

Learning From Practice:

Exploring the Relationship Between Land
Subsidence, Climate Change and Flood Risk in
Swedish Municipal Level Strategic Planning

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Linköping, May 2022

Charlotte Andersson

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Abstract

Land subsidence is in international academic literature recognised as a significant problem for urban environments. The phenomenon can cause severe damage to infrastructure and buildings resulting in expensive repairs or permanent damage to the ground's conditions and services. In more recent literature, academics have started to connect an increase in land subsidence occurrences to climate change. Performed as a qualitative case study, this thesis research how the relationship between land subsidence and climate change can be understood by exploring Gothenburg municipality's strategic planning strategies for climate adaptation for flood risk. The research utilizes the qualitative methods of document analyses and semi-structured interviews. The thesis' results show the relationship between land subsidence and climate change can be understood as a wicked problem in the sense it is hard to define and require multi-level governance to be managed. Benefits for urban planning are identified as increased knowledge on the relationship would bring more comprehensive management of land subsidence on a larger scale as well as enable faster responses in case of risk of climate change-induced land subsidence occurring, threatening the urban environment. Final suggestions are made to further research what information on land subsidence is relevant to include and in which document to enable more strategic management of the topic.

Keywords: Climate Adaptation, Flood risk, Land subsidence, Municipal planning, Strategic planning theory

Glossary

Anthropocentric	The word anthropocentric comes from the notion of considering humans as the most significant entity of the universe and/or interpreting and describing the world in terms of human values and experiences. To consider an action anthropocentric is to consider it as caused by human actions, values and/or ideas. (Merriam-Webster, n.d., row 5-6)
Aquifer	An aquifer is a geological layer in the earth's subsurface consisting of water-bearing porous rock with the ability to hold volumes of water large enough for groundwater to be collected from them in useful quantities (US Geological Survey, 2018).
Climate Adaptation	Climate adaptation is for this thesis defined according to Storbjörks (2007) formulation as follows: " <i>Adjustments in natural and human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities</i> " (Storbjörk, 2007, p. 458)
Flood risk	This thesis defines flood risk as: " <i>[...] the probability of flooding multiplied by the potential consequences of flooding, such as loss of lives and economic damage</i> " (J. Ward et al., 2011, p. 295)
Governance	Governance is " <i>the act or process of governing or overseeing the control and direction of something, such as a country or an organization</i> " (Merriam-Webster, n.d., row 6-7)
Wicked Problem	A wicked problem is for this thesis defined as a complex, chronic and intractable problem that presents issues for urban planning because of its lack of clarity and difficulty in the definition. A wicked problem also presents issues for urban planning as they are often difficult to resolve using conventional methods (Siriwardane-de Zoysa et al., 2021).

1. Introduction

This thesis addresses an empirically identified and grounded problem related to municipal-level management of land subsidence in strategic planning.

Land Subsidence is a phenomenon where the surface of the earth sinks because the water in the ground has drained. The drainage of groundwater can occur because of both natural and anthropogenic reasons, such as natural fluctuations in water levels, increasing climate temperatures or lowered volumes of precipitation. Examples of anthropogenic causes are excessive pumping of groundwater for drinking water or watering of agriculture, or addition of surface pressures such as heavy buildings (Herrera-García m.fl., 2021; Smith & Knight, 2020; US Geological Survey, 2018). Land subsidence more commonly appears in areas with sensitive geological soil conditions, such as areas with large quantities of clay. Land subsidence is not always noticeable, as it often occurs over large areas, but it can also occur on small points, causing sinkholes (US Geological Survey, 2018).

Land subsidence is in international academic literature recognised as a significant problem for urban environments. The phenomenon can cause severe damage to infrastructure and buildings resulting in expensive repairs or permanent damage to the ground's conditions and services (Herrera-García m.fl., 2021; Smith & Knight, 2020). In more recent literature, academics have started to connect an increase in land subsidence occurrences to climate change.

Climate change is, for instance, caused by emissions of greenhouse gases, causing a global increase in climate temperatures which is predicted to have devastating effects on the earth's hydrological and ecological systems. The impacts of climate change will vary geographically and are described to become manifested gradually. Examples of climate change-related impacts are global sea-level rise, changes in groundwater levels, and an increase in the frequency and magnitude of extreme events such as heatwaves and natural disasters (Sonnek et al., 2013).

These impacts can all be related to land subsidence in the sense that they can cause the initiation of new land subsidence processes or in the sense that land subsidence may enhance the consequences of the climate change impacts (El Shinawi et al., 2022; Herrera-García et al., 2021; Smith & Knight, 2020). This presents a significant problem for urban environments. The research in this thesis explores the relationship between climate change, land subsidence and strategic planning will be explored.

Because of climate change, Sweden has in recent years been experiencing increasing temperatures, especially in summertime leading to draughts. This has increased concerns about water shortages in some parts of the country (Darvishi & Jaramillo, 2020). The Swedish authority Geological survey of Sweden (SGU) published a report in 2015 emphasising the risk of diminishing groundwater levels as a consequence of the rising climate temperatures due to climate change (SGU, 2015). This prediction is supported internationally by the IPCC (IPCC, 2022), and is described as increasing land subsidence risk. Sweden's geological conditions were created during the latest ice age. The melting ice created a "clay-belt" which runs from the southwest of Sweden up towards and along the eastcoast (Schoning, 2016), see figure 1. Layers of clay have unstable mechanical properties which makes it a weak foundation for building and very susceptible to both natural and anthropogenic causes of land subsidence, such as changes in water levels (Fryksten & Nilfouroushan, 2019). Despite Sweden's geological conditions and

climate change becoming more apparent in everyday life, professional discourse concerning the prevention of land subsidence can be considered missing.

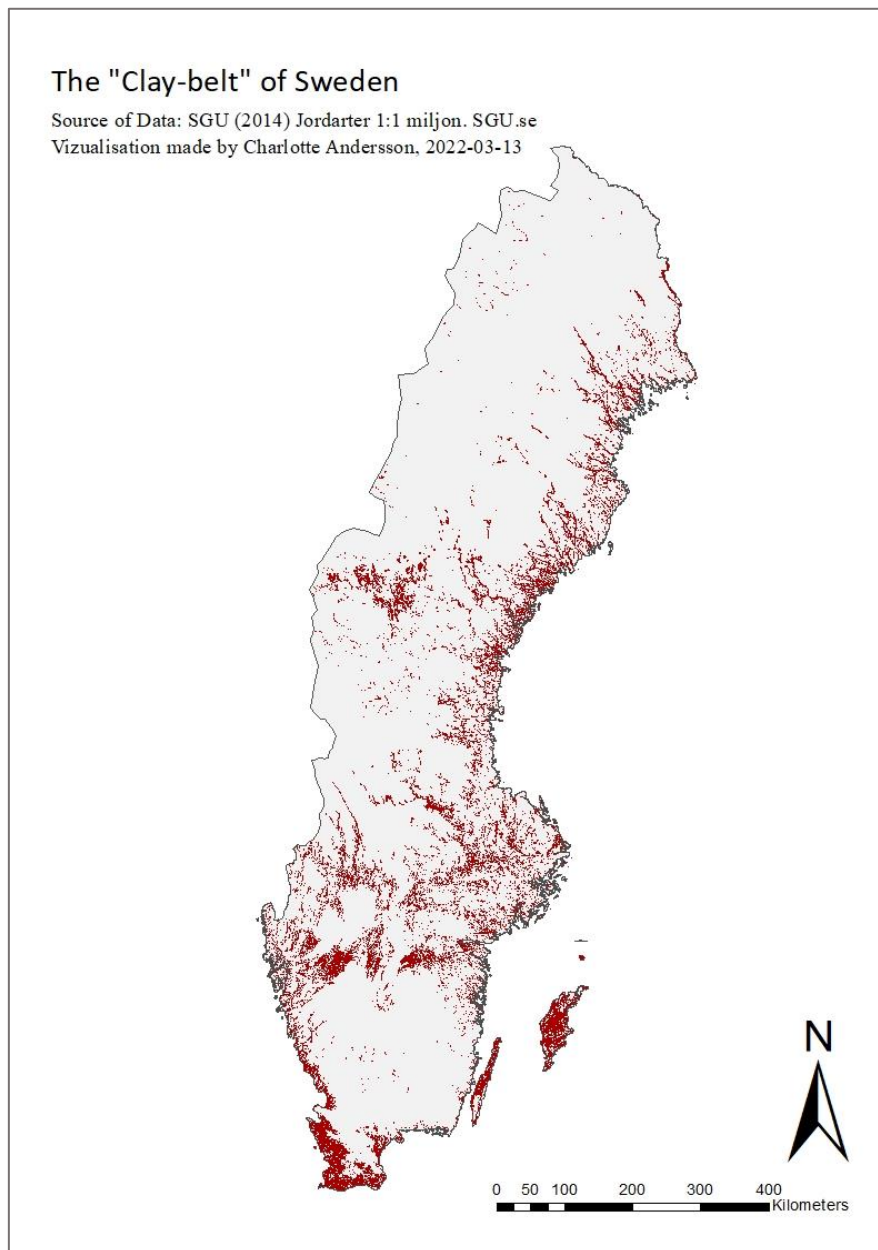


Figure 1: The map visualizes the distribution of clay-rich soils in Sweden. The map is based on data collected by the SGU (2014). The marked areas consist of soil types labelled by the SGU as “moraine or muddy moraine”, “postglacial sand - gravel” and “clay silt”.

The Swedish municipality Gothenburg is a coastal municipality located on Sweden’s west coast (see figure 2). Gothenburg municipality is currently having severe problems related to land subsidence due to its very clay-rich soil conditions. After a significant landslide occurred in the 1970s, Gothenburg has performed continuous monitoring of the municipality’s ground conditions to ensure nothing similar happens again. The purpose of the monitoring programs is towards questions concerning ground stability, which does not necessarily involve land subsidence risk. However, as the programs include monitoring of ground movements and changes in groundwater levels, the data is still used for land subsidence prevention (Andersson,

2022). Predictions for how Gothenburg municipality will be affected by Climate change show the municipality will be impacted by a general increase of water, such as through rising sea levels, increase in precipitation, and extreme weather events, presenting a high risk of fluvial floods and floods from the sea (SGU, 2015). To face these impacts, the municipality is planning for extensive climate adaptation to protect its urban environments from damage (Göteborg Stad, n.d.).

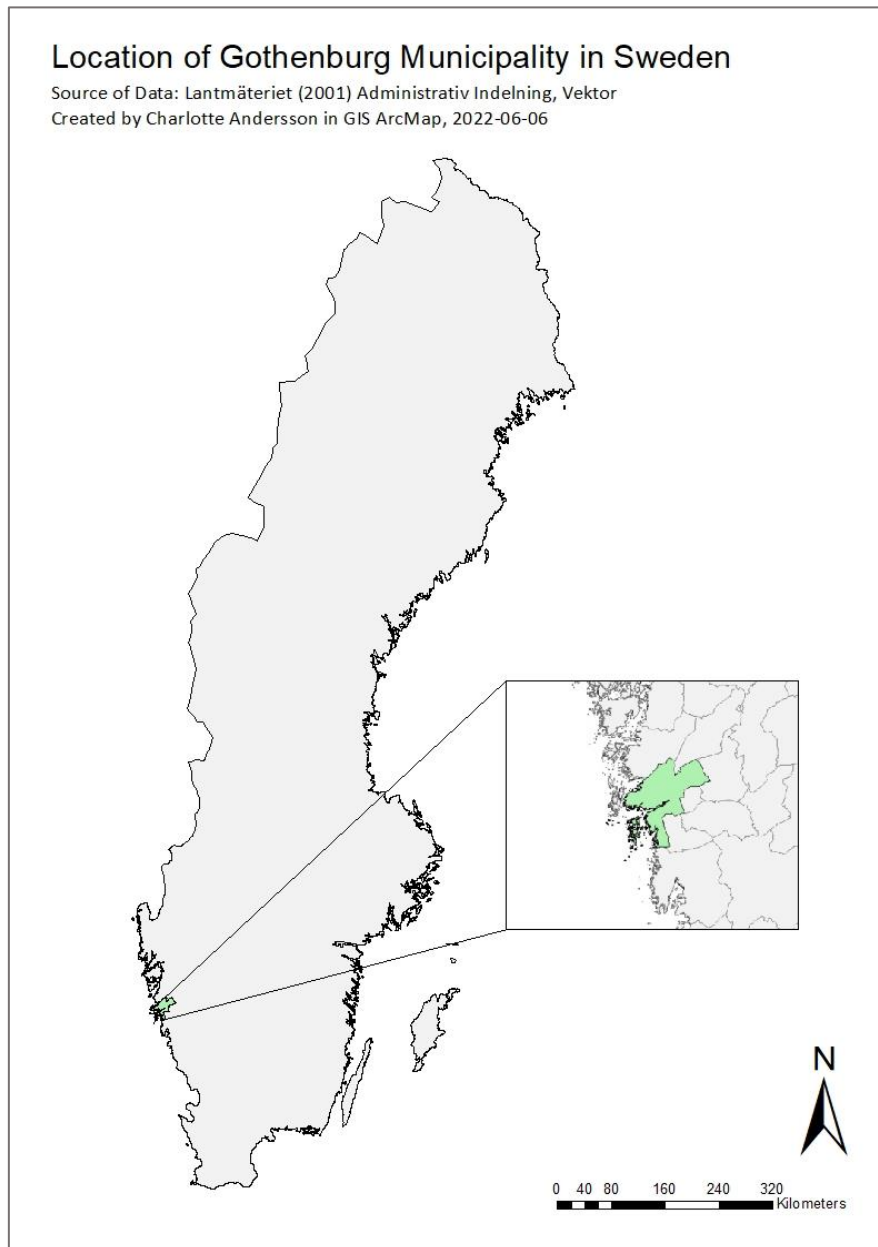


Figure 2: Map of Gothenburg Municipality's location in Sweden. The map shows the municipality's location on Sweden's west coast. The map is created by the author (Charlotte Andersson) using GIS ArcMap, 2022-06-06. Data source: Lantmäteriet, (2001).

As mentioned, land subsidence is often described as a phenomenon that can cause or enhance climate change-related impacts. This is especially true for floods and sea-level rise (Herrera-García et al., 2021; IPCC, 2022; Sonnek et al., 2013). However, the most common climate change-related cause of land subsidence is diminishing groundwater levels and higher

temperatures. In the case of Gothenburg, groundwater levels are predicted to increase (SGU, 2015). This would make it appear as if the risk of land subsidence is, therefore, smaller in Gothenburg, but the risk still exists. Land subsidence can still occur due to faults in planning practices, such as in building technical protections for climate adaptation. Unaware paving of infiltration areas for groundwater, development of sensitive land areas, or incorrect building of house fundamentals are examples of causes that may initiate new land subsidence processes (Andersson, 2022). Thus, as long as urban development continues, even if rainfall increases, the risk of land subsidence still exists and can affect the impacts of climate change. This raises the question of whether there are benefits to integrating the planning of land subsidence with the planning of climate adaptation?

Researchers explain that governing land subsidence can be considered a “wicked problem” because it needs a clear and comprehensive issue definition as well as a common, multi-sectorial policy strategy to address it (Siriwardane-de Zoysa m.fl., 2021). In contrast, climate change is described as the “ultimate” wicked problem (Head, 2014), once again presenting a parallel between the topics and their respective significance for planning. So how can land subsidence be managed strategically? To what extent can Gothenburg municipality’s management of land subsidence be described as strategic? Forsemalm *et al.* (2019), describe that the presence of wicked problems is becoming more common today as our reality is becoming increasingly complex and interconnected. The authors suggest the use of the concept of evidence-based urban planning as a method to ease definitions of wicked or otherwise complex problems and to collect information and make decisions useful to their management. How can the concept of evidence-based urban planning be used to better understand Gothenburg municipality’s management of land subsidence?

Performed as a case study of Gothenburg municipality, this thesis aims to explore the relationship between municipal level strategic planning and management of land subsidence risk and climate adaptation. It aims to explore how the municipality acknowledges and describes land subsidence as a problem for their urban environments and if and/or how they integrate it into their climate adaptation and thus relate it to their climate change-induced high risk of floods. Expected results include good examples of methods and strategies for land subsidence prevention and mitigation as well as further knowledge and understanding of land subsidence as a risk for urban environments and its relationship to climate change.

1.1 Research Problem

The identified research problem for this thesis is defined as a knowledge- gap concerning the relationship between land subsidence and climate change and how it can be integrated into Swedish municipal urban planning. Further knowledge considering how land subsidence can be induced as a result of climate change and in turn how land subsidence can affect climate change-related impacts as well as how this relationship can be strategically managed is needed to ensure the sustainability of urban planning practices.

1.2 Research Questions

The main research question for this thesis is: How can the relationship between land subsidence and climate change be understood by exploring municipal level strategic planning strategies for climate adaptation for flood risk?

Subsidiary questions:

1. How do Gothenburg municipality approach land subsidence and flood risk as strategic planning problems?
2. How does Gothenburg municipality describe the risk of land subsidence in relation to flood risk?
3. How does the risk of land subsidence appear in Gothenburg municipality's climate adaptation strategies?

1.3 Demarcations

The research in this thesis is limited to studying how Gothenburg municipality describes their *strategic* planning practices concerning the topics of climate adaptation, land subsidence and flood risk. This means researching their planning practices on a detailed level is rejected.

“Göteborg Stad” is the Swedish name of Gothenburg municipality. Directly translated it becomes “The City of Gothenburg”. This name is most often used by the municipality when referring to themselves unless in situations when their administrative role as a municipality is significant. As this thesis is restricted to researching Gothenburg municipality as an urban and regional planning institution and to avoid misconceptions, Gothenburg will be solely referred to as Gothenburg municipality.

Throughout the entirety of this thesis, an important difference is made between the terms “Strategic planning” and “Urban planning”. Both terms can in research be used to describe larger theories behind certain forms of planning practices (Gunder et al., 2017; Oliveira & Pinho, 2010) but in this thesis, only the term “Strategic Planning” means to describe a planning theory. In the instances when “Urban planning” is used, it aims to describe the planning of a certain kind of environment, in this case, an urban area's development.

2. Method and Materials

The following chapter contains a description of the thesis research design. It contains descriptions of the materials, methods, and research approach utilized for performing the research as well as a method discussion on how the design may have affected the thesis results and ethical considerations.

2.1 Research Stance

The research in this thesis is performed within the research field of strategic urban and regional planning which means it any analysis made for this thesis stances from a planning perspective. The research design of this thesis utilizes a qualitative research strategy, which means it is designed to *interpreting* its empirical material, rather than identify absolute truths. This approach was chosen as the research aims to study how a certain topic is portrayed, needing an ability to interpret and draw conclusions from textual descriptions. The research also aims for rich, detailed and more dynamic answers. Therefore, the qualitative research methods of document analysis and interviews were selected for data collection and analysis. The utilized research strategy means the results in this thesis are subjective as they are based on interpretations made by the researcher and are thus coloured by her background and personal worldview. A person of different background may thus have reached different results and conclusions (Clark et al., 2021).

2.2 Case Study

This research in this thesis is performed as a case study, which means it focuses on a singular “case” or object of research (David & Sutton, 2016). The object of research in this study is the planning institution of Gothenburg Municipality. Gothenburg Municipality was chosen as it has known and current issues with land subsidence due to, among other reasons, its soil conditions. Gothenburg has also for many years been conducting preventive measures for managing its issues which makes the municipality interesting as a study object (Andersson, 2022).

A case study is most often associated with the research of a geographical location or organization. Using several research objects (or cases) would allow a wider study of the research problem’s appearance also providing a better ability for the research to be applicable in several contexts. However, focusing on a singular case provides a better opportunity to find deeper explanations and clarity concerning the constitution of complex problems (Clark et al., 2021), which is more applicable in the context of this thesis research.

2.3 Materials

The scientific articles used in the research overview chapter were collected from the database Scopus. The search for current research was done using the keywords such as “Land subsidence”, “Climate Adaptation”, “Urban development” and “Groundwater Management”.

The empirical material collected for the document analysis was collected from Gothenburg municipality’s official webpage: Göteborg.se. All the documents used for the document analysis are published and written by Gothenburg municipality. They were selected based on their relevance to the research questions which meant they needed to have relevance for Gothenburg municipality’s climate adaptation work for flooding and sea-level rise and in some way manage the topic of land subsidence. For some of the materials, only parts of individual

documents were analysed. Other parts were left out due to a lack of relevance to the research question. See the selection of documents and respective analysed parts in table 1 below.

Document name	Selected parts	Relevance for research question
Comprehensive plan for Gothenburg (Stadsbyggnadskontoret, 2009)	From Part 1: pages 50-52 "Challenges", & 60-62" Robust society" From part 3: pages 111-125 "Environment and risk factors"	The document guides all planning practices conducted in Gothenburg municipality by presenting Gothenburg's vision for future development, including challenges to reaching the set vision.
Environment and Climate programme for the City of Gothenburg 2021-2030. (Göteborg Stad, 2022)	The entire document (85 pages)	This document is important because it sets the tone for the general climate- and environmental work conducted in Gothenburg by for instance defining important objectives.
Thematical Addition to Gothenburg's Comprehensive Plan: Risk of flooding (TTÖP). Including Appendix 1. (Stadsbyggnadskontoret, 2019)	The main document in its entirety (52 pages) and appendix 1 (52 pages).	This document was selected as it contains the collected knowledge concerning Gothenburg's flood-related risks such as sea-level rise, heavy rains, and high-water levels in watercourses.
Extreme weather situations - How prepared is Gothenburg? (Göteborgs Stadskansli, 2006)	The entire Document (66 pages)	This document was chosen because it provides knowledge of the base from which Gothenburg performs its climate adaptation.
Extreme Weather Events phase 2: Gullbergsvass December 2008 (Göteborgs Stadskansli, 2008)	The entire Document (43 pages)	This document was chosen because it provides knowledge of the base from which Gothenburg performs its climate adaptation.

Table 1: Table showing the empirical materials used for the document analysis. The table is created by the author.

2.4 Document Analysis

The main method of this thesis is document analysis. For the document analysis, 5 documents were chosen (see table 1, and chapter 2.3 above). The document analysis was performed using qualitative thematic analysis (see chapter 2.5 below). The analysis resulted in 5 themes with several sub-categories presented in the thesis' result-chapter, chapter 5.

2.5 Semi-Structured Interviews

The secondary method for data collection that was used in this thesis was semi-interviews with relevant personnel at Gothenburg Municipality. The purpose of the interviews was to collect further knowledge to deepen and complement the results of the document analysis. The interviews were thus a follow-up method/secondary to the document analysis. The interviews provided an opportunity to clarify possible uncertainties and/or add to the collected data from the document analysis. They also provided an opportunity to obtain practitioners' perspectives on the research problem.

In total three interviews were held, all performed on an online platform. The first interview was held with a climate adaptation coordinator working on a specialist level in the municipality with questions concerning climate adaptation strategy and planning for risks related to floods and sea-level rise. The second interview was held with the municipality's geo-coordinator working on a specialist level with questions concerning the ground's conditions and suitability in the context of urban and regional planning. The third interview was held with Gothenburg municipality's climate adaptation coordinator, working on a comprehensive level with responsibilities concerning the municipality's preconditions for climate adaptation.

The respondents were chosen based on their assumed and referenced knowledge concerning the thesis' research subject. For instance, when researching possible interviewees, the selected people were mentioned by their co-workers or the City of Gothenburg's customer service for having the sought information. Thus, they were considered relevant people to include in this research. They were also selected as they individually represented different planning levels ranging from the detailed planning level to the comprehensive strategic level.

The interviews were held semi-structured using an adaptive approach. Each interview was designed individually based on their professional role and responsibilities, assumed knowledge and expertise as well as earlier collected data and previous interviews. Thus, the interviews had different interview guides with different questions. As to the adaptive approach, the interviewees could also be asked questions about the answers of another interviewee. This approach to the interviews was suitable as the research topic meant a certain degree of exploration due to it being relatively unresearched in a Swedish context. As the research progressed and new knowledge was created, the focus of the interviews could be altered thereafter.

Each of the interviews ranged between 30 to 60 minutes. The interview questions were sent out before each interview and all of the respondents signed a consent form for data processing. Each interview was recorded to avoid losing or forgetting information and allow more details in the data collection. After each interview, the recordings were transcribed. The transcriptions were slightly edited for easier reading, removing interrupted sentences and pause-words such as "Uhm" (etc.) but with careful consideration to not lose context. The finished transcriptions were sent out to respective interviewees to provide an opportunity to edit, remove, or add to their answers. Thus, the interviews were performed somewhat systematically. The transcribed interviews were then analysed using the method for Thematic Analysis as described in chapter 2.6 below.

2.6 Qualitative Thematic Analysis

The selected documents for the document analysis and the interviews were analysed using thematic analysis. Thematic analysis was performed based on descriptions of the processes by Boreus & Bergström (2018) and Clark *et al.* (2021). As in their descriptions, the empirical materials are first familiarised and then coded using one- or a couple of words to describe its content. When coding, an inductive approach was used, meaning the codes were based on their content of the materials rather than a pre-set template (Clark *et al.*, 2021). Each of the materials was coded in relative detail, meaning each sentence or couple of sentences was given a certain code. The codes were then put into a table as shown in table 2 below:

Text	Page	Code
The thematic addition presents a model for planning levels that is possible to adapt as knowledge increases.	7	Approach
As flood proofing of new buildings often requires measures in the existing city, the issue cannot be limited to the City Planning Office but is a city-wide issue.	8	Needs strategic planning
Water-related questions connected to climate adaptation are complex and multidisciplinary.	8	Wicked issue
Current legislation and distribution of responsibilities are insufficient to address the adaptation needs of society.	8	Problem description
At the strategic level, further work is needed to develop planning documents to support the planning process. This type of planning document should propose a comprehensive solution for all types of flood risks, based on the strategies of the Thematic Addition.	8	Needs strategic planning
The city's current organisation is ill-equipped to meet the challenges of climate change adaptation.	9	Challenge
Responsibility for climate adaptation is shared between the state, municipalities, and private property owners/operators.	9	Division of responsibility

Table 2: Example of coding. Above coding is an example from coding the thematical addition to Gothenburg's Comprehensive plan (Stadsbyggnadskontoret, 2019).

The codes were then reviewed to identify contrasts between emergent codes as well as clarify vague differences. The codes were then categorized, gathering several codes under over-arching themes. This step provided a better view of which topics were included in each text as well as analytical perspectives on how the topics were presented. The document analysis resulted in 5 themes and the analysis of the interviews in 9 themes (See an example of thematization in Table 3 below). As a final step, the thematic analysis of both documents and analyses was compared and categorised together resulting in 5 themes presented in the thesis' result chapter.

Theme	Sub-Categories	Codes
Current Planning Practice	Approach	Motivations
		Strategic
		Foundation
		Argumentation
	Planning practices	Actions
		Focus area
		Procedure
		Requirements
Assessments	Success factors	Materials
		Resources
		Actions
		Supportive actors
	Objectives	Organization
		Collaboration
		Targets
		Regulation

Table 3: Example of thematization. The image shows a simplified version of the thematization performed at the end of the thematical analysis of the empirical documents. It aims to explain how several subsidiary themes are categorized under the main themes, which in turn contain several codes.

2.7 Method Discussion

2.7.1 Document Analysis

In similarity to the interviews, a higher number of documents would have increased the validity of the document analysis results as there would have been more sources stating the same (Clark et al., 2021). A higher number of documents would have also increased the amount of data, and thus the knowledge the finished thesis could provide to the research field (Clark et al., 2021). However, strategic documents containing land subsidence-related information were very limited and thus restricted by available research materials. Strategic documents on climate adaptation against floods and sea-level rise existed on the contrary, in plenty and the empirical material was for this topic restricted to ensure a manageable and coherent data collection.

Studying outputs of planning, such as comprehensive plans, is relevant in planning research as it can provide an image of what the planning institution in question considers important based on what is included in the documents and to what extent it is included (Silva et al., 2016). Contemporary strategic planning practices are said to have a special focus on planning outputs such as the creation of strategies and action plans (Gunder et al., 2017). Therefore, as this research is performed within the field of strategic planning research and theory, analysing documents/ planning outputs is a suitable method. It will provide answers to the research questions as well as knowledge of the planning institution in question.

2.7.2 Interviews

When conducting interviews, there are several considerations to make before and during the interviews. The interviews in this study were performed online as video calls using the platform,

Teams. The choice of using an online platform was made for two reasons: Firstly, the interviewees were located geographically far away in a different region from where this thesis was written. Secondly, during the time this thesis was written (2022) the corona pandemic was still ongoing. Conducting the interviews online instead of meeting physically was therefore considered a more convenient and safer choice. Online interviews, however, inherits several risks to the research's results and general limitation. For instance, it is harder to interpret the interviewees' body language and vocal tones as they may be cropped by the camera or distorted due to the computer's audio (Clark et al., 2021). Thus, misconceptions can be made about the undertones in a discussion, such as sarcasm. Personal meetings also promote social connection and make it easier for both parties to feel comfortable during the interview (David & Sutton, 2016). The use of the video function for the interviews, however, slightly decreased this effect. Performing the interviews online also had the risk of technical difficulties such as lost internet connection, audio, or video malfunction (Clark et al., 2021). During the third interview in this thesis, the internet connection was lost for ca 10 seconds of the interview, causing a loss of recorded audio and thus a loss of data.

Qualitative interviews are in general less structured than quantitative ones, allowing better opportunity to shape the focus and direction of the discussion. However, less structure decreases the reliability of the interview results, as (for instance) statements are less likely to be confirmed if interviewees are asked different questions in/or in different ways (Clark et al., 2021). As the interviews in this thesis were mainly meant to confirm or add to the results of the document analysis, the question of reliability was slightly decreased as the data collected from the interviews also complied with the findings in the documents. This is considered to provide general reliability to the results.

Only including three representatives from Gothenburg municipality can be considered a too small selection to be representative and provide a realistic image of the municipality's collective knowledge on the research topic. More interviews would have provided more knowledge on the topic and would have provided higher reliability to the research results (David & Sutton, 2016). For instance: amongst the selected representatives, only one considered themselves working actively with land subsidence-related questions. When talking about the work of a large organisation, one person's statement can be considered to provide insufficient validity as it isn't enough to be representative of the full organisation. However, despite Gothenburg being a large organisation, the interviewed person was recognised as the only employee with the responsibility of coordinating land subsidence-related strategic management. Therefore, it can be assumed that most, if not all, relevant knowledge on the organisation's current work on this topic could be found through this person and that his or her description is sufficiently accurate. An alternative would have been to interview people working with land subsidence on a more detailed, technical level. Gothenburg has for instance several geo-technicians working with the implementation of detailed plans or construction which includes consideration of land subsidence. However, the idea was discarded as the thesis research questions are focused on *strategic* management of land subsidence, which is conducted on higher levels.

2.7.3 Thematic Analysis

For the analysis of the strategic documents and the interviews, thematic analysis was used as a method because it is a common method for analysing in qualitative studies. Compared to other content analysis tools, thematical analysis is sometimes critiqued for being more imprecise and less distinct in its way of collecting data. The way the method is performed also inherits a risk

of losing the context of data (Clark et al., 2021). However, in terms of this research, the method is considered suitable as it can function as a tool for thematising how topics or objects are presented in a text. It also provides a platform for comparing the identified themes as well as analysing similarities, differences, and repetitions between them (Clark et al., 2021).

2.7.4 Ethical Considerations

Ethical considerations to be made concerning the creation of this thesis and its connected research are several. Research, in general, should never be performed with the aim of causing harm or for negative and/or unnecessary reasons to scrutinize a research object. It should neither be performed in a manner that could cause harm to its participants (Swedish Research Council, 2017). For these reasons, I carefully considered my research purpose for it not to aim to negatively harm Gothenburg municipality as an organisation or any of the research participants. The purpose of this study is to find good and useful examples of how strategic management of land subsidence within the frames of climate adaptation can be conducted, not to evaluate or find fault in the work of the research object. The questions asked during the interview, the interview's general setting, and the presentation of the interview results were considered in a similar manner to not cause harm, reflect badly or cause discomfort to the interviewees.

All participant included in the research has an ethical and legal right to be aware of the fact that they are included, in what way and what their inclusion implies (Swedish Research Council, 2017). If personal data is collected from a participant, such as names, voice recordings or work titles, the participant must be made aware. This involves stating why the data is collected, for what purpose and how the information is to be stored and processed. This is both for ethical reasons, as the result of the research in which the information is included may have effects on the participant but also for judicial reasons as is stated by European GDPR-law and the Swedish authority for privacy protection (The Swedish Authority for Privacy Protection, 2021). Also, Linköping University, the institution within which this thesis is created, requires written consent forms to be used for the collection of personal data when conducting research within the frames of the institution. Thus, for all the above-mentioned reasons, all participants in this study signed written consent forms for the processing of their personal information as needed for the creation of this master's thesis. What information was collected, for what purpose and how it was to be managed were clearly explained in the form. The form also stated the participant's right to withdraw their consent at any time until the final submission of the thesis.

3. Theoretical Framework

In this chapter, the theoretical framework of the thesis is presented. It begins with a description of the framework's constitution, why it was selected, why it is suitable for the thesis and what purpose it will serve for the research. The chapter then continues with a description of the framework's different parts.

The theoretical framework used for this thesis is constituted of two parts. The first part is constituted by the planning theory "Strategic Planning", as described by Gunder, Madanipour and Watson (2017). The theory of Strategic Planning is used for the purpose of setting the research of this thesis into a certain planning context, relevant to both the research object and as a stance of analysis of the research results. The theory of strategic planning is suitable for this purpose as it is an example of a contemporary planning theory commonly used in planning research for studying current planning practices (Gunder et al., 2017; Silva et al., 2016).

The second part of the theoretical framework is constituted by the concept of Evidence-based urban planning, as described by Forsemalm *et al.* (2019). The concept of evidence-based urban planning is to be used as a stance for analysis of this thesis' research results. The aim is to use the framework to further understand Gothenburg municipality's approach to performing climate adaptation and land subsidence prevention and to attempt to explain the why the municipality has chosen their methods, what kind of knowledge they use as the foundation for their decisions and when and how that knowledge is included. The concept of evidence-based urban planning is suitable for this purpose as it presents a method for how to perform sustainable urban planning. Applying and comparing this method to the work of Gothenburg municipality should shed light on the decisions behind their planning methods.

The analysis in which the framework is used is presented in the thesis discussion-chapter, chapter 6.

3.1 Strategic Planning Theory

Strategic planning is defined by Gunder, Madanipour & Watson (2017) as "*a coordinating mechanism to frame actions between diverse organizations, and authorities in the achievement of desired shared societal outcomes*" (Gunder et al., 2017, p. 5). According to the authors, strategic planning has a special focus on the production of planning outputs, meaning its result-oriented and focuses on the implementation of strategies, plans and policies. Strategic planning is sometimes described as a mechanism to create consensus between different policies (Gunder et al., 2017). This can be considered a relevant function as planning, in general, requires making trade-offs between different but equally important perspectives or interests (Allmendinger, 2017). An instance when this is necessary is in the management of wicked issues such as climate change. Bryson, Edwards, & Van Slyke (2018) defines Strategic planning as the "*deliberative, disciplined effort to produce fundamental decisions and actions that shape and guide what an organization (or other entity) is, what it does, and why*" (Bryson et al., 2018, p. 317). This definition, compared to the one by Gunder, Madanipour & Watson (2017) can be interpreted as more action-oriented, focusing on the traits in planning that make it strategic. A comparison is the first definition focusing on the coordination of the many institutions usually involved in planning through, for example, governance, versus the second definition which seemingly focuses on one strategic planning entity. Albrecht and Balducci (2013) mention an important aspect to be aware of in strategic planning is that it isn't "*a static description of problems*"

(Albrechts & Balducci, 2013, p. 20), rather it inherits an ability to comprehend and portray the increasingly dynamic and complex development of society.

Important concepts within the theory are the concepts of “becoming”, “envisioning” and “selectivity”. *Becoming* describes a sense of continuous transformation, process or movement while also emphasising actions, and change over persistence. *Envisioning* describes strategic planning’s capacity of imagining a desired future, vision or goal and the ability to create ideas and to reach what is imagined. Envisioning includes an acceptance of the uncertain and instead opens up the possibility. *Selectivity* aims to explain the involvement of prioritization, judgement, valuation, and the making of choices to reach just responses to strategic planning challenges and aspirations (Gunder et al., 2017). Louis Albrechts writes in Gunder, Madanipour & Watson (2017): “*In strategic planning, the overall picture that inspires choices is not given by a comprehensive analysis, but rather by synthetic long-term visions.*” (Gunder et al., 2017, p. 33).

A common critique of strategic planning is that it is moving away from traditional means of planning as it instead moves towards new ways of multi-level governance. The new Collaboratory planning methods decreases the transparency of planning as well as the following of the traditional planning process which diminishes the presence of democratic values as well as the legitimacy of the strategic planning outputs (Gunder et al., 2017). Albrecht, Barbanente & Monno (2019) writes, however, that the growing use of governance, what it means, is an inclusion of more actors in the planning processes that would have earlier gone voiceless through the use of different work forms. On the contrary, he describes legitimacy as one of the pillars in strategic planning as the inclusion of external (from the planning institutions) is the new natural way of planning as it is the source of important knowledge to ensure the quality of the planning outputs.

3.2 Evidence-based Urban planning

The source in the following chapter is Forsemalm *et al.* (2019), unless something else is written.

The concept of evidence-based planning was first discussed in the UK in the 1990s as a part of the idea for planning to be less technocratic and more of an interactive process (Faludi & Waterhout, 2006). Forsemalm *et al.* (2020) describe the concept as a way of understanding and describing a planning problem, based on factual knowledge on the topic and one’s understanding and interpretation of that knowledge. The purpose of evidence-based planning is described by the authors as not performing planning based on one’s prejudice, but instead stance from the most reliable sources available. The authors describe how relevant knowledge for urban planning can be categorised into four “evidences”: Professional, organisational, stakeholder, and scientific evidence.

Organisational Evidence conveys knowledge concerning the capacity of an organisation. The capacity, for instance, comes from the organisation’s ability to network and/or adapt to changing circumstances or conditions. At its base, it’s about how well the organisation know how to do its job, and how effectively and to what extent the job can be performed. For that practice, certain knowledge is needed. Forsemalm *et al.* (2019) describe the role of organisational evidence in relation to urban planning as to evaluate and scrutinize what the organisation is capable of, how it can be improved and if it could be changed for the better to improve the way it performs its current, planned, or additional tasks.

Professional Evidence describes knowledge on how to name and make professional skills and experiences visible in the process of urban planning. Forsemalm *et al.* (2019) describe how professional evidence is experience-based knowledge and is explained to bring what's known as "know-how" to a process which means knowing how an action usually plays out and why it will or will not work concerning a certain situation. Professional evidence is explained by the authors to be created in a process of test and failure and finding logical solutions to problems and evaluating their outcomes until knowledge on what works the best is created. However, the testing process is described as continuous and thus professional evidence will always be temporary as new solutions are invented and more testing is done. It will also always be situation-based and fixed to a certain context. Meaning a limitation as what works in one city may not work for another thus the experience from one situation may not be enough or relevant to solve a similar problem but in a different context.

Scientific Evidence is knowledge based on science and/or academic research. It is created within a scientific community/practice by studying different sides of reality in a systematic and rigorous way. In summary, scientific evidence can be described as knowledge that is accurate and true in many situations and circumstances. In urban planning, scientific evidence is described to be used for example, as foundations for decision making and as a way to emphasise a problem. Limitations to this kind of knowledge are that it takes time to produce and can only be acknowledged as true scientific knowledge if the way it is created follows certain rules and requirements. Another limitation is that scientific knowledge can often be too theoretical to be useful or easily implemented in practice.

Stakeholder Evidence aims to describe the knowledge held, sourced, and produced by those in some way affected by urban planning. The affected people, known as "stakeholders", are for instance made up of the population in the planned area, companies or private actors interested in the new development and other kinds of actors who for a certain reason may have an interest in current plans. The use of including stakeholder evidence is described as allowing the inclusion of local knowledge and the opinions and perspectives of those who will use the planned built environment which is described as increasing the quality and success rate of urban planning. Cooperation and collaboration with more actors are also said to be more effective and also increase the democratic aspect of urban planning. A limitation to the inclusion of stakeholder evidence is that it requires a certain degree of social ability amongst urban planners to organise, facilitate and stimulate an effective and useful dialogue with the stakeholders. It also requires a will from the stakeholders to cooperate and collaborate with the planners.

Professional evidence and scientific evidence are explained to float into each other as well as crash. As scientists and researchers are also professionals, scientific knowledge is described to also be able to be considered professional evidence. However, the differences between them are explained as scientific evidence representing theory whilst professional evidence represents practice. Whilst professional knowledge is said to be highly context-based, scientific knowledge aims to be more generally applicable.

The concept of evidence-based urban planning stances on the idea of the performance of urban planning as a wicked problem. Forsemalm *et al.* (2019) describe the term "wicked problems" was first coined in the 1970s' as a response to the contemporary rational planning practices. The rational planning practices stanch from logical decisions based on analysis which is explained to have step by step created an urban environment. An example given in the book of

rational planning is the Swedish “million programmes”, which are described as having been done as a way of solving the 1970s’ housing crisis. Although the programme created cheap and well-built homes, they are today associated with segregation and criminality. The term wicked problems arose as a critique against this rational way of planning as a way of saying that urban planning needs to be considered a complex endeavour which is hard to define. And every planning solution should be expected to create new problems. Forsemalm *et al.* (2019) argue that wicked problems are becoming increasingly common today as society is increasing in complexity and interconnectedness. This trend can’t be stopped, but Evidence-based urban planning is provided as a method for managing it.

Evidence-based urban planning is about finding platforms of discussion based on knowledge. It is on the contrary not about making decisions based on only the facts, but rather to using the facts as starting points for further discussion. By integrating different kinds of knowledge, the concept aims to make it easier for urban planners to get a more comprehensive grasp of a problem, make the problem easier to describe and frame as well as find more sustainable, long-term solutions. A solution to a wild problem is described to not be an objective choice between right or wrong, but rather a normative choice between what is considered better or worse. Evidence-based planning is therefore justified by suggesting a more systematic method of including and discussing knowledge from different sources. However, apart from the limitations mentioned about each kind of evidence, the concept also has limitations. For instance, knowledge may become unavailable due to (for example) ideological beliefs held by the practitioners or set policies and regulations. Evidence may also be limited by the number of resources needed to collect them. For example, the production of scientific evidence sometimes needs to be ordered specifically if it concerns a need for very specific facts such as statistics of a phenomenon’s occurrence or the conditions of a certain location. Such investigations can be expensive and time-consuming (Forsemalm *et al.*, 2019).

4. Literature Overview

This chapter aims to present an overview of current academic and scientific discussions on land subsidence, flood risk management and climate adaptation. As literature from a Swedish context is lacking, most literature and discussions presented in this chapter have an international stance or are set in a foreign context. However, the chapter aims to describe the general discussion held in the academic sphere concerning this thesis topic which despite an international setting is considered relevant for Swedish strategic planning.

The chapter begins with a description of the impacts of climate change, the difficulties of climate adaptation and flood risk management. It then continues to overview the literature on Land Subsidence, land subsidence's relationship to climate change, and strategic planning.

4.1 Climate Change, Municipal planning, and Flood Risk Management

4.1.1 Strategic planning, Climate Change, and the municipal level

Climate change will lead to a wide range of consequences for urban environments. It is likely to cause changes in wind patterns, precipitation, and general sea- and water levels which in turn will affect hydrological and ecological systems, likely to cause floods, a loss of biodiversity and heat waves. How exactly climate change will impact individual locations is, however, uncertain (Sonnek et al., 2013). Storbjörk (2007) writes that in the academic debate on climate change, municipalities are seen as both the solution and part of the problem. Municipalities are seen as key actors for facilitating actions and initiating and leading networks and collaborations with stakeholders, especially private actors (Storbjörk, 2007). The literature mentions placing responsibility for climate adaptation on the local level is positive as the issue requires a high degree of local knowledge because the effects of Climate change will vary geographically. However, the performance of climate adaptation is described as a task of great magnitude in need of strong collaborations horizontally and vertically, advanced policymaking and mainstreaming as well as access to updated knowledge. It is therefore suggested to possibly be a difficult task for many municipalities (Storbjörk, 2007; Storbjörk & Hjerpe, 2014). The academic literature is interpreted in different ways to define climate adaptation as the planning and making of actions towards both structural and physical changes as a response to climate-related incitements (Storbjörk, 2007). The question of climate adaptation is framed differently depending on context and purpose. For example, it can be framed as a planning issue, security issue or environmental issue, all depending on for what reason climate adaptation is discussed and/ or performed (Sonnek et al., 2013). It has been noticed that climate adaptation in Sweden is often too limited in focus leading to isolated management efforts. It is described how it is recognised that the treatments need to go from isolated physical interventions to greater institutional change (Wamsler & Brink, 2014).

4.1.2 Flood Risk Management

Flood risk is mentioned by Wilby & Keenan (2012) as “*the most common natural hazard and third most damaging globally after storms and earthquakes*” (Wilby & Keenan, 2012, p. 348). Thus, it's not surprising that academic discussion and research on flood risk management are extensive. One of the difficulties of flood risk management is the geographical variation and the many causes of how flood risks may present. It is mentioned by Ek *et al.*, (2016), how the most common flood in Sweden are fluvial floods, which are commonly associated with heavy rains and/or snow melting. However, as with all climate change-related risks, they come with a

lot of uncertainty and will vary in appearance and impact (Sonnek et al., 2013). Because of the high degree of uncertainty, creating generic approaches for flood prevention is described to be difficult as methods and tools need to be able to adjust to a local context (Wilby & Keenan, 2012). The literature suggests a wide variety of strategic approaches to adapt to or prevent flood risk. Common suggestions involve communication with the local community, the creation of knowledge materials such as topographic mappings, and risk assessments that can be more easily distributed to stakeholders, as well as the integration of flood risk-related questions into standard planning practices to ensure sustainability in new development (Ek et al., 2016; J. Ward et al., 2011; Wilby & Keenan, 2012).

Concerning the climate-induced risk of sea-level rise, Nicholls (2018) describes four approaches to adaptation common in the literature: 1. Retreat, meaning allowing climate changes to take place whilst moving endangered urbanities to safer locations. 2. Accommodating, meaning the city adapts to climate change-related changes. 3. Protection, meaning the consequences of climate change are controlled by protecting the urban using soft or hard barriers such as flood walls. And 4: Attack, meaning planning is focused on building seaward and upwards, avoiding floods by claiming new land for the purpose of economic development. It is described in the article how these four approaches are adopted differently across literature and current management practices, as an adaptation against sea-level rise is complex and varies in character (Nicholls, 2018).

4.2 Land Subsidence

4.2.1 Problem Description

Anthropogenic land subsidence is said to have been first acknowledged in the middle of the 19th century (Carbognin & Tosi, 2002) and is today acknowledged as a significant global problem affecting many of the world's most important aquifers (Smith & Knight, 2020). Today, the general literature agrees that land subsidence can be caused by both natural and anthropogenic causes (Bagheri-Gavkosh et al., 2021; Herrera-García et al., 2021; Sundell et al., 2019). Overviewing the literature, the more discussed natural causes of land subsidence are fluctuations in groundwater due to (etc.) changes in precipitation, sediments compaction and/or isostatic and/or tectonic processes. Anthropogenic (meaning man-induced) causes are for example over-pumping of ground resources such as freshwater, gas or oil, the addition of ground surface pressures such as heavy buildings or construction fundamentals and/or impacts on the subsurface or the underground aquifers (Sarah & Soebowo, 2018; Smith & Knight, 2020; Sundell et al., 2019). Commonly mentioned consequences of land subsidence can be categorised into infrastructural, environmental, economic, and social impacts (Gido et al., 2020). Examples of these are damages to infrastructure such as roads, railways, pipelines, ground deformations and a decrease in ground stability as well as structural damages to buildings, presenting health and security risks for residents (El Shinawi et al., 2022; Gido et al., 2020).

Darvishi & Jaramillo (2020) writes that there is no comprehensive information on land subsidence in Sweden and that there is a need for better mapping of occurrences to mitigate negative effects and damages. Overviewing the literature, studies researching land subsidence in Sweden are scarce, although some exist for instance studying the city of Gävle, Uppsala and the island Gotland (Darvishi & Jaramillo, 2020; Fryksten & Nilfouroushan, 2019; Gido et al., 2020). Most of the studies conducted in Sweden seem to have a technical focus and investigate

methods for measuring clay-induced land subsidence or ground deformations related to Sweden's mining industry, but a few (for example Darvishi & Jaramillo, 2020) are also found to researches land subsidence as a risk for future water scarcity.

4.2.2 Land subsidence and Its Connection to Climate Change

Land subsidence is in multiple ways connected to climate change in the literature. A more prominent connection in the literature is made between land subsidence and sea-level rise as well as water scarcity. (Esteban et al., 2020; Herrera-García et al., 2021; Smith & Knight, 2020). This is explained to have several causes: Climate change is predicted to cause higher temperatures and an increase in the occurrence of draughts. This inherits increased evaporation of water and general dehydration of water in the ground (Herrera-García et al., 2021). This is predicted to possibly lead to water shortages and changes in human behaviour as, for example, there will be an increased need for watering agriculture and a need to withdraw fresh drinking water from the subsurface (Darvishi & Jaramillo, 2020; Smith & Knight, 2020). Collectively and/or individually, the above will cause a decrease in groundwater levels, leading to a heightened risk of land subsidence.

In literature, Land subsidence is described not only as a possible consequence of climate change but also as a phenomenon that can enhance climate change's effects. One of the most prominent topics in the literature is land subsidence as a hazard to drinking water. When Land subsidence occurs, it means the subsurface is compressed, closing previous spaces underground as the water in the soil is drained or pushed out. This process is described to be able to cause permanent damage or destruction of the underground aquifers (underground layers of porous rock with the ability to store groundwater), meaning groundwater can't be re-filled. Thus, in the places where land subsidence has occurred and caused this kind of severe damage, the groundwater may always be limited, posing a risk of drinking water scarcity (Andaryani et al., 2019; Herrera-García et al., 2021; Smith & Knight, 2020).

Climate change is also predicted to cause a global sea-level rise. This is a risk as the rising sea water may intrude into the groundwater storage, causing salinization of the drinking water rendering it undrinkable (El Shinawi et al., 2022). Land subsidence, per definition, is a gradual lowering of the Earth's surface and has in known cases lowered the mean ground surface level below sea level. This is especially troublesome in low-lying coastal zones as it may intel a permanent loss of land and urban displacement if the ground coast sinks while the sea level rises (Sarah & Soebowo, 2018; Schmidt-Thomé et al., 2006; Siriwardane-de Zoysa et al., 2021). This is an example of how and why the literature can be considered to describe sea level rise and land subsidence as interconnected.

Land subsidence can also become a problem in areas predicted to have an increase in rainfall and general water levels. As land subsidence can occur in smaller areas it can create new collection places for stormwater, changing the usual way rainwater runs over the ground making existing stormwater less effective (Schmidt-Thomé et al., 2006). Climate change could mean more frequent extreme weather situations such as torrential and/or 50 and 100-year rains, land subsidence can also prolong the effects of the floods such weather can create (Chen & Tfwala, 2018).

4.2.3 Land Subsidence and Strategic Planning

Disregarding climate change, because of the wide range of anthropocentric causes, in academic literature land subsidence is in general viewed as a relevant discussion topic concerning urban planning. Still, it is by some described as “*one of the world’s most underrated problems*” (Siriwardane-de Zoysa et al., 2021, p. 2).

In literature, Land subsidence is related to common planning questions such as land use, social and economic developments, current trends, and planning and building history. An example of this is the concern over the growing human population, which as mentioned in chapter 3.2.2, the literature correlates to questions of water scarcity as it may increase the demand for groundwater (El Shinawi et al., 2022; Siriwardane-de Zoysa et al., 2021; Smith & Knight, 2020). It also corresponds with current development trends such as urbanization and densification of cities as these trends often include hardening and additional pressures on the ground surface (etc), diminishing the ground’s ability for water infiltration and compressing it further. It is also discussed as more of a pure geotechnical problem for dimensioning new construction and building, or the implications of different soil types (Fryksten & Nilfouroushan, 2019).

The literature gives multiple suggestions for how to manage land subsidence in terms of strategic planning. Important factors are the monitoring of groundwater levels, in order to detect possible changes. There should also be clear regulation on the withdrawal and use of groundwater to avoid unnecessary, excessive, or unsustainable behaviour. The regulations should be supported by scientific information (Sarah & Soebowo, 2018). The monitoring of groundwater levels could avoid any breaches of this regulation (Sato et al., 2006; Ye et al., 2016). The literature also suggests the creation of building regulation in terms of, for instance, building zones where different kinds of land use are regulated based on the ground’s suitability. This could mark areas where building is dangerous or unsuitable as it has a high risk of initiating land subsidence processes, thus bringing awareness to locations where additional caution must be taken (Hamdani et al., 2020). A last recommendation is also to ensure the active involvement of local stakeholders to increase knowledge of local land subsidence events in the planning process and create more sustainable solutions and regulations built on the local context (Sarah & Soebowo, 2018).

In the article “The ‘wickedness’ of governing land subsidence: Policy perspectives from urban Southeast Asia” (2021) land subsidence is described as a “wicked problem”, meaning it is a “*complex, chronic and intractable social issue*” (Siriwardane-de Zoysa m.fl., 2021, p. 4). Wicked issues are problematic for planning practices as they lack clear problem definitions and can’t be solved using linear, conventional methods as they are intertwined into complicated structures and systems of multiple stakeholders and conflicting goals and interests (Siriwardane-de Zoysa et al., 2021). The notion of land subsidence as a wicked problem could describe the lack of literature on the management of land subsidence on the local level, apart from studies researching methods for ground movement monitoring. As earlier mentioned, there is a wide variety of suggestions for governmental interventions for the prevention and mitigation of land subsidence, but research describing its impacts and meaning on local planning institutions can be considered lacking, especially in a Swedish context.

5. Result and Analysis

The following chapter contains the presentation of the results of the document analysis and the interview study. The presentation is structured based on the three themes created in the content analyses (see chapter 2.6). The themes are *Problem description*, *Current planning practice*, and *Assessments*. The themes are presented in that order. Problem Description presents how Gothenburg municipality describes its preconditions and related challenges concerning climate adaptation, land subsidence and flood risk. Current planning practise then continues by presenting how the municipality is currently managing said challenges, presenting the municipality's approach and planning practices. Lastly, in Assessments, Gothenburg municipality's evaluation of its planning practices as well as objectives for the future is presented. Each theme has two sub-categories for emphasizing different aspects of the theme's content.

Analysis of the results is made continuously throughout the chapter to highlight similarities, differences, and contrasts in the results. An inference, meaning a comprehensive, concluding analysis of each theme, is made at the end of each theme chapter to summarize and give depth to the research findings.

5.1 Problem Description

The theme "Problem description" describes how Gothenburg municipality describes its problems related to their prerequisites for climate adaptation and land subsidence management. The theme has two sub-categories: "Exposure to Flood risk and Land Subsidence" and "Prerequisites for Strategic Planning of Climate Adaptation and Land Subsidence". The first sub-category presents Gothenburg municipality's description of its preconditional challenges concerning land subsidence and flood risk. The second sub-category presents challenges related to organisation and the capacity and design of the planning also as described by Gothenburg municipality.

5.1.1 Exposure to Climate Change Related Impacts and Land Subsidence

The geographical and geological prerequisites are in both strategic documents and the interviews presented as a challenge which shapes Gothenburg's execution of climate adaptation. Gothenburg is located in the mouth of multiple watercourses, such as Göta Älv and Mölndalsån. This increases the effects of climate change as Gothenburg will also be affected by events taking place upstream (Göteborgs Stadskansli, 2006). It can be interpreted that in the context of water-related climate events, Gothenburg is located in an area where water-related climate affects concentrates, increasing the municipality's exposure.

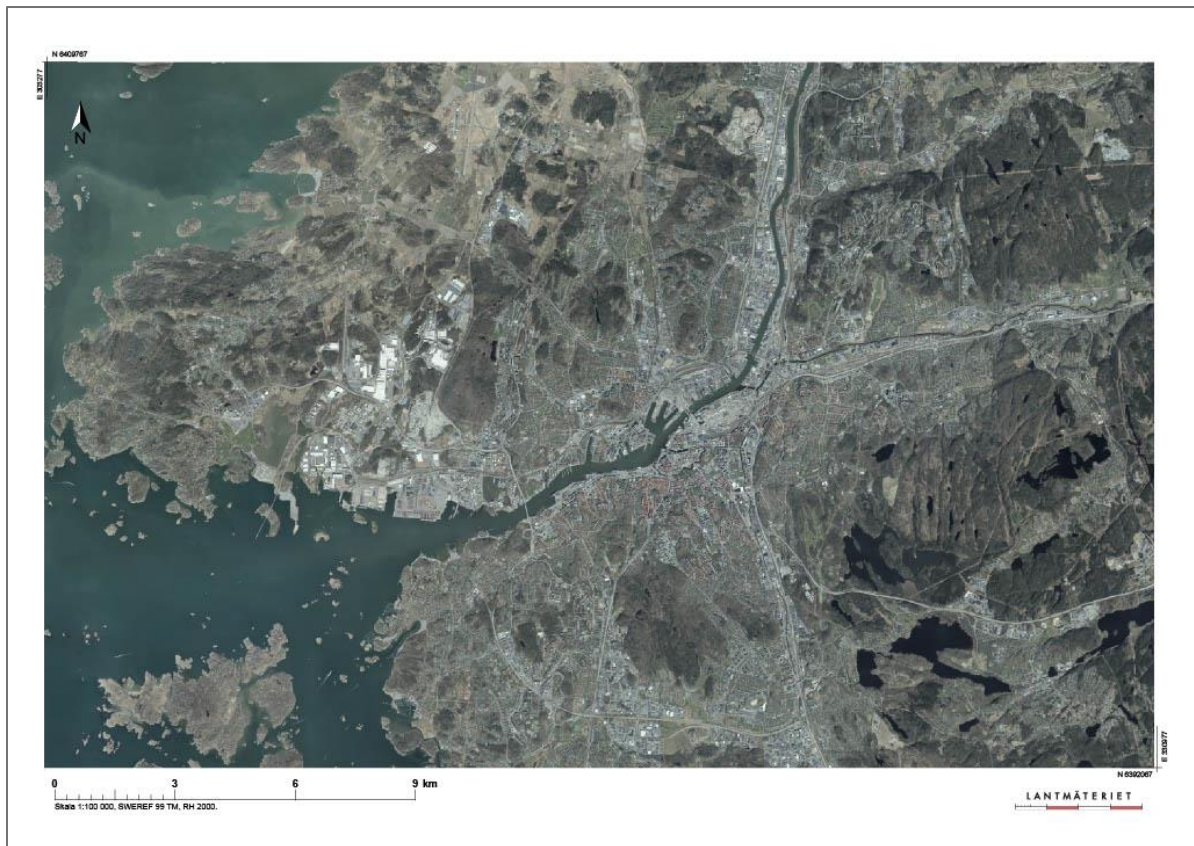


Figure 3: Map of Gothenburg municipality urban centrum from above (orthophoto). The map shows the area's topography and Gothenburg's urban environments close proximity to water. It shows the large river Göta Älv running through Gothenburg's centrum and connecting to the ocean of Skagerrak. The map is created by the author (Charlotte Andersson) using the Swedish authority Lantmäteriets online map tool "Min Karta" (open source). Scale 1:100000.

The topological conditions in the Gothenburg area are mentioned as a factor which enhances the risks of fluvial flooding (Interview 1). The conditions are described as a "crevice valley landscape", which is a topography with narrow valleys caused by withering and erosion. This topography creates a condition in which all the rain falling on higher areas, runs off onto lower plains causing a concentration of water in the bottom of the valleys (Göteborgs Stadskansli, 2006). The bottom of the valleys has a rich concentration of clay, which is a dense type of soil, making the infiltration of water slow and limited (Interview 2). Clay is therefore mentioned in the thematical addition to Gothenburg's comprehensive plan (TTÖP) as an enhancer to flood risk. If a lot of rain falls at once, such as in the case of a 50- or a 100-year rain, it will take a long time for the water to sink into the soil, causing floods in the meantime. The water flowing from the higher areas also collects in the municipality's watercourses which would then go over capacity and flood the surroundings (Interview 1; Stadsbyggnadskontoret, 2019). It can be interpreted that these conditions are the reason why the management of stormwater in Gothenburg municipality comes off as the more difficult part of adaptation against floods. It is interpreted that the location, topography, and soil conditions together create a complex and relatively unpredictable prerequisite for climate adaptation. Based on the description of these conditions, both in the documents and in the interviews, it can be considered reasonable for interviewee 3 to say that *"Gothenburg is the most exposed area in Sweden concerning certain climate related challenges. [...] above all floods, heavy rain, and extreme weather."* (Interview 3). The above can also be said to be an example of the relationship between flood risk and land

subsidence. Factors which cause flood risk, in this case, soil conditions and the ability for water infiltration, are explained to be the same as what causes land subsidence.

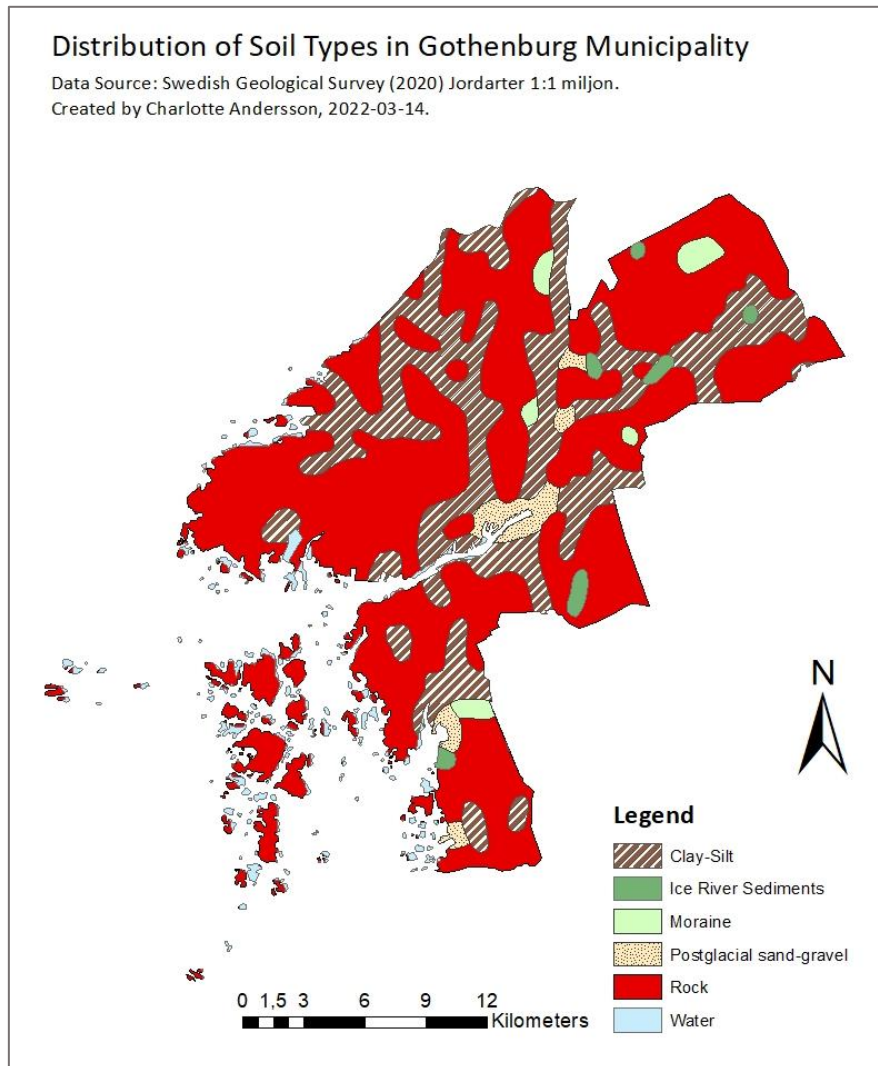


Figure 4: Map showing the distribution of soil types in Gothenburg municipality. The map is created by the author (Charlotte Andersson) in GIS ArcMap, 2022-03-14. Data source: SGU (2014).

In the reports describing Gothenburg municipality's preparedness for climate change, it is described how the city of Gothenburg was first built in the 1600s. The location was especially chosen because of the possibility of a good harbour and wetlands in the west for protection against enemy attacks (Göteborgs Stadskansli, 2006). As the city was expanded, the wetland was filled out to create new land for settlements. In interview 2, the filled-out land areas are mentioned as constituting the highest risk for land subsidence. This is because apart from the areas being naturally clay-rich and soggy, the materials used to fill the land out was of different sizes and density such as dredged materials from Göta Älv and waste from the city such as parts of demolished houses (Göteborgs Stadskansli, 2008). It created a building foundation similar to moraine. And like a moraine, this kind of foundation can have unexpected movements which present risks and problems for current settlements and new buildings. Some of these areas are currently targets for large new development projects (interview 2). Analysing this, the choice to build in the previous wetland areas can be considered as Gothenburg municipality causing

risk for flooding and occurrence of land subsidence. However, it is mentioned in interview 2 that the development aims to be sustainable as it rejuvenates older areas. The areas have qualities which make them attractive for residents such as close proximity to water and the city centrum (interview 2). This example sheds light on what can be considered an almost “classic” planning issue: often the most risk-filled areas are the most attractive location for new development, causing situations where difficult planning decisions have to be made between exposure to risks and fulfilling basic citizens needs and planning responsibilities such as providing attractive housing. It can be argued that this is an example of how land subsidence becomes integrated into different planning questions.

5.1.2 Prerequisites for Strategic Planning of Climate Adaptation and Land Subsidence

Gothenburg municipality’s climate adaptation was described by interviewee 3 to have been initiated 20 years ago. Still, in the documents, the municipality’s strategies are presented as being created in the early stages of the municipality’s climate transformation. In the TTÖP they write: *“A necessary realisation is that society's transition to a climate resilient and robust society is a large and complex undertaking that requires a long-term process that is still in its beginning”* (Stadsbyggnadskontoret, 2019, p. 11). This can be interpreted as Gothenburg municipality acknowledging the magnitude of climate change as a problem and how much work is still left for the municipality to be protected. Despite their many years of experience, they have only just begun their transformation. Interviewee 3 describes working with climate adaptation as “innovation work”, saying:

“We know how to build bridges, we know how to build railways and hospitals and so on, but we don't know how to perform climate adaptation. [...] You have to pursue it as an innovation work, and then in the long term, it will move to a more management-way of doing things. If you have that insight, I think it's easier to succeed and not get so frustrated that you don't know how to do it. We have lots of parts, but we don't have a manual.” (Interview 3)

It is made clear by both documents and interviews that risks related to water are the ones that have received the most attention by the municipality in comparison to other risks. It is implied in interviews 1 and 2 that this may have led to what can be considered an “uneven” development of adaptation, where the municipality now has developed routines for prevention against flood risk *perhaps* at the cost of routines for other kinds of climate change-related risks such as heatwaves. Put into perspective, as the risk of flood is considered the most probable/severe risk it can easily be considered a reasonable prioritization, especially since they now have integrated routines for flood risk prevention in their planning process (interview 3). However, in the documents, the uncertainty of what consequences/ weather events climate change will cause is often lifted. Prioritizing flood risks may have left them exposed to other risks such as heat waves. Heat waves are mentioned by interviewee 2 as the more likely cause of land subsidence.

In the TTÖP and the extreme weather situations phase 1-report it is described by Gothenburg municipality how adaptation measures will have to consider the entire city. Planning strategies cannot just apply to new development but must also be applied to already existing physical parts of Gothenburg. The same also applies to Gothenburg municipality’s planning system and organisation. For example, in the TTÖP it is written: *“The city's climate transformation requires the involvement and coordination of several city departments. However, in order to have full impact, cooperation is also needed with the County Administrative Board, the*

Transport Agency and other state and regional authorities.” (Stadsbyggnadskontoret, 2019, p. 10) The quote quite clearly states that Gothenburg municipality deems collaboration on climate adaptation questions as necessary to increase the quality of its adaptation measures.

Concerning collaborations, the documents and the interviews also raise the distribution of responsibility as a barrier to climate adaptation and the planning of climate adaptation. It is mentioned in the Environment and Climate programme for the City of Gothenburg (2022) that the arena in which collaboration is held has to be able to allocate responsibility and risk amongst actors in order to not overwhelm a certain department or actor. An unclear distribution of power or an inability to enforce the responsibility is described in the interviews as a barrier to planning and implementation. The interviewees suggest that the barriers could be solved by clearer regulation and making better incitements.

Returning to the topic of adaptation efforts needing to include both existing urban environments and new development, based on the TTÖP, planning for adaptation of new and existing parts is interpreted to be equally challenging and also connected. Gothenburg municipality explains this by describing how the adaptation of new developments requires the integration of climate policies into all standard planning practices to ensure thorough and continuous adaptation. Also, new development following new adaptation policies is troublesome to place within the existing urban environments, as new policies demand a certain floor height to protect against higher water levels during a flood. The new building's floor heights would thus be higher than the existing building's leading to an unevenly built urban environment. Adaptation of existing physical structures may require the initiation of climate adaptation-specific projects which are described to be challenging to support in terms of costs versus gained benefits. The new development and the existing physical parts both need to be adapted to create sufficient protection for Gothenburg's entire urban environment so one cannot be done without the other.

“Transforming to a robust city is a long-term process that cannot only be achieved through ongoing urban planning but also requires adaptation measures of the existing city. This means that the necessary measures to ensure land suitability will have to be taken in the framework of specifically initiated climate adaptation projects.” (Stadsbyggnadskontoret, 2019, p. 15)

This quote above can be argued to suggest a pressure on the planning system itself to also adapt to enable climate adaptation. In interview 1, it is expressed that the municipality needs better tools, such as judicial support, to be able to initiate climate adaptation projects. The analysed empirical documents describe a planning system that relies on cost-benefit analysis for the planning and implementation of climate adaptation. This means the cost of a project has to be comparable to the usefulness of the project. The usefulness and benefits of climate adaptation can however be difficult to support, as interviewee 1 explains, the municipality has to choose between building flood protection which they may not need for 50 years and building a new school or hospital they need now. There isn't enough money in the municipality's budget for both. The financial limitations are described as one of the biggest barriers to Gothenburg municipality's climate adaptation. According to interviewee 3, only the flood protection against sea-level rise will cost Gothenburg municipality around 20 billion Swedish kroner over the next 15 years. A similar number is given for protection against heavy rains. Interviewee 1 explains that the government need to provide them with tools for how municipalities are to afford both schools and climate adaptation or how to better decision between them. There is also a need to

clarify who (amongst citizens, municipality departments, and private actors) should help finance climate adaptation and how.

Private property owners are described as a barrier to the creation of comprehensive flood protection of Gothenburg. Currently, each property owner is responsible for protecting their property against climate change impacts. According to interviewee 1, this means that there are many areas and buildings in Gothenburg that the municipality does not have the legal right to address, leaving gaps in the municipality's overall protection. Even if they do approach the property owners, many of them don't see the purpose of investing in climate adaptation as they, for instance, may only live or own the property a few years and the flood protection may not be needed for maybe 50 years. Interviewee 1 says there is a need for new judicial tools to allow the municipality to implement the needed adaptation measures.

In the TTÖP, an opposite situation is described where judicial regulations are too far developed for the municipality to meet them: In the TTÖP it is written that certain plans may not have sufficient resources to meet the necessary adaptation levels required by the Swedish planning and building act. They are, for instance, too small projects to be given sufficient resources for proper investigations to be made. Thus, these plans won't pass the suitability assessments and can therefore not be executed. Statements made by interviewee 2 support the existence of this challenge. The interviewee describes that it is a reason why plans on occasion get made without proper investigations of the ground's conditions as the budget for the project can't cover it. A solution to the problem, according to interviewee 2, would be for higher-up authorities to provide municipalities with the necessary materials to execute their plans according to the legally required standards. Unfortunately, national investment in these materials (an example being data on ground movements measured on a national scale) does not yet seem to have sufficient support. Another barrier in the planning system is that there is no possibility/function to write in certain parts or structures in the plan to be executed at a later date. Therefore, an area always needs to be planned and executed in full. This presents a challenge since, even though new neighbourhoods need to be built, some of their correlating adaptation measures aren't predicted to be needed for many years. Building them before they are needed is described to result in sizable, "unnecessary" maintenance costs.

5.1.3 Inference

The theme "problem description" makes for an interesting stance for analysis, as it presents what the municipality's described to be the source of their problems concerning flood risk and land subsidence. These preconditions, described above, and the scientific predictions of how climate change may impact Gothenburg municipality set the arena and starting point for the municipality climate adaptation and management of land subsidence. Most of the described problems can be considered to not be anything "new" or especially unique concerning climate adaptation in general. Instead, what can be said to make their situation special is rather the multitude of problematic preconditions which concentrate in the Gothenburg area. Being the second-largest municipality in Sweden also provides special preconditions, both good and bad. The municipality, however, makes the vision for its work clear by the use of the word "robust" and "resilient" when describing its strategies for climate transformation. The word "robust" describes a future vision of Gothenburg as being able to withstand the impacts of climate change. Here, a contrast can be noticed as the other word, "Resilient", rather describes a vision of Gothenburg as being able to take a certain amount of damage as it has an ability to "bounce back" from injury.

As perhaps predicted, most of Gothenburg's problems are because of their geographical location and can be traced back to the history of how urban planning was done in the past. This does not, however, make climate adaptation any less difficult to perform only perhaps a little easier to understand. This seems to be the case for Gothenburg's risk of land subsidence. Other parts of the problem description are sourced in the current planning system's organisation and the relationships between different planning levels, such as the aid the municipality describes they need from the state or different authorities. These problems can be considered more difficult to solve as they require large organisational changes, not just in Gothenburg municipality's organisation, it inherits development for how we conduct planning in general. It is interesting to note how regulations for planning are described as both too strict (as in the case of the many considerations needed to be made in the development of plans which overwhelms the municipality's budget) and sometimes too vague (as in the case of the municipality describing how they don't always have the legal authority for executing climate adaptation). Both of these barriers can be considered to create bottlenecks for the execution of planning as they restrain what the municipality is capable of. Despite the strict regulation mentioned concerning what should be included in new plans are probably purposed to increase the quality of new development, Gothenburg municipality's descriptions of how these regulations work in practice show that the regulation may instead stop plans, and thus adaptation and/or prevention or mitigation of land subsidence, from being created at all. The same can be said about the vague regulations, as they can be used as an excuse for actors not willing to take action or a barrier for those who are willing.

5.2 Current Planning Practice

The theme "Current planning practice" presents how Gothenburg municipality describes its current planning practices concerning flood risk and land subsidence prevention and management. It highlights relevant procedures, policies and actions emphasised by the municipality to be important. The theme has two sub-categories: "Approach", presenting the municipality's description of how they undertake land subsidence and flood risk, and "Planning practices" which presents the municipality's description of how they, more concretely, perform their planning concerning land subsidence and flood risk.

5.2.1 Approach

Gothenburg municipality's approach to climate adaptation is described in the TTÖP as "adaptive", motivating it by pointing at the high uncertainty, speed and magnitude of climate change and its respective consequences. They write: *"Therefore, adaptation strategies must be flexible, and the city must follow the evolution of knowledge in this field"* (Stadsbyggnadskontoret, 2019, p. 13) Continuing: *"To be on the safe side, the city should use a scenario that overestimates rather than underestimates the risks of future climate change [...]* An adaptive approach is the strategy that can best deal with the uncertainties surrounding the pace of climate change" (Stadsbyggnadskontoret, 2019, p. 15). As quoted above from the TTÖP, the municipality's adaptive approach inherits an intention to continuously update their strategies with current research and attempt for their adaptation measures to be able to be updated or be added to if needed. Interviewee 1 explains the approach as having no other choice. Saying: *"Just today the IPCC published its latest report. So, there is always new knowledge coming in that we need to acknowledge."* (Interview 1).

Interviewee 3 says: *“I usually say climate adaptation is really a pure innovation-work”* describing how the work has no manual and thus often comes from a place of the municipality’s own engagement, initiatives, and a feeling of responsibility as a large municipality to take leadership and act as a role model for others. Interviewee 3 explains the innovative approach connects to their sense of responsibility; they should be innovative since smaller municipalities may not have the possibilities to be. However, interviewee 3 also says the municipality also aims to use existing tools. Saying; *“We don’t have to invent all of the wheels ourselves”* when describing their use of a methodology created by the Swedish Environmental Protection Agency for prioritising and structuring their climate adaptation work.

Interviewee 2 described the municipality’s situation concerning land subsidence by referring to the effects Gothenburg’s history of filling out previously water-covered land areas have had. Saying: *“We are a city that lives with land subsidence. And we need to adapt to it. We have it because we have chosen to create land. We fill in, and then we have automatically incurred it”*. The interviewee continues to describe how future development plans are set to be built on land areas with the most subsidence in the entire city. Thus, efforts toward managing land subsidence are described as a non-question. The phenomenon is described as capitol-destructive and as cause for a large proportion of current building permits to concern groundwork reinforcements. It has the potential to cause serious harm to new development unless current or possible ground movements are taken into consideration before building. Also, older structures are mentioned as at risk of land subsidence as efforts are described to also relate to the preservation of the older city centrum.

Because climate change in the case of Gothenburg is considered to bring an *increase* in water, the risk of land subsidence isn’t much considered from a climate adaptation perspective since the phenomenon is connected to a *decrease* in water (interview 1). When asked whether land subsidence is a topic considered in Gothenburg’s climate adaptation, interviewee 2 answered: *“No, not so clearly no. That’s not the question we’re linking it to. Instead, it is the landslide risk and erosion that we’re more concerned about.”*. It is interpreted that the topic of land subsidence is more often lifted as a separate risk, and instead of in terms of climate change it is lifted in relation to the general execution of plans, the suitability of the ground and dimensioning of construction. The phenomenon doesn’t seem to get lifted as a risk on a comprehensive level but rather in terms of more specific land areas.

When asked whether land subsidence could *still be* an issue as a result of climate change, looking away from Gothenburg’s predicted scenario, the interviewee describes it as possible but then more likely in connection to heat waves, longer periods of draughts and/or torrential rain.

Clearly if we have heat waves, we can have drying of the soil profile, but we can also have a lowering of the groundwater levels. Our groundwater levels, in central Gothenburg anyway, are completely controlled by the lower aquifer. Meaning the supply of very large amounts of water at 50-50 meters depth, perhaps. So, it is the influx of this aquifer that is absolutely decisive for whether we will have a new far-reaching subsidence phenomenon. So, a heat wave would have to be accompanied by a smaller kind of precipitation for a longer period of time. If we get torrential rain, it’s harder to get water to infiltrate into the ground, there could be a lot more surface water runoff for example. And that’s water that doesn’t benefit this lower

aquifer. If it's going to be replenished, we want to have, over a longer period of time, some quiet rainfall. (Interview 2)

It can be argued that the risk of torrential rain and the occurrence of drought is likely as Gothenburg's climate scenarios are also described in the extreme weather reports to predict an increase in the frequency of extreme weather events and the general average temperature (Göteborgs Stadskansli, 2006, 2008). Thus, despite the quote above being said with a tone of disbelief of it actually happening, there is a foundation to argue that it is likely. Thus, the following quote can be said to bring some discomfort:

[...] Should we get a heat wave combined with less precipitation, as it looks, well then, we could have far-reaching consequences in terms of our groundwater aquifers. (Interviewee 2)

Still, Gothenburg municipality not distinctly connecting the question of Land subsidence to its climate adaptation practices is understandable as interviewee 2 explains that the effects climate change could have on the groundwater levels, they could create themselves by wrongful planning. Saying:

We can build away a lot of these infiltration areas that exist today to replenish the lower aquifer. [...] You have to be aware of what kind of ground we are paving and building housing on. Because then we are diverting water that would normally be a good supply to these aquifers, and that will have consequences over time. [...] It's not just the heat itself or climate change, but we can do very well ourselves by thinking a little wrong (Interview 2).

Combining the quotes, it can be said to describe a perspective of land subsidence as a non-question. The municipality acknowledges that land subsidence may occur as a result of climate changes, but it may just as easily be caused by its regular planning. It appears as if the municipality's perspective is that land subsidence should be monitored with or without the risk of climate change impacts.

5.2.2 Planning Practices

When asked, Interviewee 1 describes how the ground's conditions, such as the clay-rich soil, affect climate adaptation against floods in the execution-phase, rather than in the planning stage. Interviewee 2 described that through their continuous work of measuring groundwater levels and ground movements, which is not necessarily for the specific purpose of detecting land subsidence, the municipality however collects data that is useful for such a purpose too. This would suggest a less strategic approach to land subsidence management and instead suggest management on a need-to basis in the later stages of the detailed planning process. For instance, when new settlements need to be dimensioned, earlier collected data is consulted for investigation of possible land subsidence in the specific area. If the data shows possible risks, the construction is adapted accordingly. However, interviewee 2 description of this management gave it perspective by describing that the municipality has a specific policy and procedure for including the geotechnical perspective: When new detailed plans for building are made, a remiss goes out to the municipality's geologist who consults available data to determine and give advice concerning the suitability of the specific land area. If the geologist finds that the available data is insufficient for such an assessment, or the area contains possible risks, the planners are told to investigate further. This would initiate the second part of the policy for

when a new geotechnical investigation is ordered, the municipality's geo-coordinator (interviewee 2) is notified to assess the investigation's quality. For instance, to determine whether the requirement of the investigation is well met, and possible conclusions and recommendations are well motivated. This policy's process is mentioned by interviewee 2 as a reason behind why the geo-department is often considered slow and a delay to the planning process, explaining the assessment of geotechnical data as time-consuming. However, it is interpreted as a necessary process to ensure the suitability of new development according to the ground's conditions, which the municipality is legally required to do.

[...] There are so many people actively working with geotechnical issues. We are a relatively large municipality, so we have the muscle to be able to do that. But we have also built-up routines and processes for how we should do things, because we have been working with this for a very, very long time. (Interview 2)

When asked how the risk of flooding is managed by the municipality, a work process is described by the interviewees in which they investigate the difference between the situation today and how the climate may change in the future and the corresponding consequences it will bring (interview 1). They also attempt to adjust their strategies based on how far along individual departments are in their climate transformation (interview 3).

"It's not just: How likely is it? How many people will drown in a flood situation? But it's not that simple, there's a lot of misery. Properties being destroyed, water damage, transport not working. There will be a lot of consequential effects in society" (Interview 3)

Based on the identified risks, new plans for climate adaptation are created on how to mitigate or avoid said risks. For example: Concerning the risk of heavy rains, they have worked especially with structural plans, which described how the municipality's collective water can be managed to avoid flooding. Such as how and where, in terms of the geographical landscape, the predicted future levels of stormwater can be managed for it not to cause floods in central areas. Concerning the risk of rising sea levels, because the municipality is located at the mouth of several large watercourses, the municipality's work concerning this risk is focused on increasing and further developing collaborations with other municipalities (especially those upstream) to decrease the risks and consequences of higher water levels. The work has also consisted of locating vulnerable areas and objects along the shorelines that will be damaged or destroyed if water levels would rise. For the vulnerable areas, they create plans for how they could best be protected. For this purpose, Interviewee 1 also mentions the creation of the TTÖP. In the TTÖP they describe for example objectives, guidelines, and tools they need for floodproofing.

It is also quickly mentioned that flood risk prevention is done in new planning. Its then they can demand new buildings to be a certain way. It is interpreted that in cases the buildings are not flood-proof (such as older/existing urban structures) the municipality plans for 'technical measures' instead, such as flood walls.

5.2.3 Inference

Considering the municipality's general adaptive approach to climate adaptation is, at least in part, due to the uncertainty of climate change. It can be considered surprising that despite the possibility of climate change resulting in land subsidence, the topic isn't discussed in the

context of climate adaptation. It presents a perspective of land subsidence as perhaps a minor or less prioritized risk. This can be understood if also noting that Gothenburg municipality is currently and continuously monitoring groundwater levels and ground movements. The monitoring practices would (hopefully) alert them if, despite the odds, the risk was to occur. The question becomes whether that system is enough also to stop the process in time before lasting damages occur.

This description of land subsidence as a problem mainly because it is capital destructive and a threat for physical damages could be interpreted as slightly narrow-minded. But set into a larger perspective it can be interpreted in a similar manner to how interviewee 3 describes the approach to flood risk. It's not just about numerical losses but also about the inflicted misery on the population. The destruction of a house is the destruction of a person's home and safe place. The destruction of infrastructure could be the destruction of somebody's way to work or access to electricity or drinking water. Depending on who you are, your socio-economic and/or physical state these damages may affect you differently. It is also worth noting the mentioning of how land subsidence presents a special risk to older buildings, as their foundations are built differently. This can be considered a threat with social and cultural consequences as historic neighbourhoods are then at a higher risk of damage.

As described above, the climate scenarios for the Gothenburg area are described to predict a general increase in water, thus the risk of land subsidence can be considered to go down, making it unlikely that new land subsidence processes will be initiated. Perhaps it is then the currently ongoing land subsidence processes that may be the biggest threat, as those are the ones currently making Gothenburg's climate adaptation harder by, for instance, changing the landscape for how flood impacts. It would suggest a need for the municipality to keep updating their materials describing the runoff patterns for stormwater (etc).

5.3 Assessments

The theme "Assessments" aims to describe how the municipality themselves evaluates their climate adaptation work against floods and their land subsidence management. The theme was identified, for instance, when challenges and opportunities were lifted as well as motivations were provided for their choice of methods. The theme has two sub-categories: "Success Factors", which presents what the municipality describes as key actions, parameters, or conditions for their management of flood risk and land subsidence to develop in a positive direction, and "Objectives" which presents the municipality's description of the goals and hopes they have for its planning's future development.

5.3.1 Success Factors

When asked about how Gothenburg has managed their climate adaptation and what they would consider success factors in their work, Interviewee 3 mentioned their collaborations and participation in research projects at research institutions and universities such as Chalmers as important, as they are important sources for new knowledge and innovation. It's also described that the general attitude the municipality has towards climate adaptation is also important as it sets the tone for the work and its possibilities.

[...] We must take some leadership here in Gothenburg and be this forward. And I think that has also been a success factor. The fact that we have had such a "mature" attitude to the issue. There have also been many committed officials, I should say,

who have been passionate about these issues and committed themselves far beyond what they are actually mandated to do. And they have also put forward their positions considerably. So, I think that's also a success factor, that you can get competent, committed, and enterprising people on board. (Interview 3)

Large credit is also given to the political environment in Gothenburg for its ability to develop its climate adaptation. Also, Gothenburg's participation and development of forms for collaboration and networks. For instance, the network "Göteborgsregionen", consists of 13 municipalities (Gothenburg included), and Gothenburg's "Geo-council", consists of 15 companies and administrations. The municipality uses these networks to receive input, feedback, new knowledge and help which greatly aids its management and task prioritization. Interviewee 3 explains how the form in which they work is important for managing different questions on different levels, from affecting neighbouring municipalities, to politics, to the world banks. *"Line organisation does not always benefit climate adaptation efforts. It can even hinder the development of climate adaptation work. But what does help the development of climate adaptation work is networking"* (Interview 3). Finishing her answer, interviewee 3 describes how it's truly about how one approaches a problem, relates to it, and describes it. Then based on said description create solutions.

When discussing the management of land subsidence, interviewee 2 describes how much of what they do falls back on the original assignment from the municipal council to perform certain tasks related to monitoring ground stability, land subsidence and groundwater levels. But the assignments have continuously developed based on needs and society's development. Viewing the assignments as "themes", Interviewee 2 described how they are free to decide what exactly should be done in order to fulfil the task. *"Under the umbrellas, there is a lot of freedom."* (Interview 2) Apart from the freedom, interviewee 2 also dedicates their success concerning Gothenburg's geo-related task to the available personal resources. *"I don't know when we got our first geologist, but he was there in the 1960s and early 1970s. So ever since then, there has been a continuity of having staffed geologists or geotechnical engineers in the operations."* (Interview 2).

All interviewees described that the municipality's work on climate adaptation and land subsidence prevention is conducted based on Gothenburg municipality's individual preconditions, and how it would be impossible for any other municipality to perform the same work. Interviewee 3 said: *"You can't copy Gothenburg and how we work. But you can take inspiration and learn from it. Every municipality is unique in how it needs to work with its climate adaptation challenge"* (Interview 3). In this statement, the interviewee can be said to state both that the Gothenburg municipality's prerequisites for working with climate adaptation are unique, and thus what they are able to do is unique and cannot be done in the exact same way by another municipality. Also, that the interviewee states, the challenge of climate adaptation is unique and appears differently for each municipality, thus all municipalities don't have to do everything that Gothenburg municipality does. Instead, the interviewee explains, climate adaptation needs to be based on each individual municipality's challenges and capacity for planning, finding their systems and work forms to manage climate adaptation.

5.3.2 Objectives

Both in the documents and in the interviews, several hopes for developments were presented based on what the municipality explained as needs and probably natural development.

Interviewee 2 described a need for further data on ground movements based on satellite measuring. Unfortunately, satellite measuring is very expensive for individual municipalities so instead, they hope for the government to fund it on a national level. This would provide every municipality in Sweden with useful data on ground movements, which could be used for more than just monitoring land subsidence. This data could increase the quality and efficiency of urban planning overall as it would provide a material more easily shared, read, and understood, (also by non-professional and/or external actors) compared to today's materials for decision making which are described as more time-consuming. Funding on a national level is described to lower costs immensely as it would also decrease the need for financing consultants. Interviewee 2 describes:

We also see from a societal perspective that as long as we don't get help from the national level, our consultants will do "business" on this. That is, they will sell the same information to us and to other actors in the community again and again and again. Because they have the knowledge to process this, know where to get the data and have already bought it once for example. And that doesn't feel quite right when they're working for taxpayers' money. And that's why I think it would have been much better if much more information had been produced nationally that would have given all the consultants the same opportunity to get the information and help their clients, but also the municipalities to get that information to the extent that they can process it and then distribute it to where they think it will be most useful.
(Interview 2)

Interviewee 2 also describes a begun project of creating a vulnerability map concerning risks related to the construction of fundamentals. Meaning, a mapping of locations which are especially sensitive concerning the construction of groundwork. For instance, areas where groundwater infiltrates to the lower aquifers, where there is a high risk of land subsidence or where construction would require infiltration into the lower aquifers. Such a map would provide, for instance, developers with knowledge on where they have to be particularly careful when laying fundamentals. It would also save time and resources in the planning process in the long term or for individual projects if such as map was created. It would for instance provide developers with knowledge on when, where and what to take into consideration without consulting with the municipality. It would also provide the municipality with a useful foundation from which they can assess if the developers have sufficiently investigated and planned accordingly when they submit requests for building permits (Interview 2). It is also mentioned as useful to avoid the planning mistakes earlier mentioned by interviewee 2 concerning accidentally building over water infiltration areas, causing risk of floods and land subsidence (see chapter 5.2.1).

5.3.3 Inference

Internal success factors described by Gothenburg can be considered to be the municipality's sense of responsibility, urgency and importance of climate adaptation, flood risk and land subsidence prevention. External success factors can be said to be described as the political landscape, the will of external actors to share their knowledge and invite Gothenburg municipality to participate in their networks as well as trust from decision-makers visible in the flexible assignments allowing the municipality to perform their tasks in the way it sees fit. It can be argued that much of what the municipality wishes for in the future is a "modernisation" of the planning system. Meaning they wish for new tools and methods to be used for the creation of new materials to support their planning decisions. For example, measuring ground

movements on a national scale as there is new technology available to do so. Overviewing, they can be considered to call for an update of the planning system for it to match the development of planning issues in society.

What is written in the chapter above can be considered to again fall back on the earlier mentioned description of regulations and the planning system. Gothenburg municipality explains above how much of what they do concerning land subsidence falls back on the assignments given by the municipal council, and how they *enable* planning by being shaped as umbrellas describing the general question the municipality should work with rather than depict the exact task the municipality should perform. Perhaps this way of regulating planning on the municipal level could be applied to other questions as well? Allowing the municipalities to create their own work forms rather than keeping them to a set mould.

Another interesting aspect of what is written above is how Gothenburg municipality credits their positive adaptation practices to the sense of responsibility and the personal engagement of the municipality's employees and the political climate. It would be interesting to further investigate how this sense of responsibility and engagement can be transferred to other actors and municipalities.

6. Discussion

In this chapter, the results of the document analysis and the interviews will be discussed in relation to scientific research as well as the thesis theoretical framework. The chapter aims to reflect on the results from new angles as well as to put them into a bigger planning perspective. The chapter also aims to connect the research results back to the questions asked in the thesis introduction.

6.1 Strategic Planning of Land Subsidence

Gothenburg shares the academic literature's view on climate change as highly uncertain and has integrated this into their planning practice by taking on the adaptive approach to their general climate adaptation. This reflects similarities to the theory of strategic planning, as they have "accepted" the uncertainty as a condition for their planning practice and found a way to work under those circumstances. Aspects of strategic planning are also visible in the municipality's use of the word "robust" when discussing their objectives for climate adaptation. The term is used both in the TTÖP and in the municipality's comprehensive plan (Stadsbyggnadskontoret, 2009). This is an example of the concept of envisioning. The word robust suggests a vision of Gothenburg being able to withstand the impacts of climate change. It is also similar to Nicholls (2018) description of different strategies for flood management in the academic literature, further suggesting a strategic approach. Although, Nicholls calls the approach Gothenburg municipality can be said to use "protection". The word "robust" used by Gothenburg Municipality use suggests a more aggressive approach. Other examples of envisioning are Gothenburg municipality's description of themselves as "leaders" and its responsibility towards other municipalities to be innovative or initiate climate adaptation efforts as a large municipality with resources. This gives the municipality a character, a vision of how it would like to be viewed and also provides a sense of its ambition level. Here you can also note the concept of selectivity. The municipality has chosen to attempt to take on the role of leaders within the field of climate adaptation. This choice has likely come at the cost of other options. They also present a planning process which sees planning outputs, meaning plans, guidelines and strategies, as important tools for urban planning.

In chapter 5.1, two definitions of strategic planning are presented. The first focuses on strategic planning as the coordination of planning entities to achieving a collective goal or vision, and the second focuses on strategic planning as a deliberate action for framing the purpose of a planning entity, what it does and why. Gothenburg municipality's management of land subsidence can be considered to fulfil the description of strategic planning as defined by the quotes. The result of the research presents a climate adaptation approach which values the use of network's and network's ability to aid in framing an institution's purpose and solve common problems. For example, interviewee 2 described how the municipality's "geo-council" was important for the collection of knowledge (evidence), for the municipality to receive feedback but also for the municipality to know how to prioritize their tasks and how to focus their work. Interviewee 3 described that one of Gothenburg's success factors for managing their climate adaptation was that they created networks for collaborations (both regionally between municipalities but also locally between companies), meaning that they deliberately created platforms on which to coordinate planning-related actors to help with certain planning-related questions which all the participating actors had in common.

Gothenburg municipality can be said to manage land subsidence strategically, as it has made the connection that its efforts for monitoring ground stability are also useful for monitoring land subsidence processes. The municipality continuously monitors both groundwater levels and ground movements in sensitive areas in order to identify risk areas and detect if any changes occur which may cause land subsidence. These efforts are made deliberately to prevent land subsidence effect and can thus be said to align with the second definition of strategic planning mentioned in the paragraph above. As described in chapter 5.2.2, the municipality also has procedures and policies in place for how land subsidence should be integrated into planning and be taken into consideration before building. However, those procedures can be said to be limited to the execution phase of the planning process. The procedures are also not included in any strategic document. Perhaps further benefit could be gained if also integrating knowledge on land subsidence in the comprehensive documents that guide planning on a higher level.

Land subsidence is not managed within the frames of Gothenburg Municipality's climate adaptation but rather as a separate issue. Looking at the literature, this isn't necessarily a bad approach. What the literature can be interpreted to especially want to emphasise is the fact that flood risk and land subsidence share connections and that they may affect each other. Therefore, it can be argued that land subsidence should be integrated into climate adaptation at least to the degree that the phenomenon's risks and relevance are mentioned in the documents which guide detailed planning and the execution of adaptation measures, emphasizing important considerations to avoid land subsidence and to notice the phenomenon's warning signs. It is rather the awareness of the relationship between land subsidence and flood risk that is important, not that their management methods are fully integrated. This may be where the case of Gothenburg becomes complicated as Gothenburg municipality can be considered to not always show this awareness in its guiding documents for planning.

In the interviews, the municipality express an awareness that land subsidence is a phenomenon which can be caused by climate-related factors, such as higher temperatures and draughts. They also mention that climate change may increase the occurrence of those factors and thus increase the likeliness of land subsidence occurring. In their strategic documents for guiding detailed planning, however, the municipality doesn't show the same awareness. The documents can be said to only mention land subsidence as a complicating factor for the execution of climate adaptation measures inherited because of the clay-rich soil. Neither the interviews nor the documents express a particular awareness of land subsidence as an enhancer to- or something that may make climate change-related incidents (such as floods) impact the urban environments more severely as the academic literature suggests. Gothenburg municipality did, however, make it clear in the interviews that the work on land subsidence isn't connected to its work on climate adaptation. Therefore, it shouldn't be surprising that little information on land subsidence exists in their climate adaptation documents. But that doesn't mean it is the best option. If the knowledge concerning flood risk and land subsidence is only known by the municipality through professional evidence (meaning as knowledge held by its employees), on the occasion of a generation change, or certain staff not being included in a certain project, the knowledge could easily be lost. Arguably it is therefore important to include the information in the strategic documents as they are meant to be read and followed by all who conduct physical planning.

Based on the descriptions in this thesis' result chapter, Gothenburg municipality doesn't deny land subsidence's relationship to flood risk or completely reject it. It can rather be described as de-prioritized in the context of climate adaptation. This can be understood seeing as probability

would suggest that the risk of land subsidence will stay the same, or even lessen as water levels are predicted to increase in the Gothenburg area whilst the consequences of an increased frequency of flood are depicted as severe in both probabilities and possible consequences. Thus, minimizing land subsidence in a climate change context is understandable, as the municipality has to make priorities in their workload. Making these priorities can even be considered reasonable. They are for example explained by the concept of selectivity in strategic planning theory as a natural part of planning (Gunder et al., 2017). The municipality's choice can be said to be based on scientific evidence and an acknowledgement of the municipality's planning capacity, which can be considered a solid foundation for decision making, aligning with the concept of evidence-based planning (Forsemalm et al., 2019). However, the scientific evidence emphasises the impacts of climate change as uncertain and general climate temperatures are still set to increase, something the municipality has acknowledged in their documents and general climate adaptation approach. The uncertainty means there is still a risk for climate change to initiate severe land subsidence processes which could arguably question the municipality's priorities. Also noting the fact that the municipality described an "uneven" climate adaptation development, in which they have prioritised flood risk and just recently started prioritizing adaptation for heatwaves, would strongly support the notion of a still prominent climate change-induced land subsidence risk. Even if a draught is mild and doesn't initiate large land subsidence processes, small land subsidence occurrences can still cause severe damage if it hits wrong. Such as in Gothenburg's historic neighbourhoods. Maybe it is worth it for Gothenburg municipality to further integrate or mention the relevance and the risks land subsidence has in the context of climate change (such as the risks of water scarcity) if, despite the odds, severe impacts on the groundwater levels were to happen, so counter actions can be implemented more efficiently, and knowledge won't be lost.

6.2 Evidence-based Urban Planning in Gothenburg Municipality

In accordance with the literature, Gothenburg municipality expresses that the responsibility of conducting climate adaptation can often be a heavy burden for a municipality (Storbjörk, 2007), and therefore express a wish for additional support both from the regional level, the Swedish government, as well as internationally. In the result chapter it is presented how Gothenburg describes itself to be exposed to climate change and land subsidence because of their geographical and topographical conditions, and because of its building history. Thus, their exposure can be said to be in part, self-caused. That does not, however, make climate adaptation or the management of land subsidence any less difficult to perform. And-, which was also mentioned by interviewee 3, it doesn't mean it is rational or right to place full responsibility on the municipality to fix the problems. It rather just highlights the importance of continuous evaluation of current planning practices to hopefully improve sustainability for the future.

The results of the research can be said to reflect the idea of planning as a wicked problem and practice, as described by Forsemalm *et al.* (2019) in the thesis' Theoretical framework-chapter. For example, Gothenburg municipality's description of its problems concerning climate adaptation can be said to reflect the literature's concern that climate adaptation is a too complex an issue for a municipality to handle on its own. The municipality describes the use of networks and the need for further support from the government and other authorities (which can be compared to multi-level governance) to collect knowledge (evidence) as support for their decision-making. This can be compared to evidence-based urban planning.

Gothenburg municipality also recognizes complexity when they describe how the entire city needs to be included in climate adaptation. The municipality, for instance, describes how just creating a new policy and integrating it into current planning isn't enough as it wouldn't create sufficient protection for old parts of the urban environment. It also would create an "uneven" development as the buildings would have different floor heights. This can be described as a complexity which touches different dimensions of planning: the municipality seemingly refrains from implementing policy on new development that is to be placed in existing neighbourhoods as it would create a bad experience of the built environment. Thus, they choose between protection and citizens' urban experience. A similar, but perhaps more concrete example is the complexity presented in chapter 5.1.2, in which, for financial reasons, the municipality describes they have to choose between climate adaptation or building schools or hospitals. All are important, but the fundamental conditions of planning force a priority between them to be made.

So how does the municipality manage the complex reality of planning for climate adaptation, land subsidence and flood risk? As mentioned, Gothenburg municipality undeniably recognises the need for governance to manage the magnitude of climate adaptation. The municipality emphasises the necessity for different forms of collaborations and how they create and participate in networks for the exchange of knowledge and input from stakeholders (also known as stakeholder evidence). This reflects Gothenburg municipality has a good awareness of their current organisational capacity (organisational evidence) and that it needs to be expanded. Based on the statements of interviewee 3, Gothenburg municipality attempts to create further organisational evidence by innovating, testing, and participating in different forms of collaborations and networks with different actors. As mentioned by interviewee 3, they need to create better systems and tools to increase the quality of climate adaptation. This could also be described as a need for further organisational evidence. As shown by their problem description concerning their planning capacity in chapter 5.1.2, it gives the impression of an awareness that the current planning system needs to obtain better flexibility to be able to manage the increasing complexity of today's planning problems. A similar wish to update the current planning system through the innovation of new collaboration forms is also reflected in the literature. However, this creates pressure for judicial regulations to keep up. As described in chapter 3, strategic planning is sometimes criticized for stepping outside traditional planning practices diminishing the transparency of planning and thus limiting the inclusion of democratic aspects. If the planning system – meaning the way planning is performed - is to be changed, the change must be monitored by both higher levels of government and by the public. This can be considered to limit how inventive a municipality can be in the creation of new planning methods. Updating the planning system through increased use of governance would align with the arguments of Albrecht, Barbanente & Monno (2019) who described networking as a way of increasing the possibility of participation in planning processes. However, it is also important to note that it may increase the risk of lack of legitimacy as the planning processes becomes more difficult to follow and perhaps would be shaped differently depending on the situation. If new work forms are created the legitimacy of the planning outputs created through them need to be monitored to ensure the democratic aspects are still being upheld and, for instance, citizens are still part of the decision making. It is a sensitive balance as the literature, as well as the concept of evidence-based planning emphasises the need for including the community (or similar kind of stakeholder evidence) in questions concerning climate adaptation and land subsidence as it's a source of local context knowledge, vital for the quality of the planning outputs. But it may become

difficult if the networks in which we conduct planning start ranging in shapes and become too complex. How does the public then know how to participate?

The method described by Forsemalm *et al.* (2019) in evidence-based urban planning is quite easily found in Gothenburg municipality's way of working. As explained throughout this thesis, land subsidence and flood risk are individually complex issues but they also often intersect and are integrated. In the case of Gothenburg municipality, flood risk can be considered a well-defined issue with systems and procedures for how to approach it. Land subsidence, on the other hand, may need to be looked at from other angles to get a better view of its extent. From the technical perspective, land subsidence can be considered a well-managed problem by Gothenburg municipality, but perhaps a further investigation into the ecological and social perspective would give a slightly different answer.

6.3 Concluding Discussion

This research has shown how Gothenburg municipality manages climate adaptation, land subsidence and flood risk. The research has shown that the municipality doesn't include land subsidence in their climate adaptation in a strategic way. Instead, it is managed as a separate issue and in the execution phase of the planning process. In relation to the academic literature, this is recognised as a valid approach considering Gothenburg municipality's predicted climate change scenarios. However, it is also recognised that there would be a benefit to include the subject in higher levels of planning so the knowledge is less likely to be forgotten and the topic can be managed more comprehensively treated over larger areas. This is especially relevant as land subsidence is described to be able to occur over large areas. If the risk of land subsidence being induced by climate change-related factors were to occur, the knowledge would also be more integrated and could hopefully result in quicker counteractions before damage appear.

Whilst flood risk and land subsidence are managed separately, they individually can still be considered to be managed strategically as Gothenburg municipality can be considered to deliberately put effort into preventing and mitigating the risks through networking and setting up long term visions for their solutions. The municipality presents good examples of managing land subsidence for instance in their description of the work process for how they integrate the topic into detailed planning. They provide examples of success factors such as the integration of different kinds of knowledge from different sources as well as the importance of prioritizing as there are not enough resources for all risks to be faced. Another success factor for the municipality's management was described as their attitude towards their climate adaptation work. They explained a sense of responsibility for leading the way in climate adaptation and being innovative as it may be more difficult for smaller municipalities.

Although recognising the relationship between climate change and land subsidence is relevant and supported as important by scientific research, it doesn't mean there is enough capacity or evidence available for that knowledge to be implemented in practice. In fact, the current capacity for climate adaptation may not be enough to integrate the topics. As presented by the research, society shows a current development of wicked issues, meaning its increasing in complexity and interconnectedness. The current planning system is as described currently not able to integrate everything into every plan as it is lacking resources and tools for how it should be done. It can be argued that a certain separation between planning problems needs to be made to make them workable and the planning for them doable, perhaps greater benefits come from sorting what topics should be managed strategically and what is better done on a smaller, more

detailed scale. Instead of creating overwhelming strategies by writing in the relevance of the topic. Perhaps the true wickedness of strategic planning comes from the fact that we are always forced to choose which topic, which question, which risk, or what need we satisfy now. And what we have to go without. Based on the findings in this research an argument can be made for land subsidence to be one of the topics that perhaps are better managed on a detailed level. If we can modernise the materials, we use to integrate them into planning, perhaps that is enough to avoid the bigger land subsidence event that, as the academic literature describes, would suggest the loss of drinking water, social and economic impacts by damaging our homes and cultural neighbourhoods. This would suggest more extensive monitoring and maintenance of the ground conditions. However, seeing as how the literature explains that land subsidence processes most often occur over large areas, and the interviewees described how the groundwater in Gothenburg is controlled in a few but large underground aquifers, perhaps in the case of Gothenburg the municipality would gain from emphasising the risk of land subsidence on the strategic level. Exactly in which documents or at what time in the planning process requires further investigation.

7. Conclusions

7.1 Concluding discussion

The relationship between land subsidence and climate change in the context of municipal urban planning can be understood as a wicked problem as it is hard to define and require multi-level governance in order to be managed. This conclusion is made based on Gothenburg municipality's continuous descriptions of the importance of working through different networks to collect evidence and information on how to manage and prioritise its workload. Exploring Gothenburg municipality's climate adaptation practices have shown that land subsidence may be more realistically managed separately if considering municipal planning capacity. This conclusion is made based on strategic planning theory's emphasis on the necessity of strategic planning to be selective as it describes the unrealisticness for municipalities to manage all problems. This adds to the notion of land subsidence as a wicked problem for Gothenburg municipality because although the predicted climate change scenarios for the Gothenburg area describe a lowered risk of land subsidence, the uncertainty of the prediction still makes the risk relevant and even probable if seeing to Gothenburg municipality's described "uneven" development of climate adaptation where they have prioritized adaptation against flood risk instead of adaptation for heat waves, which is the larger cause for land subsidence. Still, under the circumstance and based on the available scientific evidence, Gothenburg municipality still manages to integrate land subsidence into their planning processes in a strategic way that also includes it in climate adaptation, if only in the execution phase before building. A recommendation would however be to further document their current management procedures for land subsidence to avoid losing knowledge in case of a generational change, as most of it seems to be tied to Gothenburg municipality's professional evidence. A second recommendation is to if only as a side note, note the relationship between land subsidence and climate change in their climate adaptation strategies for flood risk to better prepare and be able to detect growing risk as climate change continues to manifest in urban society.

7.2 Final Conclusions

7.2.1 How Does Gothenburg Municipality Approach Land Subsidence and Flood Risk as Strategic Planning Problems?

Gothenburg municipality describes taking an adaptive approach to their general climate adaptation as a way of facing the uncertainty of climate change by continuously reviewing new research and adding new knowledge. This reflects the concept of evidence-based planning in the form of an integrated internal practice within Gothenburg municipality to continuously evaluate its current state, capacity, and knowledge in order to improve the sustainability and quality of climate adaptation planning.

Both flood risk and land subsidence are problems which are described by Gothenburg municipality to be non-questions. The municipality must manage flood risk as the climate scenarios for the Gothenburg area predict a high risk of floods as a consequence of sea-level rise, extreme weather events and more frequent heavy rains. The municipality must plan for Land subsidence as the municipality's geological preconditions and planning history of filling out wetlands for new development makes the risk always present.

Gothenburg municipality's approach to land subsidence prevention is strategic in the sense that it has procedures in place for how land subsidence as a planning issue should be included in the planning process. The municipality, for instance, has programmes for measuring ground movements and groundwater levels for preventive purposes. However, much of the materials founding the management of land subsidence are performed for the purpose of monitoring ground stability, and not primarily to avoid land subsidence. The result of the measuring programmes, which could indicate areas sensitive to land subsidence risk, are neither presented in the strategic documents analysed in this study. This lack of inclusion would suggest Gothenburg Municipality has a less strategic approach to land subsidence as a planning problem. This can be considered confirmed by interviewees 1 and 2 saying land subsidence isn't connected to climate adaptation, but rather to the execution phase of the planning process.

Gothenburg municipality's approach to flood risk prevention is undeniably strategic, based on the research conducted in this study. The subject is well integrated into higher-level strategic documents, such as the TTÖP, and knowledge of how to manage flood risk as a planning problem is thus easily accessed and integrated into the planning process. The use of the term "robust" in Gothenburg municipality's strategies for climate adaptation for flood risk shows the municipality has a set vision for how the final product of its climate adaptation should be, reflecting the concept of envisioning from strategic planning theory.

7.2.2 How Does Gothenburg Municipality Describe the Risk of Land Subsidence in Relation to Flood Risk?

Gothenburg Municipality can be considered to approach flood risk and land subsidence as two separate planning problems. However, the municipality's approach to both problems can be said to stance from scientific evidence. For flood risk, Gothenburg municipality bases their approach on climate change scenarios and the municipality's geological and topographic preconditions. For land subsidence the municipality base the approach on investigations of the ground's conditions and technical instructions for how to avoid land subsidence when building.

In relation to Gothenburg municipality's climate adaptation for flood risk, land subsidence is described as less of a priority as the risk of an increase in land subsidence events due to climate change is less probable. Land subsidence is also described as a phenomenon which may complicate the execution of flood risk adaptation, as a land subsidence process may cause technical protection measures to sink and thus become less effective.

In comparison to flood risk, land subsidence portrayal comes off as quite concrete and uncomplicated. It can be said to be described as the result of not considering certain factors (such as the soil conditions or water infiltration) when executing planning. But as long as you do consider the factors there will not be a problem. In comparison, flood risk is described in a more "wicked" sense. The risk is more unpredictable, it needs more advanced materials to plan for, and all its aspects and possibilities appearances seem more difficult to integrate into plans. However, the consequences of a land subsidence event and a flood event's severity in terms of damages to the urban environment are described somewhat equally.

7.2.3 How Does the Risk of Land Subsidence Appear in Gothenburg Municipality's Climate Adaptation Strategies?

The risk of land subsidence appearance in Gothenburg municipality's climate adaptation strategies for flood risk can be described as weak. Instead, knowledge on how the municipality

would connect land subsidence to flood risk has been collected through performed interviews, suggesting its tied to professional evidence. The risk of land subsidence is described as a factor which isn't connected to the municipality's climate adaptation but rather as a separate topic. If included in climate adaptation, it is in the execution phase of the municipality's planning process as it is then the ground suitability is taken into consideration.

7.3 Further Research

Suggestions for further research on the same topic as this thesis could be to continue studying how land subsidence can be better integrated into municipal level strategic planning. A suggestion for research focus could be to research how and in which strategic documents for the guiding of planning practices should include information on land subsidence. This could be done by, for instance, interviewing detailed planners, plan architects employed at a municipality or private developers to see how and/or where the risk of land subsidence should be better integrated on a strategic level (in which documents for example) to make it easier for them to consider the risk in their work. This thesis has focused on the strategic level of planning, but further research into how land subsidence is managed in the detailed planning process could provide better knowledge on how land subsidence can be more effectively managed.

A second suggestion for further research could be to perform a mapping of land subsidence incidents in Sweden and identify their causes and confirmed or possible consequences. This could further increase the notion of land subsidence as a relevant topic for Swedish planning as well as support the idea of national investments in planning tools for managing it. A mapping could also be performed of how private actors or citizens are affected by land subsidence as it could provide a better understanding of the social implications of the phenomenon.

A last suggestion for continued research would be into the need for national scale measuring of ground movements. Measuring ground movements on a national scale is described by Gothenburg municipality in this thesis as useful to lower the costs of planning as well as improve the quality of planning products. A focus for the research could, for example, be how data on ground movements can be useful for other questions other than land subsidence. If other uses are found it would support the national scale investment.

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