issue. The toolbox contains more technical elements, meaning that GIS could be positioned in the technical rationale area. An SDSS usually contains communicative elements as well, meaning that SDSS could be positioned more towards the communicative rationale area. Floodlabel.net fits perfectly within the SDSS definition: spatial (e.g. elevation) as well as non-spatial (e.g. costs) are part of the website, and it is dedicated to a particular issue, being flood risk management.

The GIS database is not always able to capture the complexity of the information, especially when the data does not contain sufficient detail (Sugumaran and DeGroote, 2010). In other words: the feature presented may be more complex than shown in the GIS. Therefore, many kinds of information are simply easier to understand by individuals than solely GIS. Those individuals are mostly experts who already have knowledge about how to handle the kind of information processed in GIS. Therefore, a step needs to be made before this kind of information is presented to laymen, in order to make sure that laymen interpret the information correctly as well.

Thus, technically speaking, it can be concluded that GIS and SDSS are complementary to each other (see figure 3). There are several issues that need to be added to help GIS function at its best within SDSS, most importantly being the non-spatial and communicative aspects, and the iterative and interactive problem solving capabilities. In many cases in a communicative world GIS functioning at their own would not be adequate.

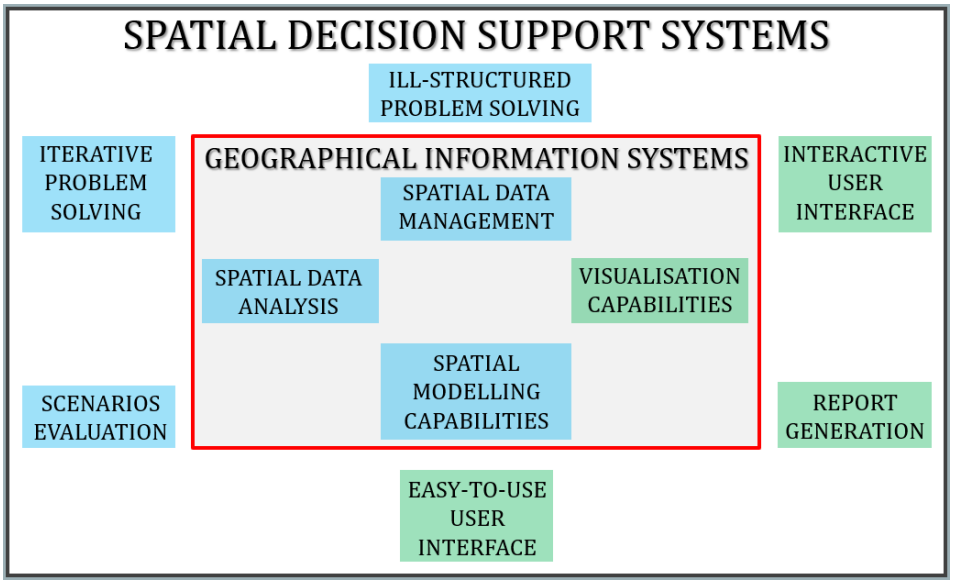

FIGURE 3: GIS AND ITS CHARACTERISTICS POSITIONED WITHIN SDSS AND ITS CHARACTERISTICS

2.3. The measurement of support systems

SDSS are not always considered successful, which makes it necessary to develop a measurement framework for SDSS (Geertman and Stillwell, 2009; Vonk et al., 2005; 2007). To examine whether SDSS do indeed fulfil a successful role in spatial planning and decision making, one could measure this in several ways.

Successful can be interpreted in different ways, which could be confusing. Therefore, before examining the different ways to measure SDSS in detail, a short overview, adapted from Pelzer (2017), is given of all terms that are used most often: (1) *performance* is the kind of influence PSS have on practice or the quality of the instrument (Te Brömmelstroet, 2013; Goodspeed, 2013[b]; Haasnoot et al., 2014); (2) *added value* is the kind of influence PSS have on practice (Pelzer et al., 2014, 2015[b]; Te Brömmelstroet, 2015); (3) *effectiveness* is the extent to which PSS have a positive influence on practice and the quality of the instrument (Arciniegas et al., 2013; Inman et al., 2011); and (4) *usefulness* is the kind of influence PSS have on practice (Larsson et al., 2014).

Although the definitions of added value and usefulness are exactly the same, these two differ in practice. This will become more clear in the following sections, where performance, added value, effectiveness and usefulness are discussed in more detail. Since these terms overlap often, in section 2.8 a conclusive framework is presented that contains the elements and terms that are considered most suitable for this research.

2.3.1. Performance

Performance is, according to Te Brömmelstroet (2013) and Goodspeed (2015), simply the influence SDSS have on practice. Yet, there are different interpretations possible. Whereas according to Goodspeed (2015) social learning is of interest, others have a different focus. For example, Te Brömmelstroet (2013) developed a comprehensive framework containing elements of the planning *outcomes* (novelty, workability, relevance, specificity) and elements of the planning *process* (reaction, insight, commitment, behaviour, communication, shared language development, consensus, cohesion, and efficiency gains). This framework is then used to assess SDSS performance. Haasnoot et al. (2014) focus in their study on the strictness and validity of SDSS, and is therefore more content-focused. From all these definitions and focuses no clear and reliable definition of performance can be created. These differences make it difficult to develop a framework that demarcates what performance entails in detail, about which a broad consensus is possible.

2.3.2. Added value

When measuring the added value, the positive influences of SDSS on practice are examined. The study of Pelzer et al. (2014) found added values in several aspects of the planning process and outcomes. They mostly found process elements that were enhanced, such as an improved collaboration between stakeholders, and enhanced communication. Thus, added value considers what has positively changed the planning process and outcomes. A drawback of added value is that it requires a comparison, since it measures the *added* value after an SDSS has been used. What is positively added can only be measured if a base situation is examined as well. For this research, this means a before- and after-situation always need to be measured when collecting data on the SDSS case. This is an extra barrier for doing empirical research.

2.3.3. Effectiveness

Effectiveness is measured by the usability of SDSS, where the interaction between people and technology is at the core of the analysis (Meng and Malczewski, 2009). However, there are more aspects that define the effectiveness of SDSS. During the development of SDSS, one must take into account three steps, developed by Arciniegas et al. (2013). The first step is thinking about which potential users you are addressing. Second, the information that SDSS use is essential to consider. Third, one should examine the final outcomes of SDSS relating to the decision(s) made with the help of the SDSS. These three steps result in three measurement aspects of effectiveness, being (1) *usefulness*: are the users of SDSS able to successfully perform their intended tasks?; (2) *clarity*: are the users of SDSS able to understand all information from SDSS?; and (3) *impact*: to what extent do SDSS (and their outcomes) influence the final decisions? (Arciniegas et al., 2013). Below these three aspects are described further (see Arciniegas et al. (2013) for further example studies on how to measure these aspects).

Usefulness:
Usefulness emphasises whether or not someone is successful in using the system in such a way that he or she is supported in his or her tasks, or has achieved a certain goal. When looking at other studies, this is often measured in degree of satisfaction of participants. Are they satisfied about SDSS after using them to achieve their goals? Usefulness can also be viewed in a broader sense. A thorough description of this broader perspective on usefulness based on Pelzer (2017) and Nielsen (1993) can be found in the next section.

Clarity:
Clarity is simply about whether or not SDSS users found the information shown by SDSS easy to understand. For instance, the preference for maps to show information is a good example of what determines whether people understand information well or not (see Janssen and Uran, 2003). There are several studies that indicated that clarity is essential for successful implementation of SDSS (e.g. Sidlar and Rinner, 2007; Pettit et al., 2011). Clarity indicates that SDSS usage is not only about the technical aspects, but also about the communicative aspects.

Impact:
Impact is about what kind of effect SDSS have on the final decision and the decision process. There are three options (where variance in degrees is possible): the effect can be positive: SDSS support the decision

process and final decision made; negative: SDSS hindered the process and the decision; or absent: SDSS did not have a significant effect on the process and decision (Arciniegas et al., 2013).

2.3.4. Usefulness

As mentioned under *usefulness* in the previous section, usefulness examines whether someone is able to fulfil a task or goal due to the support of the SDSS. However, usefulness can be measured in a much broader sense, and is defined differently by other authors. Therefore, for this research, it is also considered a component to assess SDSS effectiveness on itself. In this broader sense, usefulness focuses on a broad range of types of usefulness. Usefulness arises from the terms *utility* and *usability* (Nielsen, 1993).

Utility asks the question whether a system or tool can do what is needed. Thus, can SDSS help in achieving predetermined goals? Or, in a broader sense, can SDSS help to *support* (spatial) planning? This is the part that overlaps with usefulness as described under effectiveness. Closely related to this is the idea of *task-technology fit* as proposed by Goodhue and Thompson (1995). Put simply, task-technology fit describes the fit between the task, which is the planning task to be performed, and the technology that is used, which is the SDSS. The planning tasks are, as already mentioned under section 2.2, "the combinations of planning behaviours that accomplish particular functions or purposes" (Hopkins, 2001, p.187). Technology is needed to fulfil these purposes and can simply be described as the capabilities of SDSS to support the planning tasks.

There are two dimensions of support: *analytical support* and *communicative support*. Analytical support is about whether or not SDSS are able to enhance the understanding of the planning issue among those working on it, for example by informing them about the consequences of a certain intervention within different future scenarios (i.e. impact analyses). In case of flood risk management, the informative function can be the informative role about the impact of a flood in a certain area. Communicative support is about the communication between all actors, including those from the general public. This requires a system that enables communication and collaboration between these actors. Communicative support is therefore about whether a system is able to provide the right capabilities to enhance the exchange of knowledge between and among experts and laymen (Pelzer, 2017; Hopkins, 2001; Vonk, 2006). Communicative support clearly distinguishes itself from analytical support for two reasons:

1. Communicative support focuses on the way this content is communicated towards laymen, while analytical support focuses on the content of an SDSS itself.
2. Communicative support is about the exchange of knowledge (bi-directional) instead of the provision of information (one-directional, as meant by analytical support).

The distinction between technical rationale and communicative rationale perfectly correlates with the distinction between analytical support and communicative support.

Usability describes to what extent users are able to use the system or tool (Nielsen, 1993). One could argue that usability is closely related to the term *user friendliness*, since both are about the easiness to use SDSS by its users. However, it is considered to be more broad, as usability is about, among others, transparency, user friendliness, interactivity, flexibility and communicative value.

Thus, one aspect of usefulness is that it describes if SDSS are able to assist in achieving goals (Nielsen, 1993). Since it is difficult to clearly define those goals initially due to a high complexity and uncertainty, it is also possible to define and evaluate these goals afterwards (i.e. *ex post evaluation*). Besides the focus on achieving goals, there is also a focus on what types of usefulness are observed. Examples are an enhanced communication and more collaboration. These elements are typical planning process elements and often considered important constituents of usefulness. However, there are more types to be considered for usefulness, according to Pelzer et al. (2014). They developed a conceptual framework in which they capture usefulness into seven types (see table 1). Important in this framework is the learning part, i.e. do SDSS help users inform themselves about a certain subject? In several studies, such as Goodspeed (2015) and Pelzer et al. (2015[b]), this question is answered positively. Usefulness as described by Pelzer et al. (2014) is considered an important measurement element for this research. It addresses many elements of both the analytical support and communicative support as discussed above, and therefore gives more meaning to

these two types of support. This makes doing empirical research around measuring SDSS better structured and reliable.

TABLE 1: TYPES OF USEFULNESS. ADAPTED FROM PELZER (2017) AND BASED ON PELZER ET AL. (2014).

Type of usefulness	Description
Learning about the object	Gaining insight into the nature of the planning object
Learning about other stakeholders	Gaining insight into the perspective of other stakeholders in planning
Collaboration	Interaction and cooperation between involved actors
Communication	Sharing information and knowledge among involved actors
Consensus	Agreement on problems, solutions, knowledge claims and indicators
Efficiency	More jobs can be done with less investments
Better informed plans or decisions	A decision based on better information provision and consideration

2.4. Critique on the technical approach

Most of the previous sections described a rather technical approach to SDSS, which is important and therefore included in the conceptual model at the end of this chapter. The technical rationale approach is based in the thinking that one is able to predict in a complex dynamic world, being a set of interconnected parts (Allmendinger, 2017), i.e. in the technical rationale area of the spectrum shown in figure 1. However, this way of thinking is criticised by many authors for being a failed attempt of self-glorification of planners (Rittel and Webber, 1973). Spatial planning is too complicated and too politicalised to steer by the use of systems or tools only. Spatial planning, flood risk management included, involves many different actors, which makes the 'planner as a steersman' idea inappropriate and impossible (Faludi, 1987). Thus, using tools and support systems should not give the illusion that it is possible to completely understand and control the complex world of planning, but only partially. The technical rationale therefore has its limitations, among which are the incomplete information about alternatives, the background of the problem, and the range and content of values, preferences and interests (March and Simon, 1958). Habermas (1987) summarises this critique very well and comes with a proposal to shift: "(…) far from giving up on reason as an informing principle for contemporary societies, we should shift perspective from an individualised, subject-object conception of reason, to reasoning formed within intersubjective communication" (in Healey, 1992, p. 150).

During the 1990's, more critiques on the technical approach appeared. More authors saw that the technical rationale approach is too narrow to address all issues concerned in spatial planning. These narrow and technical views on planning neglect the unpredictable and spontaneous actions of people (Lawrence, 1998). The technical and administrative computers, and thus SDSS, stand for following predefined goals, which is also found back in the utility aspect of usefulness: *do SDSS help in achieving predefined goals*? However, these computer systems are based on narrow and a merely scientific rationalism (Healey, 1993). Furthermore, politics, opinions and thoughts are important in planning, and this is hidden when using the technical rationale approach. The world of planning is full of power relationships and political interests, which are not incorporated in this approach (Flyvbjerg, 1998). Besides that, contextual changes are and cannot be incorporated when using a technical rationale approach. A particular planning issue, e.g. managing local flood risks, is interconnected with several contexts, and context is always changing, even during the planning process. For example, climate change has a major influence on how flood risks should be managed on the short and the long term. Therefore, it is difficult to see the planning element in full isolation (De Roo, 2014).

Planning systems should not only fulfil the needs of the experts, who have knowledge of the planning institutions and specific elements of a particular issue. They should fulfil the needs of all actors involved, including those who have no knowledge of an issue. For this study those other actors are the laymen, or more specifically, the residents using the SDSS.

2.5. Communicating information to laymen

2.5.1. The communicative rationale

To get better insights into the perspectives of the laymen, the communicative rationale needs to be examined more extensively. Since the technical-functional rationale has been criticised a lot, the intersubjective coordination and communication has been seen as a driving force behind societal developments. Many of these developments can only be understood with a reasoning based on communication and interaction (De Roo, 2014). In this communicative rationale, it is all about "making sense together while living differently" (Healey, 1992, p. 143), and about the logic of behaviour, intersubjective choice, consensus seeking, learning and social action. Thus there is a shift of focus from the objective to the understanding of the intersubjective. In this intersubjective reality, there is more uncertainty, since the causal relationships are not clear, in contrast to the technical rationale (De Roo, 2014). These indirect causal relationships are due to the unpredictability of human behaviour, which is logically more present in the communicative rationale.

Because of the uncertainty in planning, a closed and object-oriented focus is not adequate anymore in the communicative era. In the communicative era, planning is characterised by an open focus on planning, and more focus on the process and institutions including its intersubjective relations. This is also the case for flood risk management, which is interrelated with several other (societal) developments (e.g. demography, welfare, climate change).

2.5.2. Expert vs. lay knowledge

Relating to the communicative rationale, risk communication is a good example of such a setting. Often, also in flood risk management, the communication of information is done in one direction: from experts to the general public, i.e. laymen. This way of communication is considered sufficient in the *knowledge deficit model*. This model has an enclosed assumption that providing information from expert to laymen on a subject, no matter in what way, will enhance the understanding of that particular subject by those laymen (Hansen et al., 2003). However, when scientific information is communicated, e.g. about flood risks, lay people do not have the knowledge to completely understand this information. Because of the gap in knowledge, the behaviour of laymen is influenced accordingly (Dickson, 2005; Hansen et al., 2003; Wynne, 1991). In other words: a great knowledge deficit leads to less awareness of a particular issue, and consequently to less support for tackling this issue. Thus, one should not assume that laymen interpret expert information in the same way as it was intended by the experts. Their actions are neither that easy to influence since their knowledge and perception is based on what information they received and, importantly, in what manner it is communicated (Faulkner et al., 2010). Another consequence of an insufficient expert-laymen communication is that the layman does not feel responsible for what they should do, e.g. in order to prevent and adapt to floods (Snel et al., 2019).

Instead, the interaction between experts and laymen should be bi-directional. Thus, information should not just go from experts to laymen, but the responses, comments, criticism and experiences from those laymen should flow back to the experts. In this, experts use this feedback in their risk communication, which enhances the overall risk communication and steps back from the outdated knowledge deficit model (Snel et al., 2019).

2.6. Flood risk communication

Although this one-directional and top-down communication has been criticised for decades, flood risk communication has not yet taken a full distance from it (Simis et al., 2016). In flood risk management the top-down orientation is persistent with aims such as enhancing risk awareness, knowledge transferral and giving subsequent advice to take action (Höppner et al., 2012). This is striking since through the years it is shown that the perception of (flood) risk is made up of various elements, including previous experiences, conversations with others (e.g. neighbours), culture, institutions, demography and geography (Maidl and Buchecker, 2015; Cole and Murphy, 2014; Bradford et al., 2012; Faulkner et al., 2010; Kashefi and Walker, 2009), which are not yet addressed.

Thus, we can state that most flood risk communication is directed towards laymen as if they were experts. A potential consequence of this is that residents do not take sufficient action to adapt to floods. Although more is likely to be needed than sufficient communication alone, this is a missed chance regarding climate adaptation measures on private grounds. Moreover, an insufficient transfer of expert knowledge to lay knowledge removes the sense of responsibility among laymen. Consequently, they look at the government as being their protector both in adaptation to flooding and in case of a flood event. A typical example of inadequate flood risk communication is the provision of flood probabilities in a *once every xx years* format. Although there are people that state that they prefer this way of communicating flood risks, they often still do not understand these probabilities correctly. Actually, a *once every 100 years* and a *once every 3000 years* probability of flooding does not make a difference for many residents. They do not realise that there could be a flood event in the upcoming year (Snel et al., 2019; Everett and Lamond, 2013). Another downside of this type of communication is that it is only informative and one-directional, while flood risk management is about taking action to protect against and adapt to floods (Snel et al., 2019).

The research of Snel et al. (2019) investigated residents' perspectives on flood risk communication. One conclusion is that the communication preferences of residents are diverse, meaning that it is impossible to develop one communication method to inform and trigger all residents while taking into account their preferences. Although most respondents are willing to visit a website to inform themselves about flood risks, still, a great variety of communication methods is needed to meet the preferences of all residents, such as face-to-face communication, national campaigns and receiving flyers (Snel et al., 2019). Considering this, one can conclude that the 'layman' does not exist as a label for an entire group of residents, but varies as different types of laymen. Thus, instead of bi-directional as mentioned in the previous section, flood risk communication should be multi-directional, in which experts and different groups of laymen are the main actors. This perfectly illustrates the intersubjectivity as described under the communicative rationale.

2.6.1. Cultural theory of risk

Thus, residents have varying perspectives. To divide residents into groups, the cultural theory of risk comes with four world perspectives: fatalism, hierarchism, individualism and egalitarianism (Douglas, 1970; Douglas and Wildavsky, 1992). These perspectives are also called rationalities or cultures (Hartmann, 2012), which are derived from their placement on an x-axis and y-axis: *group* and *grid*. Group is about whether people consider social values such as democracy, frequency of interaction and equality as important. Grid is about whether people consider the valuation of autonomy control and institutional integrity as important (Mamadouh, 1999). The four perspectives are shown in the matrix in figure 4 and described below (based on Hartmann, 2012; Mamadouh, 1999; Douglas, 1970):

- Fatalism: this perspective states that it is impossible to predict what will happen, and we are not able to influence the future. There is no kind of 'control' possible.
- Hierarchism: this perspective sees the world as a relatively robust equilibrium, where trial and error are possible to a limited extent. This extent should not be exceeded since then the equilibrium is destroyed. To prevent exceeding the extent, rules are created. Logically, hierarchy is important in this perspective. This perspective further stands for a society that gives power to an institution and where all members of that society are equal.
- Individualism: the perspective of individualists is the most robust of the four perspectives. Any disturbance will eventually bring the world back to the equilibrium. Thanks to this, trial and error are possible to a large extent and therefore considered important. Mistakes are to be learnt from and seen as a benefit for the future. As the name suggests, individualists do not want to cooperate and stand for freedom for individuals.
- Egalitarianism: the perspective of egalitarianists is the least robust of the four perspectives. Any small disturbance could destroy the equilibrium. Due to this, trial and error is not possible and one should act if any disturbance is likely to occur. In addition, this perspective looks at the results, not the process.

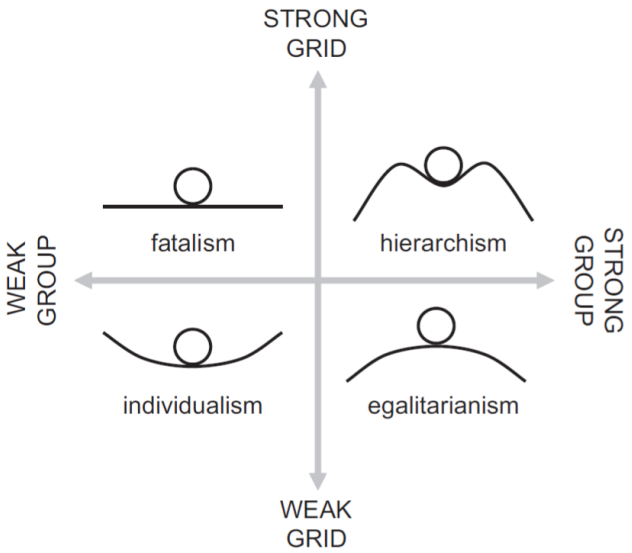

FIGURE 4: THE FOUR CULTURAL THEORY PERSPECTIVES SHOWN ON THE MATRIX OF GROUP AND GRID (ADAPTED FROM SCHWARZ AND THOMPSON, 1990)

2.6.2. Cultural theory of risk: applied to flood risk communication

The research of Snel et al. (2019) analysed the perspectives of residents on flood risk communication specifically. The cultural theory of risk can be defined broadly, but it is clear that flood risk falls within the boundaries of the cultural theory of risk. This is also what Snel et al. (2019) found in their research. They found that each of the CT perspectives can be related to the perspectives of residents of flood prone areas. For example, communicating flood risk information can be done in different ways, and it turns out that all these different ways can be found back in the varying preferences of residents in flood prone areas. Based on this and several other factors from the empirical research of Snel et al. (2019), four groups are created again, which one-to-one connect to one of the CT perspectives. These four groups are: insusceptible confident (fatalism), self-assured omniscients (hierarchism), acknowledged inexpert (individualism) and insufficiently connected (egalitarianism). These four groups are described below, based on Snel et al. (2019).

Insusceptible confident (fatalism)

As fatalism describes, the world is unmanageable. Therefore, we cannot influence flood risk and we do not need information about it. People adhering this perspective do know they are in danger but are not likely to change this. A website such as floodlabel.net, face-to-face contact, expert advice, a television commercial or a flyer are not preferred by those who adhere to this perspective. The government should provide the public with flood risk information, i.e. they take a passive role.

Self-assured omniscients (hierarchism)

In contrast to the previous group, the self-assured omniscients do think the world is manageable. Therefore, they believe in (current) flood risk management as done by the government. As described under hierarchism, rules and regulations are key, just as the hierarchy in which the government is on top managing flood risks. Since self-assured omniscients see the government as the responsible institution for flood risk management, they are not interested in expert advice, a detailed report or face-to-face communication. Rather they prefer a national campaign, i.e. a television commercial or flyers, and they need the government to stimulate them financially to take measures. According to Snel et al. (2019), this is the perspective that is mostly addressed in current flood risk communication.

Acknowledged inexpert (individualism)

Whereas the self-assured omniscients are not into face-to-face communication, a detailed report and expert advice, these communication methods are what perfectly illustrates the resident adhering to the acknowledged inexpert perspective. They prefer these communication methods over a website such as floodlabel.net. Ideally, they would like to be informed extensively by an expert, also about background

information. Further, as an individualist stands for self-determination and individual freedom, it will not be a big advocate of a national campaign on flood risk or collaborations. They regard the individual residents as main actors responsible for protecting themselves against floods.

Insufficiently connected (egalitarianism)

As an egalitarianist befits, the insufficiently connected residents are most concerned about climate change induced floods, and therefore feel the need to take measures themselves. For them, the results are more important than the process, and therefore those adhering to this perspective would like to obtain more information on what actual measures they can implement, and what the costs and benefits of these measures are. The background information comes in second place. Furthermore, the insufficiently connected residents would like to work together (community-based solutions) and they stand for common values, trust, and they would prefer a national campaign on flood risk adaptation. They want to pull out all the stops to enhance climate change adaptation and protection. In other words, they do not prefer one certain communication method, but think several communication methods together works best. In this, both the government and individual residents play a strong role.

The four groups are easily distinguishable by asking relevant questions about flood risk information, management and communication. For example, a fatalist would say that he or she is in danger, but is not willing to act. A hierarchist would look at the government and wait for them to take flood risk measures. An individualist would like to know as much as possible in order to come up with a plan for taking measures (or not) him- or herself. And an egalitarian would like to be informed on beforehand as much as possible about the final outcomes of taking measures. These are just simple examples of possible statements by respondents in one of the four groups. It would be interesting to see whether this is found back again in this research. Thus, besides examining the communicative value of SDSS, one can simultaneously look at the perspectives of respondents on flood risk communication in general in order to get a broader overview of how each groups perceives the communicative and analytical support of floodlabel.net.

To enhance the action orientation of residents in flood prone areas, intersubjectivity and sense of responsibility among individual residents, flood risk communication should address the communicative rationale by: (1) targeting information at the general public, i.e. laymen; (2) communicating individual risks (instead of e.g. 4 digit postal code area risks); (3) addressing individual responsibilities (to shift responsibilities from government to residents); and (4) asking for and processing feedback of laymen in the communication of expert information (iterative process) (Snel et al., 2019).

Still, in the communicative rationale, technical elements such as facts, links between facts, and an understanding of the reason for using those particular facts selected remain important. In addition, the communicative perspective can lead to certainties in an uncertain world, e.g. in the form of agreements. And, although the technical approach receives lots of critique and the communicative approach is considered essential, one should still aim for using a technical approach, since decisions are to be argued with facts, consistency and logic rather than intuition and emotion (De Roo, 2014). Thus, ideally but also realistically, a combination of the technical and communicative rationale approach is used in practice. An important note to this is that we should not aim for ending in the middle of the technical-communicative rationale spectrum, as Amdam (1994, p. 14) clearly describes: “The instrumental and communicative rationales can be just as utopian, but that should not prevent us from making an effort to achieve them.” In other words, within SDSS efforts should be visible to reach both ends of the technical - communicative rationale spectrum. A SDSS should therefore have sufficient analytical and communicative support.

2.7. Using the technical and communicative rationale within SDSS

Thus, SDSS should not only take into account the task-technology fit and analytical support, but also the communicative support and thus the perspective of various groups of laymen, thereby communicating information targeted at individuals in order to let individual residents take action for themselves. A special focus on the laymen’s interaction with SDSS is of particular interest. There are several suggestions on how

to optimise the human-computer interaction by taking into account user perspectives. Janssen and Uran (2003) investigated what type of information communication is preferred by stakeholders in a decision making process. Firstly, they found that the usage of maps and graphs is preferred over tables and text. Although maps are preferred as information communication method, it is not per se an indication that they are also able to use and work with those maps. Therefore one should bear in mind that a combination of visualisation methods is preferred. It is also not problematic if information is shown twice in two different manners (Janssen and Uran, 2003).

Secondly, Janssen and Uran (2003) found in their studies that the level of detail of the information has an effect on the ability of users to successfully use the information. In addition, when using maps people are more confident than when using other visualisation techniques.

When looking at the research of Andrienko and Andrienko (2003), we can see that a different thought about the role of visualisation and human-computer interaction arose previously. They see that according to Malczewski (1999) visualisation is especially important in the *intelligence phase*, i.e. the phase where the problem situation is outlined and examined (Simon, 1960). This is for flood risk communication the phase where residents are informed about their environment and where possible risks arise. However, according to Andrienko and Andrienko (2003), visualisation should also be considered in the phase where the options for a decision are evaluated and finally chosen (*choice phase*, Simon, 1960), as an addition to the analysis and modelling itself. This phase in flood risk communication is essential as it should be the first step in a call-to-action for residents to make adjustments and protect themselves better against a flood event. In here, they get an overview of what interventions they can do individually.

Their reasoning is that SDSS come with a suggestion for decisions to be made, and that particular trade-offs need to be made between choices that may be conflicting (Andrienko and Andrienko, 2003). As mentioned previously, SDSS often are expert- or knowledge-based systems, which involve knowledge that make the SDSS have their own 'reasoning' as usually done by humans. This 'human-like reasoning' is beneficial for the user of SDSS since it safes effort as the computer does the work for him or her (Sugumaran and DeGroote, 2010). However, the user, i.e. the layman, needs to be able to check what reasoning is used for a particular decision. Therefore, the user needs to know what factors are considered, what trade-offs are made, and thus why SDSS come with certain solutions (Andrienko and Andrienko, 2003). He or she cannot make this choice without knowing what happens behind the scenes. Informing laymen in an understandable manner will enhance the understanding of the choice made or advice given, and therefore potentially to a stronger call-to-action.

Allowing the users to interact with SDSS and providing them with visualisation options, support and enabling them to 'look behind the scenes', for example of the website (i.e. floodlabel.net). This is beneficial for achieving the goals as written by Snel et al. (2019), being targeting information at the general public, communicating individual risks and addressing individual responsibilities.

2.8. Measurement framework

Considering all four assessment terms as discussed in section 2.3, it is concluded that added value and performance are not suitable for usage as an assessment framework for SDSS. Performance does not provide us with a clear demarcated framework. It has many different interpretations and there is no broad consensus about what performance entails in detail. Added value is not used mainly because it has the drawback that it needs a comparison case to give proper results. For these reasons, only the terms effectiveness and usefulness are taken into consideration in this study, since both provide us with a comprehensive framework of how to measure the process and outcome aspects of SDSS, and both are widely supported and complementary: the descriptions of effectiveness and usefulness have similarities but are at the same time complementary. For example, both terms address communication, but in different ways: effectiveness in the sense of clarity (is the information communicated in an understandable manner?) and usefulness in the sense of collaboration and communication among stakeholders. Also, impact is for effectiveness described as the positive, negative, or absent influence on the final decision and process,

whereas usefulness gives more meaning to this concept by focusing on the learning part (process impact) and better informed plans (outcome impact) as written under analytical support.

The discussion on the communicative rationale in sections 2.4 - 2.6 adds several essential elements to the measurement framework. Most importantly is that, logically, communication needs to have prominent place in the framework. In here, the communicative support is given more meaning by not only focusing on communication, but also on the target group (general public, laymen), the individual focus (individual risks and individual responsibilities) and the use of a combination of visualisation and communication methods. The measurement framework consists of three overarching elements, which are: (1) Task-technology fit: are tasks fulfilled by using the technology? This includes utility (as written by Nielsen, 1993); (2) Analytical support: learning about the object and other stakeholders (process impact); better informed plans or decisions compared to non-usage of SDSS (outcome impact); (3) Communicative support: clarity of information; enhanced collaboration, communication, consensus (process impact). The conceptual model can be found in figure 5.

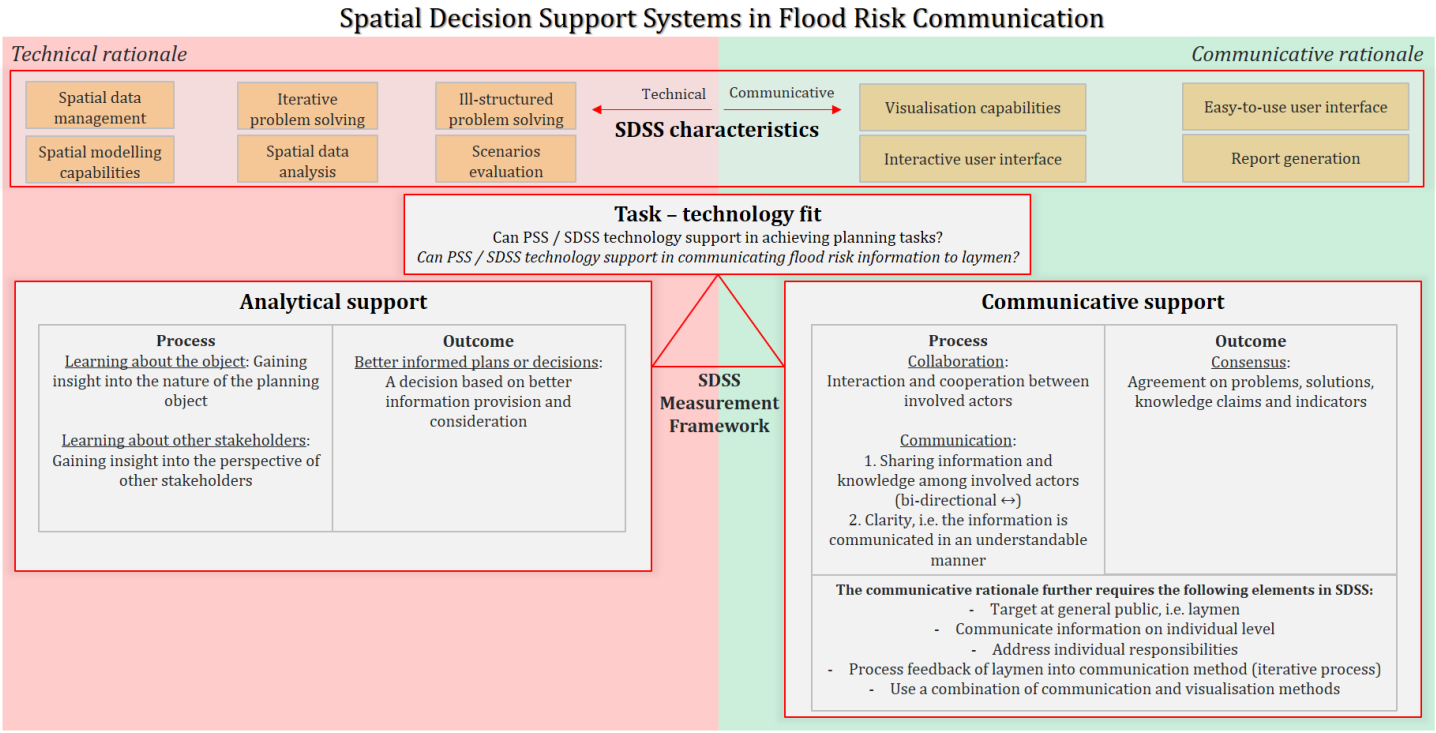

FIGURE 5: CONCEPTUAL MODEL

3. Methodology

This chapter gives a detailed description of the methodologies that are used in this research. In section 3.1, it is described how the research questions (RQ) are answered and how the research objectives (RO) are fulfilled:

3.1.1:	(RQ1)	*What is the analytical support of SDSS when communicating flood risk information according to laymen?*;
	(RO1)	*Test the analytical support of floodlabel.net in practice based on residents' perspectives*
3.1.2:	(RQ2)	*What is the communicative support of SDSS when communication flood risk information according to laymen?*;
	(RO2)	*Test the communicative support of floodlabel.net in practice based on residents' perspectives*
3.1.3:	(RQ3)	*To what extent is there a task-technology fit when using SDSS in flood risk communication according to laymen?*;
	(RO3)	*Examine the task-technology fit of floodlabel.net based on residents' perspectives*
3.1.4:	(RO4)	*Examine the flood risk communication preferences of residents*
	(RO5)	*Categorise the perspectives of users on SDSS usage in flood risk management into the four groups of cultural theory*

Information and insights are obtained through semi-structured interviews. Since both structure (statements) and flexibility (open questions and follow-up questions) are requested for data, this type of data collection is considered most suitable. This allows for both structure and flexibility (Dunn, 2005). The aim is to get a deeper insight into the experiences and perspectives of residents on floodlabel.net and further flood risk communication. Therefore, an interview is the perfect instrument to collect data on those experiences and perspectives. There are structured questions and less structured questions, which make the interview difficult to qualify as one type. One can also use observational techniques as proposed by Nyerges et al. (2006), since these can examine the revealed usefulness. However, this is not done for two reasons. First, this research looks further than only usefulness, i.e. the actual plans by residents after using the website cannot be addressed by observational techniques. Second, for user experiences and perspectives, one should take the perspective of the user itself to get a complete understanding of the issue (Geertman, 2008; Te Brömmelstroet, 2013), instead of, for example, observational techniques.

Surveys are not chosen as data collection method, since this does not allow for enough flexibility. Therefore, essential in-depth information is not gathered when using surveys. This in-depth information is required to come to coherent conclusions about the analytical support, communicative support and task-technology fit, but essentially for the CT perspectives of respondents.

The next section will elaborate on how the interviews are carried out, the content of the interviews, an elaboration on the questions that are formulated and the transcription and analysis process. Section 3.2 provides information on how respondents are addressed and selected, followed by a case study area description in section 3.3. Section 3.4 addresses possible reliability issues.

3.1. Interviews - operationalisation, content and analysis

The respondents are asked to use the FLOODLABEL website (floodlabel.net) right before the interview to let them test it as if they were to use it for their own dwelling. The interview is subdivided into themes (or sections). First, an introduction is given by the interviewer to the subject of research, including a short explanation of the FLOODLABEL project. The respondent is asked what he or she has done on the website and whether his or her dwelling is an owner-occupied or rented property. Lastly, the respondent is asked to be honest throughout the entire interview and add anything he or she wants to add, also for the statements. Thereafter, the interview is commenced with a number of predefined questions per section. All questions (and sections) address different themes throughout the interview that have been written in the

literature review in chapter two. The themes are analytical support, communicative support, task-technology fit and flood risk communication methods.

The interview starts off with statements, for which the respondent can answer *totally disagree, disagree, neutral, agree* and *totally agree*. This *Likert* scale (Likert, 1932) is used for several reasons. The statements address relatively simple issues which can be addressed 'to the point' in the interview. When asking a question that can be answered with only *yes* or *no* this affects the flexibility of the respondent when giving an answer. This missing flexibility is offered by the Likert scale. When asking an open question, the relatively clear and demarcated issues that are addressed in this section are framed too broadly to come to unambiguous answers. This makes the interviews less comparable. Yet, if more in-depth information is desired, follow-up questions are asked to the respondents. The second half of the interview contains in-depth questions, which address the potential outcomes the website can have, the roles and responsibilities, and the thoughts of respondents on flood risk communication methods. At the end of the interview, the respondent is asked to fill in a form with demographic questions. An overview of the interview structure is shown in table 3 below.

TABLE 3: INTERVIEW CONTENTS

Type of questions	Contents
Statements	Enhanced knowledge about floods and potential measures
Statements	Communicative elements of floodlabel.net
In-depth	Website aim and potential outcomes
In-depth	Roles and responsibilities
In-depth	Flood risk communication methods

The four themes are described in sections 3.1.1 - 3.1.4 in more detail, including a justification for all questions that are asked in the interviews. Questions that address CT perspectives are discussed throughout these sections. The interview guide with all questions that are asked can be found in appendix A.

The interviews are audio recorded (after respondent's permission) and transcribed right after. The transcription is used to divide answers into categories for a solid and structured analysis process. In this analysis process, the analytical support level, communicative support level and task-technology fit are examined, just as the perspectives of the respondents related to cultural theory.

After transcription, important fragments from the transcript are selected. This is done in Microsoft Word. These fragments are summarised and put into categories in another document. This is called 'summarised coding' (see Baarda et al., 2013). A comprehensive description of the categories (summarised codes) for each of the four themes is presented at the end of each of the sections 3.1.1 - 3.1.4.

3.1.1. Analytical support

This section is about whether SDSS are able to support tasks technically and analytically. Considering that residents usually make decisions without using SDSS, it is questioned whether residents are now better informed about the opportunities for adaptation measures (process impact), whether they are better able to make a well-argued decision and also actually are going to implement this decision in the end (outcome impact). Thus, this section examines whether users are better informed about the flood risk in general, the flood risk for their own dwelling specifically, and about potential measures they can take to reduce flood damage to their dwelling. This all reflects the first research objective: *Test the analytical support of one existing SDSS in practice based on residents' perspectives.* All themes concerning analytical support are discussed below.

Learning about the subject *floods*

To make sure that knowledge is enhanced due to the website, and thus the website *adds value*, a question is asked about the knowledge of floods before the website was used, i.e. "before I used this website, I had sufficient knowledge about flooding". Afterwards, the respondent is asked whether he or she did get to know more about the subject after using floodlabel.net. These questions are both about the knowledge of flood risk and the awareness of the dangers of floods. In addition, if *learning about the subject floods* is not

fulfilled entirely, there is a chance that respondents feel the need to learn more. For this reason an extra statement is added: "I would like to know more about the risk of flooding", followed by a follow-up question which asks what they would like to know in case the question is answered in the affirmative. A respondent that would like to know more is also likely to be an acknowledged inexpert (individualist) or insufficiently connected (egalitarianist). Other questions later in the interview about the respondent's preferences for flood risk communication methods validates or invalidates this assumption.

Learning about the roles of other stakeholders (government, neighbours)

Taking action to reduce flood impacts is considered not an individual activity performed by one individual or institution (i.e. government). However, floodlabel.net is not developed as a platform to share perspectives on the roles of others in flood risk management. It is rather a platform that allows individuals to gain insights about their own dwelling in their own time and as an individual activity. Beforehand it has been decided not to include this element in the analysis since respondents cannot share their perspectives on floodlabel.net. Yet, floodlabel.net does enable one to see the risks of neighbouring dwellings on a map. In addition, respondents are asked whether they feel more responsible for taking measures due to the website (statement), i.e. did they change opinion about their own role? The result of this question is not included here as it fits better with the analysis of the task-technology fit (see section 3.1.3).

Informative role of SDSS for making a well-informed decision

The website should inform residents about their flood risk and potential measures to be taken. To test whether this informative role is present, respondents answer the question whether this website informs them well enough about potential measures, their personal flood risk, and thus whether they are planning to take measures based on this information. The statement "the page with the measures is clear for me" addresses the measures explicitly, while an open question examines whether the website would help them to make plans for measures.

Analysis of results

After the interviews have been conducted and transcribed, the analytical support is analysed by examining the informative role of the website for three aspects: (1) the informative role regarding flood impact in general, (2) the informative role regarding flood impact around the dwelling of the respondent and (3) the informative role regarding potential measures to take to reduce the impact. The more respondents positively answer the statements about these three aspects, the better the analytical support. Not only the statements answers themselves are used, also additions from respondents are very useful and provide deeper insights into the analytical support of floodlabel.net. The additional answers are always leading.

3.1.2. Communicative support

In this section the focus is on the communicative rationale in risk communication and the thoughts residents have for SDSS' communicative values, more specifically about floodlabel.net. Questions about the satisfaction of the website while in use are asked in this section. These are about the clarity of the information shown and whether the residents, which are laymen, can interpret the information easily and correctly. This section reflects the second research objective: *Test the communicative support of one existing SDSS in practice based on residents' perspectives*. All themes concerning communicative support are discussed below.

Communication

Communication consists of two elements: bi-directional information sharing and clarity of information. The former is examined by questions about the easiness to request information on floodlabel.net. The clarity of information is examined by seven statements on the website being easy-to-use and having an understandable visualisation.

Collaboration

Another indicator of the communicative support is whether the SDSS enables collaboration. Beforehand it is found that floodlabel.net is not the right platform for this. Just as for the informative role about other stakeholders under analytical support, collaboration is too much focused on the website being a platform

to be used by groups instead of individuals which is the case for floodlabel.net. Still, the theme 'collaboration' is addressed in order to obtain insights into the CT perspective of the respondent. The standpoint of respondents regarding collaboration is a good indicator for the CT perspective they belong to. Collaboration in this sense is about collaboration with neighbours (taking measures together) and with the government (e.g. financial support). For example, someone who is willing to cooperate in both ways (neighbours and government) is likely egalitarian.

Target at general public

Since the respondents are laymen, information needs to be communicated in an understandable manner. Therefore questions are asked about the understandability of the information shown on the website. This includes text, images, maps, etc. The statements about various parts of the website provide insights into whether the information is easy to understand for the general public, i.e. laymen.

Communicate on individual level

The individuality of the information on the website is tested by asking respondents whether they found the information sufficient enough at the level of their own dwelling. In addition, it is asked whether this information was easy to find and request (i.e. easy-to-use website).

Address individual responsibilities

Next to addressing the individual and local information, this could also trigger residents to feel more responsible. The statement "The website has made me feel more responsible for taking measures against flooding myself") examines this issue, just as several open questions. This theme also relates to the task-technology fit of the website (see next section).

Consensus seeking

For similar reasons as for 'collaboration', consensus seeking is not taken into consideration in this research. It is an important element in most spatial planning issues. However, this is different for floodlabel.net, where other circumstances are present than for planning issues where consensus seeking is a goal in itself. Floodlabel.net is a platform that enables spatial decisions to be made mostly by individuals (e.g. purchase a waterproof door), while in other spatial planning issues a collaborative decision is to be made (e.g. windfarm). Therefore, since consensus seeking is not a relevant theme for floodlabel.net, it has been chosen to not take this element of communicative support into consideration in this study.

User feedback

The floodlabel.net website itself does not have an option to give feedback. The feedback by users is examined by seven statements about the clarity of the website's pages, plus and addition open question that asks for further points of improvement and feedback. This open question is an extra opportunity to obtain information about the communicative support factors of the website. It is conceivable that also for analytical support relevant information could be obtained here. The respondent is free to state here what he or she was not able to share before.

Analysis of results

Thus, the communicative support is determined by examining ten elements and pages of the website by using statements, plus an additional open question where respondents are allowed to give extra feedback. The statements question whether certain pages are clear (first page with the floodlabels and map, extra information about floods, questions about the own dwelling and potential measures), whether the entire website is clear in terms of text, whether the website is easy-to-use and whether it is easy to see what happens behind the scenes of the website. All combined answers to these statements make up the communicative support of the website, together with additional answers and feedback.

3.1.3. Task-technology fit

As discussed before, *task-technology fit* examines whether the planning tasks match the technology used to fulfil those planning tasks. This is related to *utility* that focuses on the goal orientedness of the SDSS (i.e. are predefined goals and tasks by the website makers achieved and fulfilled?). This is tested in practice by

simply asking residents whether the website for example triggered them to take flood risk adaptation measures quickly. If respondents feel more responsible after using the website, and therefore plan to take measures, it could be stated that there is a positive task-technology fit for floodlabel.net. Therefore, questions are asked about whether respondents feel more responsible and the willingness of respondents to take flood adaptation measures. For example, does the respondent feel more responsible for taking measures after using the website? Has the website raised awareness regarding flood risk? And has the website caused the respondent to take any measures, or make plans for short term measures? Also here, statements in combination with additional open questions are used to come to a final task-technology fit conclusion.

3.1.4. Flood risk communication methods

This section focuses on the preferences of residents for flood risk communication methods aims to assign each respondent to one group of the four CT perspectives. It reflects the third research objective: *Examine the flood risk communication preferences of residents*. It is also the essential step to later perform the fourth research objective: *Categorise the perspectives of users on SDSS usage in flood risk management into the four groups of cultural theory*. This is done after data collection. All themes concerning flood risk communication method preferences are discussed below.

Opinions about floodlabel.net as communication method

Since the CT perspectives have various views on risk communication methods, it is useful to ask whether respondents do appreciate or depreciate floodlabel.net as a communication method. This is asked in an open question ("What do you think about this website as a means of communication for information about floods and potential concrete measures you could take?"). Importantly, it is emphasised that it concerns the website as a means of communication, not the actual implementation of floodlabel.net as it is. Egalitarians are the example of the CT group which appreciates the website the most.

Preferences for potential other flood risk communication methods

Respondents might prefer other communication methods, which need to be discussed as well in order to get to know more about the CT perspective of respondents. This is examined simply asking what other preferences respondents have ("What are your further / other preferences for communicating flood information and concrete measures?"). They are free to answer what comes to their mind. It is likely that they do not name all possible methods. Therefore, as a follow-up question, suggestions are given which are to be judged by the respondents (e.g. television commercial, flyers). For example, someone who is not into a national campaign is likely to be an individualist.

Expert involvement & face-to-face communication

It is also important for the determination of the CT perspective whether the respondent has a need for additional help. Essentially, one should know whether a respondent thinks the website is not needed, suitable, or whether they would prefer to talk to an expert additionally. Respondents that prefer face-to-face communication are to be included in a different perspective than those who do not prefer face-to-face communication. For example, those who do appreciate face-to-face communication are likely to be acknowledged inexpert (individualist).

Determination of CT perspective per respondent

For the determination of the correct CT perspective per respondent, the answers to the open questions as presented this section are used. However, not only answers to these questions give insights into which perspective respondents might belong to. Throughout the entire interview, respondents make statements that provide insights as well. Therefore both the open questions especially developed for this determination process and the additional statements made at other moments in the interview are used for a reliable and complete determination process. All statements and answers are divided into categories, for which the answers help in dividing the respondent into a group. This corresponds to the characteristics of the four groups of Snel et al. (2019). An overview of all determining characteristics for the CT perspectives can be found in table 4. Since the four CT groups are mutually exclusive, these categories are sufficient to determine

the CT perspective of each respondent. Section 2.6.2 gives an extensive description of all CT perspectives and their preferences, based on Snel et al. (2019) and cultural theory.

TABLE 4: CHARACTERISTICS FROM SNEL ET AL. (2019) THAT DETERMINE THE CT PERSPECTIVE OF RESPONDENTS. A '-' INDICATES THAT THE CHARACTERISTIC IS NOT A DETERMINING FACTOR FOR THAT CT PERSPECTIVE.

Characteristic	**Fatalist** *Insusceptible confident*	**Hierarchist** *Self-assured omniscient*	**Individualist** *Acknowledged inexpert*	**Egalitarian** *Insufficiently connected*
Being concerned about floods around the own dwelling	No	No	Yes	Yes
Wanting to know more about flood risks	No	No	Yes	Yes
Willing to cooperate with others	No	-	No	Yes
Appreciate government's (financial) support	Yes	Yes	No	Yes
Roles and responsibilities in flood risk management	Government is responsible for flood risk management (passive role for residents)	Government is responsible for flood risk management	Residents are responsible for flood risk management	Shared responsibilities: strong role for both government & residents
Preferences for communication methods:				
- Website	No	Yes	No	Yes
- Flyer / folder	No	Yes	No	Yes
- National television commercial	No	Yes	No	Yes
- Detailed report	No	No	Yes	-
- Expert advice	No	No	Yes	No
- Face-to-face communication	No	No	Yes	Yes
First interest	-	-	Background information	Potential measures and their costs

As floodlabel.net is an SDSS within flood risk communication, one can draw conclusions about the analytical support, communicative support and task-technology fit of this SDSS. The conclusions are not only drawn for the website in general, but also for the four CT groups separately. For example, if hierarchists generally state that the website is informative about floods and flood risks and helpful for making decisions, it can be stated that the website has a positive analytical support for hierarchists. Logically, if another group, e.g. egalitarians, feel the website is not informative enough, a negative analytical support is observed for this group. For communicative support and task-technology fit, similar strategies are used. It is also conceivable that only partial support is found, for example only 'address individual responsibilities' is appreciated while other elements of communicative support are not. It is thus examined how the website performs analytically and communicatively among all four perspectives, and thus whether the SDSS is able to be as optimal as possible in addressing the perspectives.

3.1.5. Calculation of indicational numbers from statement results

The statements are a guiding element in the first part of the interview, and therefore one can calculate averages to give an indication of the results for each CT group, e.g. the analytical support of the website for individualists. Each statement has a *Likert* scale, ranging from *totally disagree* to *totally agree*. To be able to make calculations, each *totally disagree* answer is assigned -2, and each totally agree answer +2, with disagree (-1), neutral (0) and agree (+1) in between. For example, if for the statement "The website provides sufficient information about taking potential measures" four respondents answer agree(+1), agree(+1), agree (+1) and totally agree(+2), this results in an average of +1,25. The same is done for the questions about the task-technology fit, which could be answered with *yes* or *no*, i.e. 1 or 0. With a calculation of the average, the number between 0 and 1 could be used to compare the four different CT groups. However, all these calculations are only used as indication and are not leading in the analysis. The actual spoken words

of respondents are always leading, because the numbers are not based on any statistical analysis and can therefore not be considered entirely reliable for drawing conclusions.

3.2. Approaching respondents

The respondents are residents living in a flood prone area. These areas are three cases: Zwolle, Venlo and Dordrecht (the Netherlands). See also section 3.3 for a detailed case description. The respondents themselves are approached by the use of personal connections of the researcher, together with a snowball technique (Goodman, 1961), i.e. already participating respondents are asked whether they know neighbours, friends or family in the same municipality to also participate in an interview. Before planning addressing a respondent, a quick check is done on *overstroomik.nl* (2020) whether the respondent is living in a flood prone area (this is the 'blue' area as shown on the map on the website). Right before the interview, the respondents are asked to visit floodlabel.net. They are asked to use the website as if they were to use it for their own dwelling, and to consider what they would do with the information provided on the website regarding floods and potential flood protection and adaptation measures. The number of interviews is sufficient in case a certain 'saturation degree' is reached (Marshall et al., 2013). This saturation degree can only be reached when respondents are interviewed in all three case study areas (Zwolle, Venlo and Dordrecht), and when all four CT perspectives are represented by the respondents. Afterwards it is important to obtain as much diversity as possible within the interviews to avoid missing crucial information.

3.3. Case study areas

The municipalities of Zwolle, Venlo and Dordrecht chosen as case study areas for this research. All three municipalities contain a medium sized city, located in three geographically different areas in the country. Zwolle, capital of the province of Overijssel, is located in the middle of the country, near the rivers *IJssel* and *Vecht*. Venlo is located in the province of Limburg in the south-east of the country, and its municipality contains several small villages that are, just as the city of Venlo itself, located along the river *Meuse*. Dordrecht is located in the south-west of the country. It is part of the province of Zuid-Holland, in the most densely populated area in the Netherlands. It is located in the area of two major rivers: the *Meuse* and the *Waal*, where the *Beneden Merwede* and *Nieuwe Merwede* flow along Dordrecht itself.

26 percent of the Netherlands is located below sea level (Dordrecht among others) and 59 percent is located in a flood-prone area (Zwolle, Venlo and Dordrecht among others) (PBL, 2010). Thus, Zwolle, Venlo and Dordrecht are chosen because of their geographical location being in a flood prone area, but, importantly, their flood risk is determined by different factors. For example, flood types can be rainfall floods, river floods and groundwater floods, and the areas are protected against water in different manners. The three municipalities are chosen to be representative for flood risks in the entire country. An overview of the three case study areas is shown in figure 6.

FIGURE 6: OVERVIEW OF CASE STUDY MUNICIPALITIES WHERE RESPONDENTS FOR INTERVIEWS ARE RECRUITED.

The flood prone area is determined by using the website *overstroomik.nl* (2020): for Zwolle and Dordrecht, a major part of the municipality is covered by the blue flood prone area. For the municipality of Venlo, this is only a narrow area around the river *Meuse*. Thus, the selection of respondents in Venlo is limited by this flood prone area, compared to Zwolle and Dordrecht.

3.4. Reliability of research methods

As previously mentioned, the research is method is a semi-structured interview including statements and open questions. The structured part of the interview makes the results easily comparable with other interviews and other respondent groups (i.e. CT groups). The open questions may lead to more varying answers that are less comparable, which leads to that the goal to compare interviews is not easily achieved (Boeije et al., 2009). Fortunately, the recording and transcription of interviews is helpful in this, as this creates the option to get back to an interview at all times and draw more valid conclusions.

Another issue is the fact that respondents' answers on yes / no questions may not be fully reliable, simply because they do not know what they would do in any imaginable situation. For example, if the question

"does a commercial on television on this subject appeal to you?" is asked, the respondent might answer *yes*. A follow-up question does however tell more than only this answer. An example follow-up question in this case could be "would a commercial on television also set you to action?" Thus, a follow-up question in many cases says more about the thoughts of respondent about certain subjects than the first question on paper. This also applies to the statements. In addition, a respondent that immediately substantiates his or her answer proves to know better than someone who does not substantiate his or her answer. Therefore, a follow-up question simply being 'why?' is used as well throughout the interview.

Related to the issue discussed above, a respondent might be afraid to give 'socially undesirable' answers related to floodlabel.net, i.e. be less critical to 'keep it friendly' (Boeije et al., 2009). To prevent this, at the beginning of the interview it is emphasised that the respondent is free to be as positive or negative as he or she desires. Also, it is noted that the researcher is not involved in the development of floodlabel.net, i.e. the researcher takes a neutral standpoint.

4. Results

For this research, 17 interviews have been conducted, of which six in Zwolle, seven in Dordrecht and four in Venlo. The interviews lasted between 18 and 51 minutes, counting up to a total of 518 minutes and 30 minutes per interview on average. All four CT perspectives are represented: two fatalists, six hierarchists, four individualists and five egalitarians. An overview of all respondents is shown in table 5. The next sections present general results from the interviews (4.1), the analytical support (4.2), communicative support (4.3) and task-technology fit (4.4) for floodlabel.net.

TABLE 5: OVERVIEW OF INTERVIEWS

#	Date & time	Case city	Duration (min)	CT perspective
1	13-12-2019 14:45	Zwolle	26	Self-assured omniscient (hierarchist)
2	13-12-2019 15:30	Zwolle	22	Self-assured omniscient (hierarchist)
3	16-12-2019 19:00	Zwolle	30	Insufficiently connected (egalitarianist)
4	16-12-2019 19:45	Zwolle	26	Insufficiently connected (egalitarianist)
5	18-12-2019 14:30	Dordrecht	26	Insufficiently connected (egalitarianist)
6	18-12-2019 16:30	Dordrecht	25	Insusceptible confident (fatalist)
7	18-12-2019 17:15	Dordrecht	18	Acknowledged inexpert (individualist)
8	18-12-2019 18:00	Dordrecht	27	Insufficiently connected (egalitarianist)
9	20-12-2019 12:45	Dordrecht	25	Acknowledged inexpert (individualist)
10	20-12-2019 14:00	Dordrecht	27	Self-assured omniscient (hierarchist)
11	20-12-2019 14:45	Dordrecht	35	Acknowledged inexpert (individualist)
12	30-12-2019 11:30	Zwolle	29	Self-assured omniscient (hierarchist)
13	07-01-2020 15:00	Zwolle	24	Self-assured omniscient (hierarchist)
14	08-01-2020 12:30	Venlo	47	Insufficiently connected (egalitarianist)
15	08-01-2020 14:00	Venlo	39	Self-assured omniscient (hierarchist)
16	08-01-2020 15:00	Venlo	51	Insusceptible confident (fatalist)
17	08-01-2020 16:30	Venlo	41	Acknowledged inexpert (individualist)

4.1. General results

Generally, most respondents are not concerned about the increasing risk of flooding around their home. Only two respondents agreed to this statement. Several respondents described the two sides of the story: “We are reasonably protected, we have it under control pretty well, we know what to do. Still, there is a chance that the water raises further due to climate change” (respondent 16). Most respondents did not worry because they considered their location as safe enough. They show to be aware of their own location: “I am safe where I live, relatively new neighbourhood, 25 years old. The river is far away, there is a dike in between, so I am not concerned for the place where I live” (respondent 12). Furthermore, respondents think their dwelling is safe because they estimate a flood not to happen on the short term.

Although respondents are not concerned, most of them are positive about the idea of floodlabel.net, with personal flood risk information. Only three have a negative attitude to the website in general. They admit that they would never go to such a website from own initiative, meaning that floodlabel.net as a communication does not belong to their first preferences. Respondents who valued the website itself and as a communication method positively would like to see another communication method (flyer, television commercial) to lead them to the website. They would also not visit the website from own initiative, i.e. there must be a trigger to lead them to the website. Respondent 10 considers the website more as a platform for real estate agents than individual residents. Among those who are positive about the website, ‘It is easy’ and ‘I prefer doing this online and on my own’ are the most heard reasons for why the website is valued positively as a communication method (not how the actual website is implemented currently; this is discussed under section 4.3).

4.2. Analytical support

To come to an indication of the analytical support, the website's informative roles are assessed. The valuation of the analytical support elements varies across the respondents. Generally, the informative role of the website is valued neither negative nor positive. Only the different kinds of information are valued differently. The informative role about floods in general is valued more negatively than positively (positive: 7; negative: 10; av. score: -0,29). The informative role about flood impact, but then specifically for the own dwelling of the respondent, has also more negative than positive answers (positive: 6; negative: 9; av. score: -0,29). The informative role about potential measures is valued more positively (positive: 14; negative: 3; av. score: +0,64), although nobody indicated that he or she is planning to take any of the measures presented.

Between the four CT groups there are differences observable. Hierarchists are most positive about the measures (+1,16) while negative about general (-0,67) and specific (-0,33) flood info. Some hierarchists do not raise the bar high: they have no particular interest in this kind of information and are therefore satisfied with a low amount of information on flood risks. Further, about the informative role respondent 12 stated: "Beforehand I had no clue about flood risks, so compared to that I did get a little grasp from it, but I will not call myself an expert of floods, not at all."

Individualists are most negative about the analytical support of floodlabel.net. They generally find the information not specific enough (-1,25): it should be more tailor-made to their own dwelling. Also the potential measures are judged slightly negatively (-0,50).

Egalitarianists are most positive of all four groups: they judge the informative role about floods in general (+0,20), floods around the own dwelling (+0,40) and the potential measures (+1,00) positively.

The respondents from Venlo distinguished themselves from the respondents in Zwolle and Dordrecht. They all experienced the floods in 1993 and 1995, while the respondents from Zwolle and Dordrecht have no experiences with floods at all. This leads to a totally different interpretation of the measures page. The respondents from Venlo, which are spread across different CT groups, found the measures inappropriate for the floods they experienced in 1993 and 1995. Respondent 15 and 17 illustrate the issue with the measures clearly: "You can purchase waterproof doors, you can insulate the walls, you can insulate the basement, but then still the water comes through those holes or it comes through the window. I had a water level of 1m12, then it just comes through the window. There were measures you could actually implement, but I did not feel that it protects me in the end" (respondent 15). "Then you need totally different information (…). For me, my dwelling is of importance, that is why you go to this website. Currently, I do not see any information that could have helped me in that situation" (respondent 17, individualist). Thus, the measures could be informative, but not appropriate to the scale of the floods that could occur. Also here it becomes clear that individualists require a website that is more tailor-made to the own dwelling.

4.3. Communicative support

The communicative support is measured by ten statements about different pages of the website plus additional questions. Also here the potential measures are valued most positively (+1,29), but now in terms of clarity. All respondents gave a positive answer for the statement about the page with potential measures. Most negatively judged is the statement 'I can easily see what happens behind the scenes of the website'. This had an average score of -0,94. 13 respondents gave a negative answer. Most respondents (13/17) also stated that they would like to see more of what happens in the background in order to comprehend the information presented better. Other results show that most respondents (11/17) think that the website is easy-to-use (+0,59), even more (14/17) think the website has clear text (+0,88). However, concerning the individuality of information, there is no broad consensus among respondents (positive: 7; negative: 8; av. score: -0,06), just as for whether the website addresses individual responsibilities (-0,70). Further, the first page with the four labels is clear for most respondents (+0,64), just as the extra information about the four types of floods (+1,12). The questions about the own dwelling to specify your label are clear (+0,47). However, it should be noted that, although the questions themselves were clear and comprehensible for most respondents, for many of them it was still unclear how to discover which measures have already been

taken. For example, respondents do not know whether walls are sealed with waterproof material. Respondent 1 noted: "First, explain what a weather barrier is, how you can get such a door and how you can measure how high your front door is. These are the things you do not know." Many other respondents asked for extra explanation as well.

In general, respondents ask for more explanation for the entire website. "It was good to understand, but it is a bit too brief" is what respondent 3 stated about particular terms and images on the website. Less often mentioned but important other feedback can be summarised as follows: the choice for a label is unclear for many respondents (i.e. show more what happens behind the scenes). The type of flooding that is most relevant for the user's location should be mentioned, i.e. not all four types are relevant for all locations and the labels in this sense do not explain this well enough. Also some measures on the measures page need more explanation. Some respondents indicated that the text should be more easy to make it comprehensible for everybody. Other feedback is that the website should be more mobile phone-friendly.

All four CT groups are slightly positive about the communicative support of the website, but they differ in degree. Fatalists are slightly positive (+0,20), especially about the measures (+1,50), the labels (+1,00) and the extra info about four flood types (+1,00). They do not think that the website addresses individual responsibilities (-1,50), i.e. the website does not show what the responsibilities are of individual residents. This is found for all other groups as well. Hierarchists show similar numbers (+0,28), but ask for more information on why the website is there: "You are confronted with all kinds of risks, but I think it is also good to explain in advance why you let people do that" (respondent 2). Hierarchists do therefore not know what to do with the website: "It is a lot of information without knowing what you have to do with it as a user of the website" (respondent 12). Some hierarchists ask for more specific information. Respondent 15, who experienced the 1993 and 1995 floods in Venlo, stated: "Because I experienced floods before, I do get the right information out of the website. Someone who has just moved here would perceive that differently. I think this information should be made more specific". She added that the info should be even more specific for those dwellings that are located in the most flood dangerous area, i.e. right along the river Meuse. In addition, respondent 10 asks for more questions about the dwelling to make the label more specific.

Individualists are the least positive about the communicative support of the website (+0,13). Again, what happens behind the scenes is not shown (-1,50) while respondents would like to see that. Also individualists do not agree with the statement that the website addresses individual responsibilities (-1,25) and that the information is communicated on an individual level (-0,75). Just as other respondents, individualists ask for more explanation across the entire website, for example for the map and for why a label is chosen. Some statements on the website are too general, e.g. 'you are well protected against most types of floods'. The text on the button 'I want to know more about the floodlabel of my dwelling' is not correct since the info shown is just general information instead of specific information about the dwelling: "This states 'my dwelling', but what I see is just a general story. There is nothing about my dwelling. (…) The story was clear, but it is so general, I hear it on the news every day, so to speak." (respondent 17). This respondent (17) had also other critiques on the website: the website does not see a flood as a dynamic event (i.e. a 'wave'), but as a static thing. For his dwelling the river label is 'good', but when the dikes break and thus the impact is high, this is misleading. Furthermore, the map showing precipitation is not correct according to the respondent, since it shows the exact locations that flooded in the river flood of 1993.

Egalitarians are the most positive regarding the communicative support (+0,56). They are most positive about the potential measures (+1,20), and least positive about whether it is shown what happens behind the scenes (-0,60). Egalitarians are also positive about whether the information is communicated on an individual level (+0,80). Still there are critiques. First of all not about the website's content, but its relation to other websites. According to respondent 14 it should be coordinated with other websites which is to be used for which purpose. It should also be findable on the internet. Two respondents would also like to see a probability of flooding on the website: "I miss a probability. (…) Are we talking about once every ten years, once every 100 years or once every 1000 years? The website says: in case of a flood, you are protected in these ways, but what is the probability of such a flood? (…) For me, this influences my feeling of urgency" (respondent 5). Further, it is recommended that the inclusion of a source together with a probability would make the website more reliable: "If you are confronted with this information, my question would be: what

is the source? You are directed to such a website, but it needs verification. (…) How realistic is this? There needs to be more confidence. Then you come at the calculation of a probability, such as percentages" (respondent 8).

4.4. Task-technology fit

The task-technology fit is assessed by evaluating whether the feeling of responsibility has increased or decreased according to the respondent, whether the website has raised respondents' awareness, and whether they are planning to take measures based on the website. Since the answer could be *yes* or *no*, scores vary between zero and one. For the feeling of responsibility, a majority indicated that the feeling of responsibility did not increase: twelve respondents answered *no*, five answered *yes* (av. score 0,29). Respondent 14, who's feeling of responsibility did not increase due to the website, stated: "This is because I experienced a flood in 1993. Back then you waited for a government's decision, but it turned out that you could better use your own common sense. Because of this I already felt a responsibility and the website has not changed anything related to that." Respondent 13 answered *yes* and argued: "I feel the responsibility, but the measures are not an option for me financially. For example, a waterproof door of 1000 euros is too expensive. If I would have the money, I would at least consider doing these investments."

Before asking whether the goal of the website was achieved (awareness raising and taking measures), respondents were asked to come up with the goal they could think of themselves. Most given answer is clearly 'awareness raising' (13 respondents), followed by 'give insights into dangers' and 'give insights into measures'. When asking whether the website raised respondents awareness, nine answered *yes* and eight answered *no* (av. score 0,53). For those who have become more aware due to the website, most did not even think that a flood could happen near their house. All respondents from Venlo answered *no* as they have a high awareness of flood risks due to previous experiences.

The fact that nine respondents have increased their awareness says nothing about the plans of respondents to actually take action: nobody is planning to take measures. Many respondents indicate there is no feeling of urgency, which leaves them to wait and not take action themselves. There is a distinction between the 'bigger' and expensive measures (e.g. waterproof floors) and the 'smaller' and cheaper investments (e.g. bring belongings of sentimental value to a higher floor). Respondents would consider only the latter, only in some cases, for example when a severe flood is about to occur or has occurred already: "When the steed is stolen, the stable-door is locked" is what respondent 8 cynically added concerning this. Nobody is even thinking of doing big investments to protect their house on the short term: "When it rains a lot, sometimes water does not flow away in the garden. Something like that must happen and be even more extreme, making the water reach the house. Perhaps then you will really start to think about what you can adjust. But no, not at the moment" (respondent 12).

Fatalists do not feel more responsible after using the website (0,00), and the website only partly raised awareness (0,50). One respondent thought about the industry of materials that have to be produced for a waterproof house to be the main driver behind the website, instead of raising flood risk awareness. Hierarchists do not score better on task-technology fit. Most of them do not feel more responsible (0,33) or think that the website has raised awareness about flooding (0,33). "I do not think there are many flood events in the Netherlands" (respondent 1) is an often heard reason for why the website did not contribute to raising the respondent's awareness. Individualists show similar results as fatalists: nobody feels more responsible for taking measures after using the website and only half of them has an increased awareness. Respondent 17 added to that that "the self-responsibility has always been there". Respondent 11 acknowledges that there is a flood risk and shows that he has sufficient knowledge about it, but "I am also aware that it does not come so fast." A small majority of egalitarian respondents feels more responsible for taking measures after using the website (0,60). Most of them think their awareness has been raised after using the website (0,80), but, just as the other three groups, nobody is planning to take measures.

5. Analysis

In chapter two (theoretical framework) certain propositions are made based on previous research, which are discussed in this chapter. It is analysed whether the results of the previous chapter are in line with or in contrast to the theoretical framework, and other striking results that did or did not meet expectations are examined as well, for which explanations are sought. First, the varying flood risk awareness among residents is discussed. Afterwards, the plural perspectives (differences between respondents groups) and non-plural perspectives (aspects about which respondents are unanimous) are discussed.

5.1. Flood risk awareness

The flood risk awareness of respondents in this research is relatively low. When analysing the answers of respondents about their flood risk awareness, two groups can be created. The first group contains respondents from Zwolle and are not aware of their flood risk. The second group contains respondents from Venlo and are more aware of their flood risk. Beforehand, it was expected that respondents from Venlo would perceive flood risk differently than other respondents, as the 1993 and 1995 river floods that occurred in the municipality of Venlo would influence the perceptions of respondents on flood risk and the experience of the website. This is found to be true for this research. Since all respondents from Venlo have experiences with the 1993 and 1995 floods, this influences their view on flood risk management and makes them probably more aware of what their flood risk is. Although their perceptions are also influenced by culture, institutions, demography and geography (Maidl and Buchecker, 2015; Cole and Murphy, 2014; Bradford et al., 2012; Faulkner et al., 2010; Kashefi and Walker, 2009), their perspectives on the website are different from people who have not experienced floods.

5.2. Plural perspectives

This research found that plural perspectives do indeed exist and that they have a strong influence on how flood risk information should be communicated to residents, as also discussed by Snel et al. (2019). For example, some respondents, i.e. laymen, prefer flood probabilities as a main communication method (i.e. the 'expert way' of communication), while other respondents have no clue what such probabilities mean for them.

More interesting differences can be found between CT groups. According to Snel et al. (2019) individualists solely are interested in their personal flood risk and the reasoning behind that. Since floodlabel.net is developed as a platform to discover your personal flood risk, it was expected that individualists would value the platform positively. However, this is not the case. Individualists prefer the information to be more specific for their own dwelling, while fatalists, hierarchists and egalitarians think the measures presented on the website can help them in making decisions. Currently, the information on the website is the same for every user. Therefore, due to the lack of tailored information the website is not a call-to-action for individualists as it does not address individual responsibilities. Although individualists are negative about the measures page and the other three CT groups positive, all respondents indicated that they are not planning to take measures based on the website. It seems that the missing call-to-action is not only present among individualists, but also among the other three CT groups, albeit possibly to a lesser extent.

As already mentioned in the chapter 1 (Introduction) and section 2.5.2, transferring information from experts to laymen is a challenge of flood risk communication. The broader question around this is: can an SDSS support spatial planning? In a narrow sense: can floodlabel.net transfer information from experts to laymen and thereby support flood risk communication? This *utility* question (Nielsen, 1993) is answered negatively. There is a missing task-technology fit: residents are not brought to action after using the website, and thus it cannot be proven that flood risk communication is supported. As previously discussed in the introduction, according to Patt and Jüpner (2013) and Hansen et al. (2003) there is a miscommunication between experts and the general public when using SDSS, leading laymen to interpret information incorrectly. As for this research it is found that the website misses crucial explanation for several aspects and pages, this seems a logical explanation for the missing call-to-action and task-technology fit. Thus, the missing call-to-action is caused by a lack of tailored information and a useful explanation of expert

information on the website. When laymen do not understand information correctly, it is likely that they are not brought to action. Yet, it should be borne in mind that respondents are directed to the website because of the interview, and not because they are considering taking measures. This logically influences the number of respondents who actually plan to take measures.

Lastly, the call-to-action seems to be missing among all types of residents, but for individualists this could additionally be explained by their preference for face-to-face communication, for example by an expert, instead of an online platform (Snel et al., 2019). This is what theories claimed, and therefore it was expected that individualists would appreciate face-to-face communication more than the website. However, for this research all respondents had a positive attitude towards the website as a communication method, including individualists. This could imply that such a website is a good option as a communication method, but not how floodlabel.net in particular is currently exploited. For that reason, it may be that individualists are not brought to action currently.

5.3. Non-plural perspectives

Not for all elements plural perspectives exists, as already shown in the results chapter. Andrienko and Andrienko (2003) state that the user needs to be able to check what reasoning or calculation is used for a particular decision, what factors are considered, what trade-offs are made, and thus why an SDSS shows certain information. In other words, a user needs to be able to see what happens behind the scenes of the website. Beforehand, it can be observed that floodlabel.net does not have the option to see any calculations for the label allocation. Therefore, it was expected that users would be critical on this issue. Indeed, the results presented that users want to see what happens behind the scenes of the website. The labels and information presented are correct and informative, but it is presented insufficiently in a communicative sense. This becomes clear when people question themselves, and the interviewer, why a particular label is assigned to their dwelling. The process that precedes this is not shown, which leaves the user with questions. The same holds for the labels per type of flood, which are assigned without explanation or showing anything behind the scenes. Thus, it can be concluded that it is important to show what happens behind the scenes in order to be communicatively supportive, as written by Andrienko and Andrienko (2003).

Further, it was expected that the informative role about flood risks and personal flood risk would be valued differently between groups of respondents. However, all types of respondents have a negative response for these elements, and strikingly, also hierarchists and fatalists are not positive about the informative role of the website. The argument that hierarchists are less critical is even confirmed by one respondent, who states that her interest is not very high and that she is 'easily satisfied' with the amount and quality of information presented. Logically this would be a good indicator of the attitude of hierarchists and fatalists towards flood risk information, as this is in line with what cultural theory and Snel et al. (2019) propose. However, this is not true, as hierarchists are also critical after they have used the website. For this there are two potential explanations. First, it could be that from a hierarchist perspective, the website as a communication method is appreciated, but its current exploitation is not good for them in particular. They are positive about the website as a communication method, but critical on the website after usage. In other words, their expectations did not match reality. Second, these more critical attitudes of hierarchists towards the informative role could potentially mean that they are more interested in flood risk information than suggested in theories. In other words, when they are directed to a website (which they would not visit from own initiative), hierarchists become more interested in flood risk information than when they are not visiting such a website.

6. Conclusions

This research aimed to investigate how an SDSS that is dedicated to communicate flood risk information can be communicatively and analytically supportive for laymen that have varying preferences. Those varying preferences were categorised according to the cultural theory of risk, of which four CT perspectives are derived: fatalists, hierarchists, individualists and egalitarians. Addressing those four perspectives is a challenge for flood risk communication, since all four are mutually exclusive. By assessing a case SDSS (floodlabel.net), it is investigated whether an SDSS can be beneficial in the both the technical rationale and communicative rationale. For this, the analytical support, communicative support and task-technology fit are extensively studied, leading to suggestions for improvement in general and for each CT perspective. Since this research worked with a limited number of respondents, conclusions should be considered preliminary conclusions and indications.

For answering the first research question "What is the analytical support of floodlabel.net when communicating flood risk information according to laymen?" theories present the informative role to be an important indicator of analytical support. To fulfil the technical rationale of the SDSS, the SDSS should simply work and show the right information. More specifically, it should be informative for the process (learning about the object and learning about other stakeholders) and the outcome (better informed plans or decisions). Regarding the informative role, it can be stated that the website is not informative for flood risk information: neither about flood risk information in general nor about residents' personal flood risk. In contrast, the website is informative about potential measures. Of all CT perspectives, individualists are most negative, while egalitarians are most positive. Individualists, and hierarchists and fatalists to a lesser extent, wish floodlabel.net to show more tailor-made information, including recent floods in their own area. The potential measures are judged negatively by residents that experienced floods before, because the measures are not appropriate to the scale of earlier floods in their area. Thus, floodlabel.net is not entirely analytically supportive from a resident's perspective. There are improvements to be made on both the process aspects and the outcome aspects.

The communicative support, as asked in the second research question "What is the communicative support of floodlabel.net when communication flood risk information according to laymen?" is measured by using a larger number of indicators. According to theories, the communicative rationale in an SDSS is fulfilled when the SDSS is clear and understandable, targeted at the general public, showing what happens behind the scenes, communicating information on an individual level, addressing individual responsibilities, stimulating collaboration and consensus seeking, and using a combination of communication and visualisation methods. After empirical research it is found that for floodlabel.net the measures are clear, the website is easy-to-use and has clear text. However, explanation is missing at certain pages, such as the questions page. The website does not clearly show what happens behind the scenes, while respondents are interested in this information. For hierarchists, not only explanation about the content itself is needed, but also about why the website is built. Individualists are critical about terms and pages that imply to show individual information, but actually show general information. Egalitarians are most positive of all CT perspectives. Just as the other three CT perspectives, they would like to see what happens behind the scenes of the website. Thus, floodlabel.net is communicatively strong in some areas, but it is not communicatively supportive for all elements from a resident's perspective.

The task-technology fit ("To what extent is there a task-technology fit when using floodlabel.net in flood risk communication according to laymen?"), measures the fit between the task (raise awareness and take measures) and the technology (floodlabel.net). The aim of the website to raise residents' awareness has not been met entirely, just as the feeling of responsibility among residents regarding taking flood adaptation measures. The website does not bring residents to action. There are no differences between the four CT perspectives. They are unanimous: the technology does not entirely fit the task. Thus, there is not a great task-technology fit for floodlabel.net according to residents.

To conclude and to answer the main research question "How can an SDSS that is dedicated to communicate flood risk information be analytically and communicatively supportive for laymen that have varying preferences?" it can be stated that, according to theories, an SDSS that needs to be analytically supportive,

communicatively supportive and have a sufficient task-technology fit, should appeal to the four CT perspectives accordingly. After empirical research, it can be stated that floodlabel.net in its current form is a good starting point, but certain crucial improvements need to be made. The support level both in terms of content and communication is lacking for some parts, while sufficient for others. For an SDSS to be more analytically supportive, the website needs to contain more individual flood risk information to address individualists, and hierarchists and fatalists to a lesser extent. Recent floods in the neighbourhood and info tailor-made to residents' dwellings should be shown on the website, especially for individualists and residents that have experienced floods before. To further convince egalitarians, the SDSS should show potential measures, its costs and benefits extensively, as this is what they are interested in in particular. Communicatively, the website can be enhanced by showing what happens behind the scenes, being clear about what information is general and what information is individual, and maps and graphs should always be accompanied with texts for a better understanding. In general, explanation should be present at all times. Lastly, measures should be clear and understandable for everybody (i.e. laymen). When incorporating these improvements, the chance of success of floodlabel.net, analytically and communicatively, will increase as it takes certain important preferences of the four CT perspectives into account.

7. Discussion

As this research investigated the meaning of an SDSS (floodlabel.net) for communicating flood risk information to residents, the results and conclusions of this research can be positioned in a wider context. Section 7.1 presents suggestions for flood risk communication and floodlabel.net in particular, based on the results and conclusions. Section 7.2 examines what SDSS and an enhanced floodlabel.net could mean for future flood risk communication. Section 7.3 addresses shortcomings in this research and provides suggestions for further research.

7.1. Suggestions for flood risk communication

First, there is a missing sense of urgency among many residents. They do not see a flood to happen on the short term at their location. The missing sense of urgency needs to be addressed more in flood risk communication, as climate change will increase flooding probabilities and impact, also for the Netherlands. This could either be done by floodlabel.net or by other communication methods, but more likely by a combination of communication methods. Floodlabel.net is a support instrument for a reason: it cannot do all the work on its own. Yet, for some residents it could even be the case that floodlabel.net does not play a role, e.g. residents who prefer analogue communication methods such as a municipal letter or face-to-face communication.

For those residents where the website does play a role, this could be 'informing residents about recent floods in their area', on the website itself. This possibly triggers them and it can be considered extra individual information, which floodlabel.net aims to provide and also meets the needs of individualists. Still, many respondents have indicated not to visit the website at their own initiative, although they appreciate the idea of the website. In other words, again, other communication methods are needed. There should be a communication method directing residents in flood prone areas to the website. This could be a flyer or a television commercial triggering awareness, which would especially address needs of the less concerned CT groups (fatalists and hierarchists). These two CT groups essentially need to be triggered to invest time, effort and money in investigating their personal flood risk and taking measures. Flood risk communication should therefore develop an additional strategy to address the low feeling of urgency among fatalists and hierarchists.

Individualists complained about the lacking level of individuality when informing residents. Floodlabel.net is not valued by them in its current form, but the website as a communication method is appreciated. In addition, they prefer face-to-face communication over such a website. Therefore, an expert giving face-to-face advice and additional explanation for the website would possibly win over an individualist to also make use of the information on the website in practice.

To further appeal egalitarians, the website could strengthen its informative role regarding the costs and benefits of potential measures, as this is what egalitarians are interested in. Although egalitarians are relatively positive about the website in general, there is enough room for improvement. For example, some measures have indicative costs, but these are not shown on the measures page itself. Egalitarians would therefore be more satisfied when more info is shown about costs and benefits on the measures page. To also meet the needs of individualists, it would be a good option if measures that are not suitable for the resident's dwelling are filtered out for a better tailor-made advice per dwelling. This tailor-made information is then especially beneficial for those dwellings that are at a high risk, such as those located along the river Meuse in Venlo. If a flood occurs, the impact in such a location is totally different from when a flood occurs in for example a neighbourhood that is not close to a river with other types of flood risks.

Related to Venlo, the residents that experienced floods need a different approach than others, as discussed in this chapter. For this, a role is reserved for the website itself: the website should explain what the probabilities are of severe floods and less severe floods to let the resident understand that there is not only one type of flood that could occur. This could be a motivating factor in order to come to a better informed decision, also for those who experienced floods.

When taking all of the above into account for floodlabel.net, the experience of fatalists, hierarchists, individualists, egalitarians and residents that experienced floods is enhanced. To further enhance general flood risk communication by floodlabel.net, more suggestions can be done based on this research. Floodlabel.net should let the user get insights in what happens behind the scenes of the website. Furthermore, visualisation can be improved by, as suggested by Janssen and Uran (2003), using combinations of maps and texts. The map on the website needs more explanation to be understood better. This improves the communicative support of an SDSS. Users prefer maps and graphs, but they are not per se able to work with those, meaning that a combination of visualisation methods should be sought for.

7.2. The meaning of SDSS and floodlabel.net for flood risk communication

Considering all suggestions mentioned in the previous section, it can be stated that most challenging of SDSS to communicate flood risk information to residents is the plurality of those residents' perspectives, as classified according to the cultural theory principle. There are differences in preferences which make it impossible to develop one communication method that fulfils the wishes of all CT perspectives. This means that if the website aims to address as much as possible of all four CT perspectives, none of those perspectives is completely satisfied.

It is shown by Snel et al. (2019) that current flood risk communication is mostly directed at hierarchists, e.g. by using flood probabilities, and thus not directed at all four perspectives. The hierarchist-oriented communication method is not sufficient to bring residents to action (Mees et al., 2018; Fournier et al., 2016). Therefore, the fatalists, individualists and egalitarians should be addressed as well. This research gave insights in how to address as much as possible of those currently unconsidered CT perspectives on a floodlabel.net-like platform. By implementing the improvements for the analytical and communicative support as presented in the previous section, flood risk communication is likely to drift away from its current hierarchist-oriented communication, towards a communication that is positioned more in the middle of the four CT perspectives.

However, as previously mentioned, floodlabel.net cannot do the work on its own: it should be assisted by other communication methods. For the website itself, it should be aimed to incorporate as much as possible of the preferences of all CT perspectives. Since for none of the CT groups all preferences can be incorporated in the website, floodlabel.net should be part of a chain. As different CT perspectives need different communication methods, this chain should be comprehensive to make sure it contains communication methods that address all types of residents. Fatalists and hierarchists need an awareness raising campaign as a first step, after which they are directed to floodlabel.net. This is a call-to-action campaign, not to be performed by the website but rather by a television commercial or by distributing flyers. Individualists require experts, which is not to be used by fatalists or hierarchists. Thus, in practice, the chain should not entirely be used by every resident, but certain communication methods should be chosen from the chain for an optimal flood risk communication for each resident.

7.3. Research limitations and suggestions for further research

There are certain shortcomings and possible issues in this research which need to be mentioned and taken into account. As presented in section 2.3.4 the analytical support consist of, among others, 'learning about the perspectives of other stakeholders'. This element has not been taken into account in this research since floodlabel.net is considered not the right platform for learning about the perspectives of other stakeholders. It is rather a platform that allows individuals to gain insights in their own time as an individual activity. Although due to this it could be stated that the outcomes of this research do not fully show the analytical support of floodlabel.net, it is rather a limitation of floodlabel.net itself that this element could not be investigated. This means that, in order to increase the analytical support of floodlabel.net, the website should create an option where the user is able to see whether neighbours have already taken measures or are planning to take measures, for example. In addition, an 'other stakeholder' is also the municipality that

could inform its residents about their plans and what the residents themselves could do in that particular municipality, or more specifically, neighbourhood.

For similar reasons as described above, the 'collaboration' and 'consensus seeking' elements of communicative support are not taken into account in this research. Collaboration is too much focused on the website being a platform to be used by groups instead of individuals, which is the case for floodlabel.net. As argued before, floodlabel.net is a platform that enables spatial decisions to be made mostly by individuals (e.g. purchase a waterproof door), while in other spatial planning issues a collaborative decision is to be made (e.g. windfarm). There is not much 'consensus seeking' to be done for this issue. Thus, although floodlabel.net is an ideal prototype SDSS in flood risk communication, it was not possible to test all elements of the conceptual framework. Logically, the question is whether floodlabel.net should broaden its horizons and enable collaboration and consensus seeking on its platform in order to improve its communicative support. Further research is required on whether residents in flood prone areas would wish that such a platform is developed, where also municipalities can share their vision on flood risk management with its residents.

This research worked with 17 respondents. Considering the time investment per interview, this is relatively high. However, for drawing solid conclusions about the four CT perspectives, this is rather a too low number. Determining the CT perspective per respondent is time consuming, leading to a lower number of total respondents. For example, of those 17 respondents, only two were a fatalist. It is not reliable to draw conclusions from only two respondents. The results from this research can therefore rather be seen as indications than solid conclusions. Further research with a larger number of respondents is required to draw solid conclusions for each CT perspective.

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Appendix A: Interview questions (in Dutch)

Stellingen: Kennis overstromingen & potentiële maatregelen

1. Ik maak mij zorgen over de toenemende kans op overstromingen of wateroverlast rondom mijn woning.
2. Voordat ik deze website gebruikt had, wist ik al voldoende over overstromingen en wateroverlast.
3. Dankzij deze website ben ik *wél voldoende* / *nog meer* te weten gekomen over overstromingen en wateroverlast.
4. Dankzij deze website ben ik voldoende te weten gekomen over de gevaren van overstromingen en wateroverlast voor mijn eigen woning.
5. De website geeft voldoende informatie over het nemen van eventuele overstromingsmaatregelen.
6. Ik zou graag nog meer willen weten over het risico op overstromingen.
    a. *Eens / helemaal eens*: Wat zou u nog meer willen weten?
    b. Zou u bijvoorbeeld meer moeten weten over de kans op een overstroming zodat u weet welke maatregelen u het beste kan nemen?
7. De website heeft ervoor gezorgd dat ik mij meer verantwoordelijk voel voor het zelf nemen van maatregelen tegen overstromingen.

Stellingen: Website communicatie

8. Ik vind de informatie op de eerste pagina met de vier labels voor verschillende typen overstromingen en wateroverlast goed te begrijpen.
9. Ik vind dat ik makkelijk kan zien wat er achter de schermen gebeurt bij de berekening van mijn floodlabel.
10. Ik vind de kaart aan de rechterkant op de eerste pagina goed te begrijpen.
11. Ik vind de informatie over de vier soorten overstromingen en wateroverlast goed te begrijpen.
12. Ik vind de pagina met vragen over mijn eigen woning goed te begrijpen.
13. Ik vind de pagina met de afbeelding met mogelijke maatregelen goed te begrijpen.
14. Ik vind de tekst over de gehele website goed te begrijpen.
15. Ik vind de website over het algemeen makkelijk te gebruiken.
16. Ik vind dat ik makkelijk informatie over mijn eigen woning kan opvragen.

17. Als u één of meerdere verbeterpunten zou moeten noemen voor de website, wat zou dat dan zijn?

Open vragen: Doel en uitkomsten

18. Wat is volgens u het doel van de website?
    a. Is het u gelukt om dit doel te bereiken?
19. Heeft u hiervoor al maatregelen genomen in of rondom uw woning tegen overstromingen?
20. Denkt u dat u op basis van deze website maatregelen gaat nemen tegen overstromingen?
    a. Zo ja, heeft u al concrete plannen in het hoofd?
    b. Zo nee, waarom niet?
    c. Zo nee, zou het kunnen dat er iets verandert in uw situatie waardoor u wél maatregelen gaat nemen? En zo ja, wat?
    Evt. voorbeelden: financiële ondersteuning, grote overstroming met schade.

Open vragen: Rollen & verantwoordelijkheden

21. Vindt u dat het beperken van mogelijke overstromingsschade meer een verantwoordelijkheid is van uzelf of van de gemeente?
22. Wat vindt u dat uw eigen verantwoordelijkheid is in het beperken van mogelijke overstromingsschade?
23. Wat vindt u dat de verantwoordelijkheid is van de gemeente in het beperken van overstromingsschade?
24. Hebben uw buren maatregelen genomen om overstromingsschade te beperken?

25. *Wel van plan*: Hoe denkt u over samenwerking met uw buren in het nemen van mogelijke maatregelen?
    Niet van plan: Als uw buren wel maatregelen gaan nemen, bent u dan van plan om met hun te gaan samenwerken?
26. *Wel van plan*: Hoe denkt u over hulp van de overheid (bijvoorbeeld een financiële ondersteuning) bij het nemen van maatregelen?
    Niet van plan: Als u hulp krijgt van de overheid (dit kan bijvoorbeeld een financiële ondersteuning zijn), gaat u dan wel maatregelen nemen?

Open vragen: Overstromingsrisicocommunicatie

27. Hoe denkt u over deze website als communicatiemiddel voor informatie over overstromingen en potentiële concrete maatregelen die u kunt nemen?
    a. Wat zijn uw verdere / andere voorkeuren voor de communicatie van informatie over overstromingen en concrete maatregelen?
       Face-to-face, nationale campagne, flyers , informatiefilmpjes op TV of YouTube, informatiekrantjes
28. Wat vindt u van het gebruik van verschillende visuele manieren om de informatie aan u te communiceren?
    Bijv. kaarten, tekst, grafieken, filmpje / animatie
29. Hoe denkt u over een expert die u face-to-face extra uitleg kan geven over de overstromingsrisico's en potentiële concrete maatregelen?
30. Welke informatie op de website zou u als eerste naar kijken?