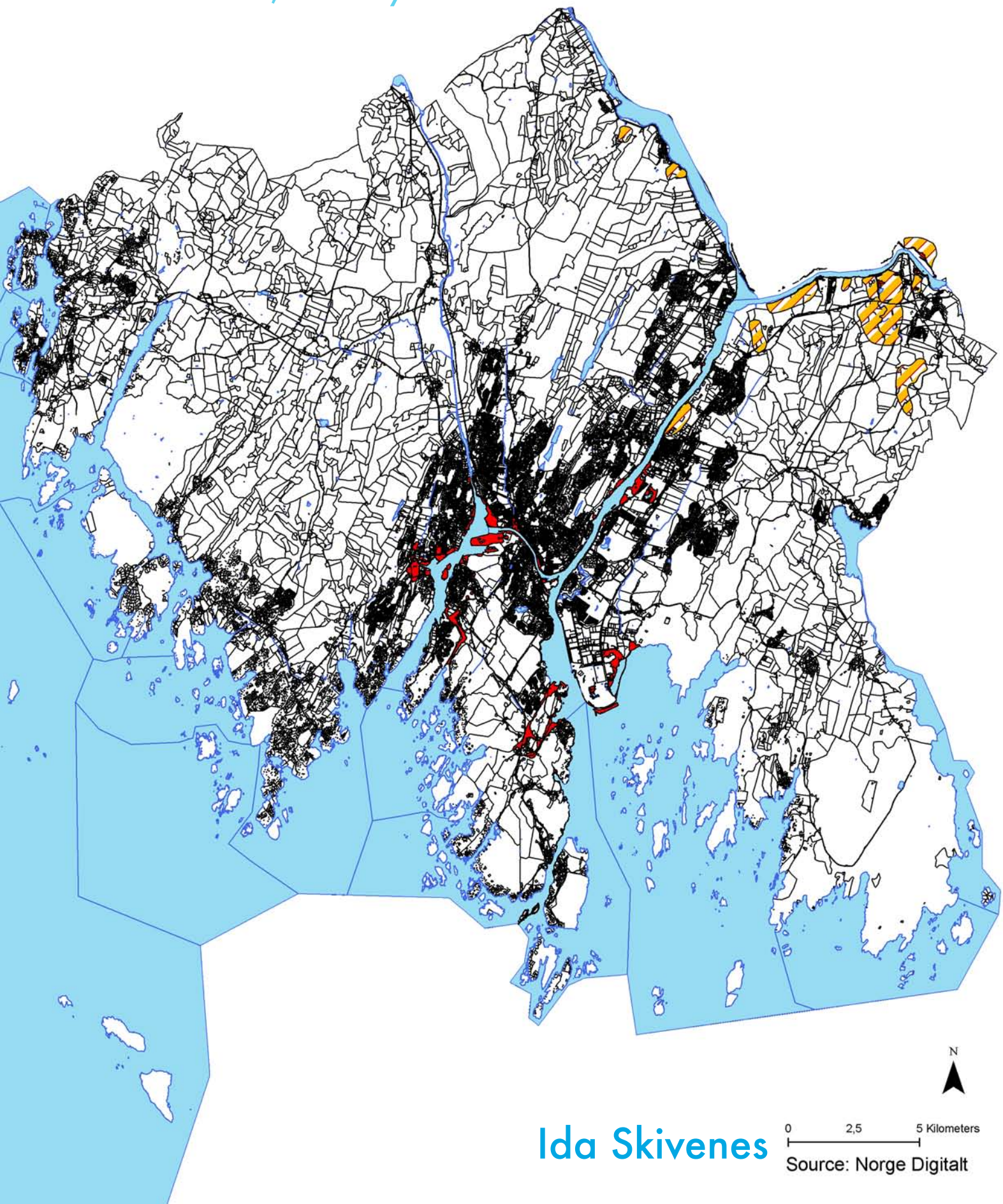
Making Maps Matter:

GIS and the Cognitive Challenges of Climate Change Adaptation in Fredrikstad, Norway.



Ida Skivenes

Front page: Map of Fredrikstad municipality with landslide and flood risk zones, made by Ida Skivenes with data from Norge Digitalt.

Making Maps Matter:

GIS and the Cognitive Challenges of Climate Change Adaptation in Fredrikstad, Norway.

Ida Skivenes

Master's Thesis in Human Geography
Department of Sociology and Human Geography

University of Oslo
December 2009

Acknowledgements

The first seed that led to this thesis was planted when I took SGO1910, geographical information systems, in 2006. This ignited my passion and critical interest in GIS, and I have ever since worked to understand how it could be used to make a real difference. When presented with the possible coupling of climate change adaptation and GIS, I sensed an opportunity to do just that. The passion for climate issues has come along the road, and even though it is hard to keep the faith up at times, I am still positive that it is possible to do something to counter the coming impacts.

Many people deserve thanks for helping me along the way with this thesis. First of all, a big thank you to my supervisor Karen O'Brien for always believing in me, being available at almost any hour to assist me and for the very inspiring work you do in the field of climate change. The second thanks goes to the one everyone else always *thought* was my supervisor, dear Lynn, thank you for your open door and both the professional and personal guidance (and fun). Sorry I could not stay around any longer.

Thirdly, I would like to send my great gratitude to the Fredrikstad informants and my contact persons in Fredrikstad municipality, Rolf Petter Heidenstrøm and Asbjørn Borge. You have been most helpful, and provided me with valuable insights without which there would be no thesis. Also, the PLAN project deserves a thank you for the support, both financially and in terms of professional input by allowing me to attend your meetings.

For proof-reading and great friendships, much appreciation goes to Marte Svare and Kjersti Nordskog. The lovely people of Harriet Holters hus, thank you for the lunchtime quizzes and supportive atmosphere!

My family and friends deserve thanks merely for existing and continuing to make my life better in many different ways. And last, but not least, thank you Gabriel; for your love, encouragement and constant entertainment throughout the years. And yes - it is finally over, and I will stop complaining!

Blindern, December 2009

Ida Skivenes

TABLE OF CONTENTS

TABLES AND FIGURES

LIST OF ABBREVIATIONS

GIS	Geographical Information Systems/Science
IPCC	Intergovernmental Panel on Climate Change
MPPACC	Model of Private Precautionary Adaptation to Climate Change
PGIS	Participatory Geographical Information Systems
PLAN	Potentials of and Limits to Adaptation in Norway

"Maps don't change the world – but people who use maps do"
(The Economist 06.06.09).

1. Introduction: Making Maps Matter

> "The truth about the climate crisis is an inconvenient one that means we are going to have to change the way we live our lives" (Gore 2007: 286).

1.1 Impetus

The likely reality of anthropogenically induced climate change has been asserted by the Intergovernmental Panel on Climate Change (IPCC 2007a). Due to emissions of greenhouse gases such as CO_2, temperatures and precipitation are projected to increase, leading to effects like reductions in snow and ice cover, ocean acidification, sea level rise, and increases in the occurrences of extreme events (drought, flooding, landslides, etc). There will be impacts on buildings, businesses, health, nature and biodiversity, infrastructure and transportation, utilities and further into every corner of society, and on all spatial scales (Meehl et al. 2007). The full extent of these impacts cannot be countered by measures to reduce emissions, i.e. by *mitigation* alone, because the effects of previous emissions linger on in the atmosphere. Therefore, climate change *adaptation*[1] is increasingly seen as a necessary response in combination with mitigative policies to the present and future impacts of anthropogenic climatic change.

Adaptation has traditionally been seen as "adjustments by the affected human and natural systems to moderate potential changes or to benefit from opportunities associated with climate change" (Grothmann & Patt 2005: 199), although this thesis will implement a wider definition presented in Chapter 2. The processes of adaptation will to a large degree take place at the local level involving multiple actors and individuals, through private initiatives to adapt and by applying publicly administered adaptive measures. Adaptation not only influences the physical impacts of climate change, but also forms a social process involving people, institutions, behaviours and decisions. This latter aspect of climate change adaptation is not well understood, and will be explored in this thesis.

However, change does not happen automatically. Climate change itself is a complex issue. The time perspective is long, the spatial extent both global and local, the consequences uncertain and the impacts difficult to separate from other ongoing

[1] In this thesis the terms "climate change adaptation" and "adaptation" are used interchangeably.

processes (Patt & Dessai 2005). People also perceive of and deal with climate change risks in many different ways. A range of cognitive factors influence both individuals and institutions as they determine what to do, and climate change adaptation is not just about understanding the complex science but also about being able to relate changes to own lives and take action, as Gore's inconvenient truth implies we need to do. This raises a number of cognitive challenges, such as perceived lack of self-efficacy, emotional numbing or risk adversity, that need addressing in order for successful adaptation to take place. The individual, cultural and psychological barriers to adaptation make it important to not just focus on technical solutions or physical barriers, but also to make room for investigating and addressing social and mental ones, as they can act as bottlenecks for adaptation (Adger et al. 2009a). While covering the existing *internal* hindrances, one must not forget the *external context*, and particularly how institutional aspects of a distinct setting can influence the outcome of adaptation on the administrative level.

In order to deal with the impacts, risks and barriers associated with climate change adaptation, we need tools that can enhance understanding, encourage action and guide decisions within a broader multidisciplinary and non-technical perspective. The usability of current policy instruments, such as utility theory, benefit-cost analysis and statistical decision theory, to new global problems have indeed been questioned and the need for new tools highlighted (Morgan et al. 1999). For this purpose it is recognized that many of the factors related to climate change impacts, vulnerability and adaptation have a spatial nature (i.e. they are associated with a specific location). This makes it possible to illustrate the data spatially, which is desirable because "spatial representation of information undoubtedly enhances precision and communication" (Forrester & Cinderby 2005: 232). Other preferred qualities of a tool is the ability to integrate large amounts and diverse types of data, visualize the impacts of climate change, and allow for wide participation. Indeed, the United Nations (in Haklay 2002: 17) has emphasized that "…environmental issues are best handled with the participation of all concerned citizens". All of these requirements are satisfied by the mapping and analysis tool *geographic information systems (GIS)*, which straightforwardly defined are "integrated computer tools for handling, processing and analyzing geographic data" (Johnston et al. 2003: 301).

This thesis will explore GIS both as an *awareness-raising tool* for the general public and as a *decision support system* for decision makers and businesses, in order to examine how the cognitive challenges of adaptation are addressed within a spatial framework. The work draws on critical GIS theory and theories of socio-cognitive processing of risks, particularly the Model for Private Precautionary Adaptation to Climate Change (MPPACC) developed by Grothmann & Patt (2005). It is in a sense a dual thesis, where climate change adaptation perceptions and challenges constitute one part, and views and critiques of GIS form the other. They are fused together by looking at the potential for applying GIS to enhance adaptation insights in a developed country context, through the case study of Fredrikstad municipality in Norway. There has not been much research on this precise combination, at least not in a developed country context, as the combination of adaptation and GIS is fairly new, particularly when dealing with qualitative data (Rantanen & Kahila 2009). However, visualization imagery technology, where GIS is one example, is increasingly being explored as a useful contribution to increasing effectiveness of climate change communication (Nicholson-Cole 2005, Sheppard 2005, Adger et al. 2007). Since no pre-existing theoretical frameworks exist this thesis is based on diverse directions of theory that can reasonably be transferred to a climate adaptation context to provide a nuanced picture of the various dimensions of using technology as a mediator in a complex social process. Lastly, as psychological factors of cognition are discussed herein, it is important to state, that this is a human geography thesis, not a psychology thesis, and the assessments of the more technical sides to cognition will not be covered in depth. The main concerns are geographical matters, i.e. relations to variations over place, landscape, space, and location, and how these are represented and reshaped by the phenomenon of climate change adaptation.

In the end, the ultimate aim of this thesis is to *make maps matter*, as the goal of climate mapping should be to empower individuals, households, businesses and decision makers to take better decisions. Indeed, it is not the maps themselves that change the world; it is the people who use them.

1.2 Thesis Objective and Research Questions

The objective of this thesis is to look at the interrelation between climate change adaptation and geographic information systems (GIS) and examine how GIS can contribute to improved climate change adaptation for relevant stakeholders at the local level. The point of departure is that the use of GIS in climate change adaptation is not neutral, and that cognitive factors in both climate change adaptation processes and map understanding influence the actions of different actors in society. The focus of this thesis is thus not on the direct technical sides of GIS, but on its theoretical and applied dimensions – taking more of a meta-GIS stance.

The following two research questions have been identified:

- *What perceptions of, attitudes towards and information needs for climate change adaptation exist amongst stakeholders at the local level?*
- *What is the potential for GIS to address the cognitive challenges of climate change adaptation in this context?*

Perception here is defined in a similar manner to Sheppard (2005: 638): "the process of seeing or otherwise perceiving phenomena, leading to particular responses or states which include both cognitive and affective outcomes".

The empirical data of the thesis is based on a qualitative case study carried out in Fredrikstad municipality, Norway. Choosing a developed country context was based on a premise of exploring the question: If a developed country with high adaptive capacity cannot adapt to climate change, how do we expect others to do it? Knowledge, familiarity and use of GIS related technology is also assumed to be quite high in Norway, creating interesting possibilities to investigate the associations between climate change and GIS perceptions. Three stakeholder groups presumably influenced by climate change in their lives and operations were interviewed: Households (general public), businesses (commercial base) and municipality administrators (decision makers). All three groups were linked but had different motivating factors, needs and cognitive challenges with regard to climate change adaptation and GIS. The interviews aimed to solicit these in order to uncover the potential of GIS to influence adaptation at the local level.

1.3 Thesis Structure

Chapter 1 of this thesis has provided the impetus and defined the research questions and their relevance. Chapter 2 will provide the background for the study by defining key aspects of climate change adaptation, theories on cognitive barriers to adaptation and an outline of the national and local context. Chapter 3 sets the theoretical basis by defining GIS, tracing the development of critical GIS theory through the three waves of critique, and finally putting GIS into a climate change context. Chapter 4 discusses the methodological choices made in during this research. The empirical analysis has been divided into two chapters, 5 and 6, which present empirical data on perceptions of climate change adaptation, information needs and views of GIS respectively. Chapter 7 puts this data into context, and discusses the two research questions, before concluding and suggesting future research directions based on the findings of this thesis.

2. Background: Defining Adaptation, Cognitive Barriers and the Local Context

This chapter provides background to the concept of and limits to climate change adaptation, as well as outlining the related cognitive challenges. Lastly, the climate impacts for Norway, details of the Fredrikstad case study and examples of climate related GIS tools will be given.

2.1 Climate Change Adaptation

2.1.1 Definitions and Characteristics of Adaptation

There are essentially two options for dealing with the impacts associated with climate change: *Mitigation* and *adaptation*. Traditionally, mitigation has been defined as "an anthropogenic intervention to reduce the anthropogenic forcing of the climate systems; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks" (IPCC 2007b: 878). Adaptation within the climate change context goes further than emissions reductions, and can be seen as "adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts" (Smit et al. 2000: 225) or "the adjustments by the affected human and natural systems to moderate potential changes or to benefit from opportunities associated with climate change" (Grothmann & Patt 2005: 199). The latter definition includes the perspective that it is likely that there will be both winners and losers from climate change. The related concept of *adaptive capacity* describes a system's ability to cope with external stress (Yohe & Tol 2002). In other words, mitigation is to 'avoid the unmanageable' while adaptation is to 'manage the unavoidable' (SEG 2007). The 'unavoidable' stems from the realization that we will be facing some climatic impacts regardless of current actions to mitigate climate change as the effects of previous emissions linger in the atmosphere.

Having said that, framing the climate change problem as a trade-off between mitigation and adaptation could lead to harmful effects, as an either/or approach risks underestimating the importance of both. Hence, the concepts should be seen as complementary, rather than mutually exclusive, as there is considerable overlap between mitigation and adaptation, and they involve processes and actions that are intertwined and feed into each other. Moreover, the determinants of adaptive and

mitigative capacity have been argued to be the same, and there has been inference that adaptive initiatives can occur in the same top down fashion as mitigative action (Tompkins & Adger 2005, Adger et al. 2009a). Earlier sentiments towards advocates of climate change adaptation was that they were "quitters"; people who did not believe that the world could mitigate climate change by reducing greenhouse gas emissions and instead chose to just deal with the consequences[2]. This view is becoming increasingly less common, as there is a growing recognition of the need to both mitigate *and* adapt.

Defining adaptation widely as *any alterations in lifestyle, business strategy or policy done as a result of changed climatic conditions* allows for a composite concept that incorporates both the traditionally separated mitigation and adaptation efforts, and ultimately most environmental behaviour. This thesis thus advocates the view that mitigation can be an important adaptation measure in itself, because reducing greenhouse gas emissions also constitutes an endeavor to make adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts. The conceptual divide is hence found redundant within this text. However, seeing that this integrated view is not ubiquitous in the relevant local context, the traditional distinctions and the friction between them will be discussed when appropriate.

Adapting to climate change involves a whole range of decisions by individuals, firms and civil society, public bodies, and governments and agencies at the local, national, regional and international scale (Adger et al. 2005). It is first and foremost a result of individual decisions taken on the basis of the information that each and everyone possess at any given time (Aaheim et al. 2009). Adaptive action will take place mostly on a non-global scale, and are context- and place-specific, thus requires a tailoring to local settings (Few et al. 2006). Adaptations are often divided into types related to the factors of timing and the actors involved. In terms of timing, they can be either *reactive* or *precautionary,* i.e. take in response to an event, or be done in anticipation of an event to prevent severe impacts. Actor-wise, adaptations can be *private* or *administrative*, where the first usually means that a private actor is spontaneously implementing a measure, and the latter carried out as an strategic planned measure by governing bodies (Grothmann & Reusswig 2006). Hence

[2] http://e360.yale.edu/content/feature.msp?id=2156 (viewed 11.10.09).

adaptive measures can be both top-down and bottom-up approaches. Public agencies can for instance plan for storm surges by building protective barriers against sea level rise, while private actors can modify patterns of production and consumption in ways that better suit the climate, for example farmers switching to drought-tolerant seeds to protect against reduced rainfall (Patt 2009). Adaptation often involves deliberate action, and may thus become an issue of governance. Building adaptive capacity may include actions such as "communicating climate change information, building awareness of potential impacts, maintaining well-being, protecting property or land, maintaining economic growth, or exploiting new opportunities" (Adger et al 2006: 79).

Climate change adaptation is also regularly referred to as an important response option in relation to the concept of *vulnerability*. It can "reduce the vulnerability of groups of people to the impacts of climate change, and hence minimize the costs associated with the inevitable" (Grothmann & Patt 2005: 200). Furthermore, multiple stressors influence a system, and interactions between socioeconomic, political and physical processes can change the characteristics of vulnerability and adaptation over time. Communities thus face "multiple exposures", for instance adapting to climate change and globalization at the same time (O'Brien & Leichenko 2000). Also, "indirect and unexpected effects of climate change created by the interaction between social and physical processes may be greater than the direct and linear projected sectoral impacts" (O'Brien et al. 2006: 52). It can be difficult to separate climate change adaptation decisions from actions triggered as a result of other events (Adger et al. 2005). Lastly, efforts to mitigate and adapt to climate change may also change the severity of impacts in the future, and it is crucial to connect climate change scenarios to societal scenarios (Leivestad et al. 2008).

2.1.2 Limits to Adaptation

It cannot be taken for granted that adaptation will take place, or that society can overcome all challenges: "Adaptation to climate change may be neither inevitable nor automatic, even if impacts and adaptation options are well known and widely documented (O'Brien et al. 2004: 54)". Also, there is a mismatch in terms of scale between global climate models and adaptation measures. The latter measures are usually local or site specific, while the climate models work on a global scale (Burton et al. 2002), making it potentially difficult to relate the two to one another. The

contemporary discourse of climate change adaptation has two foci: An 'adaptive society' discourse that focuses on how climate change adaptation can be facilitated and enhanced, and a 'dangerous climate change' discourse that asks whether there are limits to adaptation beyond which politically or ethically undesirable outcomes occur once a threshold is crossed (Adger et al. 2009a).

Generally defined there are ecological and physical limits, economic limits, and technological limits to climate change adaptation. Adger et al. (2009a) also suggest that there are social and individual factors that limit adaptation action. The importance of these is broad in that "decisions are made regularly at individual and societal levels that have implications for current and future adaptation" (Adger et al. 2007: 12). Thus, both individual limits to private adaptation, and societal limits in decision-making that affects administrative planned adaptation needs to be explored. Some of the cognitive challenges in dealing with and adapting to climate change will be outlined in greater depth in section 2.2, while the main institutional factors are listed right below.

As outlined by Næss et al. (2005), there are three aspects that define the important institutional limits to adaptation of the local decision-making context in Norway: 1) *centralization*, 2) *local conflicts of interest* and 3) *elite power*. The first institutional limit to adaptation entails that the degree of *centralization* in policymaking determines the room for governing at the local level. This principle implies that a local government may be unable to deliver on its commitment because of national and local political restraints (Underdal 1998). In Norway, the municipal budgets are to a large degree determined by economic transfers from the state, and national laws and guidelines set restrictions for the tasks and relevant policy issues that a municipality has to, or is advised to carry out. Local autonomy and financial independence is thus severely restricted in many cases (Næss et al. 2005). The second and third institutional limits are interlinked, as elite power can often underplay local conflicts of interest. Many different priorities exist at the local level, and often divergent agendas can lead to struggles of which actors get access and a voice in the system. This surely is the case when dealing with impacts of climate change, in and of itself and versus other priorities locally. The presence of local elite power can stall social learning through the filtering of new perspectives and subsequent conservation of old ideas favoring 'technical fix' solutions for instance. Furthermore, economic measures, rather than environmental or adaptation-related ones, are often favored by

local power structures – so efforts to discover and implement effective adaptation measures must be considered alongside ongoing societal and institutional changes (O'Brien et al. 2006). All of this underlines the understanding that environmental policy can only be fully understood in the context of the wider policy space in which it is situated (Underdal 1998).

2.2 The Cognitive Challenges of Climate Change Adaptation

> "…If agents systematically underestimate their own ability to act, this qualifies as a more important 'bottleneck' for adaptation than the objective physical, institutional or economic constraints" (Grothmann & Patt 2005: 203).

Climate change is both a global and local phenomenon, and all groups in society have their role in taking adequate actions in a situation of risk and uncertainty. Individuals are also important to consider, as they could be holding back adaptation, like the above quote shows. Of course the essential scientific and technical developments have to be in place, but adaptation as a social process is also a factor that matters. Following Adger et al. (2009a) on barriers to climate change, this section will deal with social and psychological factors that lie behind how humans behave when faced with risk, such as the ones related to climate change. The further basis for taking this approach is in findings in research on risk perception that public perceptions are not only influenced by scientific and technical descriptions of danger, but also by psychological and social factors, including personal experience, affect and emotion, imagery, trust, values and worldviews (Slovic 2000). This leads to the validation of affect and feelings as not mere epiphenomena, but factors that arise prior to cognition and thus play a crucial role in subsequent rational thought.

The socio-cognitive factors will be used to assess the scope and mechanisms behind stimulating environmental action and adaptation measures in relation to the informants' statements. Using such theories is based on an evaluation of mental models and what affects behaviour. Mental models are defined below:

> "Mental models are our inference engines, how we simulate sequences of events in our minds and predict their outcomes. (…) our mental models predispose us toward particular ways of thinking about a problem, its causes, effects and its solutions" (Bostrom & Lashof 2007: 31).

It is important to both understand one's own mental model and those of the people one is trying to communicate with to enable successful climate change communication.

The following sections present a selection of socio-cognitive factors and models used in this thesis, summarized in Table 1. It is acknowledged that a whole range of other frameworks exist that could possibly be used, particularly when trying to explain the gap between awareness and changing behaviour (for an overview see e.g. Kollmuss & Agyeman 2002), but due to both the nature and the time and resource limits of this thesis a selection has been made.

Table 1. Overview of the psychological models and factors presented in this thesis.

Model → **Source** →	*Processing system*	*Model of Private Proactive Adaptation to Climate Change (MPPACC)*	*Heuristics*	*Other psychological and social factors*
	(e.g. Kahneman 2003)	(Grothmann & Patt 2005)	(Tversky & Kahnemann 1974, Marx et al. 2007)	(e.g. Worthmann 1976, Leach et al. 2005, Leiserowitz 2006, Gardner 2009)
Factors ↓	Experiential (System One, feeling, gut)	Risk perception/appraisal	Affect heuristic	Finite pool of worry
	Analytic (System Two, reason, head)	Adaptation capacity/appraisal (action scope)	Availability heuristic	Emotional numbing
			Recency heuristic	Single-action bias
				Precautionary principle
				Risk aversity
				Cultural rationality
				Worldviews

2.2.2 Cognitive Processing and Heuristics

The juxtaposition of *experiential* and *analytic* processing in dealing with climate change has been emphasized by several researchers (e.g. Leiserowitz 2006, Marx et al. 2007, Gardner 2009), to describe how people most often relate current or future situations to personal or inter-personal experience rather than to statistical information. Correspondingly, psychologists differentiate between a *System One* and a *System Two* of cognitive processing (Kahneman 2003), where the first is feeling (gut) and the second is reason (head). This translates into feeling as the experiential,

and reason as the analytic processing system. Experiential processing includes causal schemes, vivid images and strong affective components, and is the process of relating present-day situations to memories of one's own or others experience. Analytic processing, on the other hand, uses ensembles of past relevant experiences to express statistical constructs to deal with current situations by abstract thinking and logical rules. The two systems interact; analytic processing can for instance modify how people categorize present situations relative to past experience, leading to a modification of action plans (Marx et al. 2007).

Indeed, concrete conditions are easier to understand than abstract thinking, and the prominence of personal images forces abstract statistical information into the background when decisions are taken. Past experiences are often linked to strong emotions which make them more memorable and dominant in processing, and the ability to relate to and use other people's cautionary stories extends the range of personal experience. This can include both personal relations and, in the case of a largely scientific issue like climate change, authorities such as experts. This is not unproblematic however; experts often disagree and even when there is widespread agreement, there are always dissenters with impressive statistics and bewildering scientific jargon (Gardner 2009). Such is indeed the case with climate change, and its contingent of climate sceptics. Findings show that when the "science" contradicts a mental model, people usually reject the science (Bostrom & Lashof 2007).

Thus, the most beneficial approach relies on a coupling of scientific understanding and personal relevance as supported by the view that

> "…analytic information is best understood when it is used to recategorize or recontextualize the decision maker's current situation. In turn, this is best accomplished when the analytic results can be translated into concrete images, strong emotions, or stories" (Marx et al. 2007: 51).

The effect of an integration of vivid imagery, strong emotions and vicarious experience has indeed been shown to have a significant effect on changing how people perceive, interpret and respond to risk (Nicholson-Cole 2005, Leiserowitz 2006, Marx et al. 2007).

It has further been demonstrated that risk information is not always processed analytically, as "people rely on a limited number of heuristic principles which reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations" (Tversky & Kahnemann 1974: 1124). *Heuristic* principles are

"experience-based techniques that help in problem solving, learning and discovery"[3], often referred to as rules of thumb in everyday speech. These principles guide action through their influence on judgments, choices and decisions, and are normally quite useful, but can on occasion lead to severe and systematic errors due to subjective and intuitive assessments of probability. These misconceptions of the real probability and risk of an event as potentially severe as climate change may hinder the scope for action among both individuals and decision-makers.

Marx et al. (2007) identify a selection of three relevant heuristics in climate change perception: The *affect* heuristic, the *availability* heuristic and the *recency* heuristic. That is; people relate to and put the most weight on information that is tied to feelings (affect), that is readily available in memory (availability) or that has happened in the recent past (recency). People are guided by their feelings about a situation when assessing risk and uncertainty. In fact, Leiserowitz (2006) found that negative affect about global warming was a stronger predictor of public risk estimates and policy preferences than sociodemography, values or political preferences. Solving problems based on the availability heuristic is important when judging risk posed by climate variability because people can typically recall unusually good or bad seasons. However, responses to long-term climate change information present a different challenge as most people do not have experiences associated with it yet and will thus assume that the future will be similar to their background so far. Other people's or media's accounts can nevertheless fill in some of the gaps. Experiential processing based on the recency heuristic can lead to both the under- and overestimation of risks of rare events, such as flooding, depending on how recently they have occurred. If a flood event has not happened recently it could lead to neglect of flood control infrastructure and precautions, while if it has, it may lead to an overestimation of the likelihood of subsequent similar events and unnecessary measures. The workings of this last heuristic could actually be helpful in climate change adaptation, as it equips people with the tools to detect and adapt to change, given that sufficient personal experience can be provided (Marx et al. 2007).

Other drivers of perception and processing are confirmation bias, group polarization, rule of typical things, habituation, inverse correlation, the dread factor, white male effect, and denominator blindness (Gardner 2009). It is beyond the scope

[3] http://en.wikipedia.org/wiki/Heuristic (viewed 28.08.09).

of this thesis to describe all of these as well as other factors that influence perception; this list is included only to point out that many theories and drivers exist.

Certain limitations to heuristic principles have been found. First of all, that people have a *finite pool of worry* (Hansen et al. 2004 in Marx et al. 2007), i.e. that concern about other types of risk decreases as worry about one risk increases as in a zero-sum game. *Emotional numbing* may also occur if the individual is repeatedly exposed to emotionally draining situations. Following on from that there is the *single-action bias*, whereby there exists a ”propensity to take only one action to respond to a problem in situations where a broader set of remedies is called for” (Marx et al. 2007: 55).

2.2.1 Further Cognitive Challenges of Adaptation

There are many barriers that prevent people from engaging and altering their behaviour in the face of change, such as abstract dimensions, long time horizons and global boundaries of a phenomenon such as climate change. For instance, Leiserowitz’s (2006) survey of the American public conducted in 2002/2003 showed that climate change was viewed as a moderate risk and that the perception of danger was placed on geographically and temporally distant people, places and non-human nature due to the respondents inability to see the local relevance of the problem. Associated confusion, uncertainty, lack of political commitment and few immediate drivers for change further inhibit action (Nicholson-Cole 2005). For a brief overview, The American Psychological Association (APA) recently compiled a list of factors that inhibit people psychologically from taking action even when climate change awareness is high: Uncertainty, mistrust of experts, denial, undervaluing of risks due to prolonged time perspective, lack of control and most importantly, habit (Swim et al. 2009).

By *whom* and *how* a message is conveyed is also a factor that matters in climate communication.

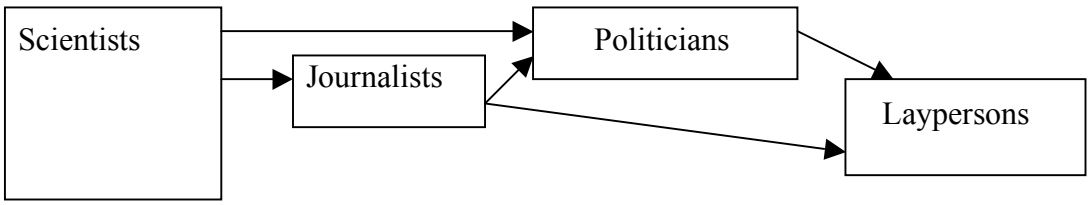


Figure 1. Dissemination of scientific knowledge concerning climate change to groups in society (reconstructed from Sundblad 2008).

Figure 1 above is a simple proposed framework for how scientific information flows from scientists to journalists, politicians and finally through to laypersons. There is no apparent direct flow of information from scientists to laypersons, so the middle layers digest the input information and transmit or translate it to the general public. The process of private adaptation will rely on available information about future changes, not just own observations and interpretations, and public authorities have an important role to play as a facilitator for adaptation by making scientific information available and by putting it into the appropriate context (Aaheim et al. 2009). Indeed, overall public concern tends to be correlated with trust of the issuing authorities, so scientific information can still play a role in how people judge risks given that the sources are considered reliable. If not, and if threat information is unspecific, uncertain or manipulative, it may even evoke resentment, dismissal or no response at all (Moser 2007).

The unconscious mind plays a further role, particularly with regards to the *language* of science, which tends to be the opposite of the simple, definitive statements that the public and the media want. This can pose challenges to the way one understands uncertainties and probabilities. Within this scientific jargon, there is never absolute certainty, only degrees of confidence either expressed through probability ranges or notions such as "*very likely", "widespread"* or *"considerable"*. The latter concepts are used by a widely cited authority in the climate change field, the IPCC, where "very likely" conveys a 95 percent degree of confidence. As these ranges are not directly stated, this use of words can cause confusion in the general population and lead to underestimation or dismissal of the threat (Gardner 2009). On the other hand, the understanding of numeric probabilities is strongly linked to the understanding of uncertainty, and research has shown that people have a tendency to overestimate small probabilities and underestimate large ones (Grothmann & Patt 2005). Dessai & Hulme (2004) have even questioned whether using probabilities in climate change adaptation is useful at all, as probability assessment is always subjective, conditional and provisional and human behaviour is largely intractable in the context of prediction. Applying the precautionary principle to climate change adaptation is a way of dealing with risk that states that the lack of full scientific certainty should not be used as a reason for postponing action to prevent environmental degradation (Rio Declaration in Gardner 2009). Yet, this is not a straightforward and easy solution, as risks are everywhere, trade-offs exist, and

choices about which risks to address must be made. People described as risk averse are often just averse to particular risks, not risks in general (Sunstein in Gardner 2009).

Specifically, a cognitive factor that points towards one explanation of why people do not take action is that weather is often conflated with climate change. However, while a region's climate determines the weather, weather events are not necessarily diagnostic of changes in climate as it is a longer-term statistically measured event (Swim et al. 2009). Still, people draw the connection that since nothing can be done to manage the weather, climate change must also be unmanageable (Morgan et al. 2002, Bostrom & Lashof 2007). Subsequently, there is a tendency for risk perception to be positively correlated with avoidant maladaptation, where people do not take any action at all, i.e. lack of self-efficacy.

Furthermore, people tend to process climate change information from a *socio-cultural perspective*, instead of focusing on the technical information at hand. Leach et al. (2005) focuses on the use of another form of rationality called *cultural rationality* as opposed to the so-called technical rationality, in their account within post-normal science. Further, cultural theorists have argued that social values and worldviews play an important role in risk perception and behaviour, that is that different individuals and groups interpret the world in different, yet patterned ways (Leiserowitz 2006).

2.2.3 Explaining Adaptation: The MPPACC Framework

One explanatory model for understanding the dynamics of action and inaction of people and decision-makers is the socio-cognitive Model of Private Proactive Adaptation to Climate Change (MPPACC) developed by Grothmann & Patt (2005), pictured in Figure 2. This model relies on protection motivation theory (PMT), a psychological model originally developed to be used in the context of health threats, but which has been successfully adjusted to deal with other issues. It is primarily a framework for private adaptation. How well this model is suited to explain planned administrative adaptation is yet to be fully empirically explored, but this thesis will still use it as a starting point for understanding this dimension.

The main feature of the model is the differentiation between two major perceptual processes, *risk appraisal* – assessment of threat probability, and *adaptation appraisal* – evaluation of ability to avert harm. Risk appraisal consists of two factors,

perceived probability, a measure of the degree to which a person expects exposure of a threat, and *perceived severity*, an evaluation of how harmful this threat would be if it should occur. Adaptation appraisal contain *perceived adaptation efficacy,* belief in the effectiveness of adaptive responses*, perceived self-efficacy*, perceived ability to carry out the responses, and lastly, perceived *adaptation costs*, how much adaptation is assumed to cost (Grothmann & Patt 2005).

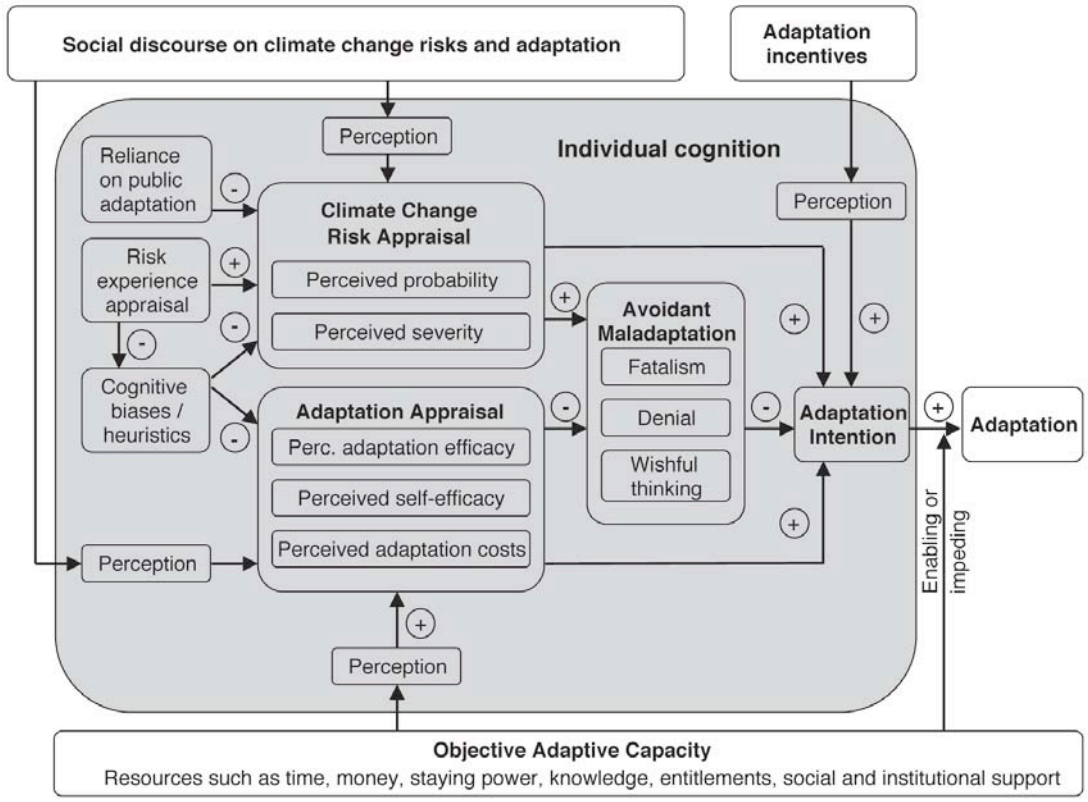


Figure 2. Process model of private proactive adaptation to climate change (Grothmann & Patt 2005: 204).

Adaptation appraisal kicks in after the risk perception process, and only if a certain threshold of threat is exceeded. Thus, a person will assess how probable it is that a threat will harm him/her, and if it is found to be overtly likely, the person will consider what can be done to withstand the threat, if anything. This is determined by the relation between *objective* and *perceived* action scope. The objective ability or capacity of a human actor only partly determines if an adaptive response is taken; the subjective or perceived ability can differ very much as humans are not always aware of their objective action scope or perceive of actions that are available physically as normatively impossible. Overestimation of action scope is also a possibility, causing 'illusions of control' (Wortman 1976 in Grothmann & Patt 2005). Most research,

however, points to the existence of a systematic bias towards underestimating objective adaptive capacity, i.e. that people perceive little control over what is conceived as global problems and thus take no action (Grothmann & Patt 2005).

A range of other factors also play a role within the MPPACC framework. For instance, private adaptation can also be influenced by reliance on planned public adaptation strategies, thus reducing individual risk appraisal, while adaptation incentives can increase adaptation intention. The social discourse on climate change risks and adaptation also matters, as well as the influence of cognitive biases and heuristics.

2.2.4 Decision-Making Under Uncertainty

While the above factors may seem mostly related to how individuals perceive of climate change and adaptation in their private lives, these influences also permeate into how decision makers operate, as they are individuals too. Decision-making always integrates both experiential and analytic processing, although the analytical side tends to be emphasized (Marx et al. 2007). Cognitive and constructivist factors are also important when it comes to decision-makers and policy making, according to Underdal (1998). The concepts involved in the development of environmental policy, like e.g. "sustainable development" or "the precautionary principle", leave considerable scope for interpretation, and decision-makers enter a policy process with imperfect information and tentative preferences. Actor perceptions and beliefs are then formed through the process of policy development, meaning that the policies themselves are based on the knowledge, ideas and beliefs of the policy makers. Awareness of such factors has implications for the study of compliance and implementation of environmental policy, "particularly in issue-areas characterized by high uncertainty about the nature and magnitude of the problems and the effectiveness of alternative 'cures'" (Underdal 1998: 26). Coping with uncertainty is one of the chief challenges for decision-making, and will hence be discussed in more detail here.

Uncertainty is an inherent property of knowledge and knowledge production (Dunn 2007), and therefore also in dealing with future climate change. Uncertainty can never be completely eliminated, but there are methods and techniques to manage the risks it poses to enable successful decision and policy making. Robustness to uncertainty is one of the key indicators of the effectiveness of an adaptation action (Dessai & Hulme 2007).

The present-day tools available to simulate the processes of climate change include global climate models that can be said to represent the current understanding of how the climate system works. The main sources of uncertainty in these models (and their representations) are 1) *emissions uncertainty*, 2) *natural climatic variability* and 3) *modelling uncertainty*[4]. First, it is difficult to project how emissions are going to develop in the future because of interaction with a range of social factors. Second, natural variability cannot be accurately projected and could serve to mask or offset human-induced change. And last, there are many ways to model the Earth system that give different results in terms of impacts. Uncertainty about the long-term impacts can also combine with potential present-day costs and be seen as an impediment to anticipatory action (Few et al. 2006). The uncertainties associated with climate data in Norway remains mostly in the realm of modeling uncertainty. Any representation of a phenomenon like climate change in a GIS also adds uncertainty due to the need to reduce complexity, and this is discussed in Chapter 3.

Nevertheless, people make choices under uncertainty all the time, so it does not have to be a problem. In fact, decisions are in general made without definite knowledge of their consequences, i.e. under uncertainty, on the basis of an evaluation of the desirability of possible outcomes and the likelihood of their occurrence (Tversky & Fox 1995). Adger et al. (2009a) has suggested that uncertainty associated with foresight of future climate change does not need to act as a limit to adaptation, as different social and organizational cultures approach the issue differently. What is needed, rather, are methods of assessing *robust adaptations* that can provide opportunities for overcoming perceived limits imposed by uncertainties. In addition, communication about climate change may be improved by a better understanding of how people learn and reason about uncertainty and probability, in addition to how uncertainty influences climate-related decisions (Marx et al. 2007).

[4] UKCIP 2008: http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=232&Itemid=326 (viewed 16.03.09).

2.3 Climate change: A Challenge for Norway?

In comparison with many countries, the climate change impacts in Norway are assumed to be positive or at least less adverse (O'Brien et al. 2006). Certain sectors of the economy could benefit from a warmer climate, and negative impacts are assumed to be relatively easily adapted to because of a presumed high national adaptive capacity constituted by factors such as wealth, technology and resource access, education, and infrastructure (O'Brien et al. 2004). Even so, there are substantial regional variations in vulnerability, and particularly cognitive challenges in terms of complacency about the climate change issue. This policy maker complacency manifests itself as low awareness levels of potential dangers and self-satisfaction that no action is needed to adapt. It is seen as generated by a narrow and sectoral view of climate change impacts, vulnerability and adaptation that favours technological solutions and treats adaptation as an afterthought (O'Brien et al. 2006). Having said that, the current media coverage and heightened public focus towards climate change and adaptation, as evidenced by the production of the recent Norwegian Public Report (NOU) (Hanssen-Bauer et al. 2009) by the newly formed committee on climate change adaptation and the new website www.klimatilpasning.no, may have changed this balance somewhat. Climate change related regulations are also starting to be integrated in building codes and requirements of local municipality governments. Yet, this is probably not enough to completely eliminate the extensiveness of complacent attitudes, particularly on the local level. Much work needs to be done to increase and shift the focus on Norwegian adaptation.

Regarding general public perceptions of climate change adaptation in Norway, a survey revealed high public consciousness about the topic coupled with an expectation that the responsible authorities will take charge of preparations to meet the arising climatic impacts (DSB 2007). Eighty-seven percent of respondents were of the opinion that the effects of climate change could already be seen to a large or some extent, while only four percent answered "not at all" or that they did not know. Eighty-six percent thought that the impacts of climate change would lead to unfavourable consequences for society, and two-thirds of the respondents were worried about the consequences for themselves and their family (to a large or some extent). Only eight percent were not worried at all. Regarding plans for concrete

measures to secure own property against possible climate change impacts, only 13 percent stated to have such plans. This is counteracted by the large contingent (two-thirds of respondents) who said that it was very or quite important for the municipality in which they live to have plans to meet the climate change impacts. In the dataset women, people with higher education and the youngest were found to be most concerned with and convinced of the impacts. For the personal worry component there were large differences with regards to educational background. Within the respondent group that had higher education 73 percent were to a large or some degree worried, while the respondents with lower education only 54 percent stated the same.

2.3.1 Projected Regional and National Climate Impacts for Norway

The regional impacts for Europe as outlined by the IPCC (Alcamo et al. 2007) imply that differences in natural resources and assets will be magnified by climate change. The main negative impacts will include increased risk of flash floods, more frequent coastal flooding and erosion (due to storminess and sea level rise) in addition to glacier retreat, reduced snow cover and extensive species losses. Also risks to health exist, unless adaptive measures are implemented.

With regard to Norway specifically, the main national findings of changes toward year 2100 from "Climate in Norway 2100"[5] (Hanssen-Bauer et al. 2009) point to a projected increase in temperature between 2.3-4.6 ºC. Further, precipitation could increase by 5-30 percent, where some areas will experience seasonal increases of up to 40 percent, particularly in the Western parts of Norway. The snow season along the coast will be cut by 2-3 months, while the growing season increases equivalently. The sea level is expected to rise by 40–70 cm dependent upon geographical location in Norway and substantial acidification of the ocean is projected. In terms of flooding, it is pointed out that the projections are uncertain, but that generally the size of floods is expected to increase (although some areas could see a decrease). The timing of floods may change though, as higher temperatures leads to earlier spring floods and increased risk of later autumn floods. Extreme weather events are expected to become more frequent. As summed up by RegClim results (Iversen et al. 2005), the climate in Norway will become warmer, wetter, sometimes drier, but not necessarily windier.

[5] Original Norwegian title: "Klima i Norge 2100".

There will be a wide range of consequences for agriculture, fisheries, energy production, buildings, transport, infrastructure, tourism, health, and water. On the positive side, the agricultural sector is overall expected to benefit from global warming, because the growing season will be prolonged, growth potential increased and there will be possibilities for importing new species. Also, potential for energy production based on hydropower will increase, while at the same time the needs for heating in winter will decrease due to higher temperatures. Some parts of society are projected to both gain and lose. For instance the impact on fisheries is uncertain, as fish migration due to higher temperatures might benefit some parts of the country at the expense of other regions. The transport sector will experience similar effects, as maintenance and preparedness budgets will increase because of extreme weather events, while less snow in winter increases the reliability and access of roads all year round plus reduce costs spent on snow plowing. On the negative side, buildings will be more exposed to damage, particularly to humidity and mould, and there will be increased pressure on the draining and water systems because of increases in precipitation. Parts of the tourism sector might also suffer, particularly the areas dependent upon snow. The effects on health for Norway exposed so far are mainly related to increased spread of ticks and thus tick-borne encephalitis (Hanssen-Bauer et al. 2009).

2.3.2 The Local Context: Fredrikstad

There has been increasing focus on local adaptation in Norway, particularly at the municipal level. Municipal governments have the potential to implement climate policy, particularly mitigation measures, to influence attitudes that can lead to behavioural changes or to stimulation of local actors (Vevatne et al. 2005). It is especially the existence of local knowledge, which enables the identification of contextually suitable adaptive measures, in combination with the desire, ability and possibility to learn, that makes this approach valuable (Hanssen-Bauer et al. 2009). Section 2.1.2 addressed a range of institutional barriers that may hinder local adaptation. To explore some of these factors and others, a Norwegian municipality, Fredrikstad, has been selected for study.

Fredrikstad is a municipality with 72 760 inhabitants per 2009[6], including the city of Fredrikstad, the 6th largest city in Norway. It is located in Østfold County, and the large river Glomma runs directly through it. The municipality has been divided into 23 local communities[7], lower level administrative and partly political units. Historically, Fredrikstad was an industrial stronghold with large timber, sawmill, brickworks, harbour and shipbuilding industries. Since the main shipyard closed in the 1980s, there has been a shift towards a base of tertiary industries, such as financial, consulting or media services, while maintaining a large chemical industry.[8] In terms of geography, the area lies on what is largely a clay foundation and several areas along the river(s) are high-risk zones for landslides. Because of the near proximity to the river Glomma, the risk of flooding is also quite high.

The national scenarios presented at www.senorge.no[9] suggest that there may be several climate impacts on Fredrikstad in the future. A plus 2.8-3.2º C increase in temperature can be expected when comparing the normal period 1961-1990 to the projected 2071-2100 time period. Precipitation is also projected to increase by 10-15 percent during the same time period. In addition the probability of extreme precipitation as presented by Skaugen et al. (2002) will increase by nine percent in yearly values for one day extreme precipitation, while there will be a slight decrease in five day precipitation. The municipality has experienced increased problems related to surface water in extreme precipitation situations and flash floods. Relative sea level rise is also an issue, and this has been estimated to constitute between 4–26 cm (most likely 12 cm) by year 2050, and between 32–87cm (most likely 52cm) by year 2100 for Fredrikstad (Hanssen-Bauer et al. 2009). These scenarios are based on the RegClim model of downscaling global data and thus have modelling uncertainties associated with them.

The information that exists on climate change scenarios and local level adaptations in Fredrikstad is currently lacking in both quantity and partly in detail and quality. Work is being carried out attempting to rectify parts of these gaps. Fredrikstad is a participant in the NorAdapt project that will provide further basis for measures. In addition to this, Fredrikstad is also part of “Cities of the Future”, a

[6] http://www.ssb.no/folkendrkv/2008k4/kvart01.html (viewed 16.03.09)
[7] http://lokalsamfunn.enkelweb.no/default.asp?ArtID=1135 (viewed 19.05.09)
[8] http://www.no.wikipedia.org/wiki/Fredrikstad (viewed 08.10.09).
[9] http://www.senorge.no/mapPage.aspx (viewed 07.08.08).

cooperation between the state and the 13 biggest cities in Norway to cut greenhouse gas emissions and make the cities better to live in by, among other things, increasing densification while reducing car traffic[10] with four priority areas: Area use and transportation, stationary energy use in buildings, consumer patterns and waste, and lastly, adaptation to climate change.[11] This partnership could also potentially help find appropriate local adaptive procedures.

The few specifically local investigations that exist have been carried out by Vestlandsforskning (Western Norway Research), and consist of an evaluation of natural disasters (Leivestad et al. 2008), a brief appendix to the local climate plan (Sataøen & Aall 2007), and a PDF document[12] on the municipal websites about the plans for climate adaptation in Fredrikstad meant for the general public. The tentative analysis in Sataøen & Aall (2007) identifies issues with flooding, landslides and erosion of arable land due to an expectation of increases in autumn precipitation, autumn temperatures and one-day extreme precipitation. As for direct impacts on the societal level, it is particularly businesses that are seen as employed in risk industries that are highlighted in terms of economical vulnerability. Accordingly, it is suggested that vulnerabilities to these issues are examined but overall no direct clues are given as to how adaptation is supposed to take place at the local level in Fredrikstad. The later published PDF document identifies adaptive measures related to the piping systems to avoid overcapacity leading to surface water flooding in extreme events of precipitation.

Concerning the perception of climate change locally, the results for Østfold county, of which Fredrikstad is part, in the DSB (2007) public survey showed an over average worry and willingness to act on all questions posed. For instance, 56 percent of people from Østfold wanted more information from the public authorities about climate change in their area compared to a 52 percent country average. Ninety-one percent over a national average of 85.5 percent believed that we were already seeing the consequences of climate change and 70 percent of Østfold respondents were worried about the direct consequences for themselves and their families (64 percent

[10] http://www.regjeringen.no/nb/sub/framtidensbyer.html?id=547992 (viewed 05.09.09).

[11] http://www.regjeringen.no/nb/dep/md/dok/andre/brev/utvalgte_brev/2008/invitasjon-til-samarbeid-om-framtidens-b.html?id=499281 (viewed 05.09.09).

[12] http://www.fredrikstad.kommune.no/Documents/Politikk/Planer/Framtidens%20byer/Tilpasning_klimaendringer.pdf (viewed 05.09.09).

national). It is thus reasonable to assume that there is at least a county level perception of climate risk.

Regarding the potential for using GIS as a tool for adaptation, the municipality of Fredrikstad already offers basic GIS services online open to the general public at http://karttjenester.fredrikstad.kommune.no/interfred/, pictured in Figure 3 below.

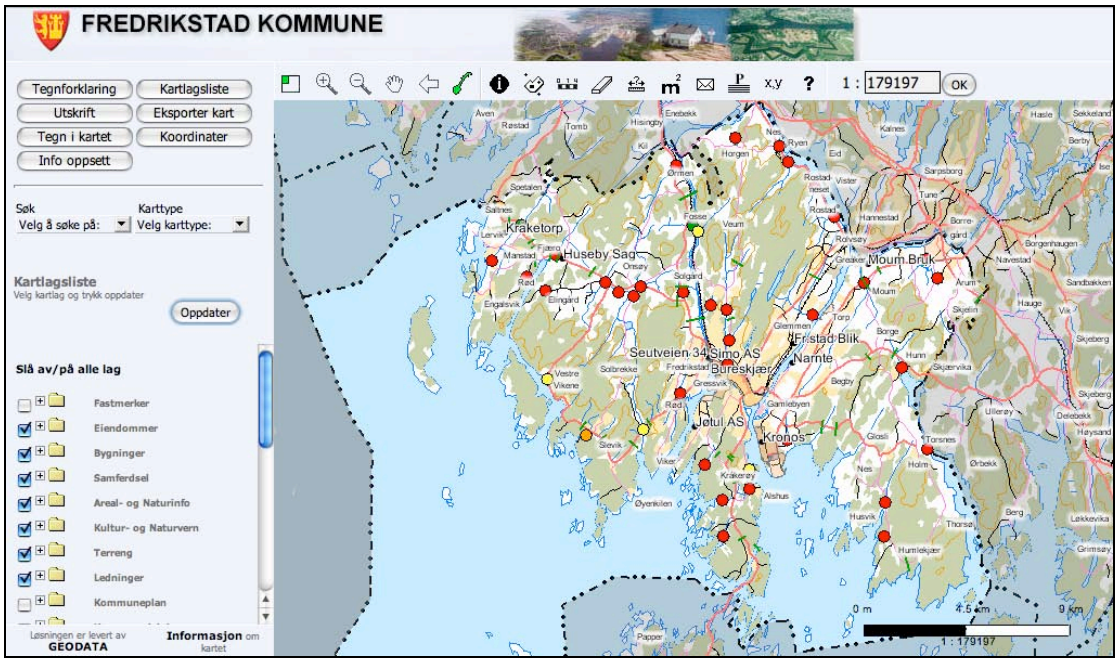


Figure 3. Fredrikstad municipal web-based GIS tool with pollution points.

This tool features baseline data, and all data available through Norge Digitalt for Fredrikstad. In addition, the regulations from the municipal regulation plan can be shown to detect which areas are affected. There is a category for environmental data, which in this case includes points for polluted property and migration paths for game. No climate change data is currently available, making it a fairly static tool at the moment. It is widely used among the local community though, and all groups interviewed claimed to be using it for various purposes.

Although not publicly available through the GIS tool, flood and landslide risk maps in GIS format for Fredrikstad do exist. This data was used during interviews with the Fredrikstad informants. Norwegian planning law requires municipalities to use these in local planning to identify areas that should not be built on without closer examination of the associated risks and the possible implementation of compensating measures. In terms of flooding, a safety margin is always added for practical use, and

for Fredrikstad this is presently 30 cm above the calculated water levels during flooding[13].

To sum up, Fredrikstad is seen as a relevant Norwegian case for the purpose of this thesis due to the municipality's own awareness of potential consequences of climate change, high probable climatic exposure due to the river location, and substantial internal GIS competence. The municipality is involved in a range of different projects to assess climate vulnerability and come up with the best policies to deal with these, as the exposed position by the water and riverfront is internally and externally acknowledged. Issues of flooding, surface water problematics and landslides are also recognized, but not necessarily mapped out. The GIS department of Fredrikstad municipality is a resource for the whole region, and sets the scene for high spatial awareness.

2.3.3 Climate Change Related GIS Tools

Since there is a lack of data related to climate change in the municipality tool and as a starting point for the theory chapter on GIS, this section will give a brief overlook of what otherwise exists online for general public view. In fact, few direct available GIS tools for climate change adaptation exist currently. There is however several tools that show climate change related factors, and in a wider definition of adaptation, mitigative efforts are also covered. The figures on the next page show some interesting ways to visualize geographical data and open up for participation. Figure 4 depicts a lightweight application developed by a Norwegian newspaper (Aftenposten) to allow the general public to report instances of tick around the country. Local and global increase in temperature can lead to increased spread of vector-borne diseases through an increased distribution of tick. This is also a rare example of participatory mapping in Norway. Figure 5 shows the initiative Solar Boston, which maps out potential for using solar panels on roofs in the Boston area. Figure 6 shows senorge.no, which is the centralized portal for climate change scenario presentation in Norway. Maps for the Fredrikstad area found on this website was used during interviews. The last figure (7), depicts weAdapt, a Google Earth connected overview of adaptation initiatives in Africa and Asia, with integrated videos, testimonials and other multi-media elements.

[13] http://www.nve.no/modules/module_109/publisher_view_product.asp?ientityID=10293 (viewed 06.07.09).

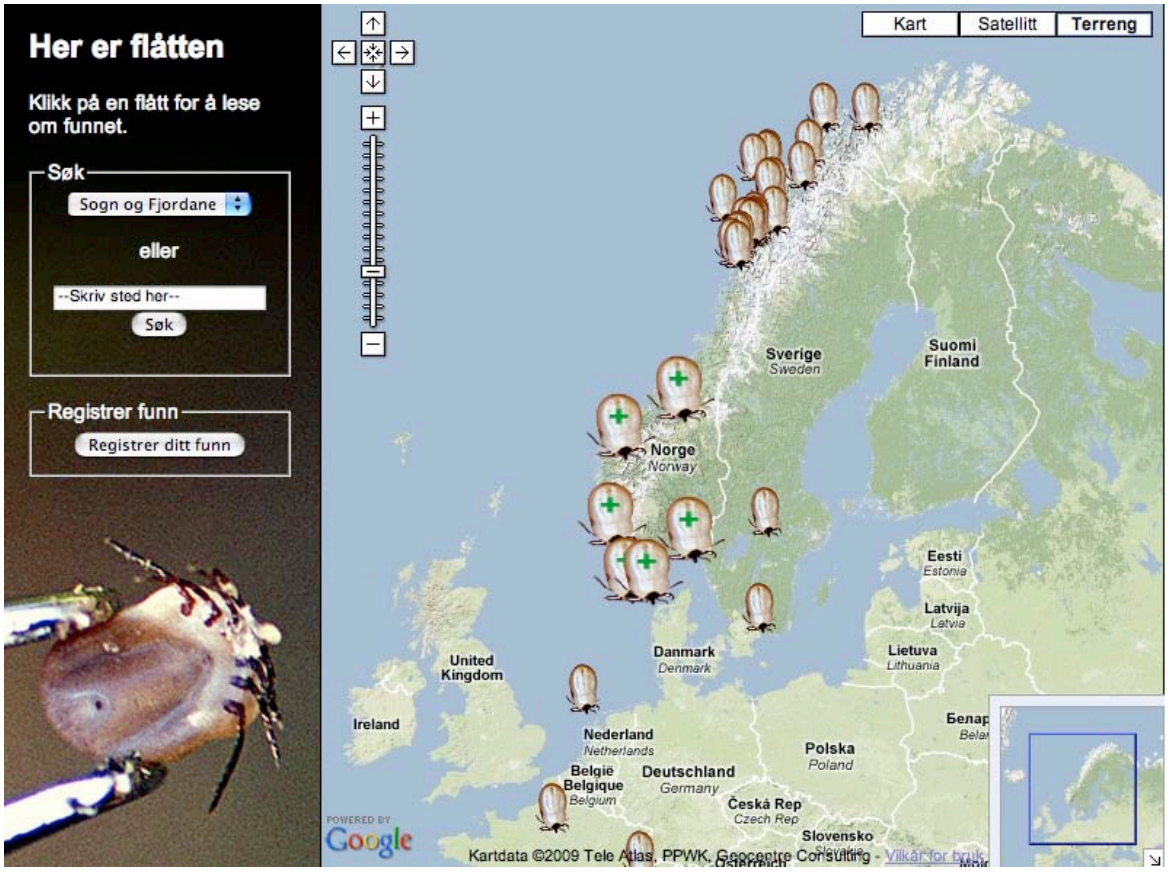


Figure 4. Participatory tool: Ticks in Norway[14].

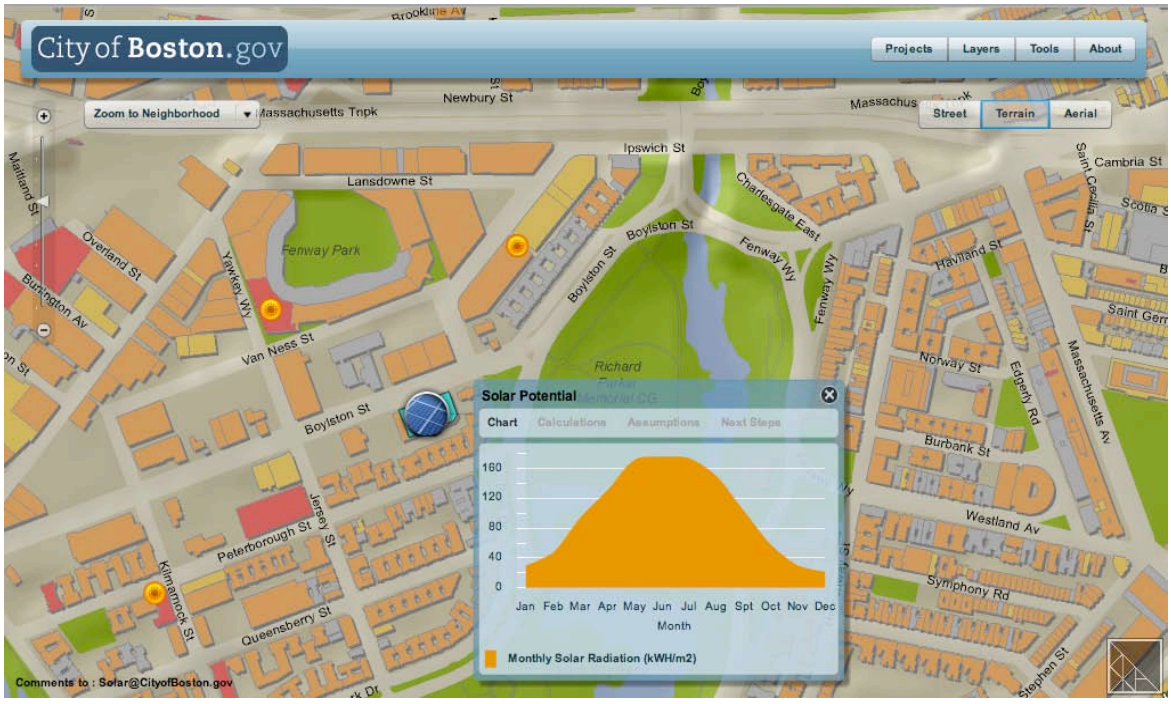


Figure 5. Mitigation: Calculating solar potential in Boston[15].

[14] http://www.aftenposten.no/nyheter/iriks/article3139218.ece (viewed 03.07.09)

[15] http://gis.cityofboston.gov/solarboston/ (viewed 03.07.09)

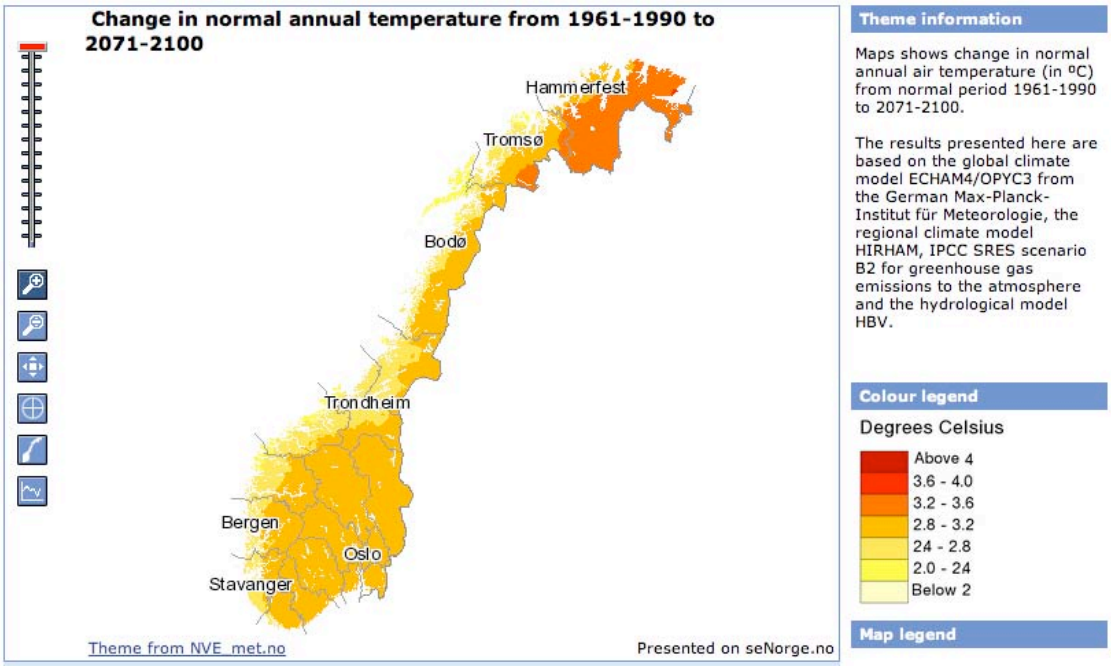


Figure 6. Scenario presentation: Norwegian climate scenarios[16].

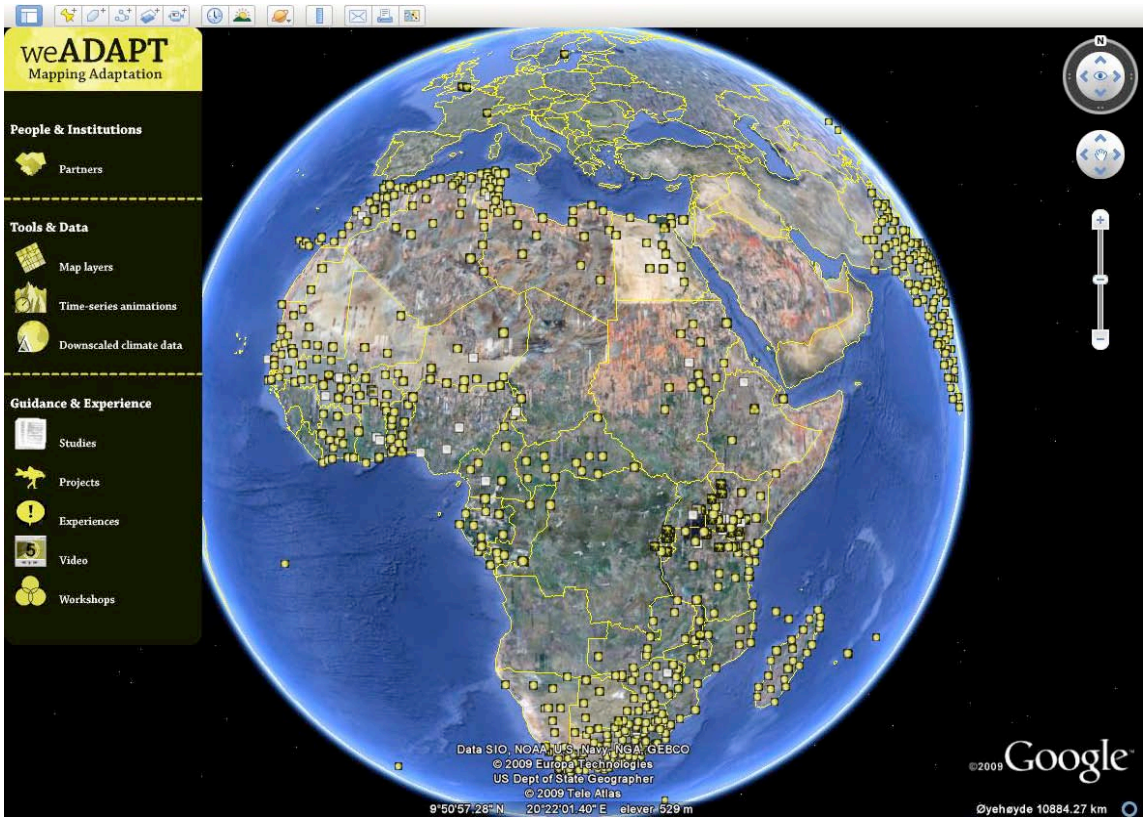


Figure 7. Adaptation overview: weAdapt application for Google Earth[17].

[16] http://senorge.no/mapPage.aspx (viewed 04.07.09).

[17] http://earth.google.com (viewed 04.07.09).

3. Theory: Looking Critically at GIS

> "What is at stake (…) is not the acceptance or rejection of GIS as a method, technology, or science per se but how GIS will be understood relative to other practices of geography…" (St.Martin & Wing 2007: 237).

3.1 Definitions, Ontology and Developments Within GIS

Our lives are spent in *places*, and almost everything that happens happens *somewhere* - these geographic facts are central to the discipline of human geography. Problems that have a geographic nature occur, on different scales, with different intent, and on a variety of time scales. Geographic information defines these issues, and geographical information systems (GIS) combines general scientific knowledge with specific information and gives practical value to both (Longley et al. 2005).

3.1.1 Defining GIS

Within the GIS community the acronym 'GIS' has two different but related meanings; geographic information *systems* (GISystems) and geographic information *science* (GIScience). Its GISystems meaning, which will be elaborated on below, is that of the hardware, software and practices that constitute the interface of the system, while "GIScience is, in the simplest sense, the theory that underlies GISystems" (Schuurman 2004: 9). In GIScience, the underlying assumptions and premises in the code of GISystems are questioned because every stage of a GISystems analysis is seen to be based on the translation of spatial phenomena into digital terms. These manipulations can affect the results of analysis and as such need to be investigated. GIScientists thus deal with how

> "spatial objects become digital entities, what effect that transformation has on their ontologies, how to represent different epistemologies within GIS, how to model relationships between spatial entities, and how to visualize them so that human beings can interpret the results" (Schuurman 2004: 11).

Most commonly the term 'GIS' refers to GISystems, unless otherwise specified. This thesis will partly be a GIScience investigation, but uses the "GIS" term in the meaning of GISystems throughout the text. Below GISystems is explained in more detail, while the three waves of GIS critique take place within the GIScience perspective.

What constitutes a useful definition of GIS, in the GISystems meaning, depend upon the target audience: It can be viewed as "a container for maps in digital form" (general public), "a computerized tool for solving geographic problems" (decision makers), "a tool for revealing what is otherwise invisible in geographic information" (scientists, investigators), and "a tool for performing operations on geographic data that are too tedious or expensive or inaccurate if performed by hand" (resource managers, planners) (Longley et al. 2005: 16). Some people, of a more critical disposition, would perhaps rather say that it is "a positivist technology that assumes the possibility of objectivity" (from a summary in Schuurman 2006: 727). There are many definitions to choose from dependent upon context, and none of them are entirely satisfactory, but most of them suggest that GIS is something more than just the technology.

According to Longley et al. (2005), there are six core GIS components: Software, data, procedures, hardware, people and the network between them. GIS uses maps as its representational form, where the locations and objects pictured are assigned their real world geographic coordinates, longitude and latitude, in the X, Y format. A GIS is able to capture, store, manage, manipulate, query, measure, analyze, model, visualize and present geographic information. There is widespread use of GIS in transportation planning, utility management, area planning, emergency services and businesses (Longley et al. 2005). The most common commercial GIS package is ArcGIS from ESRI, but many other versions exist. In Norway for instance, locally developed software such as GIS/LINE is an alternative sometimes used at the municipal level.

3.1.2 A Brief Look at Epistemology and Ontology in GIS

> "Epistemology involves the study of theories of knowledge, the questions we ask about how we know, whereas ontology involves the study of theories of being, the questions we ask about what can really exist"(Smith 2003: 279).

To be able to investigate critical claims in the following debate, it is useful to give a short overview of the epistemological and ontological characteristics of GIS. This divide between knowledge (epistemology) and reality (ontology) is not as clear cut as it sounds, as ontology can be seen as 'grounded' in epistemology, because "claims about how we know what the world is like underwrite claims about what the world is like" (Johnston et al. 2003: 226). Research into ontology can thus be fundamental if

one wishes to incorporate different epistemologies into a GIS (Schuurman 2006). Another way of talking about epistemology is to look at it as the "methods we use to study the world, and the lenses that they entail" (Schuurman 2004: 26), or as a reference to the perspective the researcher uses to interpret entities and phenomena. "Every epistemological perspective imbues the observation with different meaning, and different ontologies come into view depending on the epistemology of the GIS user" (Schuurman 2004: 26). Positivism is one such epistemological perspective that will be discussed in relation to the three waves of critical GIS critique.

The term ontology is defined differently within different fields of study, and this is a reason for confusion and debate when dealing with GIS because of its mutual roots in philosophy/social science and information science. The computer scientists interpret ontology as "a formally defined set of objects in which all the potential relationships between objects are well defined" (i.e. a data model) (Schuurman 2004: 31) while within the social sciences and philosophy it is understood to signify "a foundational reality, the essence of an object or phenomena" (Schuurman 2006: 731).

To show something in a GIS the object in question needs to be encoded digitally, as does its relationship with other objects. These rules and relationships are just as important as the objects themselves. An example of rules from Schuurman (2004) is that a road can cross a bridge, but a river must run under it. Different data models can produce dissimilar ontologies for the same objects on the ground, and thus affect the result of any analysis: "Data models reflect different ways of seeing the world. They are ways of imagining space – in order to render it in a computational environment" (Schuurman 2004: 32).

There are two main types of GIS models, making up two main ontological possibilities: Representation as *discrete objects* versus *continuous fields*. Both of them divide and define space, but they do it differently. Continuous fields are properties that vary uninterruptedly over space (like elevation), while discrete objects are the points, lines and areas of countable things in the world (like buildings or vehicles).

> "Both field and object models rely ultimately on a view of the world in which neutral and absolute space is assumed. Nor does either allow the characterization of complex, interrelated geographic entities" (Schuurman 2004: 38).

It is admitted that both models are reductionist and use a presumption that one can solve a problem by dividing it into smaller problems and use sub solutions to make a total solution in line with positivist thinking.

In addition to the two main representational models, there are two ways the models can be drawn in the computer, called vector or raster, shown in Figure 8. A vector model consists of points, lines and areas – and looks very much like a traditional map. A point is zero-dimensional, while a line, called a polyline in GIS, is one-dimensional and consists of an arc or chain linking two points. Areas are called polygons and consist of two-dimensional interlinking lines. Three-dimensional surfaces are built from areas. The raster model, on the other hand, divides the world in square grid cells that are identical and discrete entities – this creates a more pixelated look, like in a satellite photo. The grid cells are linked to a specific location and given a value; there are no empty cells (Longley et al. 2005).

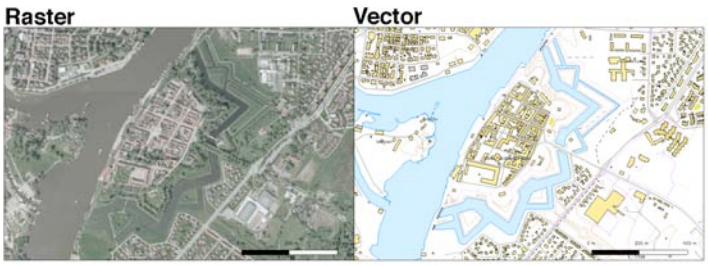


Figure 8. Raster and vector GIS models.

Both models use overlaid thematic layers for each of the object classes, see Figure 9. The GIS system uses hierarchical classes; every object is not defined individually, meaning that for instance all buildings are placed in one layer, the streets in one, and customers in another. This enables comparison in order to determine new sets of attributes from a combination of layers such as for instance the intersection between lower income residential areas and commercial zoning (Schuurman 2004).

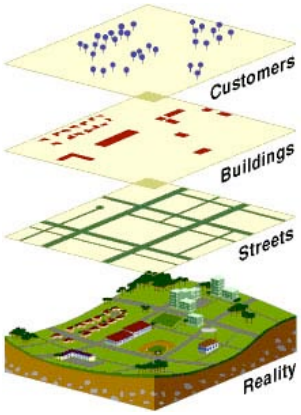


Figure 9. Thematic layers in GIS.

Every data model or system of representation is essentially flawed or limited due to the complex nature of reality. This does however not mean that it is useless, it just means that how a GIS representation is developed and used needs to be studied to enable sensible utilization with an awareness of its drawbacks.

3.1.3 Developments in GIS

In recent years several new developments in GIS, both in applications and methods, have occurred, largely as a result of the critical debate that will be delineated below. While objects and fields have remained the main ontological possibilities of GIS for a long time, change is under way in realm of using for instance fuzzy logic (e.g. Evans & Waters 2008). Open-source and free versions of GIS software, such as Q-GIS[18] or GRASS[19], have started to become widespread, and critical, feminist and participatory GIS (PGIS) have growing influence.

PGIS appeared out of a merging of participatory planning practices and GIS, and is geared towards community empowerment through tailored, demand-driven and user-friendly geospatial applications using two– or three-dimensional maps (Corbett et al. 2006). Further, PGIS efforts seeks to address uneven access to GIS and digital data, diversify the types of spatial knowledge that GIS can include and support a view of GIS as communicative media, not just spatial analysis technologies (Elwood 2006a). The link to climate change adaptation is primarily through urban planning, where furtherance of collaborative governance has lead to a rapid growth in citizen participation, and thus potential openings for PGIS.

Outside of these fundamental developments, it has also become more possible and desirable to incorporate multi-media elements directly with the maps such as photos, videos and texts. The prevalence of location-based services is also growing, most importantly through free applications such as Google Earth and Microsoft's Virtual Earth as part of the neo-geographic revolution, which have expanded the reach of geographic information immensely (Elwood 2009). This thesis will primarily focus on desktop GIS and its related web-interfaces.

3.2 Critical GIS Theory: The Three Waves of GIS Critique

> "GIS theory (…) is influenced *both* by cultural and technical factors. There is a social dimension to every digital decision, just as there are real technical strictures to conceptual formulations" (Schuurman 2004: 43).

GIS is not a neutral tool, and the use of GIS is not unproblematic (e.g. Pickles 1995, Curry 1998, Crampton 2001, Pavlovskaya 2002, Elwood 2006). Both social and

[18] http://www.qgis.org
[19] http://grass.itc.it/

technical factors influence the way GIS is used to interpret the world and how the users understand the GIS output, as the above quote emphasizes. Nicholson-Cole (2005: 256) urges people working in the field to be aware of ”the ethical and methodological issues associated with using computer-generated visualisations”. These are based on the fact that using a GIS involves subjectivity despite its appearance as an objective representation of a geographical reality – through choices about what to show (and not to show), assumptions made and how the GIS is interpreted by viewers.

3.2.1 Introducing the Main Debate

The majority of GIS critique surfaced in the 1990s, prior to that, i.e. since the 1960s, there was a relative friction free incorporation of GIS into geography. The critique grew out of sentiments that apparently had been growing for a few years on the part of human geographers, and the kick off was sparked by an editorial written by Peter Taylor (1990). Starting out, and as a recurring, unresolved theme, has been the issue of epistemology and GIS, particularly with regard to positivism. To sum up the gist of the discussions in one sentence:

> “Human geography critics felt that GIS failed to accommodate less rational, more intuitive analyses of geographical issues, and that its methodology, by definition, excluded a range of inquiry” (Schuurman 2004: 23).

The focus of the debate shifted over the course of the years, with the development of main topics illustrated in Table 2 below. It is shown as constituting of *three waves*, each with distinctive characteristics, a division set out by Nadine Schuurman (2000, 2004, 2006).

Table 2. Content of GIS critique from 1990 to 2001. Based on Schuurman (2006).

Source of critique	
Pre 1993 papers (e.g. Taylor 1990; Taylor & Overton 1991; Smith 1992; Lake 1993; Pickles 1993).	Based on data rather than information; subject to naive empiricism; a positivist technology that assumes the possibility of objectivity; complicit in warfare; based on a Cartesian framework incapable of describing human geography or natural phenomena.
1995 publications: *Ground Truth* (Pickles, ed.). Special issue of *Cartography and GIS* (Sheppard, ed.)	A masculine technology; part of a cybernetic grid of control; a marketing tool; epistemological inertia; limitations of visualization; Cartesian perspectivalism and rationalism; need to make the technology accessible.
1995-1999 (e.g. Curry 1997; Pickles 1997; Katz 2001)	Lack of attention to epistemologies and ontologies; failure to accommodate marginalized voices; a means of greater surveillance.

Aside from these philosophical and foundational issues, there are some fundamental barriers to use of GIS in general that are widely recognized on all sides; time, costs, and required skill level. To elaborate, doing GIS can be quite a time consuming process because of the many stages in the analysis process, the start up costs can be very high due to the commercial nature of the GIS software and the complexity of the software demands a certain level of skills to be able to operate it (Elwood 2006a). It also requires constant updates and possible purchases of geographic data. In effect many individuals, social groups and organizations may be barred from participating in research and decision-making where it is used, and this could constitute a new 'digital divide' (Elwood 2006a). The latter perspective takes us deep into the debate, which now will be outlined.

3.2.2 The 1st Wave: Positivism

The first wave from 1990-1994 was a period of intense debate with a particular emphasis on an epistemological critique of GIS being positivistic. Positivism in this sense emphasizes scientific facts over values, testing of theories in a deductive manner in order to create laws, and sees it as possible to practice objective science in that the researcher does not affect his or her research subjects (Smith 2003, Christou et al. 2008). In positivist geography, space is seen to be measurable in standard units, human relations are reduced to theorizations of expenditure in overcoming the friction of distance and people are treated as objects which can be observed objectively (Peet 1998).

There has been a strong association between positivistic science and GIS for a long time, partially because it was seen as a legitimate way of staging GIS' entry into science as a part of the revival of geography during the quantitative revolution in the 1960s (Goodchild 1991). Human geography turned away from the quantitative focus, and the critics saw GIS to be well equipped to deal with facts but incapable of producing meaningful analysis, viewing "space as a container of objects with a definite extent and precise location with the Cartesian grid" (Pavlovskaya 2006: 2014). This opposes the view of critical geography, where space is seen not as the objects but the relations between them, and social processes and relations are inseparable from that space. For critics, this led to "the very worst sort of positivism, a most naïve empiricism" (Taylor 1990: 212) based on the trivialization the fact focus of GIS would supposedly incur for geography. These allegations were refuted by

Michael Goodchild (1991) with the claim that GIS is most useful when guided by people trained in geography, and that geographical data has unique characteristics and problems ('spatial is special') that differentiates GIS from other information systems and which rightly needed to be addressed, particularly developing a better understanding of geographical uncertainty. The solution to overcome reductionism would be to investigate how GIS is used and how social processes are written into technology.

Positivism as an epistemological strand is in itself a floating signifier, i.e. it does not have a fixed unambiguous meaning, so it is hard to absolutely refute that it does not apply to GIS seeing that it can mean so many things (Schuurman 2004). Given that the conventional representational model (ontology) in GIS follows Euclidean geometry, which deals with so-called "real" numbers that assume continuity, it is not such a big surprise that critics attacked this side. As mentioned, it is a model that can lead to a very abstracted view of space, and stands against how human experience believes it to be (where the world itself in the end is the only effective representation). The geometric language can frequently fail to explain, and it may be these types of limitations that the critics identify as being "positivistic" (Schuurman 2004). Data models are constrained in comparison to how humans organize space and corresponding data, and a certain extent of the context of everyday social life has been harder to put in, for instance ethical statements or expressions of emotion. The data models restrict the type of data that can be included:

> "Acknowledgment of the need for formalization is both a constraint and a liberating force. It limits the types of concepts that can be implemented, while ensuring a vehicle for those concepts/epistemologies that are structured adequately" (Schuurman 2006: 734).

Certain types of knowledge can be seen as privileged because they are more tailored to the way GIS works. Knowledge forms that are quantitative, standardized and cartographic can be incorporated with greater ease (Elwood 2006a) and thus exclude other types of knowledge that are non-spatial, such as values. The discursive power of different types of knowledge can grant greater legitimacy to some types of knowledge over others in social and spatial decision-making.

One more aspect that importantly came forward during this first wave of discussions was an emphasis on that GIS is part of a large social shift of increasing

digitalization and visualization of society. Towards the end of this period, there was a critical GIS conference at Friday Harbour in Washington, and this marked the beginning of a new wave.

3.2.3 The 2nd Wave: Power

The second wave started with the publication of the proceedings from the Friday Harbour conference and *Ground Truth*, a collection of essays edited by John Pickles (1995). Summing up 1st wave critiques and extending it into the 2nd wave focus, this milestone book saw the GIS spawned by the quantitative revolution in geography as a positivist tool of the state that celebrated a data-led new geography while surveilling and controlling citizens. Themes not readily available for spatial codification were believed excluded, and a shift towards a view of GIS as not only a technology, but also a tool and a social relation was rallied for (Pickles 1995). The premise of *Ground Truth* (Pickles 1995) was largely based on Harley's work on maps and power, as envisaged by the statement that: "The map is not the territory but a representation of social relations" (Harley, 1992: 233-38 in Schuurman 2000: 579). Pickles and others extended this to GIS.

Hence, discussing GIS in terms of its map foundations is useful for understanding how the outputs are interpreted and created. Maps are *thought* to be unbiased and imply accuracy. Through the principle of veracity, people believe in maps because they think they are free of error, and cartography (as well as society in general) fosters this connotation by pointing out cases in which maps do not match reality as if they were rare, extreme exceptions. However, every map representation denotes an interpretation and partial representation of the world, and is often created to arouse emotions and persuade the viewer of the author's point of view. Maps can even exert control over places and people by establishing a claim to territory, taxes, mineral and/or social-political control over those within the map's boundaries (MacEachren 2004). Further, maps are not created in a social vacuum, as cartographers devise typologies and individual maps within a socio-cultural context that influences and constrains the categories that are considered appropriate to represent. Because cartographers work within their own socio-cultural context, they often take the features to be mapped as a given in that "what we see is less a mapping of reality than of the mapper's mental categories—in this sense, mappers map not place but their own consciousness" (Lejano 2008: 661). This gives a lot of power to

the mapmakers and GIS analysts. There are always choices about what to show and what not to show on a map and these have consequences: "Issues of spatial and temporal scale, resolution, and partitioning will dictate the questions that can be posed and the issues that can be addressed via the map" (MacEachren 2004: 334). This creates a problem for the view of GIS as a neutral, positivist tool for observation since what we observe has already been embedded. This does not necessarily entail that it has been seen through a positivist epistemological view, it all depends upon who is seeing. But it does mean that GIS maps the subject in many ways, not purely the object in an objective way thus defeating in part the assumption of positivism that it is possible to separate subject and object completely. Moreover, GIS allows for an incorporation of discursive constructions over physical landscapes, thus contributing to the reification of socially constructed categories (Lejano 2008). The case of "contested spaces" points this out, where the values associated with the territory is as important as the territory itself (Schuurman 2004).

With inputs like this, the debate now turned from more of a discussion between proponents and opponents to a full-blown critique on all sides, with different foci. The topics grew more nuanced and subtle, looking more at "epistemological integrity, gender, class, limitations of visualization, Cartesian perspectivialism and rationalism" (Schuurman 2000: 579) and having a definite social slant.

3.2.4 The 3rd Wave: Participation

Lastly, the third wave from around 1997 marked the return to a diverse discussion of power and marginalization according to Schuurman (2000). A mutual dependence between geography and GIS was detected and through a redefinition of what 'science' meant to something that is open and eludes positivism the grounds for a wider definition space for GIS lay open. Focusing on GIS' possibilities for visual analysis and expression, collaboration and uniqueness of place created a better fit between the disciplines. Themes such as privacy and surveillance were further explored, in particular by Michael Curry (1997). This third period of the main debates was also marked by the increased willingness on the behalf of both GIS practitioners and GIS critics to try to negate and find ways in which the oppressions of GIS technology can be resisted at the individual and social level. The development of (public) participatory GIS (PGIS), more critical GIS and feminist GIS marked the start of a new type of GIS more sensitive to the issues brought forward in these critiques. PGIS

can be seen as context- and issue-driven rather than technology-led, and as a celebration of multiplicity of geographical realities (Dunn 2007).

3.2.5 Where Are We Now?

Roughly summed up, the first wave of critical GIS was about *positivism*, the second about *power* and the third about *participation*. There has been a development throughout the debate towards a better awareness of what using a GIS means, and new methods and applications as mentioned above.

In light of current developments, there are reasons to question the positivist assumptions of GIS in its modern day version, as there seems to be a mixed epistemological toolkit at work. GIScientists are more open to incorporate issues of how context shapes the formation and selection of categories, and how different ontologies can appear. Also, "the emergence of critical GIS simply emphasized the need to understand and integrate issues of ontology and epistemology into GIScience research" (Schuurman 2006: 731). This has for instance been done through countering the proposed masculine bias towards the use of feminist epistemologies (e.g. Kwan 1999, Pavlovskaya 2002, Schuurman & Pratt 2002) and through PGIS work in communities (e.g. Elwood & Leitner 2003), as well as additional work by Kwan (e.g. 2000) looking at space-time constraints in relation to gender differences hence challenging the Cartesian constraints of GIS. Further, Kwan (2009) points out three important new developments within critical GIS: The use of GIS in qualitative research, for articulating people's emotions and feelings, and lastly, as an artistic medium that challenges the objectifying vision in conventional GIS practices.

All of this suggests that there are general openings for including a variety of viewpoints in maps and GIS and a need to look at GIS data representations as "interested visions", i.e. representations in which interests are vested, rather than "absolute reality" (Schuurman 2004). There has been substantial progress since the early days of critical GIS debate, and also a wider reach for the discipline of critical GIS research into a variety of fields such as for instance gender studies and anthropology.

3.3 GIS and Climate Change Adaptation

While the preceding debate over the three waves of GIS critique have outlined *where we have been*, and led us towards *where we are now*, introducing climate change adaptation in conjunction with GIS gives some indication as to *where we could* or *should be going* to make it a suitable adaptation tool. These arguments will be elaborated on in Chapter 7 in light of the empirical findings of this thesis.

3.3.1 Why Use GIS for Climate Change Adaptation?

Elwood (2006b) asks the rhetorical question of why one should bother with GIS when it is so inherently problematic and challenging in many ways, as outlined in section 3.2. Her answer is that GIS is tremendously important as a

> ”powerful mediator of spatial knowledge, social and political power, and intellectual practice in geography. In short, (...): Because the stakes are very high” (Elwood 2006b: 693).

The stakes get even higher when countering the possible impacts of climate change is added to the equation, and there are a range of roles that GIS can play in contributing to better adaptation decisions and processes. There are openings in the way GIS works that facilitate its use in climate change adaptation processes, both related to widespread social developments and specifically for adaptation. Summed up, six main functions can be seen in the intersection between GIS and adaptation that makes it a suitable framework to use: *Computerization, spatialization, visualization, participation, communication* and finally *integration*.

Firstly, using GIS involves *computerizing* relevant climate information. Computer modelling in general can help understand and find potential solutions to environmental problems (Forrester & Cinderby 2005). Processes such as

> ”stratospheric ozone depletion and greenhouse warming, (...) require large-scale simulation modelling and a rich supply of data covering a range of environmental parameters on a global scale” (Veregin 1995: 95)

into Global Circulation Models (GCMs). But even though the characteristics are similar, a GIS is not a vehicle for simulation modelling itself, but instead a framework that allows for display of the results of these simulations. GIS has the capacity to store a lot of data in one place, and to visualize it in thematic layers. Data can be integrated

and spatial analysis executed. Spatial analysis is what differentiates GIS from mapping, by going further than a what can be discovered visually through a synergistic means of extracting information from spatial data.

Secondly, using GIS means incorporating a spatial element into the analysis of possibilities for climate change adaptation. *Spatialization* can be seen as "the systematic transformation of multidimensional (non-geographic) data domains into lower-dimensional spatial representations to facilitate knowledge discovery from very large databases"[20]. This can enhance understanding of the geographic spread of the phenomenon, and help identify patterns and areas in particular need of attention. Most factors related to climate change adaptation have a spatial component, such as defining the spatial extent of drought in relation to patterns of socio-economic vulnerability. Also, fundamental to effective geovisualization is understanding how human spatial cognition shapes GIS usage (Longley et al. 2005). This is a perspective that has gained importance through the three waves of GIS critique, and the increasing focus on the *science*, not the *systems*, part of GIS. Spatial cognition is "the process by which a person understands or thinks about spatial information" (Fisher 1995), and leads to the development of an internal cognitive map, which can be seen as an "internalized GIS" according to Gollegde (1994). Examining these factors and their potential overlap with the cognitive challenges in climate change adaptation could offer interesting opportunities.

Thirdly, GIS is an effective platform for *visualization*. The visual interface of the GIS system fits in with a general tendency in society towards a 'digital revolution' and a development of a 'visual culture', that relies more heavily on images than directly on numbers and data. Visual imagery is a significant component of education, advertising, Internet and computer use. However, for effective usage, this mode of visualization must have scientific or logical underpinnings, otherwise it is unlikely to change people's minds or convince policy-makers (Sheppard 2005). Visualization is important for enabling climate change adaptation because of a range of benefits, e.g.: The capacity to convey strong messages, make them easier to remember, condense complex information, communicate new content, provide basis for personal thought and conversations, contributing to people's memories and awareness, instant communication in different media and contexts, and clarification and illustration of

[20] http://www.geog.ucsb.edu/~sara/html/research/ucgis/spatialization_ucsb.pdf (downloaded 02.11.09)

data (Nicholson-Cole 2005). For policy and decision makers the process of thematic layering allows for visualization of possibilities and impediments associated with location of strategic facilities for instance (Schuurman 2004).

Fourthly, the GIS platform equips the users with an apparatus for engaging wide *participation* of stakeholders in adaptation processes. The increasing individualization and self controlled customization that has followed the Web 2.0[21] revolution, has resonance both in the possibilities of GIS itself and the nature of successful climate change communication. In a situation where individuals are socio-politically predisposed to deal with risk information in different ways, ”messages about climate change need to be tailored to the needs and predispositions of particular audiences” (Leiserowitz 2006: 64). Climate change as a phenomenon is abstract and to some degree uncertain in its impacts, and thus requires a less formalized and exact approach with a larger degree of dialogue between different parties (Janssen et al. 2006). Increasing focus on the importance of public participation in planning processes overall substantiate the possibilities for wider cross-group involvement into the issue. There are many stakeholders in climate change adaptation, as its impacts include a wide array of sectors and layers of society, and these may have divergent agendas. Hence, there are particular problems in how to create socially robust projections with reliable knowledge about complex futures, and this points towards opening up for more collaborative forms of planning and decision-making in the face of complex societal issues, where use of participatory GIS (PGIS) could be one suggestion (Forrester & Cinderby 2005).

Fifthly, through the combination of the four above factors, GIS is viewed as a tool for enhancing *communication*. It is vital to be able to satisfactorily communicate information so that people understand and can use that understanding to guide action. What is needed is not more accurate or larger quantums of information, but *better* information that addresses the misconceptions in people’s mental models in order to encourage sounder, more proactive decisions on all societal levels (Marx et al. 2007). This entails also including aspects beyond the statistical since “neglecting the emotional reception of climate-related news makes communication and outreach efforts more likely to fail” (Moser 2007: 65). This speaks to both using GIS as an

[21] "Web 2.0" refers to a perceived second generation of web development and design, that facilitates communication, secure information sharing, interoperability, and collaboration on the World Wide. http://en.wikipedia.org/wiki/Web_2.0 (viewed 02.07.09).

awareness-raising tool to motivate towards private adaptation measures, and as a tool for decision-making for policy makers – as both public awareness and policy changes lags behind rationales from international scientific circles (Sheppard 2005).

Lastly, the sixth characteristic highlighted here is GIS as a vehicle for achieving *integration*. Goodchild (1995: 34) states that ”part of the attraction of GIS is its ability to surmount the human/physical divide”. This means being able to incorporate elements from both human and physical geography, and is interesting, especially regarding how decision-making may benefit from the inclusion of the two. This is related to all the above, but more specifically framed, climate change adaptation brings together the need to merge climate scenarios with the cognitive understanding of the issue (complexity, uncertainty, role of agency and structural factors) within a local context with the aim of developing a potentially useful GIS. A merging of aspects of both analytical and experiential cognitive frameworks can enable GIS to help make climate change personal and project the rationale for policy change to a wide selection of stakeholders. The cognitive factors are important because the ways that humans act is determined by the way that they think and perceive of issues of risk as shown in Chapter 2, and different worldviews need to be acknowledged and addressed. The local context matters because it is here adaptation will take place, and several issues can act as local barriers.

3.3.2 Preliminary Limitations to Using GIS in Climate Change Adaptation

There are certain limitations to using GIS to further climate change adaptation. The section on critical GIS (3.2) has outlined the most important general drawbacks of using GIS, and these issues also pertain to use as a climate change adaptation tool. Other more structural and contextual limitations will be discussed in Chapter 7, but two supplemental issues will be addressed here as well.

When talking more specifically in relation to climate change adaptation, it should be acknowledged that environmental information and awareness can only account for a small fraction of pro-environmental behaviour and adaptation measures (Kollmuss & Agyeman 2002), so there has to be additional action-inducing factors present, such as restrictions or incentives related to environmental behaviour. GIS as a primary awareness-raising tool relies on the power of environmental information, and its use could thus be limited. However, as a decision support tool it might be of wider use to substantiate the choice of policy instruments based geographically.

Using GIS also adds additional uncertainty into decision-making. Due to the fact that all representations of the world are necessarily incomplete compared to reality, data in GIS can be subject to measurement error, outdatedness, excessive generalization or just plain blunders. For instance, apparent spatial patterning in mapped data may be oversimplified, crude or illusory, because of an inappropriate conception of geographical scale (Longley et al. 2005). Climate change adaptation is in itself influenced by many types of uncertainty, so adding the GIS type uncertainty on top may exaggerate the issue and hinder the development of successful adaptive measures. As with uncertainty in climate modelling and adaptation implementation, there are nevertheless ways to cope with uncertainty in GIS. The key point is to identify how much uncertainty can be tolerated for a specific application, and try to at least partially eliminate or ameliorate consequences above this level.

4. Methodology: The Qualitative Approach

Research is not a linear exercise; all stages overlap and mutually influence each other (Thagaard 2003). This means that a flexible and open research approach that allows for changes as one goes along is key. Even so, there are certain choices that have to be made prior to, during and after research. This thus constitutes the organizing principle for this section on the methodological choices that have been made during this thesis project. *Before research* includes reflections on the nature of qualitative research, the case study approach and particulars of the chosen Fredrikstad case. *During research* outlines the selection of informants, considerations in carrying out interviews and implications of using maps and GIS in the interview situation. Lastly, *after research* includes contemplations on and illustrations of how analysis has been done, what ethical issues exist and how the quality of data has been maintained.

4.1 Before Research: Defining the Qualitative Case Study

> "Good social science is problem-driven and not methodology-driven, in the sense that it employs those methods that for a given problematic best help answer the research questions at hand" (Flyvbjerg 2004: 432).

4.1.1 The Qualitative Research Methodology

Quantitative and qualitative studies have a lot in common - a desire to see how society works, describe social reality, and answer specific questions about specific instances of social reality. Where they differ is in how they approach these questions and the shape of the resulting product as they are based on different logics of research (Becker 1996). Research should not be driven by methodology though, but by the problems that one wants to investigate. Qualitative methods can be particularly suitable if personal issues are to be researched, if the research questions demand a relationship based on trust, if certain groups require close researcher contact, or in the case where little research on the topic has been done prior (Thaagard 2003). The research questions of this project focuses on how people perceive and what they think about climate change and GIS, complex and often contradictory processes that require a close contact with the informants to uncover. Not much research has been carried out on the exact subject of interlinkages between cognitive factors and GIS either, making it an exploratory study and thus difficult to identify quantitative variables.

Further, particularly three aspects with regard to qualitative research are relevant to this thesis; the aim of a *deeper understanding*, *researcher closeness* and *interpretation*.

Studies applying qualitative research methodologies also attempt to achieve a *deeper understanding* of social phenomena based on rich data sets on people and situations as they are seen from the inside. That implies "thick" descriptions of human behaviour, i.e. ones that adds an aspect of meaning, not just states what is observed (Thagaard 2003). To do this qualitative researchers tend to focus on getting a lot of information on few units to emphasize related processes and meaning. This was a main goal in my thesis. Also, doing qualitative research gains wider significance seeing that the GIS system has by definition been categorized as a quantitative framework, and working with the subject in such a way can be a test to see if there is place for the qualitative in GIS.

Another unique characteristic of qualitative methods is that it bases itself on *closeness* between researcher and informant because the researcher in reality becomes the instrument of research through his/her interpretations. This naturally implies that the personal qualities and theoretical points of departure of the researcher have the potential of influencing the resulting research. The former will be addressed in relation to interviews below. Regarding the last aspect, this thesis is inspired by the critical theoretical approach, where knowledge is not regarded as something that is naturally given or objective, but instead is socially constructed, i.e. formed by people's interactions and perceptions of reality.

Qualitative research can also be seen as having an *interpretative* character. It attempts to answer the questions of *why* and *how*, as opposed to quantitative research that focuses on what, where, and when. For this thesis, the questions of *how* climate change and GIS is perceived are investigated, and the underlying factors explaining *why* are explored through work on cognitive challenges in individual psychology and its impacts on decision-making processes.

4.1.2 The Case Study Approach

Choosing the case study approach is not a methodological choice per se, but a choice of *what* to study according to Stake (2005). It is however a method characterized by an aim to gather a lot of information about few empirically bounded unit or cases in their usual context. It does not have to be qualitative, but often is. Stake (2005)

outlines three types of case study: Intrinsic, instrumental and multiple case studies. The first is studied for the interest in the case itself, for its particularity and ordinariness. The instrumental case study is examined mainly to provide insights into an issue or to redraw a generalization, and here the case itself plays a supportive role to facilitate understanding of something else. The multiple case study is an instrumental case study extended to several cases in the aim of investigation of a phenomenon, population or general condition. The case in this thesis can be characterized as an instrumental case study, in that the study of Fredrikstad municipality aims to shed light on the general topic of climate change and GIS cognition. This happens while not forgetting the intrinsic qualities of the local context, in a zone of combined purpose between the instrumental and intrinsic case study.

4.1.3 Approaching the Qualitative Case: Fredrikstad Municipality

As previously mentioned, what made Fredrikstad suitable as a case to illuminate the chosen topic was that a) the municipality was at risk of being affected by climate change, particularly through the exposure to flood and landslides, b) there was local interest for climate change adaptation, specifically through the NorAdapt project and finally, c) there was considerable GIS competence in the municipality.

The case was approached through an email sent to one of the GIS contact persons in the municipality, who forwarded the communication to the environmental adviser in the Planning and Environmental Department of the municipality government. After an internal meeting, the municipality agreed to allow me to do my fieldwork in Fredrikstad with their assistance. The environmental adviser has been my contact person ever since, with additional resources in the GIS area provided by the head of the GIS department. The help has mainly consisted of referring me to possible groups or selected private persons for interview inquiries, allowing me to use the town hall meeting room facilities and answering any upcoming questions. The association with the municipality administration gave me authority in approaching potential informants. In some contexts, being associated with an official authority can make informants wary and hold back information because they are afraid it will be used against them and transmitted to the officials. Given the nature of the questions, and the Norwegian context where there is no reason to fear persecution, this did not appear to be an issue in my study.

4.2 During Research: Informants, Interviews and Maps

Methods in qualitative research most commonly consist of interviews, focus groups, observation and document analysis. This thesis was based primarily on qualitative interviews, and there are special considerations to take when carrying out these, described below. The interviews also included the use of maps and GIS, how and why will be explained. Prior to carrying out this practical part of research, the informants were selected by applying a range of principles that will be related.

4.2.1 Selecting Informants

As a practical starting point after deciding on a case, I had to decide *whom* I wanted to interview for my project. Informants can be selected using a variety of strategies, among them choice based on strategy and convenience. Sampling within the qualitative methods is however not done to achieve representability, as in the more statistically based quantitative approaches. The goal is instead to achieve a *saturation of meaning*. A *strategic sample* means that the informants are chosen based on attributes or qualifications that are strategic with regard to the research questions, while the term *convenience sample* implies that the participants are chosen due to their availability for the researcher (Thagaard 2003).

These procedures for sampling are not problem free and mean that the researcher has to be aware of particular issues that can occur. The convenience method suggests that one often can get a sample that consists mostly of people who are already well-acquainted with research and do not mind being studied because they are resourceful, and thus other sections of society and their knowledge might go unnoticed (Thagaard 2003). As for my project, a certain portion of potential and contacted informants could possibly shy away from participating because they had no experience with climate change or lacked technical skills with regard to GIS, and thus felt like they had nothing to say. However, by stating directly that no prior knowledge of either was needed in the information letter sent out to prospective informants (see appendix 1), this problem was thought to be minimized in Fredrikstad. The inclusion of people of less resources could perhaps have been better covered, but there were practical concerns about how to get in touch with this group.

Climate change is a phenomenon that affects all groups in society on some level, and there are a wide variety of stakeholders. A driving force for the project was

an interest in seeing how different groups of stakeholders were influenced by and looked at the issue to determine differential needs for a GIS tool for adaptation. I thus decided that for my research project I wanted to interview three different groups to investigate the drivers and differences on the topic of climate change adaptation and GIS. To represent contrasting interests, the chosen groups were households (the general public), businesses (the commercial base) and municipality administrators (decision/policy makers). These were thought to cover a large part of operating society.

The businesses were contacted through the leader of the local business development association called Fredrikstad Utvikling[22], who referred me to the contact information for their member businesses on their website and gave some tips over the phone about which businesses could be relevant with regard to my chosen topic. The targeted businesses were all either perceived to be exposed physically to climate change impacts (such as location in a flood prone area) or dealt with a line of work that could be affected by such changes (for instance building houses). I did all the communication and selections myself. The municipality interviewees were recruited through municipal recommendations and are thought to represent a broad range of relevant departments that deal with the consequences of climate change.

The household group was initially selected by contacting the leaders in the 23 local community groups that Fredrikstad is organized in[23]. They were taken to represent private individuals/households throughout the municipality, and their large geographical spread as well as assumed local overview of the situation in Fredrikstad was a desired quality. Their contact information was given to me by my connection in Fredrikstad municipality, and I corresponded with them over e-mail. I got seven positive replies using this method, and set up interviews to take place in September/October with the intension of sending out reminders to recruit more household informants for later interviews to complete the household sample.

However, the decision of using local community group leaders as household representatives turned out to create a too homogeneous selection, as discovered during this first interview period. Although this does not necessarily pose a problem when using a qualitative methodology, as one is not looking for a representative

[22] http://www.fredrikstad2015.com/ (viewed 19.11.08).
[23] http://www.lokalsamfunn.net/ (viewed 08.02.09).

sample, an alternative approach was chosen for recruiting the second half of the household group to widen the views represented in the study. During the interview period, I found that three out of seven informants turned out to be so-called "climate sceptics", a by much higher rate than I had suspected. My interview guide (see Appendix 2) had not taken this possibility into proper account and was thus made partly redundant. The reason for such a high rate of sceptics is thought to be based on the characteristics of the household sample, which consisted mainly of men in their 50-60s with chiefly technical educations and conservative outlooks that are usually more prone to sceptisism. The positions as local community leaders are presumably thought to fall to such people, due to their often extensive experience and knowledge of the area, and probable willingness to take on the capacity ascribed to the associated status. Nonetheless, the inputs from the sceptics proved to be highly valuable, as they shed light on important cognitive challenges in the perception of climate change as a threat. Still, at the research moment it felt like something had to be done to broaden the household base. Thus, the second household recruitment process was approached somewhat differently, through direct person recommendation from my municipality contact. This also gave me my only female informant in the household group and a greater diversity of opinion.

My household informants were spread out over a 36-year span in age, with the youngest being 35 and the oldest 71 years old. There was only one female in my selection, although more were attempted to be recruited. Most of them were born in Fredrikstad, and had lived here for their entire lives, except for a few who moved here in the time span of 1979-1990. All informants owned their own residences; most had one-family houses, and three had apartments. Regarding occupation, there was a large spread, but it included several with a technical/engineering background. Table 3 is a list of all interviewed informants by group and profession.

Table 3. Informants by occupation.

Households (A)	Businesses (B)	Municipality (C)
A1: Technician	B1: Housing association leader	C1: City planner
A2: Engineer	B2: Port authority manager	C2: GIS analyst
A3: Public sector leader	B3: Architect	C3: Environmental health officer
A4: Engineer	B4: City developer	C4: Public relations manager
A5: Public sector leader	B5: Bank manager	
A6: Engineer		
A7: Transport organizer		
A8: Journalist		
A9: Lawyer		
A10: Environmental certifier		
A11: Police officer		

4.2.2 Carrying Out Qualitative Interviews

Next, one has to decide *how* to get information from the informants. I chose using semi-structured qualitative interviews.

Open-ended and semi-structured interviews have been identified as suitable for eliciting mental models because they allow for a more reactive interview process where the respondent is not to the same degree restricted and influenced by potential answer categories but can develop a fuller picture of complex beliefs (Morgan et al. 2002). Semi-structured interviews involve having an interview guide and plan for questions to ask or themes to discuss, but letting the order come naturally and allow for follow-up questions as is suitable. It is a very flexible research method, which enables a dynamic interview process. I had three specified but very similar interview guides, tailored to each group's needs and focus (for an example see Appendix 2). The guide had three thematic bulks of questions after the initial establishing questions: Questions on climate change, information in general and lastly GIS. These were more or less followed in the prearranged order, but allowing for flexibility and follow up.

Altogether, I interviewed 11 household informants, five businesses and four municipality administrators coming up to a total of 20 informants. Using open-ended interviews and a qualitative research methodology this sample should be a large enough sample to reveal most of the beliefs held according to Morgan et al. (2002). The interviews were conducted in a variety of locations as I gave the informants the choice of site themselves. All business and municipality employee interviews took place in the offices of the informants, within working hours. Locations for the household interviews were private homes, a meeting room at the town hall, my hotel and the working places of the informants. The choice of venue can have implications for how the safe the informant felt, and consequently, what sort of information was given. However, the topic at hand is not initially very sensitive, so the difference may not have been great.

The interviews were conducted in Fredrikstad in two main stints during autumn 2008; one in September/October (29/9-02/10) and one in November (9/11-14/11). During both periods I stayed at a hostel in town, to also be able to explore the city in between interviews. All interviews were recorded with prior consent from the informants. This can sometimes inhibit informants or they can become uncomfortable, but this did not seem to happen in my case. After a few minutes they seemed unaware it was there at all. No additional notes were taken by hand as I wanted to give the informants full attention to follow up and seem interested in what they had to say.

Using interviews as a research strategy necessitates close contact between researcher and informant, and it is therefore important to be aware of factors that could influence the interview situation and affect the way the informant answers the questions posed. Key factors are related to *power, positionality* and *interview dynamics*. Rubin & Rubin (2005) call the relationship between researcher and interviewee a *conversational partnership*. The outcome and form of the interactions can depend upon the researcher's personality, emotions, gender, ethnicity, social class, professional position and interviewing skills. It is every researcher's responsibility to behave in a courteous and ethical way, and to respect the informants.

In terms of emotions and interviewing skills, the interviews in Fredrikstad were the first interviews I had ever done, so I was feeling a bit nervous before heading into the field. This sometimes led to me having occasional outbursts of laughter,

which could potentially have made the informants feel uncomfortable and believe that I did not take them seriously. This was not my impression however, as the tone of the interviews were often casual and light, and several informants answered in a joking tone and laughed themselves. Some informants were a bit nervous because they did not believe they had anything interesting to say about the topic, and in these interviews the answers I got were more scant at first, but nonetheless interesting, and more copious as the informants warmed up. Moreover, personality can influence the interviewing style, and it is necessary to balance ones personality with the interviewing situation. I felt this was well accomplished, being as calm and emphatic as possible, and following up questions in a non-confrontational style.

Being a female, Caucasian student carries with it certain associations that might change the interview situation in certain settings in terms of *positioning*. It is important to assign a role for yourself in order to make interviewing as easy as possible. However, in a developed country context, such as Norway, issues of race, gender, education and social class are not as grave. This is because of the general homogeneity of society, for instance equal gender rights in Norway are quite advanced and hence I did not perceive being a female led to me being treated like an inferior by the informants in any way. What could affect the interview situation the most was probably the role of student or researcher, which can be seen as negative if the informants are sceptical of academics or experts. Nonetheless, it can also act as an opener as you could be seen as someone who needs to be taught what is already known locally. You must show willingness to learn and accept the local culture (Rubin & Rubin 2005). I did this through asking the informants how long they had lived in Fredrikstad and stating that I myself come from a completely different part of the country and did not know too much about the municipality. On the other hand, I did not take the role of ignorant novice, as I had to show enough knowledge to be able to pose meaningful questions.

Climate change is an issue characterized by divided opinions because of its complexity and related uncertainty, and a lot of the information is technical or scientific. This requires extra caution in terms of limiting the expression of own point of view through an understanding of own biases. I refrained to give my own opinions in most cases except when directly asked, and then I gave a brief, non-judgemental answer. It was sometimes difficult to restrain reactions when the informants stated

something I knew to be untrue or inaccurate, or be able to assess and follow up statements I did not know the elements of truth of. In these cases information might have been lost, but it was not a big issue so the quality of data is perceived to be undamaged. One issue that came up however, was how to deal with the mentioned climate sceptics, people who do not believe that climate change is happening. My interview guide was not designed very well to handle this, and twisting the questions into a hypothetical form might have been unfair and disrespectful towards the informants.

Moreover, the issue arises about whether it is fair to ask people what they associate with such a technical term like "climate change adaptation". Some researchers do not use the exact word, but phrase it differently so that it is intuitively more accessible. I was however interested in how the word was perceived among the public and practitioners, and used this more technical jargon as an opener into those perceptions. What could have influenced the way the informants saw the term though, is the way the word itself is regarded in Norwegian. "Klimatilpasning" has more passive and generic associations than the English equivalent "climate change adaptation", and suggesting that it is a process that will happen regardless of own effort, as an external process. Also, the wording of a question was seen as having the possibility to influence the informants in a certain direction by using the word 'worry' instead of the more neutral 'importance', so this was changed from the first to the second round of interviews.

Summed up, doing qualitative interviews brings a lot of responsibility in terms of consciousness around own presentation, position and ultimately influence on the informants in the research situation. What makes this a key issue is that the results of a qualitative study will be seen through the researcher's eyes and interpretations. Overall, the Fredrikstad interviews were carried out in the most neutral stance possible, and were characterized by a light and open tone.

4.2.3 Using Maps and GIS

In addition to the regular questions in the interview process, a laptop with GIS maps of Fredrikstad was used to initiate discussion and create familiarity with GIS in the latter part of the interview. It was also used as a way to test the informant's ability to navigate on a map as I assisted them as they pointed out interesting matters.

The base map was created with downloaded data from Norge Digitalt, the centralized Norwegian geodatabase, where University of Oslo has an account. Also, I received flood maps and landslide risk zones as shape files[24] from the GIS department in Fredrikstad, and these were assembled to create an overview map of Fredrikstad municipality, see Figure 10. The informants were interacting directly with the GIS program (ArcGIS 9.2) on the computer, not just with an overview map. Because of the lack of widely available climate scenarios in GIS format at this stage, I utilized screen shots from senorge.no, a website with snow, weather, water and climate maps for Norway, created by the Norwegian Water Resource and Energy Directorate [25], met.no and the Norwegian Mapping Authority[26]. An example is shown in Figure 11.

During the interviews I inquired about the informants' knowledge of GIS and if they did not appear to have any, I gave them a quick description. I then asked them to plot their residence or the position of their office buildings (except for the municipality administrators who were all in city hall). Next I asked them to point out the areas of Fredrikstad which were of highest importance to them or that they used. After this we looked at the flooding and landslide maps together and discussed them. Lastly, the climate scenarios in screenshot form on a number of variables, amongst them precipitation, snow cover, and seasonal evaporation were brought up. All of it was done with openness on my side, and acknowledgment that they did not need to know anything about GIS or climate change beforehand, as I was interested in their thoughts regardless of this. All in all, this proved to be a valuable exercise as it gave more of a face to GIS, and the informants were able to discuss things based on their experiences of the map that I could not have uncovered with just my questions.

[24] GIS-compatible file format.
[25] Norges Vassdrags – og Energidirektorat, NVE.
[26] Statens Kartverk.

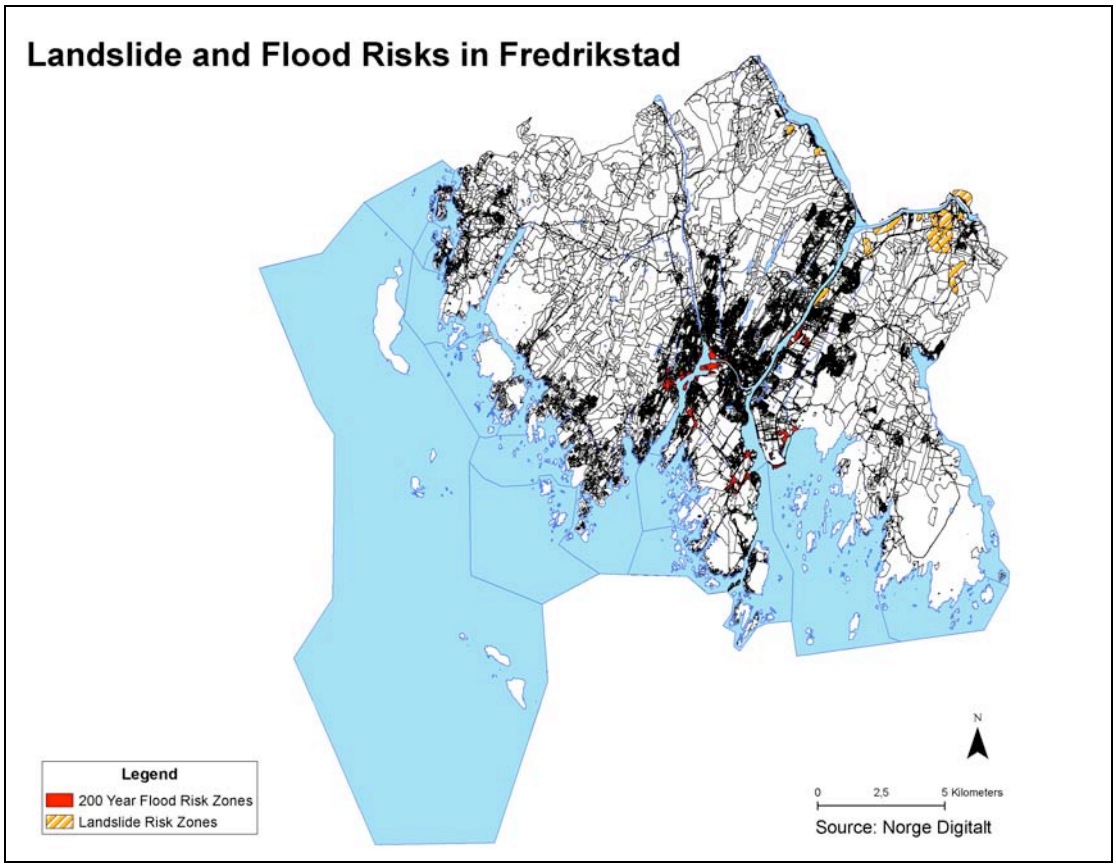


Figure 10. Key map of Fredrikstad used in interviews.

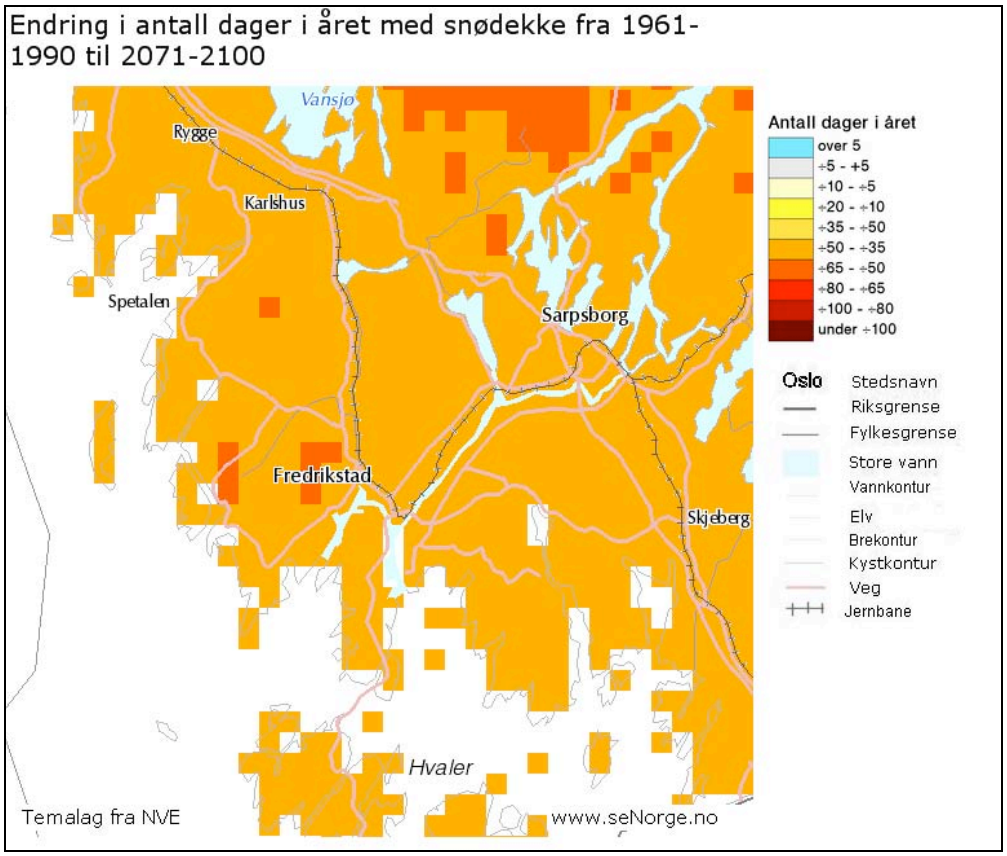


Figure 11. Example screenshot from senorge.no, change in number of snow days a year.

4.3 After Research: Analysis, Ethics and Quality of Research

4.3.1 Data Analysis and Presentation

Analysis does not only begin after the interviews are finished, it occurs throughout the research process, from beginning to the very end. The ongoing analysis leads to modifications of main questions and sharpening of follow up. Most qualitative studies rely on abduction which constitutes an alternation between induction, theory developed from data, and deduction, data compared to theory, in interpreting the findings of a study. This means that the researcher oscillates between inspection of data and development of ideas from higher-level theoretical perspectives (Thagaard 2003).

The analytical approach I have chosen has been called *issue-focused analysis* by Weiss (1994 in Thagaard 2003) meaning that the researcher studies and compares information from all the informants according to a number of defined issues or themes. To do such an analysis, one has to divide the text into categories according to relevant themes one wishes to explore. Examples of such issues in this thesis were the question of what climate adaptation is, or what the informants knew about GIS. It is important to choose the appropriate number of categories to avoid both the analysis getting too complex due to too many categories and the possibility that information is lost due to too few categories (Thagaard 2003). My analysis had three main issues, with a number of sub-issues attached to them. These were: Perceptions of climate change and adaptation, information sources and needs and lastly, views on GIS. For the purpose of analysis, a wider sub-set of issues was defined and constantly updated throughout the process.

After all 20 interviews were conducted, the tapes were transcribed producing 83 single spaced A4 pages of text. The interview pages were then read through and relevant quotes on a number of issues were selected and put into a separate document, one for each group, while at the same time highlighting them in different colours in the original context. This produced a coding of relevant statements by issues related to the interview questions. I then searched for patterns, similarities and dissimilarities, and compared the findings between the three groups. This formed the basis for my analytical process, as I then attempted to connect the statements to the theory found in Chapter 2 and 3 in order to answer my research questions and draw broader theoretical conclusions.

Regarding the presentation of the findings there is particularly one aspect that requires discussion because it might not seem like an obvious choice. The case study chosen for this thesis was a Norwegian one. Yet writing this thesis in English was a conscious decision made at the start of the research process, to enable usage of an accurate conceptual vocabulary and to expand the reach of findings outside of Norway. There has been little research on GIS in Norway, especially in combination with climate change, so to reach a wider audience English was chosen. While this was an early choice, there have been doubts all the way through writing the text, as it handles the Norwegian context and my own native language is Norwegian. It also decreased accessibility somewhat for the local informants and my contact persons in Fredrikstad municipality, although most informants do know English and can in theory read the thesis regardless. On another note, the statements of informants may have been distorted as they have been translated into English. However, this has also given me a greater creative freedom in shaping the language in a way that conveys the meaning best, without moving too far away from the original phrases. On the whole, the choice of English as a writing language feels justified and without too large consequences on the quality of the findings, as it has enabled a more precise language to be used.

4.3.2 Ethics in Social Research

No one doing social science research can avoid being confronted with ethical dilemmas in all phases of a research project. Ethics in qualitative research can basically be seen as a confrontation with yourself, because the research instrument is the individual; both you as the researcher and the informants themselves (Soobrayan 2003). Ethical dilemmas in research are related to the researcher's behaviour towards the informants and the way that the findings are presented. Protecting the informant's identity through *confidentiality*, and ensuring that the informant is aware of what he or she is participating in by making sure you have *informed consent* is central. One should also consider what *consequences of participation* there could be for the informant, good or bad. In principle, those who participate in research should not be exposed to risk by participation and the relationship between researcher and informant should be marked by mutual trust (Thagaard 2003).

My research topic and consequent interview guide handled issues that are considered relatively unproblematic material as no direct personal revelations were

required or asked for. An application for approval was sent to Norwegian Social Science Data Services (NSD) however, and the project was given an obligation to report, possibly because there was a question regarding the exact location/address of some of the informants, such that they could potentially be identified in the community. To avoid this from happening, the informants maps presented later are smaller scale maps, i.e. ones that show a larger stretch of land but with less detail. The placements of the informant markers are also approximate, and not tied to informant code names.

After the initial email and acceptance of interviewing, additional information on the purpose and topic of the research were distributed to all informants (see Appendix 1) prior to interviews taking place. Attached was also a consent form, and the informant was encouraged to read, sign and bring it to the interview if they agreed to participate. I also brought copies of this form to the interviews for the informants to sign if they had not had the chance to do so, and asked if they had any questions. None did, and they all signed the informed consent form. I gave them verbal information that they nonetheless could withdraw their participation in the project at any time, both during and after the interview, and refuse to answer any question. No informants used this opportunity, and all questions were answered.

All informants were anonymized after the interviews were over, using numeric codes in the format of "informant A1", "informant B1", informant C1" etc, each related to its informant group. This was stated beforehand, and a few informants brought up this point, and I reassured them that they would not be mentioned by personal or company name. The degree to which the informants are able to identify themselves in the text is more debatable however, since I have used quite a few direct quotes in the following chapters. The problematic side of the informant recognizing him/herself relies on the fact that the researcher's interpretations of the statements made could lead to the informant being confronted with a perspective of the self which one does not recognize or wish to see (Thagaard 2003). Something that could have obscured this in my research is the translation to English, which may make it harder for the informants to identify themselves. Recognition within the local community could also be problematic, as it is stated that the household informants are recruited mostly from the local community leaders, who are known in the community. The businesses I have talked to are also relatively unique in their position, and as for

the municipal employees, the departments are not that big so they could relatively easily be identified if one so wished. The issues discussed are, again, not that compromising though, and are presented in a way which to a large degree tries to emphasize general perspectives.

The consequences for the informants are not thought to be greatly negative, although it is hard to foresee individual reactions. I have done my best to do the informants justice in the text, but realize that by adding my interpretations I might have distorted their views. The interview experience itself seemed positive for the informants, and in fact, a lot of them expressed that it had been an engaging experience and were interested in my work.

4.3.3 Credibility, Conformability, and Transferability

Thagaard (2003) uses the three terms *credibility, conformability* and *transferability*[27] as markers to assess the quality of qualitative research as a substitution for the quantitative terms reliability, validity and generalization. These speak to the transparency of the whole research process, and validation of findings and results through a review of the methods used and processes of data interpretation (Seale et al. 2004). Assuring credibility means explaining how data has been developed, and distinguishing between data found during fieldwork and own interpretations. Conformability relates to interpretation of results and findings, as well as an examination of the researcher's basis for these, in addition to comparison with other studies or resonance with readers. Transferability substitutes for generalization, and is tied to assessing whether the understanding that is found during the project, also could have relevance in other settings (Thagaard 2003).

By explaining the approach I have taken and the reflections and considerations I have made during the research process, the credibility of the research data has been increased. Also, by confirming and explaining how analysis has taken place, and what my understandings and starting points have been, the conformability has been emphasized. This should make it possible to replicate my research process, and though not achieve the exact same results, at least something close to it. Transferability is as mentioned the qualitative substitute for generalization, as the nature of qualitative research makes statistical generalization impossible, and in most

[27] *Troverdighet, bekreftbarhet* and *overførbarhet* in Norwegian.

cases undesirable, as the purpose is to capture the density of meaning, not generate general laws. Other forms of generalization, such as analytical generalization, could be possible though, and the 'force of example' is also important:

> "One can often generalize on the basis of a single case, and the case study may be central to scientific development via generalization as supplement or alternative to other methods. But formal generalization is overvalued as a source of scientific development, whereas 'the force of example' is underestimated" (Flyvbjerg 2004: 425).

The role of cognitive challenges related to climate change adaptation and opinions of GIS have wider applicability outside Fredrikstad, at least within the developed context. Many communities are exposed to similar climate risks, and given that the psychological factors described in relation to Fredrikstad are common to a wide range of humans, it provides a starting point for other further investigations. GIS use is also increasing in connection to climate change and adaptation, and the dynamics of these processes are thought to be transferable to other contexts.

5. Empirical Analysis I: Views of Climate Change Adaptation

This first empirical data chapter deals with the perceptions and actions of climate change and adaptation, to enable an evaluation of the dynamics between risk and adaptation appraisal from the MPPACC framework presented in Chapter 2. Section 5.2 thus focuses on how climate change risks and adaptation are judged with special attention to examining any present cognitive factors. Section 5.3 then looks at adaptation appraisal and the objective and perceived action scopes of the Fredrikstad informants. The three informant groups will be dealt with together and compared within the thematic sections, although particular attention will be given to climate sceptics in section 5.1.

5.1 The Existence and Influence of Climate Sceptics

> "The consistency of observed significant changes in physical and biological systems and observed significant warming across the globe *very likely cannot be explained entirely by natural variability* or other confounding non-climate factors" (Rosenzweig et al. 2007: 81, my emphasis).

There is now a large consensus among scientists that anthropogenic climate change is happening, in line with the above quote. However, not everybody agrees with this position and such scepticism has trickled down into the Fredrikstad household group. The term often used for these lay people and scientists is *climate sceptics*, *climate change contrarians* or *climate realists,* and they challenge what they perceive of as a false "mainstream" consensus of anthropogenic climate change. Such opinions are almost a compulsory presence in the comments section of online articles about climate change in Norwegian newspapers. Climate sceptics can "pose a significant barrier to substantive communication among the scientific community, policy-makers, and the general public" (McCright 2007: 201) by distorting and confusing communication efforts in an already difficult and complex situation. Despite the efforts of the majority of the scientific community, only a minimal amount of confusion may be necessary to reinforce factors that inhibit open communication, resulting in social inertia. The confusion that arises may additionally facilitate political inaction and policy gridlock (McCright 2007).

Leiserowitz (2006) cites five reasons why the climate sceptics in his study were sceptical: 1) Global warming was viewed as natural, 2) hype, 3) doubt of the science, 4) denial and 5) conspiracy theories. In the Fredrikstad case, three climate sceptics were identified: Informant A1, A6 and A7. They showed a combination of the above reasons for being sceptical, except for 5) (conspiracies), although not without ambivalence and confusion.

Firstly, the *natural cyclic qualities* of climate are posted as an explanatory factor for climate change. Informant A1 started out by saying that he believed climate change to be the result of a mix of impacts from natural cycles and anthropogenic influence, but eventually came down to saying that he did not believe anything extraordinary to be going on presently. He had the main belief that it was part of natural cycles, and found it hard to separate out the normal climate variations. Informant A7 also viewed climate change to be a result of several factors, but ultimately he did not believe the anthropogenic factors to be of much relevance. He mentioned cosmic radiation, and how in earlier times in Norway there was rainforest on the Hardanger mountain plateau in western Norway. There certainly was forest there during the Stone Age but this was due to the gradient of the Earth's axis and its orbital position, not climate change or global warming. In fact, most of the effects were very regional[28]. This also points to a confusion of time scales, in equating events that happened over thousands of years versus decades.

Secondly, *hype* was brought up as a key point by these informants. Informant A6 stated that he saw some climate related things happening but that "there is more focus on it, more in the media, more media sources available, and then it might just feel like there is more happening than before". He further depicted the media craze as "hysteria". Informant A1 followed this up by describing climate change as portrayed in the media as "scare propaganda". He pointed to researchers with alternative views, and thought that these voices had not been heard as much as they should have been due to skewed media coverage and partialities in the research funding system. The point about alternative voices in the debate was not exclusive to the climate sceptic group however.

Thirdly, evidence of *doubt of the science* was apparent in informant A1's statement that: "My theory has been proven, that it has been like that. There is

[28] CICERO: http://www.cicero.uio.no/webnews/index.aspx?id=10961 (viewed 05.07.09).

historical evidence, what happens in the future is just prophecy". Additionally, another informant was worried that conclusions were drawn too hastily. "I am just afraid that hasty conclusions are drawn from a very short time perspective of about 5 years" (informant A7).

Lastly, traces of *denial* could be seen in the group. Informant A6 stated that: "I am not sure whether they [climate sceptics] are right, and I am not sure that anybody else is right either. Of course, if it should turn out to be correct, I would be worried". This could be a case of denial, but also points towards serious bewilderment whom to trust and doubt of science. Informant A1 said that he ignored the information about climate change impacts that was presented on the television, which could be the result of both denial and/or emotional numbing.

Nonetheless, the inputs from the climate sceptics are valid and important statements about the nature of doubting the science, dealing with risk and opinions of GIS, and are thus included in the analysis together with the information from the other informants. With regard to cognitive challenges in this group, two views are possible: That they have no cognitive challenges because they do not perceive risk, i.e. low risk appraisal, or that they have the most severe challenges because they are not able to understand the issue.

On the whole, it can perhaps be argued that the acceptance of the issue has become more widespread and communication generally better in the most recent years with the latest IPCC report (2007), which has even shifted policy in the previously headstrong USA. The recent administrative change in the United States has of course influenced this as well. Yet, there is always the presence of doubt in a percentage of the population, partly because of climate sceptics but also due to inherent properties of the way humans relate to risks as mentioned previously. Understandingly so, as climate change may be the most complex scientific problem faced by modern society (McCright 2007).

5.2 Risk Perception and the Images of Climate Change

5.2.1 The Importance of Affective Images: Ice Melting, Weather and CO_2

To tease out the informants' initial affective images of climate change the question of "what do you associate with the term 'climate change'?" was asked. The results will be compared partly to Leiserowitz' (2006) study of general public American images and values in relation to global warming.

The climate sceptics all possessed images connected to climate change, formed for the most part by TV exposure, but they were sceptical with regard to the severity and causes. In fact, informant A6 associated the term 'climate change' with "news on TV", and followed up by mentioning examples like "flooding, earthquakes, hurricanes, whatever". These images were not affective, i.e. not leading to an emotional response or related personal associations. None of them mentioned CO_2, but they talked in rather generic terms of changes in weather and "the temperature in the air", and displaying symptoms of the conflation of weather and climate that can lead to a feeling of lack of self-efficacy in accordance with Bostrom & Lashof (2007) as described in Chapter 2. Further evidence of conflation of weather and climate change was found in the remainder of the household group. This was not too surprising, as the average person usually thinks a lot about weather, but is generally less concerned about climate. Climate information is a subject that is more often thought to be used for planning and decision making (Swim et al. 2009).

Within the household group, the associations that people mentioned first were related to the *impacts* of climate change, especially global warming (e.g. "rising temperatures"), melting of ice, change in weather conditions, extreme weather, sea level rise, drought and flooding. In the Leiserowitz (2006) study the largest category of responses were related to melting glaciers and polar ice, making this the most salient images among the American public. This was an important image for the Fredrikstad informants as well, particularly concerning the decreasing winter season. Many related climate change to their own experiences and recent occurrences in the community, in line with using the availability and recency heuristic in experiential processing. Common references included an extreme weather event in August 2008, the large 1995 flood and previous snow conditions. Regarding time perspective, most informants tied the impacts to consequences for their grandchildren and future generations. This is connected to the fact that the informants are aged 35-71, with the majority over 50 years of age. Exclusively within the household group, several informants mentioned CO_2 as the first thing they thought of, thus pointing first to the *cause* of climate change, not its direct impacts. The details of these insights are included in the next section.

Understandably, the motivations for action in businesses differed from those of private households. The strongest motivation was, as might be expected, the need

or want of profit, and consequently adjustments to customer demand. In this situation the affective images of the business leaders had substantially less say in determining the manoeuvres of the company. The business group actually showed a partial lack of affective images or a rather specialized definition for the selected industry, perhaps due to a taken-for-grantedness of the issue.

The leader of the housing association (informant B1) connected the term "climate change" to global warming and extreme weather, and believed that direct consequences for Fredrikstad were probable. Similarly, informant B2 (the port authority manager) associated it with a warming of the Earth in what he called "the widest respect", while pointing out the long perspective and constant change, particularly with regard to the melting of polar ice. The architect (informant B3) was more sector-oriented, and declared climate change to be a complex issue, before talking in detail about the possibilities for mitigating and adapting to climate change within the building sector. The relevant measures were related to reduction of energy use, particularly of fossil fuels, but also effects on the construction of the building in terms of density, insulation and window placement were referred to. The above-mentioned associations were quite technical and non-affective, and clearly specialized for the industry, often on the local level. This was particularly evident when talking to the bank manager, informant B5, who stated that "I could say a lot about it [climate change]" but then went on to say nothing, but instead talked about the efforts the bank made as an environmentally certified business. However, the last informant (B4), the city development company manager, viewed the term "climate change" through a global perspective, focusing on how developing world countries were mentioned to be more vulnerable than developed countries, and how famine, war, big international conflicts could be the result. Similar associations to global and distant impacts were found in many other informants, pointing to a cognitive challenge in relating consequences to the local level.

Within the municipality group all informants showed varying degrees of concreteness and images. The city planner answered directly when asked what was associated with climate change: "Temperature. Precipitation. More extreme weather" (informant C1). The public relations manager connected it to changes in the atmosphere and on Earth, particularly related to water. Interestingly, the environmental health officer put emphasis on the way the media portrayed climate change: "What comes to mind immediately is the way it is portrayed in the media,

that things are going the wrong way" (informant C3). When prompted the examples of heating and ice melting were presented.

Moreover, what was similar across all groups was that few informants in any of the three groups mentioned impacts on non-human nature, a trait that sets my study apart from Leiserowitz' where this image constituted one of the largest categories. This may have to do with the relative lower presence of this issue in the news presently. Also, generic associations to heat and rising temperatures were highly present in both Leiserowitz' and the Fredrikstad case, although Leiserowitz relates this to his use of the word 'global warming' more directly. The concepts of 'climate change' and 'global warming' have been used interchangeably, particularly in the United States where they are often considered to be the same (Leiserowitz 2003, Whitmarsh 2008). This is, however, inaccurate and to some degree incorrect. Global warming is a much more narrow concept than climate change; whereas the former refers to increasing global temperatures, the latter refers to changing atmospheric and ocean circulation patterns and is defined by a wider number of factors such as for instance humidity, precipitation and air pressure[29]. The same wording effect is not as strong in Norway, although the two terms "klimaendringer" and "global oppvarming" are sometimes used to mean the same thing.

Summed up, there was a clear initial focus on the direct impacts of climate change in all three groups. The affective images included a widespread mention of warming and temperature in addition to melting of ice sheets being a prominent image that turns up in all groups, paralleling results from Leiserowitz (2006) as mentioned. In addition weather and CO_2 was brought up in the household group. The business group was marked by non-affective images that were in most cases industry or sector-specific. The municipal group showed a variety of images and factors present.

5.2.2 The Causes of Climate Change

The causes of climate change were seen as belonging to the following main categories: 1) Media/hype; 2) natural variations; 3) confusion; 4) a mix of anthropogenic and natural causes; and finally 5) mainly anthropogenic causes. The informants' perceptions of the cause(s) of climate change did not necessarily fall just

[29] http://www.grinningplanet.com/2007/01-02/global-warming-vs-climate-change.htm (viewed 03.04.09).

into one category, but could generally be closely tied to one over another. Categories 1, 2 and 3 primarily explained the views of the climate sceptics, as discussed in depth in section 5.1, but were also subjects that other informants reflected upon.

Many informants were confused about the issue, due to its complexity and the many conflicting views present, but overall, the majority of informants in all groups believed that it was at least partially anthropogenic and actually taking place. Within the household group there were as mentioned quite a few informants that had the causes of climate change as their first associations with climate change. Informant A8 stated that: "There will be pretty big changes in the course of this century. It is not happening very fast, but it is accelerating". When prompted for the causes of climate change the response was "emissions of fossil fuels, and oil, gas and coal combustion", in combination with a recognition that it interacted with natural changes. A few informants fell into the last category, of mainly anthropogenic causes. For example, when asked the question "do you view climate change to be a result of natural variations?" informant A2 answered that he saw it as a direct result of our "warming" that created a "lid over the earth". Informant A9 also believed it was predominantly anthropogenic, and related it to increasing CO_2 emissions occurring in the wake of the industrial revolution:

> "I know that there are cycles of warming that have been there since the dawn of times, but I also know that for the first time in history the CO_2 emissions have increased a lot more than the temperature. (...) It has happened in the industrial times, around the 19th and the 20th century up until today. (…) The decisive factor has something to do with the way humans have managed the Earth and their own lives".

Additionally, informant A10 adhered to the same view of anthropogenic causes and pointed to examples such as car travel, production of goods and consumption patterns as causes. All household informants mentioned CO_2 as the primary source of climate related emissions, while two of them pointed out what they believed to be contributing emissions. Informant A11 saw the focus on CO_2 as the "mantra" of today, while other gases such as methane and nitrogen also have an effect of changing the Earth's climate over time. Informant A2 cited the emissions of CFC as an additional factor leading to a changing climate, which is not entirely incorrect as it is a greenhouse gas, but in the interview context it was taken to mean that the informant directly confused climate change with the depletion of the ozone

layer. This confusion has been found in other cases (Kempton et al. 1995, Leiserowitz 2006, Bostrom & Lashof 2007), where people have a tendency to mix together ozone depletion and climate change. Information on global climate change is assimilated into

> "pre-existing mental models of stratospheric ozone depletion and the ozone hole. This has led to important misconceptions and confusions between the two environmental issues. Many people mistakenly believe that stratospheric ozone depletion is a cause of climate change" (Leiserowitz 2006: 47).

The agreement on the Montreal Protocol banned the use of CFC or other ozone-depleting substances (ODS), and issues of ozone are no longer critical, in fact, the ozone layer is expected to begin to recover in the coming decades (IPCC 2005).

In general, discussing the causes of climate change appeared to be a not very prominent topic for the businesses interviewed. The issue of climate change itself was considered relevant, but more in terms of potential impacts and consequences for the selected business than as a matter of principle and discussion. Few statements were made, although informant B2 of the port authorities stated that "I think there has always been climate change" and clearly saw it as a natural cycle, yet believed that humans had contributed to accelerate the development. Also, the city developer (B4) believed adhered to the same view: "I do not think many people currently doubt that CO_2 emissions and other greenhouse gases are contributing causes". He further went on to say it was possible to speculate in the degree of correlation with natural fluctuations, but that the anthropogenic causes were the chief importance.

The municipal informants more or less agreed that it was an anthropogenically induced change resulting from the overuse of energy and excess CO_2 emissions based on human lifestyle choices. The changes in seasonal patterns were seen as anthropogenic, and "it is not natural fluctuations, but at best a combination of that and human activity" (informant C4). The causes were believed to be closely related to human habits, in terms of motoring, industry and other emission related activities. The city planner stated that the energy consumption was too high, that we consumed more than we should.

All in all, there were partially divided opinions, but mainly a belief in a combination of anthropogenic and natural causes. Nuances to the portrayal and uncertainty connected to climate change are addressed in other sections.

5.2.3 The Relative Importance of Climate Change Issues

There are many issues that demand attention in terms of risks and concerns for households, businesses and municipalities. Therefore it is necessary to find out what matters most to an informant. In order to figure out where the climate change issue was placed, the informants were asked how big a concern climate change in relation to other factors was for the informant on a scale from 1-10 (where 10 was the highest priority level).

Even though several informants stated that climate change was an issue they were aware of, it was rated pretty low on most businesses priority list, i.e. fewer than 3 when directly asked (except for the bank): "If you mean directly on the running of the company it has a low impact, also over time" (informant B1). For the architect it depended on the builder or owner of a project. Comparably, the influence of cost and the bidding process in the UK construction industry has been seen to constrain the building of more 'adaptive' homes, i.e. better suited to climate change (Sorrel 2003). Informant B5 (bank) was the only one who rated climate change as a higher priority, at 6-7, and similarly justified this through customer interest.

> "I believe that a few of the businesses located by the river may be more preoccupied with climate than we as a bank are, but because the businesses and we are so closely connected we are very engaged in the climate" (informant B5).

The city development company deemed it not a central issue yet but an important piece in the planning basis for the master plan for development areas, while the housing association and port authority both rated it at a 2-3 priority. The businesses operated within a regulative framework directing the environmental requirements they had to follow and to a large degree determining and guiding their priorities and actions. The general sentiment of the group was that "if it is relevant for the businesses [customers], it is relevant for us" (informant B5).

On the other hand, and in contrast to the businesses, the issue of climate change was rated a pretty high priority within the municipal group, where the values spanned from 7 and upward. The city planner rated it to an 8 on the scale, especially since they were in a process of making a new municipal plan where environmental issues had a central position. Whether it permeated each individual planning and development case was dependent on the particular developer of the project, but it was seen as an overarching municipal priority. Within the environmental health

department it was an issue they worked with continuously, and no priority was stated. The public relations department, as a shared departmental resource, also rated it as a prominent issue at 7-8, as the climate perspective was supposed to be a part of every municipal activity. The informant (C4) stressed that it was not necessarily a new focus, but more likely a change in wording from "environment" to "climate" that happened around the years 2004-2005.

The largest spread was found in the household group, with values from 0, i.e. outside out the scale, all the way to 10. Surprisingly perhaps, the ones who stated no priority at all (0) were *not* any of the climate sceptics. This group showed ambivalence in that they all chose a value in the range from 2-5, most likely because they thought of the environment as a wider concept and expressed concerns about related issues such as pollution. Most of the other informants ended up with a score of 5 and above. The most environmentally conscious of the household informants stated his score as 10, even though he saw the concerns more in relation to future generations, a viewpoint that was voiced by several other household informants. There was also a differentiation between personal and societal importance, informant A11 chose 4-5 for a personal ranking, while the larger societal importance lay at 7-8.

Summed up, climate change as a prioritized subject of concern rated relatively low in the business group, high in the municipal group, and a span of values were found within the more diverse household group.

5.2.4 Climate Change Risk Perception in Fredrikstad

Risk perception and appraisal in relation to climate change consists of perceived probability and perceived severity of a risk, referring back to Figure 1 on page 21 describing the MPPACC model (Grothmann & Patt 2005). *Perceived probability* is asking the question of "what is the likelihood that I and the things I value are at risk?", while *perceived severity* means asking "if so, how harmful would this threat be to myself and the things I value?".

Regarding *perceived probability*, the Fredrikstad informants had in most cases seen some impacts locally that could at least partially be connected to climate change, such as more frequent extreme weather events and reduction in snow days. They still felt quite safe personally however. "I feel quite safe. I live up high, so if the water rises I will not get my cellar full of water" (informant A4). The relative priority of the issue as discussed above, gave indications as to how the three groups

viewed the risks. The household group showed very widespread results, from very high to very low. Many household informants stated that they were located too far away from flood and landslide zones to feel threatened by increased flooding or landslide frequency, and identified few other impact factors related to for instance higher temperatures or precipitation rates. As for the business group, the low risk priority meant that even those who were exposed to flooding did not see it as a high risk that could not be managed. The municipal group considered it to be a high priority.

As for *perceived severity*, investigating whether the informants saw climate change as an one-sidedly negative phenomenon could begin to reveal how dangerous or powerful risk was viewed in Fredrikstad. In Leiserowitz (2006) the term "global warming" evoked negative connotations for almost all respondents, except for the sceptics who displayed very low negative affect. Presumably, this is because they do not believe anything is going to happen so they have nothing to worry about. Alarmist images of disaster produced the strongest negative affect. These results were similar, but not identical, to what was encountered in Fredrikstad.

Many informants were confused and failed to understand the question of whether climate change was a exclusively negative phenomenon. Informant A6, a sceptic, needed it rephrased several times, and the answer was then resolutely that it was only considered to be negative. Other similar moments of confusion with other informants could be indicative of their unitarily negative connotations with the subject, and perhaps the influence of mainstream media with a slant towards the headline creating disaster scenarios instead of success stories and positive outlooks. However, the picture was nuanced for some informants: "The experience of climate change locally is not exclusively negative. The positive effects are in reality stronger than the negative" (informant A10). Another informant stated that climate change had been framed in an exaggerated negative way and that the benefits could be for example a prolonged growing season for grain. As with most of the other informants, disadvantages were also seen: "On the other hand, there may be more insects and other diseases related to heat. There are both pros and cons" (informant A7). This reflected the general feel of the household informants. They both saw positive and negative sides to it when directly prompted to reflect on the possibility of benefits. The tension between local and global levels was perceived to be critical and was pointed out by many of the informants. "It can have local effects that are not so

serious maybe, it depends very much on where you live. For the Earth as such it is very serious" (informant A8). Informant A4 saw nothing positive about it, and referred to it as scary, out of control and escalating. There were mixed feeling with regard to the possibility that some people may be benefiting from climate change in the household group. The change was portrayed as irreversible but "we have to deal with the fear and danger that is there, and trust that we are right" (informant A11). The informant obviously saw it as a frightful situation. On the other hand, this informant saw climate change as an opportunity to drive forward conscious thoughts on how many humans the Earth can sustain, and thus a force for action.

Within the business group, the port manager was the only one who identified positive effects through warmer winters and the consequently lower snow volumes:

> "It is positive because we used to have relatively large expenses on snow plowing, and ice-breaking for the ships to get in. (…) So you could say we are happy, and it does not really scare me" (informant B2).

The rest of the group mostly indicated negative effects on their sector.

The question of negative vs. positive effects was not posed to all informants, and where it was it caused some confusion, as was the case when the household group was concerned. Overall, there was overwhelmingly negative affect connected with the phenomenon, with some nuances identified when asked to reflect on the topic.

5.3 Adaptive Capacity and Action Scopes in Fredrikstad

> "For most people climate change does not lead to dramatic consequences. That is what makes it a bit difficult to talk about how things are happening at an accelerating pace, but maybe not exactly where you live. Maybe the Greenlandic or Arctic ice sheet melts, but that is pretty far from where you live. It gets a bit difficult for people to see cause and effect" (informant A8).

The quote from informant A8 above sums up important sentiments from the MPPACC model of the dynamics between risk appraisal and adaptation appraisal. To be able to actively assess and implement private adaptation measures through the adaptation appraisal function, there needs to be a certain amount of real personal risk identified. Section 5.2 looked at what level of risk appraisal the informants were on, while this section will attempt to assess the state of *adaptation appraisal*, i.e. action scopes that exist both as a function of *perceived* and *objective action scopes*.

Adaptive capacity, or adaptation appraisal, consist of *perceived adaptation efficacy*, *perceived self-efficacy,* and lastly, *perceived adaptation costs* making up the three questions of: Do you believe adapting will help, are you able to carry out the adaptive measures, and how much will it cost?

5.3.1 What is Climate Change Adaptation?

The views of climate change adaptation were to some degree connected to the belief of underlying causes. Informant A1, one of the sceptics, explained it this way:

> "Humans and nature will adapt to the climate, entirely naturally. One does not need to go many millions of years back in time to when the climate was tropical and oranges grew on Svalbard".

This paralleled the initial meaning of the word 'adaptation' in the biological sense as "development of genetic or behavorial characteristics that enable organisms or systems to cope with environmental changes in order to survive and reproduce" (Smit & Wandel 2006: 283), and constitutes a misunderstanding of climate change mechanisms. There is indeed a long history of human adaptations to changing conditions of life, but the current climate changes are differentiated by their global extent and impacts that cannot be explained by radioactive forcing or cosmic radiation, and the circumstances humans will be adapting to are much more severe. The other two climate sceptics, informant A6 and A7 was either not familiar with the expression (informant A6) or only had a vague, almost literal explanation of it: "It is all in the term, to adapt to the climate. Plants, animals and humans, how much can we adapt when climate change occurs, for instance that it is getting warmer?" (informant A7). It is not surprising that the sceptics had a low level of knowledge of the term, as they perceive no need to adapt because no risks are perceived by them, as any climate impacts that occur are viewed as natural.

At the same time, most of the other household informants were also a bit unsure what the term meant, and mostly guessed through some variation of a rearrangement of the concept and in circular definitions like "climate change adaptation could be that we adapt to the climate". One informant had negative associations with the term, because he saw it as a direct substitute for climate change mitigation, meaning that the efforts to mitigate had been given up, in line with the mentioned view of adaptation advocates as 'quitters'. Other recurring motifs were references to lifestyle changes, mainly on the individual level but changes on the

municipal and governmental level were also mentioned. Many focused on transportation policies, and there seemed to be a general confusion with the climate change mitigation term. This may however not be so surprising, given that there is a considerable overlap between the concepts and that up until now the media has mostly presented the mitigation side. Defining climate change adaptation widely as this thesis has done includes these measures in the concept. The term in the Norwegian language itself could also be a factor that increased vagueness, as it is a fairly passive concept.

The business informants often avoided defining the term directly, but usually had some sector specific associations. The port authority manager stated that:

> "We adapt when it comes to material benefits, so we adapt to the climate. It is possible to make things, lay stronger foundations for buildings, do things in a different way, and take precautions with regard to climate change" (informant B2).

Paralleling some of the household informants, informant B1 (housing association) defined climate change adaptation more like mitigation. "One emphasizes things that shall matter in terms of lessening the effects [of emissions]". The architect saw climate change adaptation in a very narrow sense, although he acknowledged the wider meaning:

> "When you say *climate change adaptation*, I assume you look at it widely, not only to shield the building entrance from wind and rain. There are many themes. One theme that has been hot for a decade is which [sea level] height to plan for" (informant B3).

The rest of the informant's associations with the term climate change adaptation centred around reduction of energy use and the ways to construct a house that ensured the highest energy efficiency, i.e. mostly technical fixes.

In the municipality group, the adaptation term was at least partially familiar. For the city planner it was associated with changes in consumption patterns, in terms of travel and volume of private consumption to try to limit the impacts of climate change. The GIS analyst also connected it to consumption: "Climate change adaptation has got to be to adapt to the climate, that you do not consume more than the climate around you can handle. It is to find a balance with nature" (informant C2). The public relations manager talked of the term in relation to the planning work in the municipality, where the role as a community planner meant that they had to

consider the effects of climate change on areas and topography. New conditions for planning work related to adaptation were felt in the daily work through regulations and laws.

All in all, *climate change adaptation* was not a widespread term; most informants attempted to define it by reusing or interpreting the concrete words (mostly guesswork). This did not mean that they were not aware of the processes that constituted climate change adaptation, it was just an indication that the *term* itself was not deeply established. Many definitions were in reality definitions of climate change mitigation, and business informants defined it more closely related to specific sides of their business operations while municipality informants had knowledge of it through area planning work.

5.3.2 Perceived Action Scopes: Possibilities for Action and Adaptation

Overall, informants A4, A9, A10 and A11 were enthusiastically positive that it was possible to do something to offset or adapt to climate change. Informant A4 for example, said that "I think that we can manage to do something about it", while informant A10 uttered that "I think that we cannot afford to doubt the prognoses. I trust the IPCC". Additional stress was put on the immediacy in the need for adaptation: "We have to start right away" (informant A9) and "I do not think we can allow ourselves to sit on the fence and wait" (informant A11).

Others were more negative. Informant A2 said that he did not think we could stop climate change and also that he did not believe that market economic measures were the right type of response to fight climate change. The climate sceptics obviously saw no need to adapt or change their behaviour as no risk was perceived: Informant A1 said that "of course I am sensitive towards the climate, but no matter what there is nothing I can do about it, not in the long run". Most pronounced was the informant with the most experience in the climate change field, who seemed disillusioned by the lengthy political processes and human nature:

> "I am negative on the behalf of humans, because we are so egotistical and unable to think of the long-term perspective. (…) Humankind will probably survive, but it will be very difficult. There will gradually be less biological diversity and natural conditions will get more meagre" (informant A10).

The informant further proposed, somewhat controversially, to give people lower wages through the yearly wage settlement process so they would have to consume less as the most effective climate measure.

When asked who should be responsible for implementing adaptive measures, a majority of the household informants pointed to a combination of national/local government *and* individual level accountability.

> "I think it is an individual responsibility. For me it feels wrong if one expects that others should do things if you are not willing to act yourself. So it is an individual responsibility, a municipal responsibility, a national responsibility and a global responsibility; it is on all levels" (informant A3).

Another informant referred to the Norwegian word "dugnad", meaning a collective action on voluntary basis. This set the informants apart from the results from the DSB (2007) study on public perceptions in Norway, where most respondents were expecting the authorities to prepare for a changing climate. However, most of the Fredrikstad informants were referring to mitigative measures, such as reducing consumption and personal travel, not directly adaptive measures, at least according to traditional definitions. Norway was framed as a country with available economic resources, and thus an obligation to help out on a global scale. Also ancillary benefits of adaptive and mitigative measures locally were highlighted:

> "I am of the opinion that those measures that are necessary, if it is possible to correct it [climate change], are also beneficial locally. (…) Even though it should turn out that there is no danger, then the measures we have implemented have not been futile, because they are advantageous for other things than climate".

The degree of thought on local responsibility in the municipality group varied. The city planner questioned the lack of responsibility taken at the national level and its seeming resistance to make the necessary moves towards change in a situation of good economic times for Norway, paralleling the complacency sentiments from O'Brien et al. (2004).

> "It is a matter of politics. I am of the opinion that the state should be clearer also with regards to the level of public fees. Encourage municipalities and the local level to work towards changes in travel habits" (informant C1).

The strategies seen as relevant and effective were in line with a general municipal strategy of urban densification and relied partly on adjustments in the tax or charge

level. However, the action scope of municipal administrations is thought to be largely determined by the level of *centralization* in the Norwegian systems. Most measures were dictated by direct national decrees, the central plan and building code and requirements attached to the economic transfers most Norwegian municipalities partly rely on for income.

As with the municipal administration, the business informants worked within certain constraints, and the general feel of the group was nicely summed up by the architect:

> "Our challenge is that we have to consider the totality. Climate change adaptation is partly about this totality, but it is necessary to prioritize with regard to certain choices. It is a matter of keeping sober in addition to engaging the customers. As actors we are completely reliant on a market economy, we have to sell our time to people because they are willing to pay for it. We are dependent upon keeping healthy business accounts, but of course we are doing what we can within those restrictions" (informant B3).

The architect did not think it was possible to reverse the trend in climate change today, but that one could work towards stopping the development in the long run and adapt to the rest of the impacts. The other business informants also seemed positive regarding being able to do something within the frames of their operation, primarily employing technical solutions.

> "We can adapt to the new changes related to climate (…). It requires money, the condition is that there is money available and will to do it. But technically it is possible to do" (informant B1).

The societal perspectives were not very central. The bank was interested in sponsoring climate related events, and the manager uttered the colloquial Norwegian expression "we have climate on our forehead", meaning that they were encountering climate issues all around.

What was evaluated here were mostly higher level spatial scale action scopes, few informants assessed their own local capacity as the risk was not perceived to be very high, highlighting the tensions between risk and adaptation appraisal. Altogether, divided opinions, but general positive attitudes toward the possibilities of adaptation existed in the three groups.

5.3.3 Role of Conflicting Expert Views, Media Coverage and Uncertainty

> "There are so many theories out there - so what shall we, ordinary people, trust?" (informant A6).

Informant A6 articulated a view shared by many of the informants in Fredrikstad, a genuine confusion over many aspects related to climate change and adaptation. This was not surprising as climate change is a complex scientific and social topic that does not speak directly to the experiential processing system (feeling). It requires deciphering by the analytic processing system (head), and this mechanism is often underplayed by the prominence of personal images. As stated, the dynamics of information flows become important, i.e. how and through whom information is transmitted. Issues that have the potential to complicate useful information flow are conflicting expert views, media coverage considered as biased, and uncertainty.

The climate sceptics showed the most substantial symptoms of not trusting experts and were confused by the range of views presented, but this was also found in both the general household group and partially in the business group. The expert scepticism was particularly framed as a gap between local and scientific knowledge, and correspondingly practice and theory. Informant A2 mentioned that experts came to Fredrikstad after the 1995 flood and argued that problematic flooding would continue to be for the lower Glomma region. The informant disagreed and believed rather that the effects would be most severe in the upper parts of the river, in the neighbouring Sarpsborg area. Informants A1 and B2 backed this up, and also questioned the predictions the experts had made before the actual flood event. "Some experts estimated how much the water would rise. It did not nearly go as high [as they thought]" (informant B2). Despite that, the latter informant stated that "of course I believe in the experts, but naturally experts can be wrong. One thing is that you are able to calculate, but you should also consider how things are done in practice". Supplementing this view was informant A11 who professed a great respect for authority, self-related to his profession as a police officer. He said that "I cannot stand alone and say that I do not trust it [research], that would be a bit too narcissistic". Yet, he is not uncritical as such of the results that had come forward.

> "If the world's scientific community had not been so unanimous I would personally think it was a cycle, yet we have not had such numbers of animals and humans on this planet before, which in itself creates a lot of extra emissions" (informant A11).

Related to conflicting expert views is how these views were seen to be portrayed in the media. Many informants presented a view of TV as exaggerating the extent of climate change events.

> "I feel that TV is what is most strongly pushing the view that climate change is a threat most strongly. I cannot say I have noticed many debates or news of it being a completely natural process. Those views are not represented well on TV" (informant A6, climate sceptic).

This is generally quite a common argument coming from climate sceptics, but also other informants said similar things. For instance informant C4 as quoted in section 5.2.1, on media showing "things [climate change] going the wrong way". In fact, a recent poll done by University of Maryland's Programme on International Policy Attitudes showed that Americans prioritized climate change lowest among a large group of countries, and a theory for why this was is that climate sceptics get more coverage in the media in the US[30]. Similarly, in the Norwegian context, it has been shown that 1 out of 5, the largest percentage in the Nordic countries, question the anthropogenic causes of climate change, most likely due to the strong media presence of the Progress Party (FrP), which presents such views (Dagbladet 06.10.09).

Concerning uncertainty, several informants noted that the projections were seen to be too modest, and that the development of climate change impacts was moving faster than had been previously thought. "I am noticing that things [climate change] are going faster than assumed" (informant A2). Another informant looked at uncertainty as a measure of how one-sided future conditions are going to be.

> "A majority of people think that it is anthropogenic in proportion to those who do not, which makes me assume that the probability is large that it is anthropogenic" (informant A3).

When confronted with the senorge.no maps, showing projected changes in precipitation and snow patterns, informant A4 was confused, also in terms of dealing with uncertainty and felt no personal background to evaluate the information: "Is it a trend we are seeing now, or are other things influencing the amount of precipitation?" (informant A4).

[30] http://www.treehugger.com/files/2009/08/usa-lags-understanding-climate-change.php (viewed 30.08.09).

The business group generally took a pragmatic approach:

> "The challenge is to take the information that appears to be most relevant and have a conservative approach to it. So far my impression is that the analyses differ substantially" (informant B4).

The architect of the business group said that uncertainty was just something to live with, paralleling with informant A9 above. "A prognosis or budget is something to steer towards, let's hope it does not turn out as bad as the prognoses, it is something we can deal with" (informant B3). The city developer talked about information being "reliable" in terms of being the basis for large financial investment. To be able to rely on prognosis these had to be pretty dependable, due to the large societal and economic consequences of development decisions.

Also in the household group ways to deal with conflicting expert views and uncertainty were found, although with more insecurity and doubt related to them than in the business group. The majority of the "confused" informants were more prone to consider things carefully before taking a decision, though different ways to handle it was put forward. Case in point was using dark humour as a way to deal with the catastrophic prospects of climate impacts, in statements such as "I am glad I am situated up high so when the landslides come, I will get a very nice big lot" (informant A1) or "if the sea level rises by 8 meters, the beach will be closer" (informant A11). Nonetheless, most informants resorted to accepting that a degree of uncertainty existed, and applied measures following the precautionary principle. Informant A5 believed that anthropogenic emissions mattered and that

> "it is important that there are initiatives to reduce anthropogenic influences even though other circumstances, which we do not know too much about, could have an effect".

Also supporting this view was informant A5 in saying that "if one can lower the risk even though there is uncertainty about how big the risk or influence is, the basis is that one should do something". This also applied even though the risk turned out to be smaller than initially thought.

> "I think there is a preponderance of evidence that it [climate change] is very probable, and we should listen to the people who know more about it, and be part of the positive developments, accept the measures that are needed, even if it will be a bit more expensive. This is better than sitting around doing nothing, and *then* experience a catastrophe" (informant A9).

This view was supported by informant A11, who also considered it safest to believe what the majority of scientists said: "We must act according to what research states at any given time, we cannot do anything else". This informant trusted science and research because he felt that he had to as he did not have the relevant knowledge, training or background himself to evaluate the issue and thus no basis for mistrusting scientists – even though he saw that science in many cases had been proven to be wrong in retrospect. This is an example of extending own knowledge field by relating to other people's cautionary stories, in line with experiential processing and application of the availability heuristic to fill the gaps in knowledge. Nevertheless, using the precautionary approach has related dangers according to Gardner (2009), in that in most cases there is a trade-off between risks, so that doing something about one can lead to other risks being magnified.

The topics of conflicting expert views, media coverage and uncertainty were not very significant in the municipal interviews. The matters appeared to be largely settled. The public relations manager shed a bit of light on the subject of uncertainty and scenarios in saying that the law of large numbers[31] was applicable for the municipality as well, meaning that as the evidence and changes had become so clear that they had no other choice but to pass the information on. Further, political factors were related to uncertainty and choice of scenario by the same informant: "Ultimately, it could be a political choice what version of the prognoses one chooses to use as basis for one's policy" (informant B4). Seeing that the job of the municipal administration is to carry out the resolutions that publicly elected politicians make based on professional opinions, the departments do not have much say in the matter. Importantly though, the informant stressed that he did not believe there to be great disagreements in matters of climate change in Fredrikstad.

In short, aspects of expert scepticism, reflections around uncertainty and media were uncovered in Fredrikstad but all groups had found ways to deal with the effects on their daily lives and it did not act as an impediment to action. Indeed, as shown in Chapter 2 by Adger et al. (2009a), uncertainties do not need to act as a limit to adaptation or change, as long as methods for assessing robust adaptations can provide opportunities for overcoming the perceived limits exist. A better

[31] Statistical concept that states that the probability distribution around the expected value narrows as the number of observations increase. Source: http://hurl.no/JHn (viewed 12.11.09).

understanding how people learn and reason about uncertainty and probability, and how decisions are impacted, can also help.

5.3.4 Existing Climate Change Adaptation Efforts

Few informants in either group had implemented adaptive measures into their daily lives or operations, perhaps because the direct impacts had not been very visible so far in Fredrikstad, and consequently risk perception was low.

In the household group, the changes that were observed as a result of climate change were energy economization and extra insulation on houses, switches to wood fuel for heating, recycling, composting, reduction of car travel, draining measures and membership in environmental organizations. Quite a few people were doing nothing, the climate sceptics not surprisingly among them. Despite many informants believing in combined efforts from individuals and authorities, national or municipal measures were proposed instead. The suggested measures were mostly economical such as subsidies of public transport or increased charges for gasoline. Some believed in attitude campaigns, referencing the apparent success of anti-smoking campaigns. “One is affected by campaigns and attitudes, no doubt“ (informant A9). Informant A8 recognized the need for changes in much larger global structural measures, particularly to ensure fairer distribution of resources, as a prerequisite for fair climate change adaptation measures.

Likewise, few adaptations or changes were found in the business group, even though some challenges were recognized. The most direct measures were identified by the architect and the city developer. The architect saw factors such as height above water, energy use, building materials, insulation, and position of windows to take advantage of solar input as related to climate change impacts in house construction. Other “adaptive” measures included considering the positioning of the houses to avoid corridors of wind, as well as monitoring of erosion and sediments in the river that might start to behave differently. In addition to customer demand, building codes dictated a lot of the work in the sector, and these prescribed a 2-meter safety zone above sea level. The architect’s office buildings were furnished with a floodable ground floor, an effort that could help reduce the sensitivity towards climate change exposure (Adger et al. 2005). In contrast, the port authority manager could not identify direct adaptations, although actors in the line of business had started to take precautions when building near the sea in terms of sea level rise and

exposure to wind. The bank mainly focused on internal changes, such as paper recycling.

The measures of the municipal group/departments were to a large degree decided by the central decrees that had been adopted politically by the municipal administration. The political administration in Fredrikstad was led by the Progress Party (FrP) and the Conservative Party (Høyre), two parties that in general do not have a very good track record when it comes to prioritizing environmental or climate change issues. How, or if, this affected policy development and implementation of administrative adaptation measures in Fredrikstad was however unknown. The public relations officer emphasized the municipality's role as a societal developer with a basis in the national planning and building code. The planning perspectives incorporated the impacts that climate change had on area and topography, and climate change consequences were seen in the daily work. Further, there was intermunicipal, professional and international cooperation on the issue of climate change. As mentioned in Chapter 2, Fredrikstad had joined "Cities of the Future", and the local emphasis was mostly on mitigation through densification and urban centralization in conjunction with a transport effective/intensive model with increased share in public transportation and development of a bicycle trail. The issue of insufficient public transport was raised by many household and even business informants, connected to the dependency on individual car travel, which led to a situation of few behavioural alternatives to individual car transport and low self-efficacy due to habits. Issues of erosion, flooding and surface water were also central, with planning going on to develop a better piping system. A concrete measure that has been put into place to deal with the issues due to increased problems with surface water and piping capacity was cutting the rain gutters open to allow free flow onto the street instead of into the piping system. Related to environmental and public health, the current situations will just be intensified:

> "The issues are the same as before, but perhaps we will get more enquiries. There will be more frequent flooding and more vermin. The measures will probably be a pretty much the same" (informant C3).

The climate plan (Fredrikstad kommune 2007) for the municipality was written in the environmental health department, however not with the direct participation of my informant. The focus was mostly on mitigation and reduction of pollution, although

the plan also outlined the need to evaluate climate change adaptation, and this was currently happening in coordination with the NorADAPT project.

Summing up the findings left the impression that little private adaptation in the household groups was taking place. For businesses it was stated as a factor, but not particularly strategic and relevant outside of regulations they were put under. With regard to planned administrative adaptation, the municipality had joined several climate change efforts, among them "Cities of the Future" and NorADAPT, and some measures were implemented such as changes to the piping system. It was still mostly mitigative and influenced by the effects of *centralization*.

6. Empirical Analysis II: Information Needs and Tools for Adaptation

The second and last part of the empirical analysis will emphasize information needs and views on GIS as a tool for adaptation in Fredrikstad. Part of the rationale behind interviewing three different groups was to see if the groups showed different characteristics and information needs with regard to climate change in order to discover the potential for information presentation in GIS.

6.1 Differing Information Needs for Climate Change Adaptation?

The focus of this section relies on a basic belief that information transmission has the power to change behaviour, through awareness raising and influence on municipal decision-making. Whether this is a reasonable or problematic assumption to make in general, and in the specific Fredrikstad context will be discussed further in Chapter 7.

6.1.1 Current and Preferred Sources of Information

> "If you do not close your eyes you will find information everywhere" (informant A11).

As emphasized in the above quote, there was no apparent lack of information on climate change. In fact, it could be seem as hard to avoid getting information on it, at least in the eyes of the climate sceptics, who resorted to ignoring it. Most of the household informants got their climate information through mass media, predominantly television. This was generally also the preferred information source for this group, and several informants pointed to age or generation as a possible influencing factor for this choice. The immediacy and emotional force of the TV medium, coupled with the benefits of visualization and illustration, were mentioned as reasons for preferring this format. The climate change coverage by TV was generally reliable and offered good overview. Certain insight into its drawbacks were however voiced:

> "TV is one of the most important media sources. The combination of seeing and listening in addition to short, summed up conclusions is key. (…) TV provides more superficial knowledge, yet it has the ability to present conclusions with stronger impact than the written press has" (informant A5).

Newspapers were also cited as a recurrent source, next after TV, and some of the household informants preferred this medium to TV coverage. Informant A7 stated that using written sources gave the opportunity of time to reflect upon the information, not just absorb it from a TV program. More active and participatory forms such as Internet use were viewed as less accessible and not as engaging. "Internet is for those who sit around looking for information. You are not reaching people this way, only the ones who are specifically seeking the information" (informant A1). For the few who actively used it, Internet was seen as a contributing information source, for elaboration on previously presented information, not a primary starting point.

In the business group, most of the information stemmed from central sectoral organizations, such as engineer's unions, SINTEF, Byggforsk, banker's associations, etc, in partial combination with personal input from media. This information was tailored to each business' needs, but only sought if directly needed: "It has to be something that is useful for us" (informant B1). The main benefit of relying on centralized information was that the issues within the sector were similar, so the problems were addressed with the relevant setting and topics in mind. Little information seemed to be sought, and if there was a need, it was seen as easily covered.

Similarly, the municipality group derived most of their information from centralized distribution through the work place and relevant organizations. Environmental health for instance, got much information from state agencies such as the Norwegian Institute of Public Health[32] and the Norwegian Pollution Control Authority[33] in addition to the department's own gathered information. The public relations manager stated that they used the municipal climate plan and partners in the Environmental and Planning department, there was no capacity for own information gathering, nor an immediate sensed need.

Summing up, TV was the main information source for the households, while the businesses and municipality administration relied mostly on centralized information.

[32] Folkehelseinstituttet, www.fhi.no.
[33] Statens forurensingstilsyn, http://www.sft.no/.

6.1.2 Expressed Information Needs in Fredrikstad

In terms of information needs the public relations manager had some useful inputs on the general value of information and attitude campaigns. The informant did not believe in information itself as a measure for changing behaviour:

> "Believe it or not, I do not really believe in information as a measure. We [the information department] are a weak contribution factor in creating attitudal and behavioural changes. It has to be accompanied by other things, like regulation and rewards, stick and carrot" (informant C4).

However, in co-existence with concrete measures attitudal campaigns could potentially be positive, the informant stated. Other challenges to reaching target groups were dependent upon a pre-identified and current need in that group, as the "information only works when there is a need for it" (informant C4). Informant A11 also added some perspective on information in general: "Information is important, but information can be very wrong", questioning the supposed neutrality of information.

It seemed that most informants in all three groups found their information needs mainly covered. The climate sceptics were the most insecure about their own information needs: "I feel it is under my control, but others probably do not think so. There is probably lots missing" (informant A6) and "I honestly do not know [if I have sufficient knowledge]" (informant A7). Informant A1 (climate sceptic) stated that he would like to have more historical information in addition to a presentation of alternative points of view, which was backed up by other non-sceptics::

> "Are there other ways to explain the present changes? Are there other scenarios we could envision? (…) I think it is very one-sided, not all the findings in the world can be so unambiguous, it does not quite fit" (informant A11).

Moreover, informant A2 wanted more factual scientific background information that could lead to the revelation of clear connections in the climate change area, while feeling that knowledge and information on the impacts or consequences were covered. Another informant exhibited similar wishes, but put more emphasis on the consequences, both now and in the future, particularly the probability of extreme events such as the ones Fredrikstad had witnessed recently. Other issues raised were better coverage of expected benefits and effects of the measures that were adopted. This was to help the political discussion on what actions would give the highest "yield". Related to GIS, higher resolution and updated data was raised as an issue.

Another household informant wanted prospective new information on climate change to be attached to the already existing framework of the municipal GIS tool, maintaining wide availability.

The general sentiment of the business group was one of sufficiency of information, or alternatively that they could obtain it themselves. The city developer pointed to the fact that the issue was more concerning how to use the available information in a practical sense and assessing to what degree it was reliable. The company would be in the front of the line for demand if reliable prognoses for a relevant time perspective of 50 to 100 years ahead were available. Only the architect replied with a clear "no" to the question of sufficiency of available information. This was related to sector specific information, such as how to build the best isolated wooden houses and how to deal with climate change induced issues with brick houses. Informant B5 mentioned interest in demographic factors, mostly to facilitate direct marketing or information spreading.

The municipality group expressed very similar opinions and need levels to the business group. For the purposes served by the different departments the information was presently sufficient: "So far I feel that we have sufficient information for we are working with and has had the use for up until now" (informant C1). Environmental health wanted more general, contextual information, while public relations pointed out how they were cooperating with relevant professionals to get the information they needed.

Generally summed up, there were variable degrees of self-identified information needs, but mostly there seemed to be satisfaction within most groups. Certain gaps existed in the household group, while the business and municipality group relied on internal specific information they had easy access to.

6.2 Views and Understanding of GIS

6.2.1 Awareness and Views of GIS

Within the household group, there was a division between those who had heard of GIS, those who (wrongly) thought they did not know what it was and a few with no actual prior knowledge. One informant had even built a GIS setup for a water and piping company he was employed in, but this was in 1974-75, in a more mathematical form than the visual interface of today. Most informants had used lightweight GIS

applications online such as the map service of the Yellow Pages mapping service[34], Google Earth, Virtual Earth and the municipal mapping tool, though not necessarily being aware that this was *GIS* per se. Many used GIS as a form of "entertainment" to explore potential locations for holiday travel. A certain confusion and mix up between the capabilities of a GIS and normal maps existed. One informant referred to "digital maps", another to using printed map books when discussing GIS. Two of the informants had no prior knowledge of GIS or online mapping tools, one when asked if he has used the Yellow Pages maps online, says that "no, the Yellow Pages are in the phone book" (informant A7) – this informant was over 70 years of age though, part of an age group which does not use computers much.

The household group was in general quite interested in the capabilities of GIS use once they were made aware of the basic possibilities: "It is very informative" (informant A1), "it is very easy to use" (informant A2), "I find digital mapping services to be superior" (informant A4). More supporting statements are outlined in the advantages of GIS section. Nevertheless, some household informants were disinterested or partially indifferent to GIS use. The main reason for this was lack of personal utility, not a dismissal of the tool itself per se:

> "I do not think it would be something *I* would look up. I am not a habitual Internet user. I think it is important and useful that there are such web sites particularly for the current and next generations that are using the Internet medium more. (…) Information influences you" (informant A5).

The generational aspect entered here, and GIS was seen as a way to reach new more responsive generations. The current information access of today contrasted with the previous generations possibilities, which was also highlighted by informant A11. The direct relevance for life situation was also seen as key:

> "I would be interested if I was going to buy something, move back into town. I would probably read this type of information on climate change. I am unsure whether it has practical utility in relation to the place one lives though" (informant A8).

This was followed up by informant A9 when asked if GIS would be interesting:

> "Absolutely. But I do not know what I should use it for other than to get information and know it. I do not need to use it actively for something, it would have to be a case where I had a job where I would have to prepare for the future".

[34] http://www.gulesider.no/kart

None of the businesses had a GIS department or employed professional GIS packages directly, but all used geographical information and GIS indirectly and had some concept of what it was. One informant expressed what GIS was this way: "The way I see it, it is a tool to try out different scenarios, if this happens, what will be the consequence then. That is an interesting area of use" (informant B5). Informant B4, the bank manager, made a brief overview, slightly simplistic overview of GIS: "This GIS, to use maps to obtain, what I assume is already saved data, which has been systemized in a little bit different way and appears in map form".

The housing association (informant B1) used GIS as a reference source through the municipal websites. In fact, most of the uses of GIS in the business group consisted of utilization of the web GIS tool that Fredrikstad municipality offers on its website (see Figure 3). For the architect GIS or mapping data through this tool was used on a daily basis. Additional needs were filled by outsourcing or using secondary sources. "To have the right kind of data is vital. If we do not have a proper base map we almost cannot work" (informant B3). The informant did believe that most needed data could be ordered though. He knew GIS quite well and the customers were very appreciative of map information: "It is very easily accessible and good maps are also important planning tools. (…) In many instances we even wish we had better maps". Particularly height information and detailed topographical quotas were in demand, as architects work with the shape of the terrain and aim to hinder excessive excavations and blasting. Another important aspect was an expressed want of wider 3D availability for municipal data as architects often work in 3D, not 2D.

The overall business attitudes towards GIS seemed positive, it was praised for its ability to simplify and visualize. There was little critical thought with regard to the technology and its use. The concerns were more regarding the necessity of the businesses currently than information diffusion in general, quite understandably. Informant B2 (port authority) said, for instance, on the question of whether it was relevant: "Of course one can use it, but temperature in itself is not a very big problem for our operation. It is the water level that matters". The bank used it nationally, for preparedness and disaster mapping to keep their buildings secure, but not at the local level in Fredrikstad. The potentials to use GIS as a tool for direct marketing was mentioned. Informant B1 of the housing association did not see the need for the

business to be frequent GIS users, however there were uses for potential house buyers, for instance in the cottage market where snow prognosis is important.

All of the municipality informants had heard of GIS previously due to the strong presence of the GIS department in the municipal administration. However, this meant that none of them had really used it much directly in their current jobs as the work was "outsourced" to the GIS practitioners. Some use was identified though. In the environmental health department GIS was used to monitor pollution levels and drain capacity, for instance by making a "carefulness" map for Fredrikstad. During an outbreak of legionnaires disease in 2005, GIS was successfully utilized to find the source of the outbreak by plotting in locations and movements of infected patients, cooling tower points and information on meteorological conditions. This case of successful GIS use got extensive media coverage, and was a recurring anchor point for a lot of informants when talking about GIS. The informant did however raise the issue of wanting to have a broader type of mapping tool available for statements they had to make to municipal plans (for instance to identify polluted land or risk of flooding in the area). Additionally, the city planner had been involved in the use of an area and transport-planning model for GIS (the ATP model[35]).

The skill level needed was mentioned: "You have to use it [GIS] a lot to be a good user I think" (informant C1). There have been courses in GIS offered for the municipal employees, but since the software was not used afterwards, the skills were quickly forgotten. The reliance on and existence of the GIS department meant that this did not constitute a problem. It is probably unreasonable to expect every sub-department to run their own GIS operations, but consequently this led the GIS department to have a lot of definitional power over what went into the GIS tools and analysis. The informants' feelings towards the GIS department were that they were good at what they did and safe to use.

Summing up, most people had tried or were aware of some sort of mapping tool. Further, the municipal tool was well known and well used in Fredrikstad, and constituted a great resource in its current form, regardless of group. Although interest and positive attitudes did exist towards GIS, some informants had trouble seeing own utility in relation to climate change, or referred to greater needs in younger generations (for households).

[35] http://www.atpmodell.no/ATP.htm

6.2.2 Advantages and Disadvantages of GIS Use

The statement that most informants had a positive view of GIS is elaborated on in this section, while providing nuance through looking at some disadvantages in use that came up during interviews.

As for the *advantages* of using GIS, the easy use and practicality was commonly cited across the groups. "There is very good information in maps, it is a practical tool" (informant A8). Visualization was also stressed: "It is important to be able to make probable and visualize information" (informant A10). The informant who had designed his own GIS system in the 1970s stressed the flexibility and possibility for openings in GIS for innovation in that "I can also see many possibilities for creative people, to connect data to the map. There is so much data that can be added" (informant A2). As a form of information tool, GIS was seen as useful for most municipality departments. Also a basis as a tool for potential house buyers was mentioned several times, by both household and business informants.

> "On a micro level to plan areas in the cities; what will happen; the conditions of regulation; how it will be in 30 years time - that is interesting for people buying houses today" (informant B1).

The Fredrikstad legionnaires disease incident was mentioned again by the environmental health officer and several others when asked about the advantages of using GIS. The environmental health officer identified no disadvantages.

Several informants looked at GIS as a framework that could help induce action. For instance:

> "It is a useful tool to show politicians and others the importance of action. One thing is to change behaviour to limit emissions, but the other thing is that one should safeguard oneself against those climatic impacts that are coming related to precipitation and flooding" (informant A8).

Informant A7 also identified this aspect, but highlighted that it is not just a matter of registering, ascertaining and seeing developments, but also to make these insights lead to action. Particularly in the Norwegian context this was seen as a possibility as "Norway has a lot of money" (informant A7).

In pinpointing the *disadvantages* of GIS, the Fredrikstad informants touched upon most of the basic disadvantages of GIS use. For instance, informant A8 called attention to the skill level required: "There is a threshold to use it properly I think. It

demands some skills". This was reflected in statements by municipal informant C1 and others. Moreover, the amount of data needed and the requirement of high processing power in the computers was mentioned. The base maps for GIS being old and rarely updated could also cause problems, in addition to the issue of different rates of resolution dependent upon geographical location. Fredrikstad, being a relatively small town in Norway, is generally not well covered in international applications such as Google Earth as "it is probably not interesting enough" (informant A1). This has been partially rectified through later updates in these programs, and Norwegian services like www.norgeibilder.no are naturally better at this due to their more specialized geographical focus.

Informant A11 referred to his own particular preference for and easy understanding of maps but contrasted it with other people's lacking *spatial literacy*:

> "I know if you had shown it [GIS maps] to my mother you may as well have shown her a tomato or a white sheet of paper, she lacks spatial literacy. It would not have had any significance at all" (informant A11).

The informant attributed this to individual human characteristics, and how it was possible that the brain reacts differently to different stimuli. This might make it harder to process information and use it as a backing for behavioural understanding.

On the whole, however, there was generally a positive attitude to and widespread firsthand knowledge of lightweight GIS applications. The advantages and disadvantages were not necessarily concluded upon by the informants, and the direct connections to climate change issues was diffuse. There was no distinction in perceived *general* usefulness between climate sceptics and the rest of the informants.

6.2.3 Attitude towards PGIS possibilities

The creativity aspect mentioned by informant A2 was further seen as an advantage, to let people who do not know much about the underlying GIS structures come forward with wishes and demands from the GIS analysts. "There is a certain bind when you know how it is constructed, you see the limitations" (informant A2). When asked directly this informant was positive towards mapping tools where one can add information oneself. However, informant A3 felt that there would not be grounds for adding information and changing maps himself, and the prospect clearly made him unsure.

> "It is going to turn out to be a sort of Wikipedia arrangement, and I perceive this to be disorderly. I want it to be more formalized, because it is such important information" (informant A3).

The GIS practitioner himself was open to the notion, but similarly brought up the need for quality control. Informant A10 had been involved in projects where participatory GIS mapping had been used by school children to gather information on cultural heritage sites. "It is a way to "trick" people into becoming interested, it is much easier to be interested in what they know, and what matters at home on your street" (informant A10).

The issue was not discussed with all informants, particularly in the business group, but based on the comments above, the desirability of direct participation seems somewhat limited. The potential will be further discussed in Chapter 7.

6.2.4 Direct Map Interaction and Perceptions

The mapping exercise with GIS on the PC was executed partially to reveal how the informants orientated themselves on the map, which areas were important to them and to see if the presented map information overlapped with their experiences in Fredrikstad.

First, the informants were prompted to indicate on the map where they lived, or where their business or work headquarters in Fredrikstad were, in addition to which areas of the municipality were important for their lives or operation. For the municipality informants, all had the city hall for location of operation, so they are not indicated on the map. Most informants were quite confident while they orientated themselves on the Fredrikstad maps. When asked about the areas that were important for them, for various reasons for the households and in professional capacities for the businesses, many of the same areas were chosen, although the data showed a large spread, as seen in Figure 12 and 13. For the household informants, emphasis was on leisure areas such as the forests located in the northern and the western parts of Fredrikstad municipality. Most of the businesses had many very localized activities based on housing or development in different parts of the municipality, so they indicated the main areas of current work.

Next, maps of flood and landslide risk zones were presented. A few informants had not seen them before, and were partially surprised to see the risk

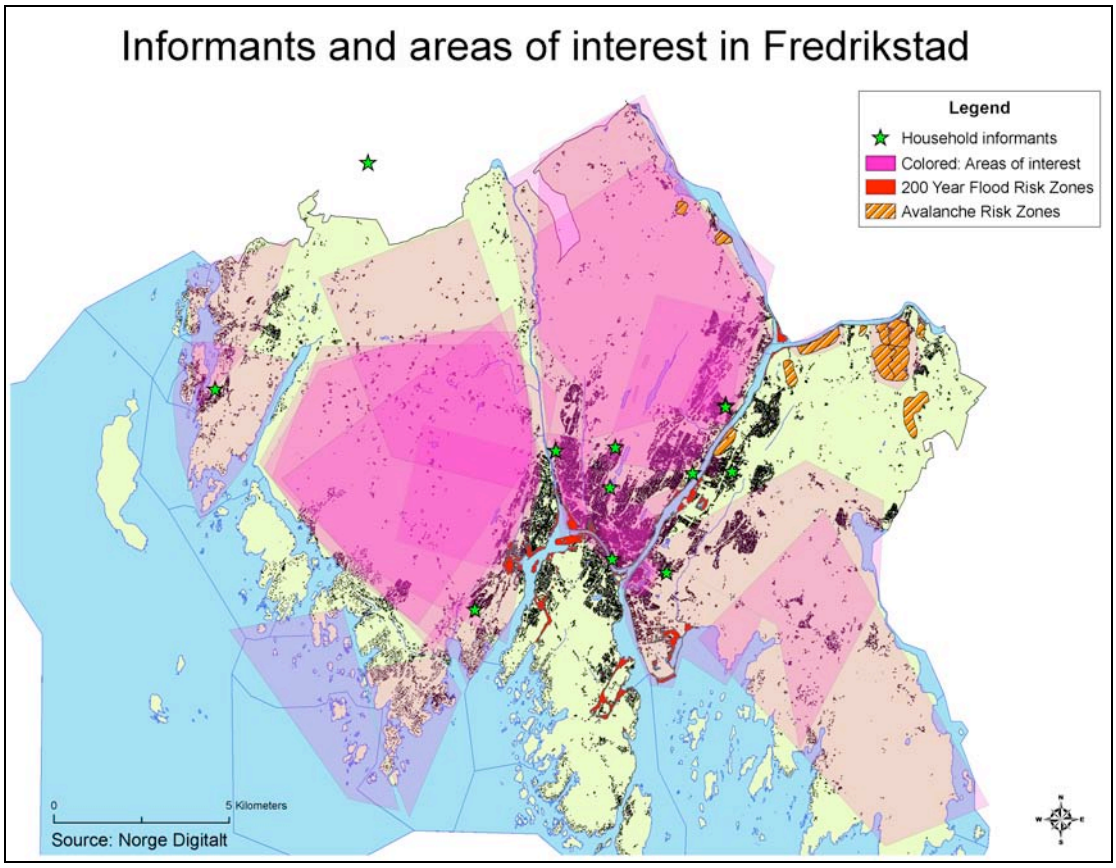


Figure 12. Household informants and areas of interest in Fredrikstad.

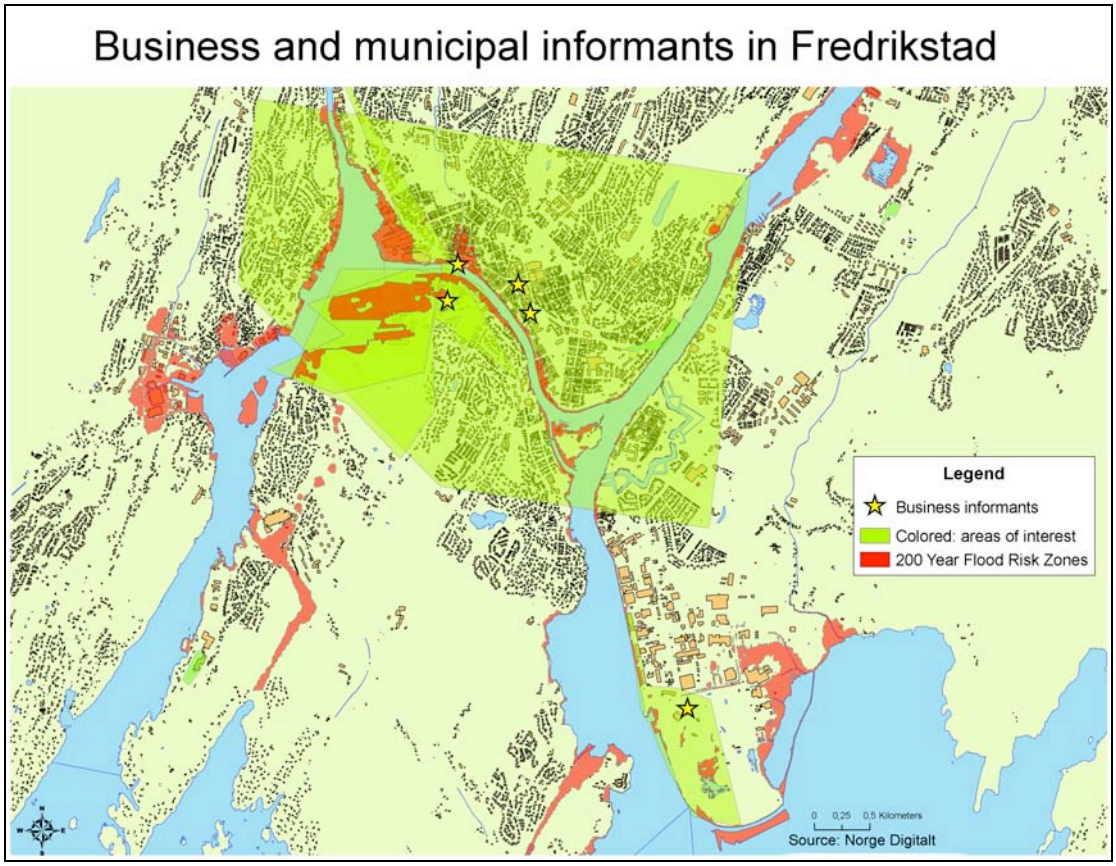


Figure 13. Business and municipal informants in Fredrikstad, location and interest area.

areas. On the whole though, most informants were aware of these issues and their extent – there thus appeared to be a considerable cognitive overlap between experience and the GIS maps. The city developer had good knowledge of the flood maps, and saw the 50-100 year flood layers as relevant for dimensioning of buildings. The climate scenario maps seemed more unfamiliar, and the estimate of an average of about 3°C increase surprised the city developer, leading to statements that it was something that should be included in plans, in addition to societal development. The climate scenario maps were viewed as interesting for the architect, with regard to presentation for their employers/customers.

One household informant questioned the usability and direction of the GIS tool through asking the question of *who* GIS is visual *for* and what one sees when one looks at the map. His own interpretation of the flooding maps was:

> "When I see the red fields [risk zones], I imagine that these are areas which one should put restrictions in planning and choose other areas. (…) Even if I had never been in this city, I would have said so" (informant A11).

He also believed that people would become more aware of risk factors when choosing where to live in the future:

> "Insurance premiums will rise and full compensation will not be given for natural damages if you have built in areas where you should have known something could happen. (…) Then only the so-called "stupid" will buy into these areas because it is financially favourable" (informant A11).

This perspective highlighted how social inequalities could be exacerbated by climate change, and the GIS maps made this clearer for the informant. It could thus be argued that GIS maps could work as a starting point for discussion.

Altogether, the GIS map interactions were perceived to be useful, and to a large degree overlapped with the informants' experiences of Fredrikstad.

6.3 The GIS Practitioner Perspective

The GIS department in Fredrikstad was relatively large in comparison with most Norwegian municipalities, with 21 permanent employees, half of which worked with surveying. The main task of the department was to run and maintain the main mapping database (felles kartbase, FKB) that forms the basis for all map handling in addition to creating thematic maps, carrying out map analyses, and keeping track of

buildings, addresses and property. One of the reasons for the size and capacity of the department was that work for neighbouring municipalities and the county level (such as regulation plans) were done on request. The employees were mainly a mix between natural scientists, computer scientists and technicians that had specialized in GIS.

The GIS analyst I interviewed had worked with the ArcGIS software from ESRI for over 17 years, all the way from the command stage to the graphical user interface of today. A current round of revisions and reconsiderations with regard to choice of software package was taking place in the municipality, and the informant highlighted the tensions that existed between the GIS provider's commercial interests and the need to develop municipal applications, which are less profitable. There was a wide variety of data available for Fredrikstad, both on physical and thematic variables. However, no data related directly to climate change or possible adaptive responses had been added. The reason for this was that presently demand for such information in the municipality did not seem to exist:

> "We are here to serve the customers, as we are the professional [GIS] department. Of course, if our environmental department should present such inquiries we would do it" (informant C2).

There had nevertheless been increasing focus on topics such as sea level rise and flooding, particularly with regards to flood-exposed cellars, so a potential for inclusion of this type of data existed, according to the informant. The municipality was also looking into using GIS in emergency planning, something that had emerged as a priority in the aftermath of the previously mentioned outbreak of legionnaire's disease:

> "It is actually quite simple, it is just a matter of thinking through the situation and know what to do when it [emergencies] happen. The GIS setup gives it all to you, as long as you have the database" (informant C2).

There were intentions of doing risk and vulnerability (ROS) analysis as well, as interesting use of data they already had. "Focus on the environment in Fredrikstad is high on the agenda, but there has been little attention towards use of GIS" (informant C2).

When asked to define GIS, the informant responded:

> "There are many definitions of it. The name is geographical information systems, so it is to manage geographical information. (…) In a GIS setup you have to be able to make connections and create new datasets from what you have, do analysis. (…) A GIS system is not just maps, it is tables and a whole lot of other things, like the combination with pictures…" (informant C2).

This definition aligned with a lot of the theory in section 3.1 on what GIS is, particularly the additions beyond pure mapping into capabilities for analysis and manipulation. The informant was unaware of GIScience research though. After a brief explanation of the main points of GIScience, the following reaction was voiced:

> "Of course it is relevant, but we try to show objectively how things are. Thematic maps can become somewhat tendentious, but I have not experienced this to be a problem for us" (informant C2).

The maps were thought to be kept objective mainly by using standardized symbology and standard methodology. There were also procedures for metadata documentation, but the informant was not sure how good or consistent they were.

The advantages of using GIS were defined:

> "The advantage of having the data in an ordered system enables us to run analyses and make thematic maps to visualize information. It is much easier for people to read a map than a table" (informant C2).

This aligned with the findings referred to in Chapter 3 on the benefits of visualization. When asked if the informant could see any disadvantages with using GIS, the answer was initially "no". Later, the issue of capacity was brought up, in terms of being more work than running a usual file based mapping base. It was justified in that it "does after all give vastly greater opportunities" (informant C2). The biggest cost involved in a GIS operation was stated to be the resources to establish geographical data, and the start up costs could thus be large.

The department had the intension to release and share as big a portion as possible of their data with everyone. Only certain data concerning the whereabouts of endangered species was not given out, to protect them from threats. The web tool was widely used, as the most visited sub site on the municipality main web page, something that had been prominent in the interviews with all three groups. According to the GIS analyst, his perception was that people used it mostly to find addresses and areas, paralleling use of the Yellow Pages. In addition, the regulation plans for the

municipality were embedded and this service was accessed a lot. The mapping tool was set up in connection with the local community project, and anybody could file requests regarding new additions if they so wished.

When asked if they had considered enabling PGIS capabilities, the informant stated: "In the long run it could be interesting, but it demands more of the person who receives the data as it has to be quality assured" (informant C2). There had been examples of schools using it for local environmental projects, and the GIS system allowed it quite easily. The primary reason for not doing it regularly was resources and prioritization. In terms of incorporating more multimedia elements, they had connections to photos in parts of their GIS systems. Another new feature was 3D visualization of the central parts of Fredrikstad, to aid the politicians and create a more lifelike visualization of the effect of planning measures.

The GIS analyst associated much the same with the climate change term as the other municipal informants. He felt optimistic with regards to action scope: "Climate change for me is the anthropogenic climate change, because that we can change". What was required was political and attitudal changes, but mainly based on mitigative measures. Climate change adaptation was defined in terms of decreasing personal consumption, and changing attitudes towards an ever-increasing need for growth in the economy at the expense of the environment. The local relevance and experience was highlighted: "We have had personal experience with climate change here, through torrential rain that exceeds the capacity of our surface water pipes". He had been considering using GIS to show the impacts, something he regarded as "quite easy". He had tried out some sea level rise analysis to see the consequences for the buildings in Fredrikstad. GIS was seen as a tool for awareness building: "We have to make people conscious, and for this purpose I think the GIS system can be powerful to portray what the consequences [of climate change] are". The informant recognized that knowledge from many different fields was needed, the GIS analyst saw the GIS department as *one* part of it.

> "GIS is a tool to be able to simulate and show things. We know how to handle the GIS tool, but professionals must tell us what to do. Then we can find out what the [climate change] impacts will be".

When asked whether there were possibilities to combine such physical impacts with other processes, such as societal development and politics, the informant

was positive. He mentioned the environmental interest of the founder of ESRI, Jack Dangermond, and his connections to Al Gore and Barack Obama. “The problem is that we do not have the time to sit down and brood over this locally, but it would be immensely interesting to work on it” (informant C2). The attempts to integrate qualitative data were unknown to the analyst but he was open to the notion.

> “We have been raised to deal with X and Y coordinates, which are absolutely localized, with attributes tied to polygons and areas. Tying things to bigger undefined amoebas, I have not worked with. It is an interesting field, we would be happy to contribute”.

Overall the image of the GIS department based on this informant's statements was one of openness to trying new things, but also of drivenness of other departmental needs leaving little room and time for independent manoeuvring. The possibilities for working with climate change adaptation within the GIS framework seemed promising reflected in informant C2s eyes.

7. Discussion and Conclusion: The Potential for GIS in Climate Change Adaptation

This final chapter will discuss the findings of Chapter 5 and 6 in light of background and theory in order to answer the two initial research questions. Lastly, a conclusion will be offered outlining the main points and suggesting needed future research focus.

7.1 The Context of Cognitive Challenges: Perceptions, Attitudes and Information Needs in Fredrikstad

- *What perceptions of, attitudes towards and information needs for climate change adaptation exist among stakeholders at the local level?*

The cognitive challenges as defined through the concepts of *risk appraisal* and *adaptation appraisal* from the MPPACC will be employed to evaluate perceptions and attitudes towards climate change adaptation at the local level in Fredrikstad.

7.1.1 Local Perceptions of Climate Change: Defining Risk Appraisal

Analyzing *risk appraisal* is an evaluation of whether the informants think it is probable that a risk or threat exists and has the ability to influence them (*perceived probability*), and whether this risk will be severe (*perceived severity*) (Grothmann & Patt 2005).

The Fredrikstad informants were in general quite informed about environmental issues, although certain cognitive challenges, especially in the household group, could be identified. For instance, a partial cognitive attribution of causes to the global level, connected to impacts for distant places and people could downplay the local risk experience. Affective images connected to both the causes and consequences of climate change were present in the household group and municipal group, while there was a gap in the business group. The images were influenced by media coverage and personal experiences, and consisted largely of generic associations to heat and temperature, precipitation, ice melting, extreme weather events, sea level rise, flooding and CO_2 (the latter only found in the household group). To a certain degree, people related current and future situations to personal or inter-personal experience, i.e. to something that had happened to

themselves or someone they knew, but also tried to decipher media-presented statistical information, such as different scenarios, and integrate the two. In Fredrikstad, the main impact related challenges at the time of the interviews were extreme weather events leading to surface water flooding because of over-strain of the piping system. One of these events occurred in August 2008, and several informants referred to this. Another common point of reference was the flood in June 1995 (Vesleofsen) that had large consequences for Fredrikstad, which is located on the river Glomma. Thus the affect, recency and availability heuristics, discussed in section 2.2.2, appeared to be at work.

The majority of informants believed that anthropogenic climate change was an actually occurring phenomenon, and attributed the causes to greenhouse gas emissions, in combination with a naturally cyclic climate. Together with the aforementioned local extreme event and flooding impacts, this could be seen as constituting a *perceived probability* of threat locally. A counterweight was found as most households saw themselves as relatively safe, often owing to the geographical and topographical location of their houses, meaning that this result could be more due to the sample than the actual conditions. However, given that few informants from either group identified positive effects of climate change, it is reasonable to assume that the issue was seen as a phenomenon with *perceived severity*, not advantage. Still, it varied between the groups, as the rankings of climate change as a priority on a scale from 1-10 (where 10 was the highest value) differed widely between the three groups, with the household group spreading from 0-10, the businesses generally low and the municipal at 7 or above. The municipal informants viewed climate change and sustainability as core values for the work of Fredrikstad, and were involved in a range of projects within the field. The degree to which it penetrated each and every daily case varied, as pointed out by the city planner. For the businesses, it was particularly the architect who identified impacts and challenges for his industry, while the others did not perceive such a gravity of consequences. The large spread in the household group reflects the diversity of human cognition and how different risks impact differently with relation to other priorities.

All in all, a nuanced awareness and risk perception appeared to be present.

7.1.2 Attitudes Towards Adaptation: Evaluating Adaptation Appraisal

The term *climate change adaptation* was not particularly familiar to the household and business groups. Most of the existing associations and definitions were circular in some form ("climate change adaptation is to adapt to climate change"), or confused with primary emissions reducing behaviours. This may be related to the status of the term within the Norwegian language, where "klimatilpasning" is more passive and generic than it is in English, implying that it is something that will take place regardless of one's own effort. It was also viewed as a negative term in line with earlier mentioned competition between mitigation and adaptation, and was often considered as a substitute, not complementary, to mitigation. The municipal level was aware of the term, but it had received little attention in the two previous climate plans (Fredrikstad kommune 2001, 2007) – it was mentioned as an issue to investigate in the latter plan, and the connection to NorAdapt was also trying to investigate options for administrative adaptation.

Linking this to perceived action scope, there appeared to be a large range of views of whether it was possible to adapt. In the household group several informants were very positive that it was possible to do something to offset or adapt to climate change, while others were more negative. The informants generally did not regard themselves as without control over global problems, at least not in handling local impacts, and there was no evidence to suspect a systematic bias towards underestimating objective adaptive capacity. The necessity and responsibility of action at all spatial scales, including the individual, were recognized. Interestingly, the measures discussed were mostly related to mitigation aspects of climate change, at least in a traditional way of defining the concepts. Personal consumption and lifestyle patterns, transport efficiency and pollution were issues that were raised. The business group generally viewed it as technically possible to adapt, and saw no unmanageable problems.

Overall, the measures stated as put in place were limited. A few of the informants in the household group had done things associated with environmental behaviour, such as energy savings, added insulation, recycling, reduction of private car travel, and one informant was a member of an environmental organization. These are not considered to be strictly adaptive measures. The business informants were aware of some challenges, but generally followed centralized guidelines. The

architect was the informant who was most closely involved with adaptation, in terms of changing the way houses are built – but this was mainly following building codes. The municipality policy makers were also to a large degree dependent upon national, regional and local regulations due to the large degree of *centralization* in the Norwegian governmental system, which limited the scope of autonomy. Few administrative adaptations had been identified and carried out so far. The densification and transport efficiency measures were implemented mostly to reduce emissions of greenhouse gases.

Certain elements of confusion related to conflicting expert views, media coverage and uncertainty persisted in the household group. Yet, there was no *major* concern with uncertainty; it was viewed as a fact of life, particularly within the business group, and thus not holding back adaptation. The general confusion was more evident among the sceptics, where these issues were magnified to create a background to base their beliefs on. Aside from these three informants, the other views reflected the precautionary principle, which holds that even though not all information is available one should implement preventive measures to be on the safe side. Habit and lifestyle choices were framing factors for the households for explaining why they had not done much to change their behaviour. Habit has indeed been found to be the strongest factor inhibiting environmental action, according to Snow et al. (2009). The positive thing about this finding is that habits can be changed, particularly if people get immediate feedback on how change may be benefiting them.

Summing up the Fredrikstad experiences on the topic, awareness of climate change appeared to be high, but studying risk appraisal led to the identification of varied results. Even though most people had vivid affective images of climate change and views that supported doing something even in the absence of full information, there appeared to be a disconnect between awareness and behaviour. Although the phenomenon was viewed as almost exclusively negative, most informants did not perceive many direct impacts. The business group the least, followed by the household informants, while the municipality was most aware of coming challenges due to its sector-spanning responsibility. Yet, and as a result, few actual adaptive measures were put in place. Similar results have been found in numerous other studies, and is according to Weber (2006) an example of disassociation between the outputs of the analytic and affective systems, as strong visceral reactions towards the

risk of climate change are needed to provoke adaptive behavioural changes. The analytical side, System Two, suggests that global warming/climate change is a serious concern, but the affective system, System One, fails to send an early warning signal. This parallels the dynamics of interrelations between risk appraisal and adaptation appraisal, where a certain threshold of perceived probability of threat (risk appraisal) has to kick in before a person will consider what can be done to withstand the threat (adaptation appraisal) (Grothman & Patt 2005). For the climate sceptics, these factors become redundant since they did not perceive anything to be amiss, hence the risk appraisal part of cognition did not kick in, as no risk is perceived, and adaptation appraisal was thus redundant.

In general, climate change is a long-term phenomenon, and perhaps the local level impacts are not visible enough for the household and business informants to react. Of the six factors listed by APA as inhibiting environmental action, *uncertainty, mistrust of experts, denial, undervaluing of risk associated with a long time perspective, lack of control* and *habit*, all are to a certain degree present in Fredrikstad, and can thus be seen as contributing factors to explain the findings.

7.1.3 Self-identified Information Needs

The lack of adaptation was thought to be potentially related to gaps in information needs. Dunn (2007) emphasizes that local knowledge is often viewed as more accurate since it embodies generations of practical knowledge, while official data is seen as less accurate since experiences cannot be directly linked to it. In Fredrikstad, this was visible through the critical stance towards experts apparent in both household and business group informants. “One thing is to be able to calculate, but you should also consider how things are done in practice” (informant B2). Other informants questioned the usability and accuracy of predictions of risk zones for flooding, and pointed to own experiences as evidence in showing that Fredrikstad is not particularly exposed to risk.

The directly voiced information needs or wishes were mostly quantitative and related to emissions reduction, such as more factual background on causes, impacts and measures on the local scale. Most informants, particularly within the business and municipal groups, were generally satisfied with the level of information they had already. This does not eliminate the need to investigate openings for more, or

particularly, improve information needs that the informants themselves cannot articulate.

7.2 The Potential for Use of GIS in Climate Change Adaptation

- *What is the potential for GIS to address the cognitive challenges of climate change adaptation in this context?*

The socio-cognitive context in Fredrikstad as illustrated in the previous section revealed subjective differences in perceptions of and attitudes towards climate change adaptation. The three groups had differing motivating forces, different goals and a variety of cognitive challenges. A central premise of this thesis is that climate mapping should empower individuals to take better decisions. This is based on the idea that climate change and adaptation options need to be satisfactorily communicated so that people understand them and can use that understanding to guide action on all spatial levels. The apparent disconnect between awareness and action is a key starting point for evaluating the role of GIS use in Fredrikstad.

GIS use in climate change adaptation will be explored both as a decision support tool for policy makers and as an awareness-raising tool for the general public, while highlighting its related implications for businesses. GIS is a powerful tool, representing great advantages but also potential disadvantages in its use. The Fredrikstad informants have identified a portion of the these, and the findings will be put into a wider perspective in this section, when seen in light of the three waves of GIS critique and the local context.

7.2.1 Arguments for Using GIS in Climate Change Adaptation

To assess whether there is potential for GIS use in adaptation, the general views and status of GIS in the community needs to be addressed. After that an evaluation of the six factors from section 3.3.1 (*computerization, spatialization, visualization, participation, communication* and *integration)*, their relation to the cognitive challenges of adaptation will be judged.

Using GIS as a climate change adaptation tool in Fredrikstad, both for decision support and for stimulating private adaptation, is firstly substantiated by the fact that most of the interviewed informants were already familiar with the GIS

framework. Only two informants, from the household group, had not tried any kind of GIS or did not know what it was. This general *familiarity* was likely based partly on a generally heightened awareness of open-access online GIS tools, in addition to the strong presence of the local GIS department and web tool. Particularly within the municipal group, but also overall, the GIS department was seen as a strong and reliable source of geographic information. The municipal web tool was universally used regardless of group, for a variety of both private and professional purposes. Furthermore, on the municipal level, Fredrikstad already uses GIS for crisis planning and risk-and-vulnerability analysis, and has competent and flexible GIS practitioners. They had begun to simulate climate change related flooding scenarios to identify flood prone areas to implement proactive (technical) measures such as redirection of infrastructure[36], and were thus in possession of a basis and an openness on which to build a potential adaptation tool.

Moreover, general *availability* of GIS in Fredrikstad is perceived to be good, as well as the possible access to geographic data on climatic factors. The main climate data providers in Norway, the Norwegian Meteorological Institute (met.no), rely on GIS tools and GIS concepts to meet information needs about both past and future climate at any location in Norway (Tveito 2008). Most standard climate data is thus available in GIS compatible formats, and can easily be incorporated into already existing GIS applications. Also, the identified information needs from the Fredrikstad informants are all easily represented in a GIS system because of their mostly quantitative characteristics. As mentioned earlier, most of them were connected to reducing emissions rather than adaptation, such as factual information on causes, impacts and local measures related to climate change.

There was an overall *positivity* related to the impression of GIS in all informant groups, although some informants could not see its utility for their own interests, as will be discussed later. GIS was portrayed as informative, practical and interesting – particularly related to its visualization and spatialization capacities and potential power of persuasion with regard to politicians and policy makers.

The aspect of *visualization* is taken further in the importance placed on visual media and new technology particularly by household informants, and this points towards further openings for GIS. Although the TV media is the main information

[36] http://geodata.no/GIS-i-praksis/GIS-gir-bedre-beredskap/ (viewed 20.09.09).

source and preferred format for many informants in the household group, problematic sides to its climate change coverage are voiced. Also, newer applications of GIS can also incorporate photographs, video and other multi-media related material. Of particular importance in evaluating the relevance of such new applications for climate change adaptation is attention to age and related generation, an aspect that was raised throughout the Fredrikstad interviews. Today's generations grow up using computers and Internet from an early age, and are thus more open to the possibilities of these media, while older generations often struggle with new technology. It could be interesting to explore whether this was an underlying reason why many of the informants could not see own utility of the proposed GIS tools.

The *integration* and *computerization* qualities of GIS were highlighted by the informants, and it is here that a lot of the potential for addressing the cognitive challenges lie. GIS has the potential to store a significant amount of data in one place and visualize it in thematic layers, and data can be integrated and spatial analysis executed. High spatial resolution is also possible, highlighting big differences on a small scale, e.g. comparing different sides of the river – although this may not be of any help given that climate scenarios cannot yet be downscaled to such a level with desirable results. The Norwegian scenario based climate data is being downscaled to a spatial resolution of 1x1 km (Tveito 2008).

More directly, in terms of addressing the cognitive challenges of climate change adaptation, a GIS can facilitate greater integration of experiential and analytical knowledge through its thematic data layering properties and possibility for qualitative data integration. This enables presentation of multiple perspectives in a non-reductionist way and offers potential for portrayal of a holistic worldview (McCall 2003). The personal experiences of the informants can be recontextualized by integrating local knowledge perspectives, if a more participatory mode of GIS is used. Local policy makers are dependent upon getting public legitimacy for implemented measures, and the early inclusion of local knowledge and opening up of the process can add to this (Forrester & Cinderby 2005).

Following on from this, GIS can enhance greater feelings of local responsibility and impact through *participation* and *communication* by visualizing outcomes for the relevant community, overcoming the cognitive challenges of attributing the causes of climate change to the global level and the impacts to distant

people and places. This was a challenge that was partially present in the three groups interviewed, most noticeably in the household informants. The GIS framework allows for an integration of both global and local level information. The use of GIS could also be connected to risk appraisal, to assess how big the risk of being flooded is for instance. Presentation of various scenarios and climate change adaptation relevant factors could make this process easier. This should be followed up by information on the possible responses to the presented risks, in line with being able to evaluate adaptation appraisal, what can be done to address the identified threats. Otherwise the result may be denial or non-action.

The three cornerstones of *familiarity, availability* and *positivity* were recognized as clear structural advantages of using GIS in climate change adaptation in Fredrikstad, in addition to addressing the cognitive challenges of the awareness/action gap through benefits of *computerization, spatialization, visualization, participation, communication* and *integration* as outlined in section 3.3.1.

7.2.2 Drawbacks to Using GIS in Climate Change Adaptation

Several general arguments and nuances to the earlier mentioned advantages came up during the interviews, and these will be discussed below, particularly in relation to how these interact with the cognitive challenges of climate change adaptation.

The concrete and widely recognized problematic sides to GIS use consisting of strains on time, resources, and requirements of skill level were identified by the Fredrikstad informants. The three groups had different starting points for evaluating the tool, but a perception of needing a certain skill level before proper use was a recurring theme. This does not have to be overtly problematic if one is mostly considering using GIS as a decision support tool, with an additional unit for awareness raising with a simpler interface. Building on the already established knowledge base of the GIS department would to a large degree mean less time needed to be spent on knowledge and skill upgrading in terms of the technical sides to GIS at least. However, Sheppard & Cizek (2008) point out how using visualization tools such as GIS for climate purposes requires the engagement of a diverse range of disciplines such as environmental psychology, landscape assessment and human-computer interfaces beyond a preoccupation with the norms and methods of both physical sciences and cartography. The GIS practitioner himself made this point

during the interview, describing how his department could be of technical service if other professionals told them what they wanted.

Another important empirical point is that even though most informants were positive towards GIS and interested in its abilities, they sometimes did not see the personal *utility* as a tool for climate change adaptation. This applied to all groups, for different reasons. The municipal group saw their information needs covered by the GIS department, the businesses mostly outsourced or had a perception of sufficient data for their use, and the household group framed it more as a tool for planning purposes, or for the younger generations.

Also, using GIS requires *spatial literacy*, and it has been proven that not all humans are equally able to encode, process, store and retrieve digitized spatial information (e.g. Taylor & Tversky 1992, Ishikawa & Kastens 2005). To be able to use GIS as an awareness building tool for climate change adaptation, such differences should ideally be reflected in the way a GIS is constructed:

> "It has been suggested that a GIS must take into account factors such as the natural use of spatial language (e.g. Mark 1989), cross-cultural differences, and individual differences in spatial abilities" (Golledge 2002: 251).

Informant A11 raised this issue, in terms of the difference between himself and other members of his family, and attributed it to individual dispositions. Through direct interactions with the Fredrikstad map used in the interviews, most informants showed a good ability to orient themselves on the map, but there were individual differences.

On the individual level, GIS was presented as requiring *active initiative* to use. It does not have the immediacy and easy access as the TV format for instance. It may then just cater to the informants who are already aware of climate change, and not increase the outreach of climate change related information to the other groups. Views of PGIS were not entirely positive either, with household informants questioning the validity of adding user-generated data, at least without some form of monitoring. Having said that, again, one informant framed it as a generational issue.

It was not surprising that few informants mentioned the philosophical critiques, summed up in the three waves from Chapter 3, as these are concerns that are mostly identified and discussed within the academic GIS community. People normally do not question map subjectivity, and take for granted that what is represented is unbiased and correct. This was also the case with all the Fredrikstad

informants. The few voiced concerns were more related to data quality, resolution or updating frequency than worry over power and exclusion. Nevertheless, what including issues like this adds to the discussion is that it serves as a backdrop towards assessing the theoretical usability of GIS in climate change adaptation, particularly discovering deficiencies where the cognitive challenges of adapting are not well enough represented.

7.2.3 Requirements and Conditions for Local Context Use

A local level contextual factor that might inhibit the use of GIS in addressing climate change adaptation in general is *centralization* (Underdal 1998). This limits the scope of decision-makers on the municipal level, as they have to operate within a given budget of economic transfers and compulsory tasks. This factor has been addressed in terms of institutional adaptation to climate change related floods by Næss et al. (2005). Together with a weak culture of participatory planning processes in Norway, and few, if any, attempts at utilizing participatory GIS, the potential scope for this approach looks limited. However, the empirical data collected in Fredrikstad testify to a countering force, in its already established strong GIS capacity and willingness to further GIS as a tool for adaptation. The individual capacity of the GIS practitioner and the environmental adviser, in combination with efforts connected to Cities of the Future and other research programmes that Fredrikstad participates in, suggest the there is potential for GIS at the local level. One issue that has to be resolved nevertheless, is availability and quality of local level climate data, both quantitative, and, above all qualitative. Few plans describing how adaptation is supposed to take place locally exist.

The GIS tool does not need to be participatory as long as multiple perspectives and stakeholders are allowed to come with suggestions for relevant factors to be added. The already established GIS tool on Fredrikstad's website is a good platform on which to continue to build on, both as a decision support tool and as a form of communication and awareness rising for the local community. More vivid and concrete information is needed, and perhaps opening up for multimedia could tie the information closer to home, and bridge parts of the gap between awareness and action.

7.2.4 GIS, Cognition and the Three Waves of Critique: Towards a 4th Wave?

Regarding the first wave of critique on charges of *positivism*, this thesis finds that there are reasons to at least question the positivist assumptions of GIS in its modern day version. Most of the current work done within GIS does not intend to establish global laws, but rather to explore alternative representations of reality and the notion of objective and neutral science is highly questioned by the discursive elements of GIS representation. The connection to climate change adaptation may also require a mixed epistemological toolkit to be at work, and a need to look at GIS representations as "interested visions" rather than "absolute reality" (Schuurman 2004). The social factors and mechanisms of adaptation are not necessarily easily shown as a concrete objects on a GIS map, but insights could be embedded in the way GIS is constructed and by using newer methods such as fuzzy logics. This could possibly also align better with cognitive needs.

The issue of *power* highlighted during the second wave of critique is particularly interesting in light of climate change adaptation as a social process. New challenges are raised for GIS, as it is not clear cut or obvious what the "right" ways of representing the phenomena is due to abstract nature of climate change and adaptation, uncertainty and differences in views and cognitions. This grants great power to the makers of maps and GIS representations, in the Fredrikstad case, the GIS department of the municipality administration. The empirical data points to the preference of most informants for them having this definitional power as authorities in the local community.

The third wave deals with *participation* as a solution to the critiques of the two earlier waves. As shown, the feelings with regard to using participatory GIS (PGIS) in the community were slightly tepid, at least as a freestanding entity without some element of control. However, the findings imply that it may be a generational issue. In general, openings for PGIS use has to be assessed closely, as this is not a finite "solution" to the critical GIS critiques, and has been seen in itself not enough to ensure an unbiased starting point for decision making based purely on the multiplicity of voices and perspectives. There must also be agreement about common standards and starting points for instance (Sheppard & Cizek 2008), if it is to be a desirable and trustworthy tool.

With these concerns taken into account, perhaps it is time for a *4th wave of critique* that addresses the cognitive challenges that arise in light of the new social problem of climate change impacts more closely? Psychological factors have not been addressed sufficiently in the GIS literature so far, although some more progressive efforts, such as weAdapt and SoftGIS, exist. weAdapt (see Figure 7) includes narratives, video and text in a more advanced setup that normal GIS. SoftGIS research focuses on "analysing experiential knowledge of the residents with GIS and quantitative techniques" (Rantanen & Kahila 2009: 1981-1982) and has roots in urban planning, organization and learning studies, geography and environmental psychology. Such multi-disciplinarily and multi-media frameworks could be interesting for developing future climate change adaptation applications, and a wider inclusion of for instance environmental psychologists in the development of a GIS tool for adaptation would be beneficial. The proposition of a 4th wave of critique related to *psychology* means that GIS practitioners and developers need to consider more closely how psychological factors are represented in GIS, and how these principles affect the people who view the maps and carry out analysis. Both cognitive factors in dealing with risk, and in understanding map and GIS information itself should become a more central part of GIScience research. That most people outside of the academic debate do not recognize or question map information, just means that it becomes increasingly important to provide as multi-faceted representations as possible in light of new social challenges.

7.3 Conclusion

The aim of this thesis was to explore the cognitive challenges of climate change adaptation, and assess the potential for GIS to address these in order to enable both successful adaptive decision-making and awareness-raising at the local level. The starting point was a critical view based on three historical waves of GIS critique, as a way to stage the discussion to point out *where we should* or *could be going* in the future based on the findings from the Fredrikstad case study.

Many cognitive principles appeared to be at work in the complex local assessments of climate change adaptation. The first research question led to the identification of a disconnection between high individual climate awareness and limited climate change adaptation even for informants that were not climate sceptics. An explanation for this gap could be that the high awareness was accompanied by a impression of few serious local impacts in Fredrikstad, and consequently low risk perception. Since the risk threshold was not crossed, adaptation appraisal did not activate and no measures were implemented, in accordance with the workings of the MPPACC (Grothmann & Patt 2005). Even when the risk was perceived to be great, other factors such as uncertainty, mistrust of experts, denial, undervaluing of risk associated with a long time perspective, lack of control and habit, could impact on the scope for adaptation. These dynamics particularly applied to the household informants, but also affected the other two groups. The actions of the business group were additionally controlled by customer demand and national regulations. As for the municipal level, institutional barriers to adaptation determining local scope for action, particularly *centralization,* could be an influencing component. As a result of this the related information needs were mostly connected to getting more detailed scenarios, not identifying possible adaptation measures.

The second research question assessed the potential for GIS to address these local contextual cognitive challenges to adaptation. Firstly, structural factors within Fredrikstad opened up possibilities for GIS use, but not without nuance. GIS was predominantly approved of and liked, linked to general *familiarity*, *availability* and *positivity*. Yet, the individual actors had some difficulty in grasping personal utility of GIS, while the businesses perceived no apparent direct needs and the municipality interviewees felt themselves covered by the internal GIS department. Norway does

not have an extensive culture of participation either, and most informants were not too enthusiastic toward participatory tools. A key factor determining this interest and applicability for the household group was age or generation, where younger generations who have grown up in the current visual culture were thought to benefit the most from using GIS.

On the other hand, the beneficial sides to GIS in relation to climate change, constituted through *computerization, spatialization, visualization, participation, communication* and *integration* were recognized and have the potential to increase the viability of GIS as a tool for climate change adaptation. GIS was overall framed as a planning tool, and this points towards using it as a decision support system primarily, with an additional public awareness interface, to advocate a goal of implementing administrative adaptations while stimulating private adaptation. The main potential for GIS to address cognitive challenges lies in its ability to *integrate* analytical and experiential information, *visualize* different scenarios and patterns, and open up for *participation* and *communication*. The municipal GIS department in Fredrikstad was positive to contribute, with the professional input of other disciplines.

Climate change adaptation brings together the need to merge climate scenarios with the cognitive understanding of the issue (complexity, uncertainty, role of agency and structural factors) within a local context in order to communicate adaptation options that can guide action. To do this more successfully, GIS must enhance its ability to integrate experiential and analytical knowledge, to strengthen feelings of local responsibility and impact, elicit stronger images in a visual culture, and enable responsible governance and empowerment. Due to the strong influence of cognitive factors in deciding behaviour both for private adaptation, and for decision makers, it is thought fruitful to advise an even further strengthened inclusion of psychologists in the development of climate change adaptation GIS tools. Initiatives such as weAdapt or SoftGIS are promising starting points for such more radical GIS approaches.

As an extension of this and in light of the new social conditions related to complex and severe climate change impacts it may be time for a *4th wave of critique* within the academic world focusing on *psychology,* in addition to the three preceding of positivism, power and participation. The cognitive factors have and are becoming ever more important, and for GIS to grow a new discussion of its terms and effects on human behaviour is needed. The work on the influences of GIS on behaviour in the

field is as of yet exploratory and not adequately tested empirically. The MPPACC has proved a valuable explanatory framework, but also needs more testing for application as a model for explaining how decision makers and administrative adaptation works.

The final conclusion of this thesis is that in order to make maps that matter, we need to investigate the underlying challenges that may hinder adaptation from taking place at all societal levels, and integrate them into how we construct the tools we use to take decisions. GIS is not, and will probably never be, a neutral tool, and there are several problems associated with its use. The philosophical critiques presented in Chapter 3 are not what occupies the informants' minds though, as they express everyday needs based on the practicality of the tool and priorities in their lives or operation. Reaching beyond focusing on problems, great opportunities for powerful integration and communication with GIS exist, as the stakes are getting higher. Not just in Fredrikstad, but all over the world, as the effects of climate change are increasingly seen. The challenges for Fredrikstad are not unique, and these dynamics may be found elsewhere. This thesis has highlighted the need to include multiple views and factors that influence how the world is seen in a GIS, although a tool that tries to include everything and everyone can ultimately risk ending up a tool for no one, and therefore we may need multiple GISes.

8. References

Aaheim, A. (ed), Dannevig, H., Ericsson, T., van Oort, B., Innbjør, L., Rauken, T., Vennemo, H., Johansen, H., Tofteng, M., Aall, C., Groven, K. & E. Heiberg. 2009. Konsekvenser av klimaendringer, tilpasning og sårbarhet i Norge. Rapport til Klimatilpasningsutvalget. CICERO Report 2009: 4. http://nou-klimatilpassing.no/Lists/Nyheter/Attachments/26/NOU_Klimatilpassing_konsekvenser_av_klimaendringer_rapport_II.pdf (downloaded 01.11.09).

Adger, W.N., S. Agrawala, M.M.Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit and K. Takahashi. 2007. Assessment of adaptation practices, options, constraints and capacity. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 717-743.

Adger, W.N., Arnell, N.W. & E.L. Tompkins. 2005. Successful adaptation to climate change across scales. *Global Environmental Change, 15, 77–86.*

Adger, W.N., Dessai, S., Goulden, M. Hulme, M., Lorenzoni, I., Nelson. D.R., Næss, L.O., Wolf, J. & A. Wreford. 2009a. Are there social limits to adaptation to climate change? *Climatic Change, 93, 335-354.*

Adger, W.N., Lorenzoni, I. & K.L. O'Brien (eds.). 2009b. *Adapting to Climate change: Thresholds, Values, Governance.* Cambridge University Press: Cambridge, UK.

Alcamo, J., J.M. Moreno, B. Nováky, M. Bindi, R. Corobov, R.J.N. Devoy, C. Giannakopoulos, E. Martin, J.E. Olesen, A. Shvidenko. 2007. Europe. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 541-580.

Becker, H.S. 1996. The Epistemology of Qualitative Research. In: Jessor, R., Colby, A. & R. Schweder (eds.). *Essays on Ethnography and Human Development.* University of Chicago Press: Chicago.

Bostrom, A. & D. Lashof. 2007. Weather or climate change? In: Moser, S.C. & L. Dilling (eds). *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change.* Cambridge University Press: Cambridge, UK.

Burton, I., Huq, S., Lim, B., Pilifosova, O. & E.L. Schipper. 2002. From impacts assessment to adaptation priorities: the shaping of climate policy. *Climate Policy, 2, 145-159.*

Christou, E., I. Valachis & C. Anastasiadou. 2008. Research Methodology in Hospitality Industry: The role of the Inquiry Paradigms. Conference paper, http://www.ul.edu.lb/fthm/papers/3rd%20Axis/Methodology%20greece.doc (downloaded 27.11.08).

Corbett J, Rambaldi G., Kyem P., Weiner D., Olson R., Muchemi J., McCall, M. & R. Chambers. 2006. Mapping for Change: The emergence of a new practice. PLA 54:13-19

IIED, London, UK. http://www.iapad.org/publications/ppgis/ch01_overview_pp13-19.pdf (downloaded 18.09.09).

Crampton, J.W. 2001. Maps as social constructions: power, communication and visualization. *Progress in Human Geography, 25 (2), 235-252.*

Curry, M. 1997. The digital individual and the private realm. *Annals of the Association of American Geographer, 87, 681-99.*

——1998. *Digital places: living with geographic information technologies.* Routledge: London, UK.

Dessai, S. & M. Hulme. 2004. Does climate adaptation policy need probabilities? *Climate Policy 4, 107-128.*

—— 2007. Assessing the robustness of adaptation decisions to climate change uncertainties: A case study on water resources management in the East of England. *Global Environmental Change 17, 59-72.*

DSB. 2007. Befolkningsundersøkelse om klimatilpasning. Rapport. http://www.dsb.no/Global/Publikasjoner/2007/Rapport/befolkningsundersokelseweb.pdf (downloaded 18.06.09).

Dunn, C.E. 2007. Participatory GIS – a people's GIS? *Progress in Human Geography, 31(5), 616-637.*

Elwood, S. 2006a. Critical Issues in Participatory GIS: Deconstructions, Reconstructions, and New Research Directions. *Transactions in GIS, 10 (5), 693-708.*

—— 2006b. Negotiating Knowledge Production: The Everyday Inclusions, Exclusions, and Contraditions of Participatory GIS Research. *The Professional Geographer, vol 58 (2), 197-208.*

—— 2009. Geographic Information Science: new geovisualization technologies – emerging questions and linkages with GIScience research. *Progress in Human Geography, 33 (2), 256-263.*

Elwood, S. & H. Leitner. 2003. Community-based planning and GIS: Aligning neighborhood organizations with state priorities? *Journal of Urban Affairs 25: 139–57.*

Evans, A.J. & T. Waters. 2008. Mapping vernacular geography: web-based GIS tools for capturing "fuzzy" or "vague" entities. *International Journal of Technology, Policy and Management, vol. 7 (2), 1468-1495.*

Few, R., Brown, K. & E.L. Tompkins. 2006. Public participation and climate change adaptation: avoiding the illution of inclusion. *Climate Policy 7: 46-59.*

Fisher, P. (ed). 1995. *Innovations in GIS 2: selected papers from the Second National Conference on GISResearch UK*. Taylor & Francis: London, UK.

Flowerdew, R. & D. Martin (eds.). 2005. *Methods in Human Geography. A guide for students doing a research project.* 2nd edition. Pearson Education Ltd: Essex, UK.

Flyvbjerg, B. 2004. Five misunderstandings about case-study research. In: Seale, C., Gobo, G., Gubrium, J.P. & D. Silverman (eds.). *Qualitative Research Practice.* Sage Publications: London, UK.

Forester, J. & S. Cinderby. 2005. Geographic information systems for participation. In: Leach, M., Scoones, I. & B. Wynne. *Science and Citizens. Globalization and the challenge of engagement.* Zed Books: New York.

Fredrikstad kommune. 2001. Klima- og energiplan 2001 for Fredrikstad kommune. http://www.ceroi.net/kommuner/fredrikstad/files/klima_og_energiplan.pdf (downloaded 11.03.08).

—— 2007. Klima- og energiplan 2007 for Fredrikstad kommune. http://www.fredrikstad.kommune.no/Documents/Politikk/Planer/Klimaplan_2007.pdf (downloaded 11.03.08).

Gardner, D. 2009. Risk: The Science and Politics of Fear. Virgin Books: London.

Golledge, R. 2002. The Open Door of GIS. In Bechtel, R.B. & A. Churchman (eds). *Handbook of environmental psychology.* Wiley: New York.

Golledge, R., Bell, S. & V.J. Dougherty. 1994. The cognitive map as an internalized GIS. *Paper presented at the 90th Annual Meeting of the Association of American Geographers, San Fransisco, USA.*

Goodchild, M. 1991. Just the facts. *Political Geography Quarterly, 10, 335-37.*

—— 1995. Geographic Information Systems and Geographic Research. In: Pickles, J. (ed). *Ground Truth. The Social Implications of Geographical Information Systems.* The Guilford Press: New York.

Gore, A. 2007. *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It.* Emmaus, PA: Rodale.

Grothmann, T. and A. Patt. 2005. Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global Environmental Change, vol. 15, no. 3, p. 199-213.*

Grothmann, T. & F. Reusswig. 2006. People at Risk of Flooding: Why Some Residents Take Precautionary Action While Others do not. *Natural Hazards (2006) 38: 101–120.*

Groven K., Sataøen og C. Aall (2006): *Regional klimasårbarheitsanalyse for Nord-Norge. Norsk oppfølging av Arctic Climate Impact Assessment (NorACIA).* Vestlandsforsking, rapport nr. 04/06.

Haklay, M. 2002. Public Environmental Information – Understanding Requirements and Patterns of Likely Public Use. *Area, vol. 42, issue 1, 17-28.*

Hanssen-Bauer, I (ed.), Førland, E.J., Roald, L., Hisdal, H., Lawrence, D., Drange, H., Nesje, A., Vasskog, K., Sandven, S., Ådlandsvik, B., & S. Sundby. 2009. *Klima i Norge 2100. Bakgrunnsmateriale til NOU Klimatilpassing.* Foreløpig utgave juni 2009. Norsk Klimasenter: Oslo/Bergen.
http://nou-klimatilpassing.no/Lists/Nyheter/Attachments/16/klimatilpassing_endelig_lavoppl.pdf (downloaded 26.06.09).

IPCC. 2005.Special Report on Safeguarding the Ozone Layer and the Global Climate System. http://www.mnp.nl/ipcc/pages_media/SROC-final/SpecialReportSROC.html (downloaded 30.05.09).

IPCC. 2007a. *Climate Change 2007: Synthesis Report*. *Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Core Writing Team: Pachauri, R.K. & A. Reisinger (Eds.). IPCC: Geneva, Switzerland.

IPCC. 2007b. Appendix I. Glossary. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J.& C.E. Hanson (Eds.). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press: Cambridge, UK and New York, USA.

Ishikawa, T. & K.A. Kastens. 2005. Why Some Students Have Trouble with Maps and Other Spatial Representations. *Journal of Geoscience Education, 53 (2), 184-197.*

Iversen, T., Benestad, R., Haugen, J.E., Kirkevåg, A., Sorteberg, A., Debernard, J., Grønås, S., Hanssen-Bauer, I., Kvamstø, N,G, Martinsen, E.A., T. Engen-Skaugen. 2005. *Norges klima om 100 år. Usikkerheter og risiko*. RegClim, met.no, Oslo. http://regclim.met.no/presse/download/regclim_brosjyre2005.pdf (downloaded 11.10.09).

Janssen, M., Goosen, H. & N. Omtzigt. 2006. A simple mediation and negotiation support tool for water management in the Netherlands. *Landscape and Urban Planning, vol. 28, 71-84.*

Johnston, R.J., Gregory, D., Pratt, G. & M. Watts (eds.). 2003. The Dictionary of Human Geography.

Kahneman, D. 2003. A Perspective on Judgment and Choice. Mapping Bounded Rationaly. *American Psychologist, vol. 58, no. 9, 697-720.*

Kempton,W., Boster, J. S., and Hartley, J. A.. 1995. *Environmental Values in American Culture*. MIT Press, Cambridge.

Klein, R.J.T., Alam, M., Burton, I., Dougherty, W.W., Ebi, K.L., Fernandes, M., Huber-Lee, A., Rahman A.A., and Swartz, C. 2006. Application of environmentally sound technologies for adaptation to climate change; United Nations Framework Convention on Climate Change Secretariat, Bonn, Germany, Technical Paper FCCC/TP/2006/2, 107 p.

Kollmuss, A. & J. Agyeman. 2002. Mind the gap: why do people act environmentally and what are the barriers to pro-environment behavior? *Environmental Education Research., vol. 8 (3), 239-260.*

Kwan, M-P. 1999. Gender and individual access to urban opportunities: A study using space-time measures. *The Professional Geographer, vol. 51, no.2, 210-227.*

—— 2000. Gender diffences in space-time constraints. Area, 32, 2, 145-156.

—— 2009. Three recent developments in critical GIS. *Cartographica, vol.44, no.1, 11-12.*

Leach, M., Scoones, I. & B. Wynne. 2005. *Science and Citizens. Globalization and the challenge of engagement.* Zed Books: New York.

Leiserowitz, A. 2003. *Global Warming in the American Mind: The Roles of Affect, Imagery, and Worldviews in Risk Perception, Policy Preferences and Behavior,* Environmental Science, Studies and Policy, University of Oregon.

—— 2006. Climate change risk perception and policy preferences: the role of affect, imagery, and values. *Climatic Change 77, 45-72.*

Leivestad, H.H., Groven,K., Aall, C., Selstad, T. & Ø.A. Høydal. 2008. Naturskade i Fredrikstad kommune. Klima- og samfunnsscenarier for 2025 og 2060. *Vestlandsforsking-notat nr. 1/2008.*

Lejano, R. 2008. Technology and Institutions: A Critical Appraisal of GIS in the Planning Domain. *Science, Technology & Human Values, volume 33, number 5, 653-678.*

Longley, P., Goodchild, M., Maguire, D. & D.W. Rhind. 2005. *Geographic Inbformation Systems and Science.* Wiley. 2nd edition. Wiley Ltd: Chichester.

MacEachren, A. M. 2004. *How Maps Work: Representation, Visualization and Design.* Paperback edition of the 1995 original. The Guilford Press: New York.

Marx, S.M., Weber, E.U., Orlove, B.S., Leiserowitz, A., Krantz, D.H., Romcoli, C. & J. Phillips. 2007. Communication and mental processes: experiential and analytic processing of uncertain climate information. *Global Environmental Change 17 (1), 47-58.*

McCall, M.K. 2003. Seeking good governance in participatory-GIS: a review of processes and governance dimensions in applying GIS to participatory spatial planning. *Habitat International 27, 549–73.*

McCright, A.M. 2007. Dealing with climate change contrarians. In Moser, S. & L. Dilling. *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change.* Cambridge University Press: Cambridge, UK.

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao. 2007: Global Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press: Cambridge, UK and New York, USA.

Morgan, M.G., Fischhoff, B., Bostrom, A. & C.J. Atman. 2002. *Risk Communication: A Mental Models Approach.* Cambridge University Press: Cambridge, UK.

Morgan, M.G., Kandlikar, M., Risbey, J. & H. Dowlatabadi. 1999. Why Conventional Tools for Policy Analysis Are Often Inadequate for Problems of Global Change. *Climatic Change 41, 271-281.*

Moser, S.C. 2007. More bad news: the risk of neglecting emotional responses to climate change information. In Moser, S. & L. Dilling. *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change.* Cambridge University Press: Cambridge, UK.

Moser, S.C. & L. Dilling (eds). 2007. *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change.* Cambridge University Press: Cambridge, UK.

Nicholson-Cole, S. 2005. Representing climate change futures: a critique on the use of images for visual communication. *Global Environmental Change, vol. 17, 47-58.*

Næss, L.O. et al. 2005. Institutional adaptation to climate change: Flood responses at the municipal level in Norway. *Global Environmental Change, 15, 125-138.*

O'Brien, K., Eriksen, S., Sygna, L. & L.O. Næss. 2006. Questioning Complacency: Climate Change Impacts, Vulnerability, and Adaptation. *Ambio Vol 35, No. 2, 50-56.*

O'Brien, K. L. & R.M. Leichenko. 2000. Double Exposure: assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change 10, 221–232.*

O'Brien, K., Sygna, L. & J.E. Haugen. 2004. Vulnerabile or resilient? A multi-scale assessment of climate impacts and vulnerability in Norway. *Climatic Change, 64, 193-225.*

Parry, M.L., Canziani, O.F., Palutikof, J., van der Linden, P., & C. Hanson (Eds.). 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 976pp.

Parry, M., Lowe, J. & C. Hanson. 2009. Overshoot, adapt and recover. *Nature, volume 458, 1102-1103.*

Patt, A. 2009. Learning to crawl: how to use seasonal climate forecasts to build adaptive capacity. In: Adger, N.W., Lorenzoni, I. & K. O'Brien. 2009. *Adapting to climate change: Thresholds, values, governance.* Cambridge University Press: Cambridge, UK.

Patt, A. & S. Dessai. 2005. Communicating uncertainty: lessons learned and suggestions for climate change assessment. *C.R. Geoscience 337, 425-441.*

Pavlovskaya, M. 2002. Mapping urban change and changing GIS: Other views of economic restructuring. *Gender, place and culture: A journal of feminist geography, vol 9 (3), 281 – 289.*

—— 2006. Theorizing with GIS: a tool for critical geographies? *Environment and Planning A, vol 38, 2003-2020.*

Peet, R. 1998. *Modern geographical thought.* Blackwell: Oxford.

Pickles, J. (ed). 1995. *Ground Truth. The Social Implications of Geographic Information Systems*. Guildford Press: New York.

Rantanen, H. & M. Kahila. 2009. The SoftGIS approach to local knowledge. *Journal of Environmental Management 90, 1981-1990.*

Rosenzweig, C., G. Casassa, D.J. Karoly, A. Imeson, C. Liu, A. Menzel, S. Rawlins, T.L. Root, B. Seguin, P. Tryjanowski. 2007. Assessment of observed changes and responses in natural and managed systems. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 79-131.

Rubin, H.J. & I.S. Rubin. 2005. Qualitative interviewing: the art of hearing data. Sage Publications: Thousand Oaks, US.

Sataøen, H.L. & C. Aall. 2007. Introduksjon til klimasårbarhet og klimatilpasning i Fredrikstads klima- og energiplan. In: Fredrikstad kommune. 2007. *Klima- og energiplan 2007 for Fredrikstad kommune.*

Schneider, S.H. 1996. Don't Bet All Environmental Changes Will Be Beneficial. *APS News Online August/September 1996 Edition.* http://home.att.net/~rpuchalsky/sci_env/sch_quote.html#quote *(viewed 29.10.09).*

Scientific Expert Group on Climate Change (SEG). 2007. *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*. Report prepared for the United Nations Commission on Sustainable Development. Sigma Xi, Research Triangle Park, NC, and the United Nations Foundation, Washington, DC, 144 pp. http://www.globalproblems-globalsolutionsfiles.org/unf_website/PDF/climate%20_change_avoid_unmanagable_manage_unavoidable.pdf (downloaded 17.10.09).

Schuurman, N. 2000. Trouble in the Heartland: GIS and its critics in the 1990s. *Progress in Human Geography, vol. 24, nr. 4, 569-590.*

—— 2004. *GIS: A Short Introduction.* Blackwell Publishing: Oxford, UK.

—— 2006. Formalization Matters: Critical GIS and Ontology Research. *Annals of the Association of American Geographers, vol. 96, nr 4, pp. 726- 739.*

Schuurman, N. & G. Pratt. 2002. Care of the Subject: feminism and critiques of GIS. *Place, Gender and Culture, vol 9, issue 3, 291-300.*

Seale, C., Gobo, G., Gubrium, J.P. & D. Silverman (eds.). 2004. *Qualitative Research Practice.* Sage Publications: London, UK.

Sheppard, S.R.J. 2005. Landscape visualisation and climate change: the potential for unfluencing perceptions and behaviour. *Environmental Science & Policy, Issue 8, 637-654.*

Sheppard, S.R.J & P. Cizek. 2008. The ethics of Google Earth: Crossing thresholds from spatial data to landscape visualisation. *Journal of Environmental Management, 1-16, doi: 10.1016/j.jenvman.2007.09.102*

Skaugen, T., Astrup, M., Roald, L.A. and Skaugen, T.E. 2002. *Scenarios of extreme precipitation of duration 1 and 5 days for Norway caused by climate change.* Consultancy Report no 7-2002, met.no Report 21/02 KLIMA. Oslo: Norwegian Water Resources and Energy Directorate/Norwegian Meteorological Institute.

Slovic, P. 2000. *The Perception of Risk*. Earthscan, London.

Smit, B., Burton, I., Klein, R. & J. Wandel. 2000. An anatomy of adaptation to climate change and variability. *Climate Change, vol. 45, 223-251.*

Smit, B. & J. Wandel. 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, vol. 16, issue 3, 282-292.*

Smith, M.J. 2003. *Social Science in Question.* Sage Publications: London.

Snow, J., Clayton, S., Doherty, T., Gifford, R., Howard, G., Reser, J., Stern, P. & E. Weber. 2009. Psychology and Global Climate Change: Addressing a Multi-faceted Phenomenon and Set of Challenges. *A Report by the American Psychological Association's Task Force on the Interface Between Psychology and Global Climate Change.* www.apa.org/releases/climate-change.pdf (downloaded 02.11.09).

Soobrayan, Venitha. 2003. Ethics, Truth and Politics in Constructivist Qualitative Research. *Westminster Studies in Education, 26(02), 107-123.*

Sorrell, S. 2003. Making the link: climate policy and the reform of the UK construction industry. *Energy Policy 31, 865–878.*

St.Martin, K. & J.Wing. 2007. The Discourse and Discipline of GIS. *Cartographica, 42(3), 235-248.*

Stake, R.E. 2005. Qualitative Case Studies. In: Denzin, N.K. & Y.S. Lincoln (eds). *The Sage Handbook of Qualitative Research.* Third edition. Sage Publications: Thousand Oaks, US.

Sundblad, E-L. 2008. *People's knowledge about climate change: Uncertainty as a guide to future commitments.* Dissertation. Department of Psychology, University of Gothenburg, Gothenburg, Sweden.

Swim, J., Clayton, S., Doherty, T., Gifford, R., Howard, G., Reser, J. Stern, P. & E. Weber. 2009. Psychology and Global Climate Change: Addressing a Multi-faceted Phenomenon and Set of Challenges. A Report by the American Psychological Association's Task Force on the Interface Between Psychology and Global Climate Change. http://www.apa.org/releases/climate-change.pdf. (downloaded 19.10.09).

Taylor, P. 1990. GKS. Political Geography Quarterly, vol. 9, 211-12.

Taylor, H. A. & B.Tversky. 1992. Spatial mental models derived from survey and route descriptions. *Journal of Memory and Language, 31, 261-282.*

Thagaard, T. 2003. *Systematikk og innlevelse. En innføring i kvalitativ metode.* 2.utgave. Fagbokforlaget: Bergen.

Tompkins, E. & W.N. Adger. 2005. Defining response capacity to enhance climate change policy. *Environmental Science & Policy, 8, 562-571.*

Tveito, O.E. 2008. The use of GIS for decribing the Norwegian climate. Paper for the 20th Nordic GIS user conference 2008, Fredrikstad. http://www.ginorden.org/events/gikonferanser/the-20th-nordic-gis-conference-2008-in-fredrikstad-1/session-c-environment-and-climate/the-use-of-gis-for-describing-the-norwegian/at_download/file (downloaded 02.05.09).

Tversky, A. & C.R. Fox. 1995. Weighing Risk and Uncertainty. *Psychological Review, vol. 102, no. 2, pp. 269-283.*

Tversky, A. & D. Kahneman. 1974. Judgment and Uncertainty: Heuristics and Biases. *Science 185, 1124-1131.*

Underdal, A. 1998. Explaining Compliance and Defection: Three Models. *European Journal of International Relations, Vol. 4(1), 5-30.*

Veregin, H. 1995. Computer Innovation and Adoption in Geography. In: Pickles, J. (ed). *Ground Truth. The Social Implications of Geographical Information Systems*. The Guildford Press: New York.

Vevatne, J., Westskog, H. & K. E. Hauge. 2005. *Betydningen av kommunal klimapolitikk. Virkemidler, potensial og barrierer. En utredning for Miljøverndepartementet.* Report 2005:06. CICERO: Oslo, Norway.

Walker, B. H., L. H. Gunderson, A. P. Kinzig, C. Folke, S. R. Carpenter, and L. Schultz. 2006. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society 11(1): 13*. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art13/ (downloaded 03.06.09).

Weber, E. 2006. Evidence-based and description-based perceptions of long-term risk: Why global warming does not scare us (yet). *Climatic Change, 77, 103-120.*

Whitmarsh, L. 2008. What's in a name? Commonalities and differences in public understanding of "climate change" and "global warming". *Public Understanding of Science, Vol. 17, Sept., 1-20.*

Yohe, G. & R.S.J. Tol. 2002. Indicators for social and economic coping capacity – moving toward a working definition of adaptive capacity. *Global Environmental Change, vol. issue 1, 25-40.*

Appendix 1. Information Letter for Participants in the Study

The following letter (in Norwegian) was sent to all informants, in addition to a consent form for signature prior to the interviews.

Information for Participants in the Study

Project title: "Use of geographical information systems (GIS) in climate change adaptation – possibilities and challenges".

What is the study about?

The study will be carried out by Ida Skivenes, a master's student in human geography at the University of Oslo. The thesis will be about use of a mapping tool called geographical information systems, GIS, in climate change adaptation on the local level. The aim of the project is to see how this tool can be useful for supporting different adaptation decisions, and possibly what problems such a use can entail. Fredrikstad has been chosen because GIS is used relatively actively here, and there has been interest for climate change questions through municipality plans and participation in other projects.

What is the purpose of the interviews?

The interviews are done to reveal different understandings of climate change and adaptation, and what type of information different groups feel they need. Further, there will be focus on views of maps and the GIS tool.

How and why was I chosen?

A selection of three groups of stakeholders in Fredrikstad will be interviewed: households, businesses and municipality employees. You have been chosen as a representative from one of these categories communicated through contact from environmental advisor Rolf Petter Heidenstrøm in Fredrikstad municipality. The household representatives were chosen from a list of leaders of local community associations, while the businesses are recruited through recommendation from Fredrikstad Development Association.

What does participating entail?

I want to do an interview with you that will take about 45-60 minutes. With your permission I will tape the conversation, and afterwards transcribe it so that it becomes a text. Examples of GIS will be shown on a PC, and I will ask for your comments through my guidance. The interview questions will be about climate change and the mapping tool, GIS. No previous knowledge or experience with neither climate change nor GIS is required to participate. No sensitive questions will be asked, and your name or directly personal identifying information will not be included in the end product of the study.

Who will know what I said?

The only people who will have access to your recordings and transcribed text will be Ida Skivenes (the interviewer) and professor Karen O'Brien (her supervisor at UiO). All information will be dealt with in a confidential manner and be anonymized at the end of the project.

What risks and benefits are related to participation?

Breach of confidentiality is a potential risk. To protect against this, all recordings and transcribed manuscripts will be kept safely with the interview, access is restricted to this individual and her supervisor. Your name will not appear in the transcribed manuscript or the master's thesis text without your specific permission. As mentioned, the recordings and manuscripts will be destroyed after the conclusion of the project.

Sometimes people experience that an interview can be positive because you get the opportunity to talk about your experiences and expectations. Your participation could also potentially lead to a better understanding of climate change and the use of GIS.

What are my rights as a participant?

Participation in the study is completely voluntary, and you have the opportunity to withdraw from the project whenever you'd like as long as the project is going on. You can refuse to answer whichever question you'd like, or stop the interview at any time if you like.

Where can I get more information about this study?

If you have any questions, want to change your consent or change information you have given, relevant contact information is shown below. Supervisor, and hence the responsible for this project, is Karen O'Brien, professor in human geography at the University of Oslo. Her contact information is also below for any questions.

Supervisor:
Karen O'Brien
Tel: 22 85 84 80
Fax: 22 85 52 53
Email: karen.obrien@sgeo.uio.no
Website: http://www.iss.uio.no/instituttet/ansatte/karenob.xml

Interviewer:
Ida Skivenes
Tel.: 41 50 99 61
Email: idaskivenes@gmail.com

Appendix 2. Example of Interview Guide

The following is an example of an interview guide for businesses and municipality informants. The questions for households followed the same pattern.

Introductory questions
1. Type of business/department?
2. Position?
3. Education?
4. Time of employment?

Climate change
5. What do you associate with the term ”climate change”?
6. Have you seen any changes that you think are related to climate change?
7. What do you think ”climate change adaptation” means?

Impact
8. How does climate change influence your work?
9. What do you consider to be the most important climate change impact for your business/department?
10. Is climate change considerations included in decision making?
11. Has your work place/department implemented any climate change adaptation measures? What/why not?
12. Who do you consider to be responsible to implement climate change adaptation measures?
13. On a scale from 1-10 (where 10 is the highest), how important is climate change for you work place/department?

Information
14. Where do you get information about climate change?
15. How do you prefer to have this information presented?
16. Do you feel that you have the information you need? Why/why not?
17. Which information, if any, do you feel is missing?

GIS
18. Do you have any prior knowledge of GIS? [Short explanation if not.]
19. Do you use GIS in your work? How/why not?

Reaction towards GIS maps on the computer
20. Can you point out the locations important to your business/department?
21. Do you find it easy to understand the maps?
22. Is map/GIS presentations useful for your work? How/why not?
23. What type of information is missing?
24. How does these maps overlap with your perception of the area?
25. Would you be interested in using GIS to learn how to adapt to climate change?