

# Climate Change Adaptation Monitoring on a Local Scale

An explorative study into the use of monitoring practices  
in Dutch municipalities



Merlijn Anderiesse

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Nijmegen School of Management

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# Colophon

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<b>Author:</b>	Merlijn Anderiesse
<b>Student number:</b>	1046300
<b>Contact:</b>	<a href="https://www.linkedin.com/in/merlijn-anderiesse-2188b0108/">https://www.linkedin.com/in/merlijn-anderiesse-2188b0108/</a>
<b>1<sup>st</sup> assessor &amp; supervisor:</b>	Dr. K.M.C. Raaphorst
<b>2<sup>nd</sup> assessor:</b>	Prof. Dr. S.V. Meijerink

## University

Radboud University  
Nijmegen School of Management  
Elinor Ostrom-building  
Heyendaalseweg 141  
Mailbox 9108, 6500 HK Nijmegen  
024-3612118

**Radboud University**



## Internship placement

Deltares  
Daltonlaan 600 3584 BK Utrecht  
+31 (0)88 335 7775

**Deltares**

**Internship supervisor:** Gerald Jan Ellen

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# Preface

Through my academic years, I have always had an interest in how we can shape our physical environment to not only deal with climate related aspects, but also use them as an opportunity to create something of value. Which is why the topic of climate change adaptation monitoring interested me so much, because implementing adaptation measures is one thing, but assessing whether it works or not is another. Because climate change is continuing to become such an important aspect of our daily lives, it's effects will continue to shape our future and how we deal with it by altering our physical environment. As such, I hope that my input through this study can aid in an improvement of the way in which we deal with climate related effects.

Before starting this thesis, I had very limited knowledge on the topic of monitoring related to climate change adaptation. Which made it both a challenge as well as an opportunity to learn something new. Which is why after finishing this research, I can say that I have learned a lot about how we can monitor climate change adaptation measures, and what kind of functions it has in a municipal organization. I therefore hope that with this newly acquired knowledge, I can aid in building a future which is not only resilient to negative effects of climate change, but also aims to identify possible opportunities to make our living environment more natural and enjoyable.

While the bulk of this work is my own, I did receive plenty of help from different people through my overall graduation period of five months from March 2021 to August 2021. Which is why I would like to take this moment to thank the following people. Firstly my supervisor at Deltares, Gerald Jan Ellen, who, in times of covid-19 helped me a lot during the overall internship process. He helped motivate me, and provided me with helpful insights which were very beneficial for writing this thesis. The meetings which we would have together and with the other interns were very accessible which gave me the feeling that I could be myself. Which made the internship period very enjoyable, which I think is also reflected in this thesis. Secondly, I would like to thank my supervisor from the university: Kevin Raaphorst. Kevin provided me with many helpful insights into the overall academic research process, during which I had plenty of moments of feedback which helped me maintain the academic integrity of my thesis. During this time, Kevin was very approachable and always provided the feedback in a positive way, which made working with Kevin very accessible and enjoyable. Also, I would like to thank the employees at Deltares who in any shape or form helped me with getting into contact with other people, or providing me with insights with regard to my topic. Even though the internship period was entirely online, I found Deltares to be a very friendly, approachable and professional company, for which I am happy to have been a part of. Last, but certainly not the least, I would like to thank all the respondents from the interviews and the focus group for their time and interest in my study. Without them, I could not have produced the results which I did. As such, they themselves have contributed to the overall increase of the knowledge base with regard to this topic. And for that, I am thankful.

I hope that you, the reader, finds this thesis educational and enjoyable to read!

# Abstract

Within the Netherlands, the ambition of the Deltaplan Spatial adaptation is to become climate resilient by 2050. Which means that local governments will need to adapt their physical environment in order to become so. However, this task is difficult due to the fact that climate change adaptation faces many barriers. Within the adaptation process, the process of monitoring is seen as a means to assess the overall effectiveness and degree of implementation of the options which are implemented by means of a municipalities' climate change adaptation policy. However due to a lack of knowledge and implementation on monitoring practices, assessment of the effectiveness and degree of implementation of adaptation can prove to be difficult, which can result in municipalities not being able to achieve their adaptation goals. Which is why the aim of this study is to study climate change adaptation monitoring strategies in Dutch municipalities which have developed an adaptation strategy, to serve as learning outcomes for other municipalities. As such, the following research question was set up to achieve this aim: "to what extent can climate change adaptation monitoring result in improved adaptation policy in Dutch municipalities, and how can principles of learning be implemented to improve this process?"

This study used an existing framework for climate change adaptation monitoring in which the system of interest; indicators; responsible organisations and procedures for monitoring need to be identified for monitoring to take place. Along with this framework, principles of learning were applied due to the fact that the practice of monitoring constitutes a continuous learning cycle. Which include concepts of single- and double loop learning, along with social learning. The methods which were used to answer the research question by means of the above provided theory included semi-structured interviews with thirteen individuals from municipal organization who are connected to its climate change adaptation policy. To further test the result which came out of the interviews, a focus group was planned during which six respondents engaged in an online group discussion on each of the results per concept.

After assessing the results, it became clear that the monitoring of climate change adaptation in municipalities is still performed on an incidental basis due to the fact that none of the municipalities possessed a monitoring protocol in which clear agreements are made on the monitoring process. The emphasis therein is currently mainly on water nuisance related monitoring, with drought and heat related monitoring being in the start-up phase. The lack of monitoring practices is mainly due to the fact that municipalities find it difficult to determine when their municipality is considered to be climate resilient, which makes setting up goals for monitoring more difficult, which makes setting-up measurable indicators difficult. Along with the fact that many municipalities do not have enough funding, time, or capacity to engage in monitoring tasks. As such, climate change adaptation monitoring can result in an improvement of the adaptation policy when clear adaptation goals are formulated, and municipalities are able to engage in monitoring practices. In order for principles of learning to complement this process a municipality will need the capacity to learn in an integral way; have the willingness to learn and have the capacity to cooperate with other actors and share learning outcomes. In doing so, the learning cycle which is tied to climate change adaptation monitoring can be used in the optimal way, which can result in an improvement of local climate change adaptation policies.

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# 1. Introduction

The introduction section aims to introduce the research topic which is central to this thesis. It includes background information on the context, the problem statement, research aim, research objectives, the research questions, a justification of the societal and scientific relevance and the overall research outline.

## 1.1 Background

The Netherlands is, according to PBL (2017): “one of the most densely populated and urbanised deltas in the world which is facing complex challenges with respect to managing the effects of climate change and providing a safe and prosperous environment for the Dutch population, economy and ecosystems” (p. 10). In tackling these different challenges, the national government established the so called Delta Program, which is built around three central themes: water safety; freshwater supply and spatial adaptation. With regard to the theme of spatial adaptation, the national government established the Deltaplan Spatial Adaptation which includes guidelines for how different government levels including municipalities, waterboards, provinces and the national government can accelerate the spatial adaptation process and tackle climate related problems (Ministry of infrastructure and water management & Ministry of economic affairs, 2017). Related to the concept of adaptation, it is defined as an: “adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts” (Smit et al. 1999, in de Bruin et al. 2009, p. 24). Consecutively, by means of this plan the national government of the Netherlands aims to become climate resilient by 2050 which essentially means that it is resilient to these actual or expected climatic stimuli,

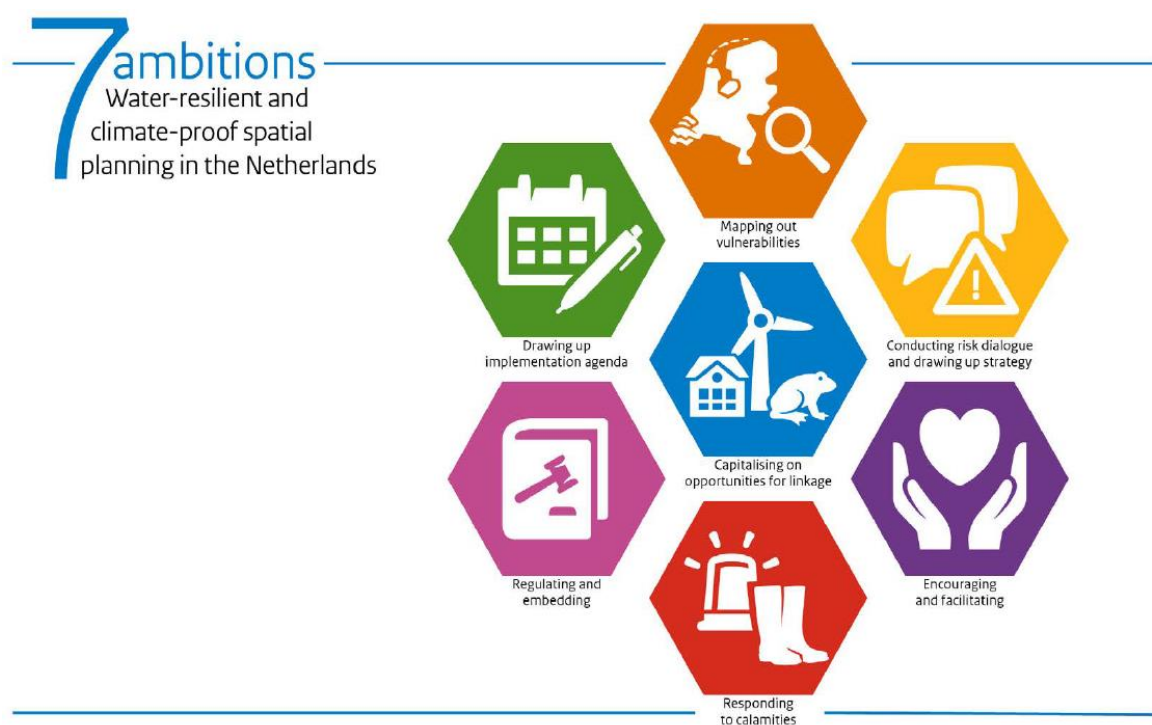


Figure 1: Seven ambitions for water-resilient and climate-proof spatial planning in the Netherlands (Ministry of infrastructure and water management & Ministry of economic affairs, 2017).

effects and impacts (Ministry of infrastructure and water management & Ministry of economic affairs, 2017). This Delta Plan Spatial Adaptation states how municipalities, waterboards, provinces and the national government can speed up and intensify the process of adaptation, by means of seven ambitions, as is shown in figure 1. The ambitions can be substantiated concurrently and the sequence may differ from one location to the next (Ministry of infrastructure and water management & Ministry of economic affairs, 2017). The first ambition is to map the climate related vulnerabilities within each of the municipalities with a so called climate stress-test. Which are focused on four climate related themes: water nuisance; heat; drought and flooding. An explanation of each climate theme is shown in table 1 (Stichting Cas, n.d.).

Water nuisance	Heat	Drought	Flooding
Water nuisance caused by heavy rainfall in a short timeframe; water nuisance caused by heavy rainfall in a long timeframe; and groundwater nuisance.	Heat stress caused by high temperatures.	Drought caused by a shortage of water, which can occur when the demand for water in an area is higher than the amount which is available.	Flooding from sea and flooding from rivers.

*Table 1: The four climate-risks (as explained by Stichting Cas, n.d.).*

Based on the stress test, a risk dialogue is established which aims to determine the risks based on the four themes. After which an implementation agenda is drawn up which aims to implement adaptation interventions which will need to tackle these risks. In a monitor and evaluation of the current progress towards the Deltaplan Spatial Adaptation, published by Stichting CAS, (2020) it is stated that by 2019, all municipalities executed the climate stress test for their entire territory which is to be repeated once every six years to cope with overall changes in the spatial environment and the climate. Consecutively, regarding the drawing up of the implementation agenda, during the writing of this research, (2021) municipalities are currently working on the establishment of adaptation strategies to tackle the vulnerabilities (Ministry of infrastructure and water management & Ministry of economic affairs, 2017). However, in an assessment of the progress, as of the end of 2020, it is stated that around twenty-five percent of municipalities and waterboards have established a climate adaptation strategy based on the vulnerabilities (Stichting CAS, 2020). It is acknowledged that during and after the writing of this thesis the establishment of climate adaptation strategies of municipalities is to have increased.

With regard to the subject of climate change adaptation, Moser and Ekstrom (2010) state the following: “adaptation to climate change has risen sharply as a topic of scientific inquiry, in local to international policy and planning, in the media, and in public awareness” (p. 22026). They continue by stating that the actual or expected climatic stimuli reflect the importance of adaptation in both tackling current-day issues, as well as issues which will exist in the future

due to the changes in climate. With regard to the Netherlands, due to its high population density, economic activity, and the fact that it has a strong spatial component, climate change adaptation is strongly tied to the spatial planning doctrine (Goosen et al., 2014). Related to spatial planning, Moser and Ekstrom (2010) established the adaptation planning cycle, as shown in figure 2, which state the different steps within the adaptation process in chronological order, starting with a detection of the problem. The focus for this thesis will be on step eight of the process: monitor option and environment as part of the management stage. As such, monitoring is defined as: “the systematic collection of data, based on pre-defined indicators, to enable stakeholders to check whether a policy process, programme or project is on track and whether the stated objectives can be achieved” (Lamhauge et al. 2012, in Klostermann et al. 2015, p.118). The policy process as explained by this definition is, in this sense, the climate change adaptation policy progress of the Netherlands in achieving its goal to become climate resilient by 2050. As such, monitoring can aid in determining whether municipalities are on track in achieving this objective.

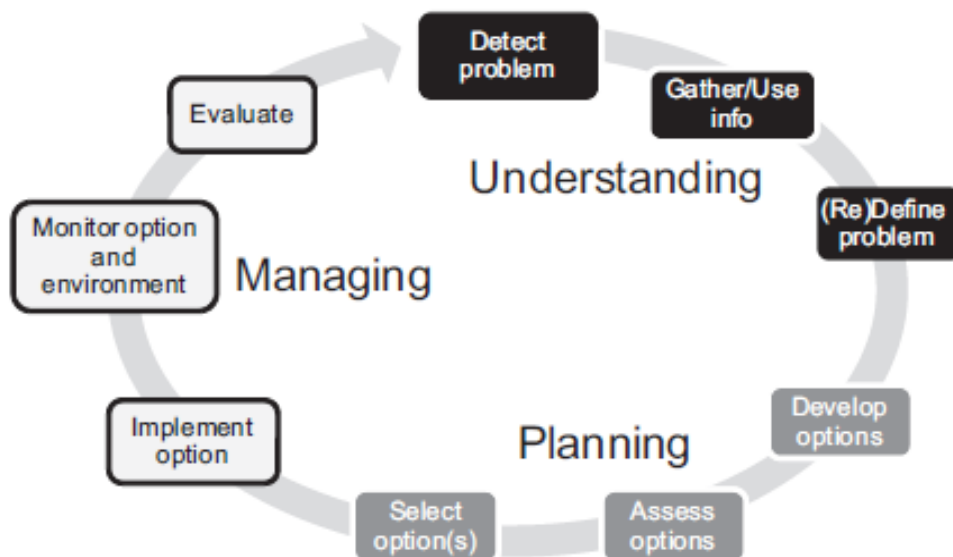


Figure 2: phases and subprocesses throughout the adaptation process (Moser & Ekstrom, 2010).

## 1.2 Problem statement

Before following up on the monitoring phase, it is important to determine the challenges which climate change adaptation faces, as monitoring is directly related to the understanding of these challenges, it can help understand the importance of monitoring.

### 1.2.1 Barriers to climate change adaptation:

Within the literature on climate change adaptation, many barriers could be defined, among which the following are included:

**Context and scale:** Climate change adaptation is highly scale- and context specific across many sectors, due to the fact that it is dependant on different political, social and environmental conditions within a certain area. (Füssel, 2007; PBL, 2018). Moreover, Bours, McGinn and Pringle (2013) as well as Harley et al., (2008) name shifting baselines and changing contexts presented by climate change as barriers to adaptation.

**Uncertainty:** Certain methodological challenges exist due to the fact that: climate change adaptation contains a large degree of uncertainty and complexity with regard to the hazard that climate change faces (Fussel, 2007); due to shifting climate change patterns and their effects in a given locale (Bours, McGinn and Pringle, 2013) and the inherent uncertainty associated with climate projections (Harley et al., 2008). These uncertainties are related to the magnitude in climatic changes and the probability of extreme events. (Klostermann et al., 2015).

**Involvement and integration of sectors and actors:** Adaptation planning requires close collaboration between different actors among which include scientists, practitioners on a sectoral level, decision makers and other actors or policy analysis tied to adaptation planning (Füssel, 2007). Moreover, because of the fact that the nature of adaptation is very multi-sectoral, it requires the involvement of many different organisations and partners which are responsible, which in turn provides challenges for management due to the fact that wishes and needs may differ per actor and sector Harley et al., (2008).

**Definition of adaptation and success:** USAID (2019) states that success of adaptation is hard to define which can result in maladaptation, which means that adaptation can worsen the development process, and/or transfer a certain issue to another social group or area. Harley et al., (2008) adds to this by stating that further barriers include a lack of agreement on performance indicators for successful adaptation, meaning that it is hard to define when it is deemed to be successful. As such, Bours, McGinn and Pringle (2013) name the inappropriateness of universal indicators as barriers.

### **Barriers throughout the whole process**

Moreover, Moser and Ekstrom (2010) state that more barriers exist which are repeated through the entire process. They briefly describe the following barriers which can occur throughout every phase of the climate adaptation cycle:

1. Leadership is critical throughout the adaptation process as it can help overcome barriers, however ineffective leadership or a lack thereof can create more barriers to the overall process.
2. Sufficient possession of the right resources is important within each stage of the process, however, it is most important within the management phases of adaptation which is very science heavy. These resources among which include financial, technical, information means, as well as the expertise of staff and the possession of time.
3. Proper functions with regard to communication and the provision of information about certain problems, solutions, and the magnitude of their implications, are necessary throughout the adaptation process.
4. Values and beliefs that influence how people and their management value risk, information and knowledge, are very important for adaptation as these have a large influence on the process (Moser and Ekstrom, 2010, p. 22029).

### 1.2.2 Barriers to monitoring

Related to barriers to monitoring Preston et al., (2011) state that “the lack of consensus among guidance instruments highlights the fact that a systematic approach to monitoring and evaluation for climate change adaptation has yet to emerge, and the capacity to undertake such monitoring and evaluation and incorporate it into adaptation policy is lacking” (p. 411). Klostermann et al., (2015) supports this claim by stating that because of the fact that climate change adaptation is currently in the early stages of development, a common standard for the monitoring of climate change adaptation is lacking. Also, it has received only limited attention from science and practice so far (Feldmeyer et al. 2019). This suggests that there is currently a lack of knowledge on the subject of climate adaptation monitoring. Füssel (2007) adds to this by stating that research areas on climate change adaptation which require particular attention include amongst others, monitoring and indicator studies. The issue related to attribution of success is also stated by Klostermann et al., (2015) to be a barrier to the monitoring process. On which Harley et al., (2008) states the following: “the issue of attribution in developing sound indicators is crucial, and depends on the purposes for which monitoring is being carried out. If indicators are needed in order to show that a particular policy, project or investment has been worthwhile, then it will be essential to find ways to attribute measured successes to those individual actions” (p. 11). For these reasons given, Klostermann et al., (2015) suggest that it is necessary to establish monitoring programmes due to the fact that these can generate knowledge, data and learning processes that can support adaptation governance. Moser and Ekstrom (2010) however name multiple other barriers which can occur throughout the monitoring phase of the adaptation cycle. Which includes the lack of:

1. The existence of a monitoring plan.
2. Agreement and clarity on monitoring targets and goals.
3. Availability and acceptability of established methods and variables.
4. Availability of technology.
5. Availability and sustainability of economic resources.
6. Availability and sustainability of human capital.
7. Ability to store, organize, analyse and retrieve data (Moser & Ekstrom, 2010, p. 22029).

To conclude, many Dutch municipalities have yet to establish an implementation agenda as a result of the stress tests and risk dialogue. Along with the fact that climate adaptation and monitoring include many challenges, and monitoring is relatively underexplored both in the literature and practice. It can prove to be a difficult task for these municipalities to determine their progress towards the goal in becoming climate resilient by 2050. These factors together form the main problem statement for this research:

*Due to a lack of knowledge and implementation on monitoring practices, an assessment of the effectiveness and degree of implementation of climate change adaptation can prove to be difficult, which can result in Dutch municipalities not being able to achieve their adaptation goals.*

## 1.3 Research aim & objectives

As was mentioned in the previous part, climate change adaptation and the monitoring strategies involve several challenges in its implementation. Along with the fact that both topics are relatively underexplored in both practice and literature as of yet, in the context of Dutch municipal climate change adaptation policy, it can be concluded that monitoring practices within climate change adaptation is a topic which requires research, in order to make sure that Dutch adaptation policy by municipalities is performed in such a way that the national goal to be climate resilient by 2050 can be met. This research can therefore be distinguished as exploratory research with the following aim:

*To study climate change adaptation monitoring strategies in Dutch municipalities which have developed an adaptation strategy, to serve as learning outcomes for other municipalities.*

In order to achieve the stated research aim, the following objectives will need to be met:

1. *Define the concept of climate change adaptation monitoring based on the literature.*
2. *Identify concepts related to climate change adaptation monitoring based on the literature.*
3. *Identify how actors can learn by means of monitoring practices based on the literature.*
4. *Analyse how monitoring practices are performed within Dutch municipalities who have a climate change adaptation strategy established.*
5. *Assess best-practice examples and bottlenecks in climate change adaptation monitoring practices in Dutch municipalities.*
6. *Determine in which way Dutch municipalities can improve upon their monitoring practices by using learning outcomes.*
7. *Conclude upon the findings.*
8. *Critically assess these findings and the overall process of the research.*
9. *Provide both academic and practical recommendations with regard to the topic of climate change adaptation monitoring in a local context.*

## 1.4 Research questions

Following the research aim and objectives is the main research question. Which is the over encompassing question that will need to be answered in order to tackle the research problem and achieve the aim of the research. As such, it is defined as:

*“To what extent can climate change adaptation monitoring result in improved adaptation policy in Dutch municipalities, and how can principles of learning be implemented to improve this process?”*

In order to help answer the main question, different sub-questions need to be answered related to the subjects of climate adaptation monitoring, the municipal climate adaptation strategies and the concept of learning. The sub-questions include:



1. *How is climate change adaptation monitoring defined, and what are known principles according to the literature?*
2. *How do Dutch municipalities currently monitor climate change adaptation measures?*
3. *What role does monitoring play in the municipalities' adaptation policy?*
4. *How are principles of learning applied during the monitoring process?*
5. *How can principles of learning improve the adaptation and monitoring processes for Dutch municipalities?*

## 1.5 Relevance

The societal relevance of this research is supported by an increase in the understanding for inadequate monitoring practices, as well as an understanding of monitoring practices which are implemented. By understanding both the bottlenecks as well as positive examples, it can create an understanding about the topic in a local context. Which in turn can aid in an increase in the learning capacity and the overall learning base for other municipalities on this topic. Which could result in an improvement of climate change adaptation monitoring practices, as well as climate change adaptation in general. Which in turn can indirectly speed-up and/or make climate adaptation measures more (cost)effective, which will ultimately result in an improvement of safety and opportunities as well as the achievement of the goal to become climate resilient by 2050. The scientific relevance is supported due to the fact that climate adaptation monitoring is a relatively underexplored topic. As such this research can aid to the accumulation of scientific knowledge on the topic of climate adaptation monitoring, and the use of learning practices within climate change adaptation processes. This accumulation of knowledge is important as it can provide a base for further in-depth research on the topic.

## 1.6 Research outline

The research outline as is shown in figure 3, includes the following. An introduction which includes the background, research aim and objectives, the research questions and a justification of the societal and theoretical relevance. The theoretical framework includes a discussion on the relevant theoretical concepts tied to the research topic, along with a conceptual framework which aims to visualize the interaction between the concepts. The methodology section includes a discussion on the research philosophy, and the use of methods, along with a justification of the validity and reliability of the research, and how this is achieved. The results of the interviews includes a discussion of the result for each of the concepts which are identified in the theoretical framework, which is presented in a narrative way along with the use of quotes from the interviews to provide context. The results of the focus group are presented per concept, in a narrative way. Lastly, the conclusion aims to answer the main- and sub-questions which are composed in the introduction. The discussion provides a critical reflection on the following aspects: the results; the use of methodology; the use of theory and the development of theory; the limitations of the research. Lastly recommendations for further research are provided.



Figure 3: Research outline (own work)

## 2. Theoretical Framework

The theoretical framework consists of a literature study on the definition of climate adaptation monitoring; monitoring indicators; adaptive management and learning practices and a framework for monitoring adaptation. This chapter starts with a conceptual framework that aims to provide insight into the interactions between the concepts. In the end, an overall conclusion is provided. The framework functions as a theoretical assessment for the phenomenon of climate adaptation monitoring based on the literature.

### 2.1 Conceptual framework

The conceptual framework shown in figure 4, aims to summarize and visualize the interactions between the concepts which will be explained in this chapter, which are based on the research questions. Starting point concerns the climate change adaptation policy goals which a municipality would have formulated, with information on how to achieve those goals. Secondly, the four elements of the framework from Klostermann et al., (2015) serve as the starting point for the monitoring process. During which the municipalities make agreements on the interpretation of the system of interest; the indicators which will be used to monitor the system; the assignment of responsible organisations; and the overall procedures tied to the monitoring process. Besides this, the relevant actors within the municipality engage in a participatory monitoring process, during which social learning occurs between them and the municipality. The overall monitoring process is on the climate change adaptation measures. After which the municipality engages in a single- and double loop learning process. After these two learning processes the climate change adaptation policy goals can be re-iterated, alongside the four elements of the monitoring framework. After which the entire process is repeated according to the adaptive management principle in which monitoring serves as an iterative learning cycle.

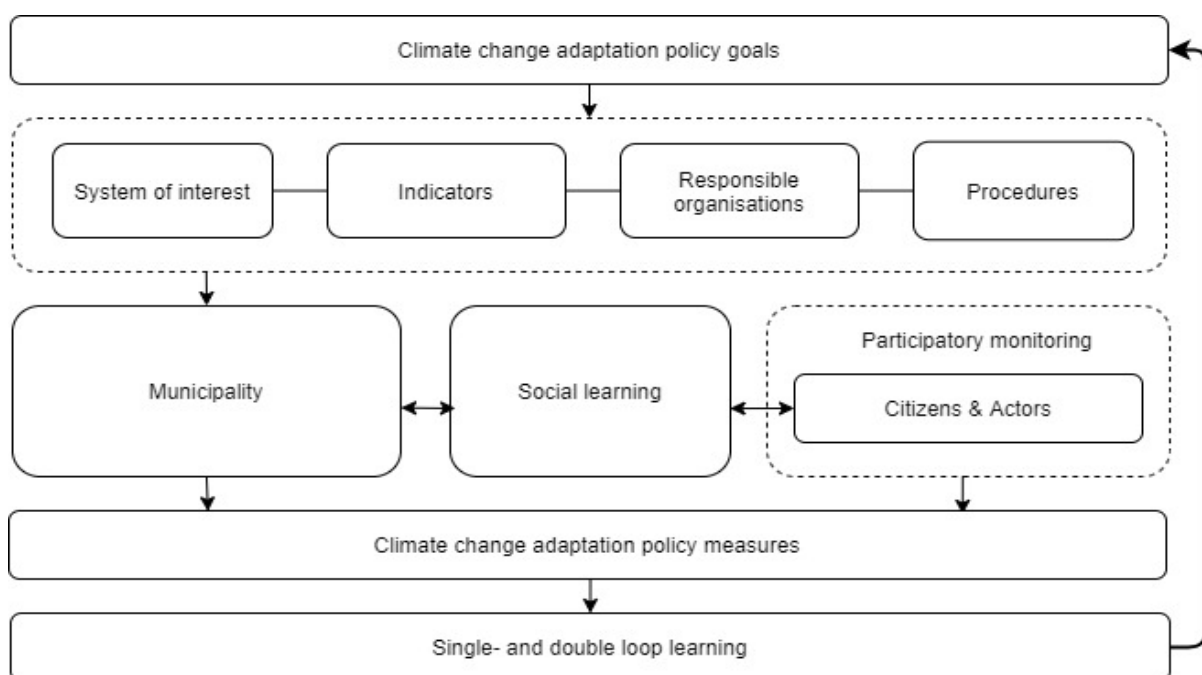


Figure 42: Conceptual model (based on Klostermann et al., 2015; and Pahl-Wostl et al., 2007).



## 2.2 Defining climate adaptation monitoring

Because climate adaptation monitoring is the main theme within this research and used throughout, it is important to define it properly to serve as a base for understanding throughout this research. Within the literature, monitoring is widely mentioned alongside evaluation practices. However, the difference between the two is that monitoring is undertaken on an on-going basis, while evaluation is conducted in a certain point in time (Leitner et al., 2020). As such Lamhauge et al., (2012) provide the following definition of monitoring: “monitoring refers to the systematic collection of data on pre-defined project or programme indicators. It enables the stakeholders involved to check whether an initiative is on track in achieving set objectives” (p. 18). Furthermore, Lamhauge et al., (2012) mention that monitoring can help identify practices which are deemed effective or not effective, which in turn can aid in the improvement of the decision making process. As such, related to climate change adaptation, Harley et al. 2008 in Klostermann et al., (2015, p. 188) state that “the purpose of monitoring and evaluating adaptation is to follow progress in implementing adaptation policies, measures and actions, to assess the effectiveness of resource commitments and to share information on good practice”. Klostermann et al., (2015) therefore concludes that “feedback from monitoring and evaluation is expected to improve adaptation policies, measures and actions” (p. 188). To summarize, monitoring for climate change adaptation aims to collect data based on pre-defined indicators in a continuous way. In doing so, the data which is collected through monitoring can act as a feedback mechanism for actors to assess the effectiveness and progress as well as to identify good and bad practices in order to improve upon their climate change adaptation policy.

## 2.3 Adaptive management policy cycle

Within spatial planning, planners will seek to act in an adaptive way in order to be able to handle change and uncertainty within spatial and environmental planning (Zandvoort et al., 2018). As such, Zandvoort et al., (2018) state that planners can strive for adaptiveness in three ways. First, by managing resources in an adaptive way through focussed experiments and closely monitoring the change within them. Second, by increasing the adaptive capacity of institutions and learn from past experiments. And last, to iteratively take decisions and create room for future adjustments to cope with uncertainty when planning for interventions in the physical environment. These aspects are directly related to the concept of adaptive management, which involves taking action during uncertainty, and not waiting to take action when sufficient amount of information or knowledge is provided (Lyons et al., 2008). This is relevant for the practice of monitoring of climate adaptation policy, as there is always some uncertainty about whether or not an intervention functions as intended. Also, adaptive management and learning through monitoring exercises are widely mentioned together in the literature. As such, Pahl-Wostl et al., (2007) define adaptive management as “a systematic process for improving management policies and practices by learning from the outcomes of management strategies that have already been implemented” (P. 5). “In simple terms, it can be described as learning by doing, and adapting based on what’s learned” (Williams & Brown, 2018, p. 995). The main difference between traditional and adaptive management is that adaptive management is considered to contain a more holistic and multidisciplinary approach, which requires more coordination across stakeholders with different disciplines (Johnson, 1999). The adaptive management policy cycle is shown in figure 5, which is based on the works of Williams and Brown (2018)

and Pahl-Wostl et al., (2007). For their version of the cycle, Pahl-Wostl et al., (2007) explain each step:

1. Within the problem definition different perspectives need to be taken into account from multiple involved stakeholders, which reflects back to the participatory element of the cycle.
2. The policy design or formulation includes an analysis on the overall scenario which is used to highlight the most important uncertainties, as well as to identify possible strategies which perform well under different possible developments in order to search for the best strategy for specific conditions.
3. During the process of implementation, positive or negative feedback mechanisms need to be evaluated by planning and implementing other related policies.
4. Monitoring programs need to include processes which can aid in identifying undesirable processes at an early stage in the process. For which the possession of knowledge is necessary.
5. They state that the performance of management strategies and the possible implementation of changes need to be assessed by actors (Pahl-Wostl et al., 2007).

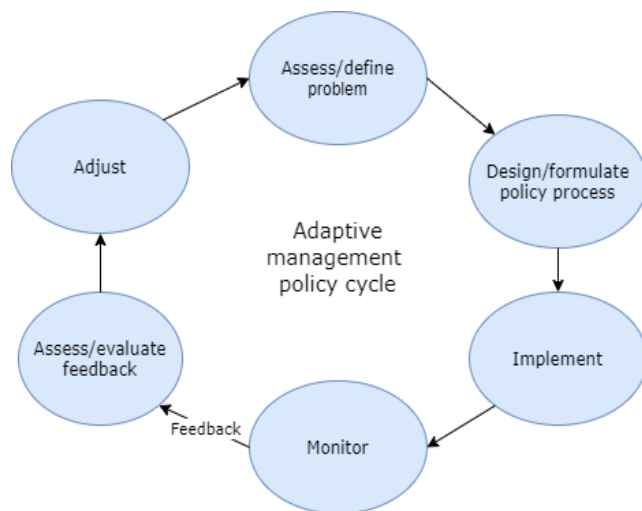


Figure 43: the adaptive management policy cycle (adapted from Pahl-Wostl et al., 2007 and Williams & Brown, 2018).

According to Lyons et al., (2008) there are three roles which monitoring plays within the policy cycle of adaptive management: first, monitoring provides feedback which is needed to close the cycle of planning, implementation and evaluation. Second, monitoring can evaluate the performance of management and help determine whether the actions which are implemented in the previous cycle are achieving their objectives. In order to do so, the management objectives should be quantifiable in order to determine when said objectives are reached. Lastly, a third role which monitoring plays within the policy cycle is to provide the information which is necessary to make choices amongst competing hypothesis about the managed system which includes a feedback loop for learning to improve upon practices. Arvai et al., (2006) supports this claim by stating that adaptive management to climate policy could provide policymakers with the flexibility needed to proceed and to learn over time. As such, continuous replanning and reprogramming in an iterative way can be achieved based on the results of monitoring and evaluation (Pahl-Wostl, et al., 2007). To summarize, adaptive management of spatial policy is about dealing with uncertainty, through careful monitoring and learning from the monitoring practices to improve upon policy in a holistic and multidisciplinary way. The next section will elaborate on a framework to monitor climate change adaptation.

## 2.4 A climate change adaptation monitoring framework

In their paper, Klostermann et al., (2015) establish a framework to assess, compare and develop monitoring and evaluation of climate change adaptation within Europe. As is shown in figure 6. This framework will be explained and used throughout this research as this framework provides an understanding of which elements are necessary to perform climate change adaptation monitoring tasks. The framework which they propose combines four different aspects: the system of interest; indicators; responsible organisations and procedures for monitoring. These will be explained individually further on in the report. All four elements of the framework are tied together by a scientific analysis and policy debate which includes the overall adaptation goals, meaning that the framework is dependant on these goals. Moreover, Klostermann et al., (2015) state that the framework is developed through principles of adaptive management which include assessing challenges of uncertainty; shifting baselines and attribution, which includes a cycle of learning at its core.

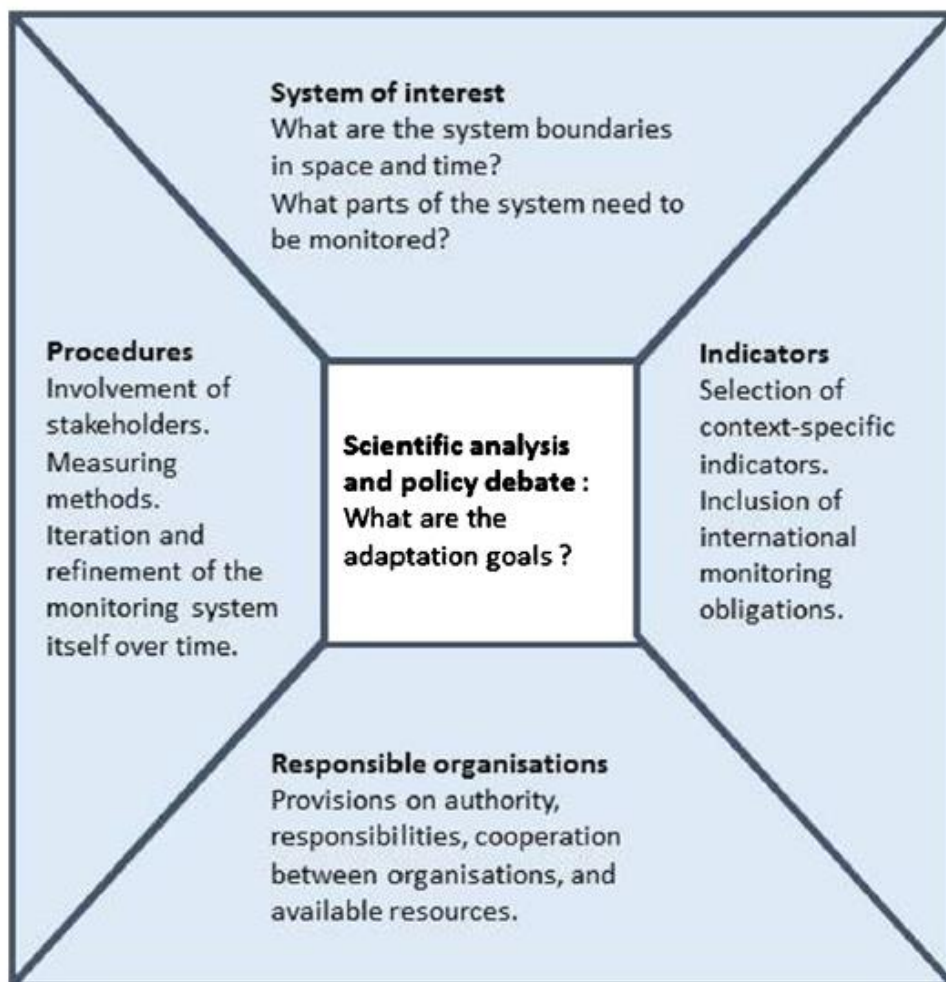


Figure 124: Framework for monitoring adaptation (Klostermann, et al., 2015).

Klostermann et al., (2015) argue that the framework can be approached in two ways. By choosing clockwise, a more science-dominated approach is chosen where, after identifying

the system of interest, the respective indicators which will need to be chosen based upon the adaptation goals and context of the system. The next step in the cycle is the choosing of the organisations which will be responsible for the monitoring. After which the procedures will be negotiated between the organisations. By choosing a counter-clockwise approach, first the responsible organisation is chosen after which it will determine the system of interest to be monitored. Next, these organisations will determine and facilitate the selection of indicators and a design for the specific procedures. Klostermann et al., (2015) add to this by stating that while both approaches are different, “a combination of both could result in more indicators being selected and other organisations being added to the monitoring network” (p. 198). The cyclical and iterative nature of this framework should stimulate learning in a wide range of adaptation contexts and should be able to be applied across multiple levels of governance, which can include different policy areas and sectors (Klostermann et al., 2015).

### 2.4.1 System of interest

According to Klostermann et al., (2015) “the system of interest defines which parts of the physical and social context are to be monitored. In practice, these are likely to be found in adaptation strategies and associated objectives” (p. 195). As such, the following questions can be asked:

- What are the system boundaries in space?
- What are the system boundaries in time?
- What parts of the system need to be monitored?

The system of interest is related to specific sectors and functions as well as geographically specific areas (Klostermann et al., 2015). The system of interest is therefore particularly important in adaptation strategies, as differences in monitoring exercises at the strategic level include many spatial scales which are context specific, as was explained in the introduction. In an appendix of their paper Moser and Ekstrom (2010) provide a table in which multiple diagnostic questions are posed with regard to monitoring of the system of interest, which read as follows:

- What is the goal of monitoring?
- Are the targets clear?
- What kind of baseline information exists about the system of concern, if any?
- What type of monitoring does the system and implemented strategy require?
- Are there time lags in the system that obscure or delay revelation of effects?
- Does significant system variability and uncertainty prevent clear detection and attribution of observed changes?
- Is monitoring needed continuously or periodically?
- Are there known and accepted indicators for monitoring the variable or goal? (Moser and Ekstrom, 2010, Appendix A p. 6-7).

In order to further comprehend the system of interest, Klostermann et al., (2015) argue that local research can aid in understanding how different mechanisms operate within a particular system. Which can improve the overall understanding of what needs to be monitored, along with the timeframe and the overall procedures which are needed. This can improve the overall effectiveness of communication and engagement with other stakeholders.

## 2.4.2 Indicators

As monitoring indicators are very important for local policy makers to support further adaptation measures (Feldmeyer et al., 2019). It is important to define what these indicators entail. Schumann, (2016) states that within monitoring processes, indicators play an important role by producing regular and objective feedback, about the extent to which progress is made towards certain policy objectives. Furthermore, they represent the current state of conditions within a policy field. As such, it can be used by policy makers to determine the effectiveness of their policies, as well determining when to make adjustments. Also, according to Glahn et al., (2007) indicators can help actors in the organisation, orientation and navigation perform learning tasks, through the provision of information in a certain context. Harley et al., (2008) state the fact that stakeholders are increasingly demanding information on best practices with regard to climate change adaptation, as well as metrics to track progress and efficacy of resource commitments. Which is why according to their report, indicators can also serve as a communication tool to promote awareness among policymakers and practitioners. Moreover, it is mentioned by Harley et al., (2008) that indicators are needed to help decision-makers and others to advance strategically and proactively through the adaptation process, which can result in having impact on the long-term success of their adaptation policy. Furthermore, Shahin and Mahbod (2007) state that indicators should be based on what is known as SMART criteria which stands for: specific (goals should be as detailed and specific as possible); measurable (in order to clearly determine if objectives have been achieved, it should be measurable in a qualitative or quantitative way); attainable (goals should not be out of reach); realistic and result oriented (goal should be realistic) and lastly time sensitive (goals should have a time frame for completion). Monitoring indicators range from input indicators to process, output and outcome indicators (Lamhauge et al., 2012). Each of these indicators will be described separately to get an indication of what they entail.

### **Input**

According to Schumann, (2016) input indicators can give an indication of the amount of resources which are used within a certain policy. Which includes according to (Biesbroek et al., 2013) the following:

- Human capital (amount of labour power assigned to a policy).
- Financial capital.
- Technological resources.
- Time.
- Instruments.
- Activities.
- Knowledge (Biesbroek et al., 2013; PBL, 2017).

Moreover according to Schumann, (2016), input indicators only show how much effort is put into a policy, they do not show whether the resources are being used efficiently or whether the policy is effective in accomplishing its goals. As a result, input indicators' role in monitoring is limited to giving information on the degree to which a policy is implemented.

## **Process**

The aim of a process-based approach is, according to Harley et al., (2008), to determine at which point a certain decision will lead to the best choice of action. Which will, according to Klostermann et al., (2015), track the policy, institutional and governance processes which are necessary for developing and implementing adaptation policies, measures, and activities. As such, a variety of elements such as effective governance, and the use of skills and dedication, can influence an institutions ability to adapt to climate change (Georgi et al. 2012 in Klostermann et al., 2015). This building of adaptive capacity is what Harley et al., (2008) deem to be necessary to develop process-based indicators which are needed in order to monitor the progress to which adaptation measures are implemented. As such Engle and Lemos (2010) define adaptive capacity as “the ability to recover or adjust to change through learning and flexibility so as to maintain or improve into a desirable state” (p. 4). Moreover, Spearman and McGray (2011, p. 35) state that practitioners should consider the following things to identify useful indicators for measuring adaptive capacity:

- The foundations of effective organisational structures around adaptation-related issues.
- The resources and capabilities within institutions working on adaptation-related issues.
- The relevant experiences and skills of target groups and individuals.
- The sources of quality information on the effects of climate change.
- Other resources or conditions that may support actions that may lead to improved adaptation (Spearman and McGray, 2011, p. 35).

According to Harley et al., (2008) the advantages of process based indicators are that it can help stakeholders to determine which of their actions related to adaptation is most effective in meeting a certain outcome. As such, it allows for a flexible approach as adjustments can be made when new information becomes available. The disadvantages however are: that adaptation is not always guaranteed to be successful when processes are defined. Along with the fact that it can prove to be difficult to integrate certain adaptation targets with objectives in other policy areas, due to the fact that it is not necessarily sector-specific. Lastly, experience on this approach can be limited due to the fact that the approach itself may differ from other government targets.

## **Output**

Output indicators are the products, capital goods and services which are the result of a development intervention (Lamhauge et al., 2012). Which also includes measures and activities (PBL, 2017). They capture the implementation of adaptation policies, and monitor their effectiveness (Klostermann et al., 2015). They can help improve policy implementation with the information they supply. It includes anything that a policy generates directly from the inputs it receives. They track the quantities produced by a policy in order to fulfil its goals, but not the progress made toward those goals (Schumann, 2016). In other words, one could ask the question ‘what’ is the policy producing? (Schumann, et al., 2016). Examples of such output indicators are for instance climate change adaptation interventions (Biesbroek et al., 2013).



## Outcome

Outcome indicators are immediate effects on target groups and systems (Biesbroek et al., 2013). They measure the effectiveness of certain measures and interventions in relation to their policy (Georgi et al., 2012 in Klostermann et al., 2015). As such, outcome-based indicators can define a certain end-point which a certain adaptation measure can produce, such as for example an increase in drainage capacity as a result the development of a certain adaptation measure (Harley et al., 2008). In other words one could ask the question ‘why’ does the policy produce it? (Schumann et al., 2016). According to Harley et al., (2008) the advantages of using outcome indicators is the fact that most policy objectives within governments are outcome-based, along with the possibility to link the goals of adaptation to those in different policy areas. The disadvantages are however that even though governments can define a certain outcome, it does not always guarantee successful adaptation. Also, there is a certain risk of adaptation options becoming overly prescriptive. And lastly, defining certain outcome indicators may be inflexible, which can make introducing new information more difficult. Table 2 aims to summarise the different indicators and the interaction amongst one another based on the previously provided information.

<i>1 - Input indicators (monitor effort)</i>
Measures the amount of resources spent, which may include: <ul style="list-style-type: none"><li>• Human capital needed</li><li>• Financial resources spent</li><li>• Technological resources used</li><li>• Instruments used</li><li>• Knowledge needed</li><li>• Activities performed</li><li>• Time spent</li></ul>
<i>2 – Process indicators (measures process)</i>
Measures the capacity of an institution to develop adaptation policy which may include: <ul style="list-style-type: none"><li>• Organisational structure</li><li>• Resources and capabilities within the organization</li><li>• Skills and experience of target groups and individuals</li><li>• Sources of quality information on the effects of climate change</li><li>• Other resources, conditions, or actions that may lead to improved adaptation policy.</li></ul>
<i>3 – Output indicators (monitor efficiency)</i>
The measures which are produced by means of the input, which may include: <ul style="list-style-type: none"><li>• Products</li><li>• Capital goods</li><li>• Services</li><li>• Activities</li></ul>

4 – Outcome indicators (measure effectivity)
Measures what kind of results are produced by the output, and the effectiveness of policies in achieving their objectives, which may include: <ul style="list-style-type: none"> <li>• The effectiveness of the output related to a certain policy goal.</li> </ul>

*Table 2 Climate adaptation monitoring indicators adapted from (Schumann, 2016; Biesbroek et al., 2016; Spearman & McGray, 2011; and Lamhauge et al., 2012).*

To conclude, sound indicators for monitoring can provide a way to measure what is monitored. As such, Harley et al., (2008, p. 12) provide key principles for defining adaptation indicators, stating that indicators should:

- Sit in the spectrum between vulnerability and resilience.
- Fit within the concept of adaptive management.
- Focus on monitoring progress rather than measuring effectiveness.
- Be sectorally distinct.
- Include checklist-type indicators.
- Include process-based and outcome-based indicators.
- Include narrative reporting alongside quantitative indicators (to provide context and explanation).
- Be used to avoid mal-adaptation.
- Be simple and transparent for communication purposes.
- Be dependent upon the purpose of the evaluation.
- Not duplicate pre-existing indicators (Harley et al., 2008, p. 12).

### 2.4.3 Responsible organisations

In order for monitoring to be effective and efficient it is important to clearly define who will be responsible for the acquisition and evaluation of data (Biesbroek et al., 2010 in Klostermann et al., 2015). As adaptation takes place in an interdisciplinary environment, which concerns a multitude of stakeholders it is important to ensure a clear distinction of tasks for the organisations which are responsible for the monitoring. Which requires coordination by a permanent trusted organisation acting as a general coordinator who can provide sufficient staff, and credible and legitimate data (Klostermann et al., 2015). For actors who are involved in the monitoring process, Moser and Ekstrom (2010) provide the following diagnostic questions within their appendix which need to be answered:

- Have the actors developed a monitoring plan?
- Have the actors specified and do they agree on the monitoring goals, design, targets, approaches, needed resources, and the intent and schedule for analysis and assessment of the obtained data?
- Is additional capacity or expertise needed to design and implement the monitoring program? (Moser & Ekstrom, 2010, Appendix A, p. 6).



Klostermann et al., (2015) add to this by stating that the responsible organisations should be equipped with appropriate resources needed to gather data on climate adaptation through monitoring on an ongoing basis.

#### 2.4.4 Procedures

According to Kohn, Corrigan and Donaldson (2000, p. 8). “A Protocol defines a set of procedures or steps to be followed for the accomplishment of a given task.” The task in this sense being monitoring the climate change adaptation measures. Accordingly, “Monitoring protocols are detailed study plans that guide how data are to be collected, managed, analysed and reported, and are a key component of quality assurance for natural resource monitoring programs.” (Oakley et al., 2003 p. 1000). According to Oakley et al., (2003, p. 1001-1002) a monitoring protocol should include the following sections as is shown in table 3:

<i>1 - Narrative</i>
The narrative contains the overall rationale which is given for why a certain aspect of the system is monitored. Along with providing information on the following necessities within the protocol:
<ul style="list-style-type: none"> <li>• Background and objectives – background information on the context along with measurable objectives for monitoring.</li> <li>• Sampling design – site selection, boundaries and amount; sampling frequency.</li> <li>• Field methods – equipment needed, and details of the taken measurements.</li> <li>• Data handling – analysis of data; data entry in a database; and overall reporting format.</li> <li>• Personnel requirements – roles and responsibilities; qualifications needed; training procedures.</li> <li>• Operational requirements – annual workload and schedule, equipment needed, start-up costs and budget considerations.</li> </ul>
<i>2 - Standard operating procedures</i>
Step-by-step instructions on how to carry out each procedures. Along with an overall refinement of the procedures over time.
<i>3 - Supplementary materials</i>
Supplementary materials which can be used alongside the procedures to improve the overall monitoring process. Such as existing databases, measurements, reports and other forms of information which are available to an organization before the monitoring process is commenced.

Table 3: Monitoring protocol contents (Oakley et al., 2003, p. 1001-1002)

## Participatory monitoring

One concept which is relevant to the overall concept of climate change adaptation monitoring is that of participatory monitoring. As such, this concept will be briefly mentioned due to the fact that even though it is not the main emphasis of this research. According to Guijt et al., (1998), participatory monitoring involves the use of different groups of people which perform monitoring tasks for the purpose of observing change. Which in the context of climate change adaptation, can involve actors who gather data in elements which are relevant to the subject. Such as for instance measuring temperature, groundwater levels, etc. Within their paper Estrella and Gaventa (1998) mention that there is an increase of importance of participation in development monitoring practices which involves an understanding of the social processes of the actors; methodological issues and the institutionalisation and scaling up of participatory monitoring frameworks.

## 2.5 Learning through monitoring

Within the literature, learning is seen as an important aspect throughout the policy cycle. As such, according to Pahl-Wostl et al., (2007), learning is necessary to develop and maintain the capacity of various authorities, experts, interest groups and the general public to manage their environment in a sustainable manner and to achieve a balance between competing interests in the social-ecological system. In the literature on adaptive management, related to monitoring, three types of learning stand out: single loop learning; double loop learning; and social learning.

### 2.5.1 Single- and double loop learning

In the literature on adaptive management and monitoring, the concepts of single loop and double loop are widely mentioned together. According to Pahl-Wostl, (2009) “single-loop learning refers to a refinement of actions to improve performance without changing guiding assumptions and calling into question established routines” (p. 359). Pelzer and Geertman (2014) add to this by stating that: “single loop learning takes place when the focus is on improved techniques of efficiency, and goals, values and strategies are taken for granted” (p. 529). According to Williams and Brown (2018), as shown in figure 7, single loop learning adjusts decisions made in the adaptive management cycle based on what is known as technical learning. Which PBL, (2017) defines as: “technical learning involves acquiring and exchanging data and knowledge, paired with critical debate on the process itself. It enlarges the knowledge base underlying policy choices and measures” (p. 16). To summarize, single-loop learning can

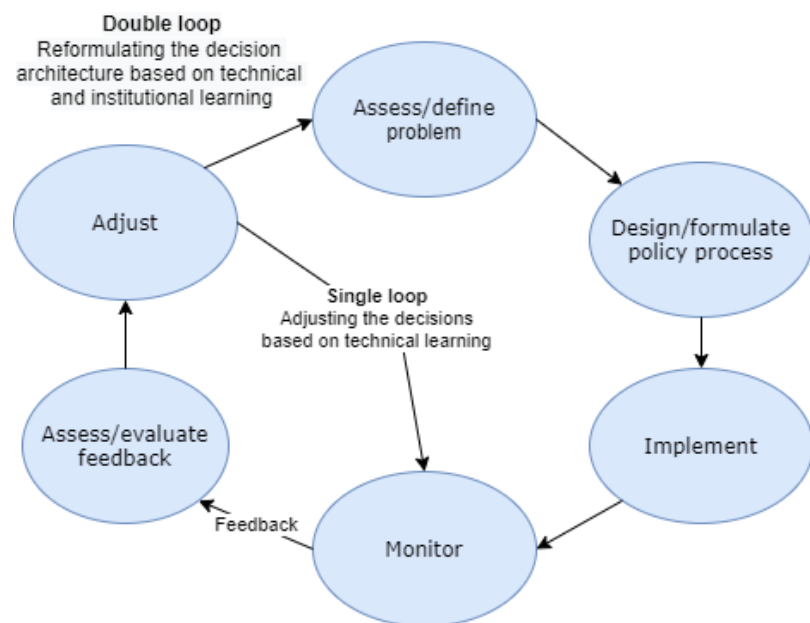


Figure 7: single- and double loop learning in the adaptive management policy cycle (adapted from Williams & Brown, 2018).

result in an adjustment of the policy based on acquiring knowledge and data on the process itself without changing the established routine. This is shown in figure x as after adjustment, the feedback loops back to the monitoring phase. However, according to Pelzer and Geertman (2014) single-loop learning does not provide further insight into how other disciplines view and approach the planning problem. Which is where double-loop learning comes in.

According to Pahl-Wostl (2009) “double-loop learning refers to a change in the frame of reference and the calling into question of guiding assumptions. Reframing implies a reflection on goals and problem framing (priorities, include new aspects, change boundaries of system analysis) and assumptions how goals can be achieved” (p. 359). She adds that because of this, social learning processes are essential. According to Pelzer and Geertman (2014), frames entail the disciplinary background that guides how planning actors view problems and solutions and, as a result, how they complete their responsibilities. As a result, actors must learn to identify how their own frames of reference impact and constrain their thinking, as well as that other legitimate frames of reference exist, in order to avoid lock-in circumstances that block changes toward new resource management schemes (Pahl-Wostl, et al., 2007). Within figure 7, according to the works of Williams and Brown (2018); double loop learning reforms the decision architecture based on technical and institutional learning. According to Williams and Brown (2014), the difference between technical learning and institutional learning, is that while technical learning focusses on the process itself, institutional learning constitutes a social learning cycle, and includes learning about institutional arrangements and societal structures and processes which require the development of social capacity and willingness from actors to actively participate in the learning process. The combination of technical- and institutional learning together is as such referred to as “double-loop” (Argyris & Shon, 1978 in Williams & Brown, 2014). Within the conclusion of their paper Pelzer and Geertman (2014) mention the following: “It is important to note that both single-loop and double-loop learning are relevant to understand interdisciplinary communication. Single-loop learning can have important added value in solving concrete planning issues, whereas the benefit of double-loop learning can be found mainly in situations in which a holistic and comprehensive approach is needed, for instance when developing a long-term vision or solving “wicked” planning problems” (p. 538). As such, double-loop learning can be seen as a valuable approach in climate adaptation monitoring practices as these can be distinguished as “wicked planning problems” due to their inter-sectoral nature.

### 2.5.2 Social learning

Due to the fact that climate adaptation involves and integrates different actors and sectors, a cooperative learning method is important to analyse. In searching for methods related to learning in a multi-actor environment, one learning type which is broadly mentioned in the field of adaptive management is that of social learning. According to Bouwen and Taillieu (2004), “facilitating social learning is the capacity to design a process in which different stakeholder groups engage diverse forums and activities so that knowledge is generated, ideas, values and perspectives are shared and can be contested (p. 144). It is about cultivating a shared understanding of experiences, outcomes, and repercussions of activities performed, which can lead to practical modifications or strategic action, as well as revisions of the assumptions, ideas, and values that underpin those actions (PBL, 2017). “We speak of social learning, when the learning process: are a means towards a goal, such as innovation, or complex problem solving; involves contributions from multiple people; involves people with different backgrounds and

aims to reap the benefits of diversity for its goal” (Beers et al., 2010, p. 145). As such, it can directly be linked with climate adaptation involves complex problem solving which requires the involvement of multiple actors. It is based according to Pahl-Wostl (2002) on the idea that social change requires: “critical self-reflection; the development of participatory, multi-scale democratic processes; reflexive capabilities of individuals and societies and the capacity of social movements to shape the political and economic boundary conditions toward improvement of the current situation” (p. 399).

However, as Beers et al., (2010) point out the complexity of social learning in a multi-actor setting is characterised by the fact that actors can have different goals and interests which can have interplay between the personal and organisational level. As such, Beers et al., (2010) continues by stating that social learning outcomes are an interplay between elements of mutual trust, commitment and a shared frame, as is shown in figure 8. Related to this, Beers et al., (2010) note that “social learning is a dynamic process, in which three different social learning outcomes are continuously produced through the actions of the individual actors. And in turn, changes in shared frame, mutual trust and commitment influence the actions of the actors involved” (p. 148). They state that within the action-oriented process of social learning: “a shared frame and mutual trust help actors to commit in both word and deed to innovation. The better the quality of the social learning process, the higher the innovative performance” (p. 148). In their research, Beers et al., (2010) conclude that the most crucial factor for the selection of collaboration partners is a shared problem or challenge. In addition, a partners’ trustworthiness grows as his devotion to the project increases. In this context, commitment can take the shape of monetary or labour contributions to a project, or public affirmations of support for the initiatives’ goals and objectives.

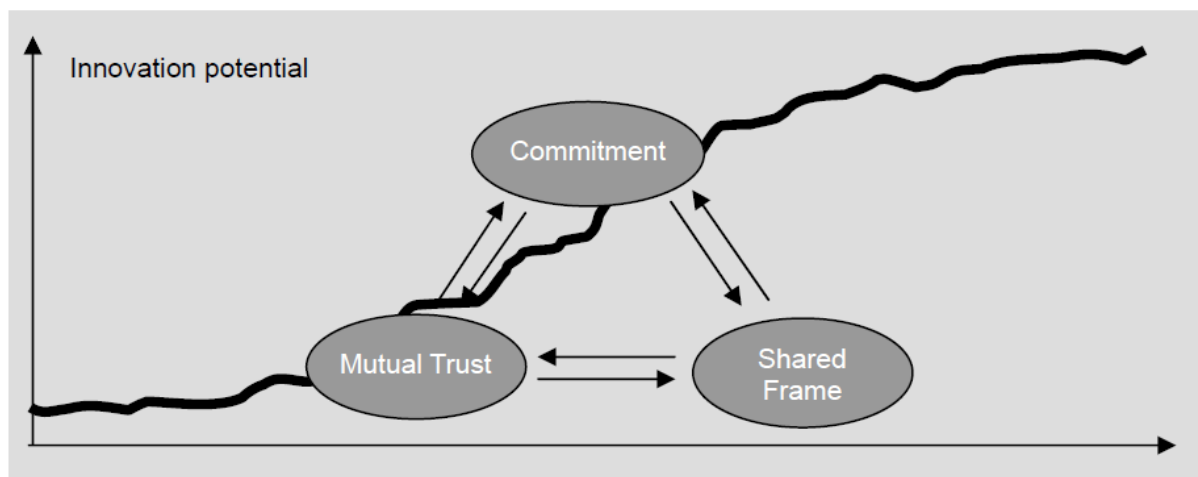


Figure 8: Social learning elements (Beers et al., 2010)

## 2.6 Conclusion

To conclude, the literature tells us that monitoring and learning principles are strongly linked throughout the adaptive management process. In order for municipalities to engage in monitoring activities, the respective features of the monitoring framework should be accounted for. Which means:

- Defining the goals and objectives in relation to the system of interest in space and time.
- Setting up context specific indicators which are measurable and can identify the progress towards the goals set within the climate change adaptation policy.
- Assigning the responsible organisation(s) and individuals who should be in charge and/or involved in the monitoring process.
- Setting up a monitoring protocol to identify the procedures needed to measure the indicators.

Through this framework, alongside with the help of actors who engage in participatory monitoring. Climate change adaptation measures can be monitored in an effective way. Which in turn will result in learning outcomes upon which the municipality and the involved actors can adapt their activities to in turn become able to achieve its climate change adaptation goals.

## 3. Methodology

The methodology section includes a critical discussion on the relevant methodologies and research methods which were used during this research. As well as argumentation for the choice of the methodological approach and research methods used. This chapter includes the following: the research philosophy; research design; data collection methods; data analysis methods and a justification of the validity and reliability of the research.

### 3.1 Research Philosophy

Before providing an argument for the use of philosophy, it is important to determine whether this research is of a qualitative or quantitative nature, as the research philosophy is strongly related to this aspect. The main choice is a qualitative nature because Creswell and Poth, (2016) define qualitative research as follows: “qualitative research begins with assumptions, a worldview, the possible use of a theoretical lens, and the study of research problems inquiring into the meaning individuals or groups ascribe to a social or human problem. To study this problem, qualitative researchers use an emerging qualitative approach to inquiry, the collection of data in a natural setting sensitive to the people and places under study, and data analysis that is inductive and established patterns or themes” (p. 37). Due to the importance of social elements related to learning in context with climate adaptation monitoring it is argued that the research is in fact of a qualitative nature. Following up on this, related to research philosophy, Guba and Lincoln (1994) define four paradigms for qualitative research: positivism; post-positivism; critical theory and constructivism. Related to constructivism Crotty (1998) defines it as “the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context” (p. 42). Creswell and Poth (2016) add to this by stating that constructivist researchers often address the “processes” of interaction among individuals. This aligns with the previously stated importance of learning processes in climate adaptation monitoring between municipalities and actors where interaction is an important aspect. As such, constructivism is the main research philosophy. To conclude, the choice of research philosophy ultimately provides argumentation for the use of certain methods.

### 3.2 Research design

The research design includes a summary of the research methods and overall process which was used in order to answer the following questions:

1. *How is climate change adaptation monitoring defined, and what are known principles according to the literature?*
2. *How do Dutch municipalities currently monitor climate change adaptation measures?*
3. *What role does monitoring play in the municipalities’ adaptation policy?*
4. *How are principles of learning applied during the monitoring process?*
5. *How can principles of learning improve the adaptation and monitoring processes for Dutch municipalities?*

Figure 9 shows the entire research process and methods used to answer the research questions. Starting at the top with an initial background study of the research context and the formulation of the research problem, aim, objectives and questions. After which a literature review was performed on the topic of climate change adaptation monitoring which served as the theoretical substantiation for the interview guide which consisted of the questions posed during the semi-structured interviews. After transcribing, coding and analysing the interviews results, a focus group with presentations and initial statement per concept were set up based on the interview results for further testing during the focus group. The overall results of the literature review, interviews and the focus group provided the results necessary to answer the sub-questions and conclusion. During the whole process, a mix of deductive and inductive research methods were used. Deductive in the sense that the answers to the sub-questions were substantiated by theory which was derived from the literature review. And inductive by finding themes otherwise not derived from theory but from practice through the interviews and focus group.

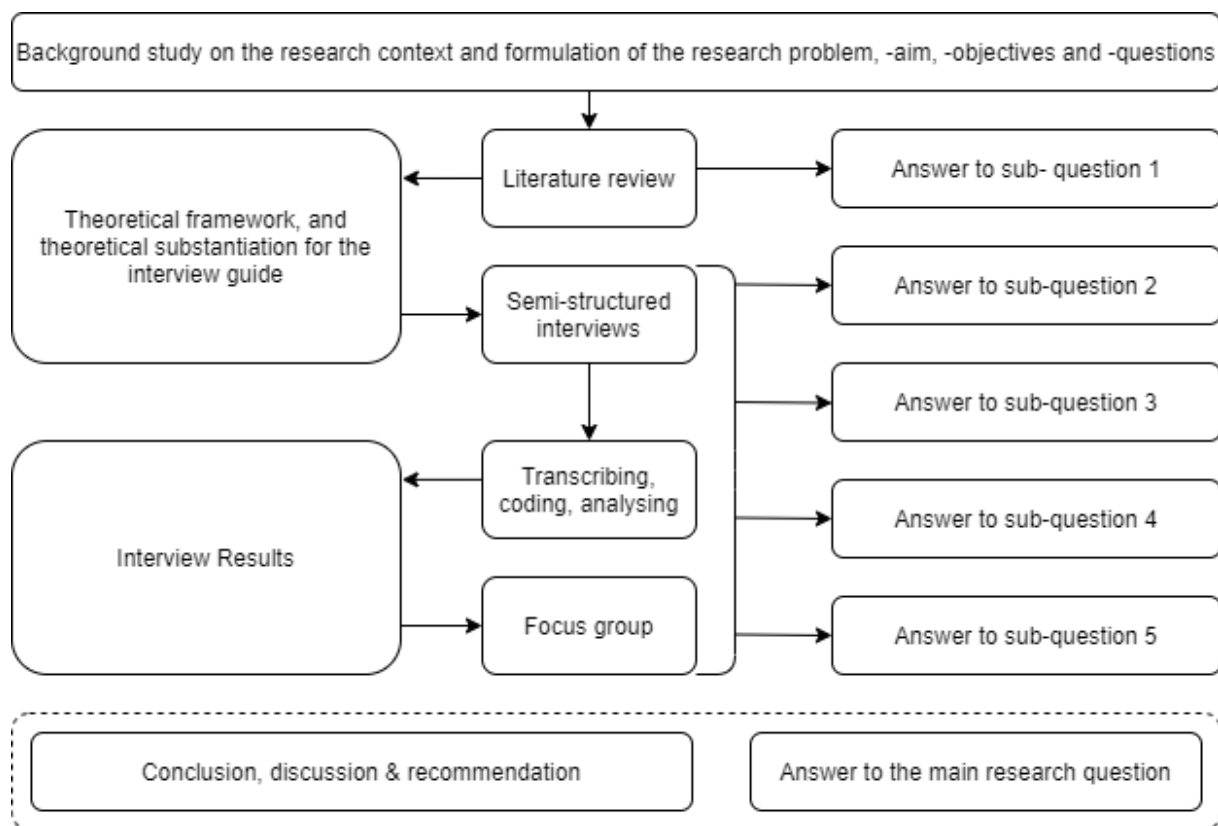


Figure 9: Research design and process (own work)

### 3.3 Data collection: literature review

The first choice of method which was used within this study was that of a literature review. Rowley and Slack (2010) mention different goals which a literature review can achieve among which two are most relevant to this research: “building an understanding of theoretical concepts and terminology” and “identifying the literature to which the research will make a contribution, and contextualising the research within that literature” (p. 32). It is with these two goals that a literature review was performed. Also, due to the exploratory nature of this research, it was important to consult the relevant literature on the concept of climate adaptation monitoring



which in turn provided a base on which the rest of the study was built. The main database which was used to find the relevant literature was that of Google scholar. In order to find the relevant literature, search terms included the words: “climate change adaptation”; “monitoring”; “indicators”; “learning”. Of which a combination was made between the different terms. Moreover, one of the most useful methods of finding literature was that of the snowball method, in which more literature was found by searching within the reference list of other sources. The main aim was to find the most relevant literature, as well as the most recent ones in time, or certain founders of a concept or theory relevant to this study. Due to the fact that climate change adaptation monitoring is a relatively underexplored subject, finding the relevant literature in the early stages of this study proved to be challenging. Overall, a library was established within Zotero, for easy to use access to the literature.

### 3.4 Data collection: semi-structured interview

The bulk of the data which was collected was done through the method of semi-structured interviews. Within interviews, Longhurst (2003) distinguishes between three types: structured; semi-structured and unstructured interviews. Semi-structured interviews are conversational and informal in tone allowing for an open response in the respondents own words (Longhurst, 2003). The questions asked throughout the interview were based upon an operationalization of the concepts out off the conceptual framework, which provided a deductive way of data collection. However, due to the fact that this study is exploratory, there is room for an open interpretation of the questions as well as more discussion on the subject in an inductive way. As such, the semi-structured interview was the method of choice.

#### **Sample selection**

The sampling strategy is a purposive strategy which means that participants are chosen based on specified criteria, which are relevant to the overall objective of the research (Guest, et al. 2006). Due to the fact that the research objective entails exploring into the topic of climate change adaptation monitoring, the respondents were selected based on their affiliation with that particular topic. As such, the sample selection criteria were the following, the respondent should:

- Be employed within a municipality which has experience with climate change adaptation. Related to one of the four climate risks: water nuisance, heat, drought and/or flooding.
- Be employed within a municipality which has experience or knowledge on the subject of monitoring.
- Have a professional affiliation and knowledge on the topic of climate change adaptation as well as monitoring.

The purposive choice of respondents was based on the fact that specifically municipalities were chosen who, according to a report on the state of climate change adaptation in Dutch municipalities from Stichting CAS (2021) were considered to be one of the frontrunners on climate change adaptation. A distinction between geographical location was not made, as the main focus was to interview respondents in municipalities who have experience with monitoring, as monitoring proved to be a practice which is still relatively underused by many municipalities. Also, respondents were contacted based on suggestions given by other professionals at Deltares or other organizations. All respondents, were contacted by e-mail.



Lastly, all interviews were held in the Microsoft-Teams environment due to Covid-19 considerations. Table 4 and figure 10 below serves as an overview to see which municipalities and individuals were interviewed during this study:

Nr.	Municipality of	Date of interview
1	Nijmegen	5 May
2	Arnhem	11 May
3	Rotterdam	12 May
4	Zwolle	17 May
5	Goeree-Overflakkee	17 May
6	Groningen	18 May
7	Eindhoven	20 May
8	Tilburg	25 May
9	Amsterdam	28 May
10	Apeldoorn	3 June
11	Amersfoort	4 June
12	Meierijstad	4 June
13	Gouda	16 June

Table 4: Overview of interviewed municipalities, with date.



Figure 10: Municipality locations (Openstreetmap.org)

The interview questions are based on an operationalization of the concepts which are derived from the theoretical framework. As such, the interview questions aim in a deductive way to analyse in which way the empirical findings correlate with the theory. Aside from this, in an inductive way, questions of an explorative nature as asked to serve as an addition on the theory. The interview guide consisting of the questions can be found in appendix 1.

### Ethical/privacy considerations

Each respondent was asked beforehand within the first email for their willingness to answer a set amount of questions within the timeframe of 45 minutes to an hour. Aside from this, within the email it was mentioned that the interview was to be recorded through audio in order to transcribe it for the analysis. It was mentioned that this recording would only be internally available for me the researcher and the university. This was later repeated in the introduction part of each interview before the questions were asked. Moreover, respondents were asked whether they wanted to check the transcript for confidential/sensitive information or factual uncertainties. Lastly, it was stated within the email and the introduction of the interview that the respondents names would be anonymised for privacy reasons. Which is why within table 4, the function and name of the respondents are left out on purpose.

## 3.5 Data collection: focus group

The focus group was organised following the end of the interviewing process. And was prepared after finalizing the coding process and reporting of the results following this process. According to Breen (2006) the purpose of a focus group is to generate ideas on a certain topic formed within a social context. These ideas aimed to further verify the results which were found within the interviews, as well as possibly find new themes otherwise not found through the interviews. According to Breen (2006, p. 467) a focus group can have the following advantages and disadvantages as is shown in table 5:

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Attitudes and opinions are socially formed; focus groups provide a social environment in which to articulate them</li> <li>• Gives us a deeper understanding of the phenomenon.</li> <li>• Gives us new insights.</li> <li>• Complements and further explains statistical information obtained from other evaluative processes</li> </ul>	<ul style="list-style-type: none"> <li>• More expensive and time consuming than quantitative evaluating procedures</li> <li>• Harder to get everyone in the same place at the same time</li> <li>• Problem of obtaining a biased sample</li> <li>• Reliability of thematic analysis</li> <li>• Reliability of perceptions (not always accurate)</li> <li>• Difficulties preventing a particularly vocal or dominant participant from coercing others to agree with his/her views.</li> <li>• Data obtained are very context-specific and therefore not generalizable to other institutions or contexts.</li> </ul>

Table 5: Advantages and disadvantages of a focus group (Breen, 2006, p. 467).

These advantages and disadvantages were taken into account before conducting the focus group. The focus group took place in a Microsoft-Teams meeting and lasted for one and a half hours. The start of the focus group was an initial introduction of each participant. After which the researcher engaged in a presentation using Powerpoint to present the research and the initial results of the interviews. After which one statement was asked per concept, which were both finalized based on the findings of the interviews as well as to encourage discussion. As are shown in table 6:

Topic	Statement
System of interest	The main goal of the monitoring of climate change adaptation policy is to assess the effectiveness of the measures and indicate the progress of policy
Responsible organisations.	The responsibilities for monitoring of the climate change adaptation policy and measures should lie with the department in charge of management and maintenance.
Procedures	Every municipality should possess a climate change adaptation monitoring protocol, which serves as a feedback mechanism for policy and implementation/maintenance.
Indicators	The indicators which are used for the monitoring of climate change adaptation are focussed on the physical measures and not the implementation process.
Participation	Participatory monitoring with citizens is essential to make their environment aware of the importance of climate change adaptation and their role/task within it.

Learning aspects	The main goal of monitoring is to learn and based on this adjust: why do we learn exactly?
End statement	What is the importance of the monitoring of climate change adaptation now and in the future? Which developments do you see in the coming 10 years?

Table 6: Focus group statements per concept

### Sample selection

Similar to the interviews, respondents were selected based on an affiliated with the topic of climate change adaptation. During this focus group, a total of 8 people were present, in which the researcher took up the role of organizer and moderator, during which one person provided support. Meaning that a total of 6 respondents were present during the focus group session. As is shown in table 7. Again, due to privacy reasons, the names of the respondents are purposely left out.

Nr.	Organization
1	Deltares & Radboud University (interviewer 1)
2	Deltares (interviewer 2)
3	Municipality of Nijmegen
4	Municipality of Rotterdam
5	Municipality of Amsterdam
6	Municipality of Eindhoven
7	Municipality of Goeree-Overflakkee
8	Province of Noord-Brabant

Table 7: Sample selection focus group

## 3.6 Data analysis

The main means of analysing the data was done by means of the grounded theory approach of open, axial and selective coding. Which was originally developed by Corbin and Strauss in 1990. According to Walker and Myrick (2006, p. 551) “in open coding, analysts immerse themselves in the data through line-by-line analysis, coding the data in as many ways as possible and writing memos about the conceptual and theoretical ideas that emerge during the course of analysis”. The process of open coding was repeated in at least two rounds during which the first round consisted of coding every transcript. And the second round comparing, merging and/or splitting codes otherwise forgotten in the first round to make sure that the data codes were saturated as much as possible. The second phase included axial coding. “During axial coding, the researcher works to understand categories in relationship to other categories and their subcategories. The purpose is to delineate and extricate relationships on which the axis of the category is being focused (Strauss, 1987 in Walker and Myrick, 2006, p. 553). In this phase, codes were compared with one another and put into certain categories or code groups. In this sense the code groups comprised of each one of the concepts delineated from the conceptual framework and sub-categories found within them. The last step of the coding process involved

selective coding which is “the process of integrating and refining the theory” (Strauss and Corbin, 1998. In Walker and Myrick, 2006, p. 556). During this step, each of the pieces of text per category and sub-categories were analysed to distil a core theory or result per theme and sub-theme. Which were then reported within the results section per concept. The coding software which was used was Atlas.ti in which the transcript of each interview was uploaded and coded according to the above explained process. The coding scheme which was used for this process can be found in appendix 2.

### 3.7 Validity and reliability

This last section of the research design will describe how validity and reliability of the research will be achieved. “Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are” (Joppe, 2000 in Golafshani, 2003, p. 599). Within validity, two types exist namely internal and external. Which LeCompte and Goetz (1982) define as: “internal validity refers to the extent to which scientific observations and measurements are authentic representations of some reality. External validity addresses the degree to which such representations may be compared legitimately across groups” (p.32). Aside from validity, reliability is seen as an important determination of the credibility of a research. As such, reliability of a research is defined as: “the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable” (Joppe, 2000 in Golafshani, 2003, p.599). In order to improve both validity and reliability, methods of triangulation can be used, which is a strategy for improving the validity and reliability of research or evaluation of findings that strengthens a study by combining methods (Patton, 2001 in Golafshani, 2003). According to Denzin (1970) four types of triangulation can be used:

- Triangulation of data: use of a variety of data sources.
- Triangulation of methods: use of a variety of methods.
- Triangulation of investigator: use of more than one investigator/researcher.
- Triangulation of theory: use of multiple theories and/or hypothesis.

Overall the following actions were taken to ensure validity and reliability as is per table 8:

Validity		Reliability
Internal	External	
<ul style="list-style-type: none"> <li>• Choice of independent respondents otherwise not influenced by a bias and/or an agenda.</li> <li>• Choice of respondents which have professional expertise on the subject of climate change adaptation monitoring</li> </ul>	<ul style="list-style-type: none"> <li>• Choice for municipalities who are considered ‘frontrunners’ on climate change adaptation.</li> </ul>	<ul style="list-style-type: none"> <li>• Use of an interview guide for each of the respondents</li> <li>• Use of a coding scheme to code each transcript in the same manner</li> </ul>

<ul style="list-style-type: none"> <li>• Use of theory to substantiate the interview guide questions (construct and content)</li> </ul>		
<ul style="list-style-type: none"> <li>• Triangulation of data: a total of 13 sources were used for the semi-structured interviews, along with an additional 6 for the focus group.</li> <li>• Triangulation of methods: literature review, semi-structured interviews, and a focus group.</li> <li>• Triangulation of investigator: during the focus group, one additional interviewer was present which aided during the focus group process.</li> </ul>		

*Table 8: Justification of validity and reliability*

To conclude, it is important to note that the degree of reliability is difficult to determine due to the fact that many municipalities differ socially and geographically, and also due to the fact that for many municipalities climate change adaptation monitoring is seen as a new subject, for which knowledge is lacking, even for the so-called ‘front-runners’ on climate change adaptation. As such, the degree of external validity can be questioned as well. Nonetheless, during the research process, steps were taken to ensure as much validity and reliability as possible.

## 4. Results: interviews

During the coding process, codes were assigned to the concepts related to the conceptual model. After analysing these codes, different themes and sub-themes could be distinguished per concept. These are presented in a narrative way supported by information from each interview, shown as such: [interview number] along with quotes to provide a deeper understanding of the subject matter. As such, each result can be directly correlated to the corresponding interview.

### 4.1 System of interest

The first concept which will be explained based on the interviews is the system of interest. According to the conceptual model and the literature, determining the system of interest is the first step in developing a monitoring protocol/program, as it provides the basis for the other concepts. During the coding process the following themes and sub-themes could be identified:

Theme	Sub-themes
Definition of climate resilience	<ul style="list-style-type: none"><li>- Spatial element</li><li>- Social element</li><li>- Participatory element</li><li>- Awareness element</li></ul>
Definition of monitoring	<ul style="list-style-type: none"><li>- Effectiveness</li><li>- Degree of implementation</li></ul>
Purpose and use of monitoring	<ul style="list-style-type: none"><li>- Setting goals</li><li>- linking opportunities</li><li>- creating awareness / motivating citizens</li><li>- identifying problems</li><li>- verifying calculations / models</li><li>- saving money / prevent disinvestment</li><li>- substantiate decisions to politics</li></ul>
Monitoring scale	<ul style="list-style-type: none"><li>- Neighbourhood scale</li><li>- Project scale</li><li>- Vulnerable locations</li></ul>
Monitoring timeframe	<ul style="list-style-type: none"><li>- Zero measurement / baseline</li><li>- Continuity</li></ul>

Table 9: Themes and sub-themes of the system of interest

These will be discussed, also in relation to the climate themes of water nuisance, heat and drought. Before assessing the importance of monitoring in the system of interest, it is first important to determine how the interview respondents define climate resilience. As the respondents viewpoint on monitoring is highly related to their definition of it.

#### Definition of climate resilience

At the end of each interview, the respondents were asked how they imagined their municipality to look like if it were 100% climate resilient. This question was asked to identify what they constitute as climate resilient. As the main ambition for each municipality is to become so by 2050. As such, this is the first theme to be reported on, as the goals for monitoring are tied to the respondents comprehension of the topic.

**Spatial element** – Climate resilience is strongly related to the spatial element. The main conclusion which was drawn was the fact that the respondents [1, 2, 3, 4, 6, 7, 8, 10, 11, 12, 13] found the implementation of green infrastructure such as trees, vegetation and green roofs to be important conditions to become climate resilient alongside with decreasing the amount of impermeable surface space. As these elements were heavily related to climate aspects such as water retention/storage; evapotranspiration and providing shade. Such kind of adaptation measures were preferred by many respondents. Another element which was mentioned several times by respondents [2, 6, 7] was decreasing the amount of cars in a city, as cars and parking take up a lot of paved surface. The argument for this was that a decrease in the amount of cars in an area, results in less parking space used. As such, this space can be used for climate adaptation measures such as green infrastructure. One respondent [6] stated that in becoming climate resilient you would want to implement as many physical interventions as possible.

**Social element** – Climate resilience is not only related to the spatial element, but it also has a strong social component to it. The social aspect with regard to climate was something that was mentioned by respondents [9, 10]. It was mentioned that citizens should experience the least amount of nuisance from climate risks or experience nuisance on an acceptable level [5]. Related to this, negative effects as resulted by the climate risks should have the least amount of effect on the vulnerable groups of society [9] due to the fact that vulnerable groups are more affected by climate related risks: *“Someone with a low income might not have the money to buy air conditioning.”* [9].

**Participatory element** – Citizen participation was discussed as a very important aspect when thinking about climate resilience, because a municipality can not do everything on their own, and a lot of space is in private possession [3, 11]. Which is why citizens need to take responsibility for improving the spatial conditions. Also, it is not only about making sure that climate risks are minimized, but also that the cohesion within the society is maintained.

**Awareness element** – Climate robustness is also about making sure that the awareness of citizens with regard to the different climate related risks is high [1, 6, 11]. As a higher awareness can result in them taking action themselves, as well as accepting the fact that these climate risks are part of everyday life: *“For me, it is also part of the awareness amongst residents with regard to climate. Meaning it is fine if water sits on the street for an hour after disappearing for example.”* – Anonymous respondent [11]. Not only related to the awareness of citizens, but also with businesses, acting in an adaptive way. Lastly another aspect of becoming climate resilient is for the climate adaptation doctrine to be integrated in every policy, and it not being a standalone policy on its own [4].

Overall for many respondents, the question on what they constitute as a resilient city/municipality was difficult to answer. Because while many respondents provided different examples, many found it difficult to determine when something is considered to be resilient, as resilience in itself is difficult to measure.

## Definition of monitoring

One of the first questions which was asked to the respondents was how they understood monitoring. This was done to create a first insight into the respondents position towards the subject and to follow up on during the interviews.



**Effectiveness** – The main agreement on its definition is the following: assessing the effectiveness of climate change adaptation measures after implementation [1, 6, 7, 8, 12]. However, as the definition suggests, being focussed on effectiveness, many respondents found it difficult to assess when something is considered to be effective or not. As well as when something is considered to be the right measure. It was stated that monitoring of the effectiveness can both be quantitative in the form of numbers, as well as qualitative in the form of perception. Overall, the respondents found the question to be broad, as monitoring in itself was considered to be a broad topic. This was reflected by the fact that one respondent [6] mentioned that monitoring can constitute many different elements such as monitoring the progress towards a certain policy goal and the monitoring of the process throughout.

**Degree of implementation** – The second definition of monitoring is the following: assessing the degree of implementation of the climate change adaptation measures in relation to the goals which are set by the DPRA in becoming climate resilient by 2050 [4, 8, 10, 11, 12]. Not only does it concern the bigger picture, but in monitoring the degree of implementation, monitoring can also be used to monitor the progress of individual projects or certain areas of focus. As such, the monitoring of climate change adaptation concerns different scales.

Overall, most respondents agreed on the fact that monitoring of climate change adaptation constitutes and assessment of the effectiveness of the measures along with the degree of implementation towards a certain policy goal.

### **Purpose and use of monitoring**

Aside from assessing the effectiveness of adaptation measures and the degree of implementation towards a certain policy goal. Monitoring in itself can have other functions as well. Throughout the interviews, many other purposes and uses of monitoring were identified. Which are explained below.

**Setting goals** – Because different monitoring exercises can help assess the degree of implementation towards a certain policy goal, it can also aid in setting goals for further action [9]: *“Of course you have certain ambitions and goals. And the manner in which you achieve those goals, and work towards them, is related to monitoring. Which can visualize where you are at the moment. How close you are to your goal, and whether you need to adjust. That’s something which is becoming more important. Not only keeping track of your performance or how close you are in achieving your goals. But also in determining your goals, could monitoring be used. If you were to have access to the data, you can deduce goals from it.”*  
– Anonymous respondent [9].

**Linking opportunities** – Because monitoring practices can identify the effectiveness and overall functioning of adaptation systems. As well as monitoring of climate risks. It can help substantiate decisions and provide linking opportunities when a non-climate related project is executed, the insights which are derived from the monitoring can help in finding opportunities to link adaptation with non-climate related projects [4, 8]. Different respondents [1, 2, 4] stressed the fact that in doing non-climate related projects, one condition is that it should be developed in a climate adaptive way.

**Creating awareness** – Monitoring can also be used to increase the awareness within the municipal organization; citizens; and other actors [1, 6, 8, 12]. As providing proof through monitoring can show that adaptation measures do indeed have an effect, which can contribute



to the overall awareness with regard to the topic of climate change. However, in doing so, the citizen should be able to understand the data. One respondent stated that monitoring can be used to see whether a certain project aids in the enlargement of the awareness. Another respondent stated that showing people that adaptation measures work can motivate them to invest in adaptation measures themselves: *“If you were to invest in a green roof, to see if it benefits the neighbourhood, if you were to monitor that, you can prove to people that it works. Which can contribute to the intrinsic motivation of other people to get them across to invest in adaptation measures”* – Anonymous respondent [6].

**Identifying problems** – Monitoring can help identify problems within a neighbourhood, which makes it easier to tackle them [6]. Which can also result in making it easier to make combinations when developing that particular area. An example which was given by the same respondent [6] was that if citizens were to notice their neighbourhood to have a higher wind chill than other neighbourhoods after monitoring, it could incentivize them to, for instance, add trees to provide more shade.

**Verifying calculations/models** – The monitoring of the climate change adaptation measures can also aid in verifying certain calculations and models which are made before implementation [2, 3, 7]. Due to the fact that models are based on calculations, they do not always reflect a situation in the right way. As such, monitoring practices can help verify them: *“You can demonstrate a lot with calculations, if you have sufficient amount of trust in them. And if you were to occasionally measure to see whether the calculations reflect reality. You are doing well.”* – Anonymous respondent [7]

**Reducing costs / preventing disinvestment** – While monitoring in itself can prove to be expensive, when it is done in a proper way, it can also help reduce certain costs or even prevent disinvestments [7]. As monitoring can help in finding the optimal solution for a certain situation, it can save money in the process. In relation to the previous subject of the verification of calculations, the following quote exemplifies how monitoring can help reduce costs and prevent disinvestments: *“A storage settling tank is a big tank in which you can store sewage water which is then discharged into the sewage system. But those are expensive installations. I have heard stories about one of those being installed based on calculations. However, the sewage system functioned completely differently, resulting in a huge disinvestment. Those are expensive. So yeah.. measuring is and will stay important to know whether your calculations are correct.”* – Anonymous respondent [7]

**Substantiate decisions to politics** – Politics and monitoring are also related [2, 10]. Because the people in politics provide finances for a certain project. If monitoring practices show that a project is successful, it makes it easier to substantiate the decisions which you have made. One respondent stressed that they have a monitor to show the progress of certain programmes and report this to the aldermen: *“The better you substantiate something with scientific evidence or at least with hard data and data of what the effects are of our programs or the things we do outside, the easier it is to support your decisions and to also help the politics to conduct a sound discussion”* – Anonymous respondent [10]

Overall, there seem to be different purposes and use of monitoring practices. The type which is used to substantiate monitoring decisions differ according to the goals set by the municipality.

## Monitoring scale

During the interviews, it became clear that monitoring is very dependent on the scale and context of the municipality. Also, the parts of the system that were monitored differed.

**Neighbourhood scale** – One example of such a scale is the neighbourhood scale [1, 2, 3, 4, 6, 8, 10, 11, 12, 13]. One respondent [4] noted that with regard to monitoring, they put more emphasis on certain neighbourhoods which, according to their models would experience the most water nuisance. Which they in turn prioritized within their adaptation policy. Another respondent [6] also noted that they put more emphasis on a neighbourhood-oriented approach, during which the ambition was to monitor the effects of the climate risks per neighbourhood. The same respondent [6] stressed the fact that by doing so, it becomes easier to determine areas of priority: *“We are planning to do it (monitoring) in a neighbourhood-oriented way. So for each neighbourhood we want to map the effects, another dimension of monitoring which we want to process is of course the actions of the local residents”* – Anonymous respondent [6]. Another respondent [11] mentioned the fact that their adaptation interventions are focussed on the neighbourhood scale during which the degree of implementation with regard to pavement and green was monitored, also they mentioned the fact that the climate risks were recorded per neighbourhood.

**Project scale** – The second scale on which monitoring was performed was on project scale [1, 2, 3, 6, 8, 10, 11, 13]. Both climate adaptation projects as well as the monitoring of the interventions are performed on a project basis. It is mentioned that the monitoring takes place after the implementation of a certain spatial project. Another aspect which is related to this scale are pilot projects. A couple respondents [2, 3] mentioned the fact that after implementation of a certain pilot project, monitoring was used to test the effectiveness of the pilot. To monitor the degree of implementation, it was mentioned that municipalities [3, 10], would use the amount of projects on a certain topic as an indication to measure the degree of implementation towards a certain policy goal. In relation to monitoring on a project scale, one respondent mentioned the following: *“On a project level, you would want to measure the effectiveness of the measures one time, which you’re not going to do in each project. Because that’s very time intensive, because the data must be validated. That’s something you need to arrange well”* – Anonymous respondent [10].

**Vulnerable locations** – The last scale which was identified during the interviews was the ambition of respondents to focus on vulnerable locations [2, 6, 13]. Which were either identified through the stress-test or through monitoring practices.

Overall, the parts of the system which were monitored are different according to the goals set by the municipality, along with its geographical/spatial and social features.

## Monitoring timeframe

Monitoring is strongly linked to time-related elements, as it can either be done continuously or periodically. During the interviews, it became clear in which timeframe monitoring was used and which elements were important.

**Zero measurement / baseline** - In order to monitor, it was stressed that it is important to set a certain zero measurement or baseline [1, 3, 8, 9], because when measuring the effectiveness or degree of implementation, it is important to be able to compare the collected data to a certain

point in time. One respondent [9] sees the stress-test as a form of baseline: *“You can see it as a kind of baseline measurement. Where do we stand now. And after taking all kinds of measures in the public space, where will we be in a few year’s time.”* – Anonymous respondent [9]. However, after asking another respondent [11] on whether they see the stress test as a zero measurement, the following was stated: *“Yes, we have not done it a second time yet, we have improved it in certain areas within neighbourhoods. Yes, I have never heard the stress test to be a zero measurement”* – Anonymous respondent [11].

**Continuity** – The continuity and timeframe in which monitoring is performed is an important aspect which came up multiple times during the interviews. The time which a municipality spends on monitoring is very dependent on their goals; availability of time, funding and personal; and their overall stance towards it. Throughout the interviews it became clear that monitoring of water nuisance related topics has been performed for the longest period, while heat and drought are monitored less, due to the fact that municipalities have less experience with these subjects, and due to the fact that these two subjects are less tangible than water nuisance. Meaning that the effects are less visible in the physical system. The question remains whether monitoring is done periodically or continuous. Most respondents [1, 3, 13] opted for periodic monitoring per project. As continuous monitoring can prove to be most expensive and time intensive. One respondent [12] therefore mentioned that monitoring should be performed in a cyclical manner, another respondent [13] adds to this by stating that monitoring is performed cyclically when setting up new policy. However, as was stressed by multiple respondents [1, 3, 13], continuity of monitoring practices may prove to be difficult due to the cyclical manner of politics: *“Yes, every four years or so you can change it (a physical element). You’re putting effort into it now, but after that, people might want to do it differently you know.. So the continuity (with regard to monitoring) is not always there”* – Anonymous respondent [8].

Overall, the continuity of monitoring practices is dependent on the importance of monitoring within a municipalities’ adaptation policy, along with the resources which a municipality has to their disposal, such as labour, and finances.

## Summary

Overall, for the system of interest, which includes agreements on goals; the scale and timeframe of monitoring can be determined as a cyclical pattern as is shown in figure 11:

1. During the interviews, it became clear that one of the conditions for the monitoring of climate change adaptation is an understanding and definition of the goals to which a municipality should monitor. Which can include: assessing the effectiveness and/or degree of implementation of climate change adaptation measures; setting goals; linking opportunities; creating awareness; identify problems; verify models/calculations; saving money and substantiating decisions to politics. The type of goal is dependent on the overall climate change adaptation goals of a municipality, along with their capacity to perform monitoring tasks. Also, it should be noted that a combination of different goals can be made to substantiate the decision to perform monitoring tasks.
2. Next, agreements should be made on the parts of the system which should be monitored. Which can include: neighbourhood scale; project scale; vulnerable locations.
3. After determining the goals, it is important to identify a sort of zero-measurement or baseline which can be used to compare the data with. Which can include existing data

on the system of interest, as well as the stress-test which can give an indication of the current climate-related risks for a municipality.

4. The timeframe to which monitoring tasks are performed should be determined. Which can include either a continuous monitoring function or a periodic one based on the capacity of a municipality along with their vision on the importance of monitoring.
5. Monitoring practices are performed to indicate to what extent the goals which are set are reached, comparing the data to the zero-measurement, an indication can be given to the degree to which that goal is reached or not.
6. Based on the information, adjustments to the physical- and monitoring system are made based on the information which is gathered. From which the cycle begins anew.

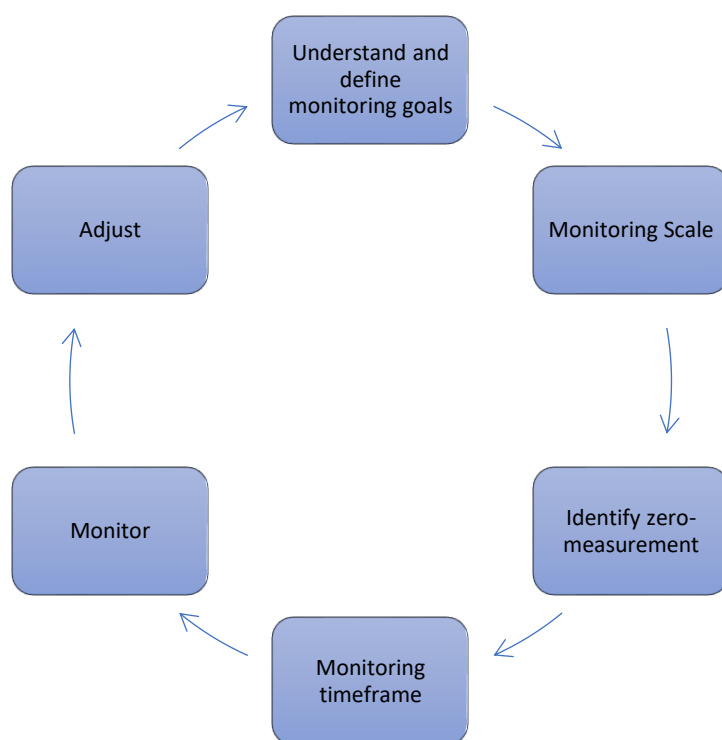


Figure 11: Steps to identify within the system of interest

## 4.2 Responsible organisations

The second concept which will be explained based on the interviews is that of the responsible organisations. Which is according to the conceptual model and the literature the second step in the development of a monitoring plan. Which includes the actors who engage in the monitoring practices, and the assignment of responsibilities for monitoring. The following themes were identified during the coding process, which include two sectors:

Theme	Sub-themes
Public sector	<ul style="list-style-type: none"> <li>- Other public authorities</li> <li>- Coordinator</li> <li>- Departments and responsibility</li> </ul>
Private sector	
Integrity	

Table 10: Themes and sub-themes of responsible organisations

## Public sector

The sector which is mentioned most in relation to monitoring is that of the public sector, and the municipality in particular. Because the municipalities themselves engage in the implementation of adaptation measures, monitoring is tied to it. However, not only the municipalities engage in monitoring practices.

**Other public authorities** – With regard to monitoring, not only municipalities are mentioned to be the ones responsible for monitoring. Other authorities include the waterboards, provinces, local health authorities, drink-water companies, and the national government. The waterboards were mentioned to be in charge of the monitoring of flooding related elements, as well as drought in the form of groundwater levels. Who, along with the provinces possess and use maps as a means of monitoring. The local health authorities were mostly tied to the monitoring of the climate risk of heat, as heat, in relation to the other three climate risks has the most impact on health. Also, it was mentioned that within the monitoring process, collaboration happens amongst all sectors.

**Coordinator** - One respondent [1] stressed the fact that the intention is to find one coordinator who is in charge of the measurements and monitoring. Because even though measurements are performed, the respondent stressed that it is a challenge to organise this in a good way due to lack of capacity and time. Another respondent [3] supports this claim by stating that when initiating a project, the project leader should be the one that needs to initiate and guide such a monitoring plan. Also safeguarding the data and ensuring that the same data is evaluated over time.

**Departments and responsibility-** One respondent [1] mentioned that they have a department in the municipality in charge of research and statistic, who amongst other things, track the amount of vegetation in the city. Another one of such was the geological department who make maps. Another respondent [7] stated that the geological department possess a lot of satellite data, which the environment management department can use within the physical environment. It was mentioned that the data which is gathered from monitoring is processed by environment- and neighbourhood management. Another respondent [12] supports this by stating that environmental management should be responsible for the monitoring process, because they have a lot of knowledge on for instance soil and vegetation. However, the following quote, which was about monitoring groundwater levels disproves this point: *“...And yes, it is nice to have done it one time [measuring groundwater levels] and to know what you run into. But that suits environment management more, but management does not see that as their task. Management is to ensure that the sewer system functions and not to measure the groundwater level. While we do know something about the groundwater level.”* – Anonymous respondent [7]. One respondent [7] explained that whether monitoring happens is dependant on the initiative of one person. And that monitoring in itself is not part of the regular process within the municipality. It is seen more as a side-task rather than a main one. This is supported by the following quote from another respondent: *“I think that some things you can do yourself, which means that you do not necessarily need to do it within the context of a college or a council.”* – Anonymous respondent [8]. Related to this, a third respondent [10] stressed the fact that for monitoring it is important to have one holder of knowledge with regard to the data, as you can collect a lot of data. But having one person to manage the data is important. However, this can also include a division of people who engage in the processing of data. The same respondent

[10] also stressed the fact that determining who is responsible for the processing of monitoring data, is still a search, and that it is not set in stone who's responsibility it should be: *"If you just collect a lot of data, and nobody is responsible for it, someone can come along and say: you know what.. we're going to clean it up. Then you've lost it. So you want to prevent that."* – Anonymous respondent [10].

## Private sector

Aside from the public sector, the private sector was mentioned several times as organisations who can be involved in the monitoring process. The type of private companies which were mentioned most were those of knowledge institutes; consultancy firm; housing corporations and drink-water companies. In particular the knowledge institutes and consultancy firms were mentioned to be the most important as they possess the knowledge to help monitoring. Lastly, it was mentioned by several respondents [6, 9,] that these two were to be involved within the monitoring process when the municipality themselves do not possess the right amount of knowledge, funding, or time available to monitor themselves.

## Integrity

The last theme related to this concept is that of integrity. As it was mentioned several times [4, 6, 8] that in order for monitoring to be used within the municipality. It should be important to take an integral approach, in which all departments within a municipality are aware of climate related risks and integrate them next to their regular activities.

## Summary

The question to who should be responsible for the monitoring of climate change adaptation measures is difficult to answer. As respondents provided many different insights and answers. Also, it was mentioned that because of time, capacity and money restrictions, appointing an organisation or person responsible for the monitoring procedures did not happen as often as was desired. Another aspect for inadequate monitoring involved the fact that within the adaptation policy, monitoring is not seen as a priority next to the implementation of adaptation. Overall, capacity and the lack of a clearly defined responsible organisation/person is the main reason for inadequate monitoring.

## 4.3 Indicators

Throughout the interview, it became clear that even though no municipality possessed a predetermined monitoring protocol, different indicators could be found. Which are mostly related to the following:

Theme	Sub-themes
Input indicators	- Cost - Subsidies - Information and time
Output indicators	- water nuisance; heat; drought; flooding and other.
Outcome indicators	- water nuisance; heat; drought; flooding and other.
Climate-related aspects/indicators	- water nuisance; heat; drought; flooding and other.

Table 11: Themes and sub-themes of indicators



## Input indicators

**Cost** - During the interviews, the main input indicator which was mentioned most was cost [2, 3, 4, 6, 8, 9, 12, 13]. Which could be distinguished between the costs of implementing adaptation measures; the cost for maintenance and the cost to monitor the degree of implementation and effect of those measures. Cost is noted to be a very important indicator due to the fact that all the actions performed by the municipality are funded by taxes, which means that when funding is limited, it should be used in the most efficient way: *“In the end, I think, if you possess a limited amount of money. You need to make sure that you use the money in such a way that it can make the most impact”* – Anonymous respondent [8]. Overall the use of funding is very dependant on the goals which the municipalities have set in relation to the climate risks and their effect on the municipality. For instance, if a municipality is more at risk of water nuisance and less so of heat, they would be inclined to invest more in adaptation measures which aim to tackle the water nuisance. Another point to note with regard to cost is the way in which civil servants have access to certain budgets. An example which two respondents [8, 13] made was with regard to the sewage charges, of which the funding was only allowed to tackle water nuisance related projects, and not for heat. Meaning that the budget to tackle one climate risk in relation to another can vary substantially based on the funding which a municipality possesses. Overall, funding for water nuisance related issues was proven to be more available due to the fact that municipalities have more experience with water nuisance, as well as the fact that it is more tangible. While drought issues are more tangible than heat, meaning that the physical effect on the environment is more noticeable. This has a large effect on the assignment of funding towards a certain project: *“You do have to make a distinction for the water component, but we do have quite a few resources for tackling water nuisance, but they come from the exploitation of the sewerage charge, that's a different discussion. Really for tackling heat stress it is just very minimal. We try to be very smart about it.”* – Anonymous respondent [8]. Related to the cost of monitoring, it was stated that monitoring in itself can be a costly activity [3]. Due to the fact that data needs to be gathered, and analysed accordingly. The equipment and the man-hours needed to perform the monitoring activities can cost a municipality a lot of money. However, as one respondent noted [7], due to technical developments over the years, monitoring is becoming cheaper. Another aspect which was related to cost which was mentioned is the fact that when combining certain functions together, when developing something, money can be saved. Monitoring methods are getting increasingly cheaper. Still, it is important to consider whether the information which is gathered from the monitoring is worth the cost. The main conclusion which can be drawn from the cost indicator is that respondents find it important to ensure that the measures which are implemented relate to the costs made in a positive way. And that the limited amount of money which is available is used in the right way.

**Subsidies** - Another form of cost which was mentioned was those of subsidies. Which include subsidies for the implementation of climate adaptation measures. Multiple respondents [1, 3, 5, 6, 11, 13] mentioned that they have subsidies for such measures. When handing out subsidies to citizens, it can also create an indication as to how many adaptation measures are implemented by citizens. With more subsidies being handed out meaning a larger degree of private equity can become more climate resilient: *“We have a green roof subsidy, so you have a very good idea of how far you have come in making roofs green.”* – Anonymous respondent [11].



**Information and time** – Lastly, the use of information and time were mentioned as input indicators [8]. Both indicators are tied to the cost indicator, as the right information on a certain issue can help speed up a certain process, which in turn requires less time and money. Which results in an overall decrease of the cost of development for adaptation measures as well as monitoring practices.

## Output indicators

The output indicators which could be identified from the interviews mainly consist of physical interventions which are implemented to tackle a certain climate risk topic. These are outlined below, wherein one such intervention can have an effect on more than one climate risk, as indicated by the two brackets: "...". Also, the amount of quotations are shown in the left to indicate their grounded-ness throughout the interviews. The type of measurement to each indicator is not provided, due to the fact that this was not specifically exemplified in the interviews and due to the fact that these are case-specific.

Amt	Water nuisance	Heat	Drought	Flooding	Other
53	• Green space developed	• "..."	• "..."		
22	• Paved surface removed	• "..."	• "..."		
21	• "..."	• Trees planted	• "..."		
15	• Sewage system adapted		• "..."		
12	• Water stored	• "..."	• "..."		
11	• "..."	• Green roofs constructed			
7	• Rain gutters disconnected		• "..."		
5	• Sewage system adapted		• "..."		
4	• "..."	• Façade gardens developed			
4	• Permeable pavement constructed		• "..."		
3	• "..."	• Trees provided for citizens	• "..."		
3	• Infiltration wells installed				
3		• Local heat plan			
3	• Infiltration connections improved		• "..."		

3	• Bioswales constructed	• “...”	• “...”		
2	• Storage settling tanks installed				
2	• Private garden percentage	• “...”	• “...”		
2	• Water square developed	• “...”			
2				• Dikes reinforced	
1					• Money made
1			• Irrigation system		
1	• Sewers cleaned				
1	• Armed grass constructed	• “...”	• “...”		
1	• Rain barrels facilitated		• “...”		
1					• Amt. of projects executed
1			• Crop sprinkling system		
1			• Level-controlled drainage		
1		• Cool routes			

Table 12: Output indicators

## Outcome indicators

Outcome indicators are the effects which are a direct result from the outputs which the municipality produced. Which are stated below in the same manner.

Amt	Water nuisance	Heat	Drought	Flooding	Other
23		• Temperature decrease			
22	• Water storage capacity		• “...”		
11		• Shade provided			
11	• “...”	• “...”	• “...”		• Increase in awareness

10	• Decrease in water nuisance				
9	• Water retention		• “...”		
9					• Increase in biodiversity
8	• Drainage capacity	• “...”			
7	• Infiltration capacity		• “...”		
4					• Progression in time
3		• Distance to cool area			
3	• Increase in climate resilience	• “...”	• “...”	• “...”	• “...”
2	• Distance to green	• “...”			
2		• Heat perception			
1				• Water safety	
1			• Fresh water supply		
1	• “...”	• “...”	• Vitality of trees and vegetation		
1					• Public health
1			• Crop yield		
1	• Water quality				
1					• Increase in liveability
1					• Air quality

Table 13: Outcome indicators

Overall respondents [3, 9, 12] found an outcome indicator difficult to determine, mainly because determining when something is considered to be climate resilient is difficult to do: “Climate resilience may not be something you can measure. You will need to have certain indicators for that. If you were to say, climate resilient means a wind-chill temperature under 23 degrees, and a drainage capacity of 60mm in two hours. Those sort of things mean you can judge it better.” - Anonymous respondent [9]. Another reason is the fact that an outcome

indicator may be less tangible than an output indicator as it can include qualitative data as well as quantitative, which can be difficult to measure.

### Climate-related aspects/indicators

Because of the fact that the interview questions were centralized around the four climate-risks, indicators were identified as well. The degree of grounded-ness can give an indication as to which climate related indicators are most discussed.

Amt	Water nuisance	Heat	Drought and soil	Flooding	Other
10	• Soil composition		• “...”		
10		• Heat stress / extreme temperatures			
8	• “...”	• “...”	Drought impact on green infrastructure		
7			Groundwater levels		
7		• Paved surface / buildings			
7					• Social inequality
7	• Sloping area				
6	• Heavy rainfall				
6	• Water in buildings / vulnerable areas				
5					• Effect on health
5	• Water on the street				
3			• Subsidence		
3			• Foundation rot		
3				• Flooding	
2				• Moraine	
2		• “...”	• Decrease in groundwater levels		
2	• Amount of water				

	nuisance in mm				
1		• “...”	• Forest fires		
1			• Salt intrusion		
1	• Underground infrastructure				

Table 14: Climate-related aspects/indicators

## Summary

Throughout the interviews, different indicators could be distinguished which the municipalities would use to measure their progress towards a certain policy goal. The output indicators which were mentioned are mostly tied to water nuisance, wherein the development of vegetation related measures can have an effect on water nuisance, heat and drought. Overall, indicators related to the physical environment are easier to determine, as these are more tangible. Indicators related to health, and social aspects such as heat-related risks, are less easy to determine as these are more emotionally based. Overall, due to the fact that climate resilience is mentioned to be difficult to measure, establishing sound outcome indicators is seen as difficult by many municipalities. Indicators related to flooding are less easy to determine as municipalities do not see it as their task to tackle flooding related issues.

## 4.4 Procedures

This part about the procedures is divided into three sections: the methods which are used by the municipalities to monitor the effectiveness and degree of implementation of their adaptation; the information which those methods produce; and the degree to which this information is used to aid in the process.

Theme	Sub-themes
Monitoring methods and feedback	- Qualitative - Quantitative
Use of feedback	

Table 15: Themes and sub-themes procedures

## Monitoring methods and feedback

During the interviews, the respondents were asked which type of methods they were using for the monitoring process. During which, a distinction could be made between qualitative monitoring methods and quantitative. These are discussed below, for a more complete overview of all of the methods and the feedback they produce, see appendix 3.

**Qualitative monitoring methods** – These types of monitoring methods contain more intuitive methods as opposed to measuring hard data. Which are mostly tied to observations and communication with citizens. Observations are mostly tied to the climate risks such as water nuisance and drought as these have the largest physical noticeability. With water nuisance being the most tangible, with observations of inundation of a certain area to be the most predominant method. With drought resulting more in the quality of the surrounding vegetation being affected due to fluctuation in groundwater levels and drought periods. Heat while less visible in the

physical environment has a more social component to it, being that it affects the health of citizens, which is why heat is more tied to amenity value of the local citizens/visitors of a city. Notifications, complaints and overall feedback from citizens was named as the most used method to monitor these climate effects. Another form of qualitative monitoring methods which were mentioned is the use of observations in the form of infrared images, in which the effect of vegetation on heat could be analysed: *“We went into the field with infrared pictures to see how the environment functions. What warms up and what doesn’t. Which is very valuable for designers. With such an infrared-camera you can really see what a tree and vegetation does to its environment. That’s an interesting one.”* - Anonymous respondent [7]. All and all, qualitative monitoring methods is mostly reflected in the overall quality of living for citizens as well as the quality of the physical environment.

**Quantitative monitoring methods** – The most common monitoring method are related to the collection of quantitative data, in the form of measurements; datasets; models; calculations; maps; etc. Again, water nuisance was the climate risk which municipalities had the most experience with in regard to monitoring, as such, monitoring methods related to water nuisance were widely used. Another aspect is the fact that effective monitoring related to water nuisance, is sometimes dependent on a certain event happening: *“Also, climate change adaptation is something which is difficult to measure, because such a rain-shower happens once in a while. The other day we had a large shower, but at the same time you might get nothing for years. We installed overflow-measurements, and the first three-quarters of the year after installing, nothing happened. On the one hand you want to measure it and show that it works, on the other hand, nothing happened”*. [7]. Lastly, measurements are not always as reliable: *We developed a water storage basin, in which we hung a measurement to see whether it fills up. It turned out that it was not filling up, because a valve was opened at some place. Sometimes it is difficult to fix it. You would think, walk over to that valve and shut it. That’s something someone needs to do. And for some reason that is not always that easy (because someone needs to take initiative).*” [7]. One important aspect which respondents [2, 3, 7] named is the fact that the difference between theoretical models and practice is important. As theoretical models are not a perfect reflection of reality, it may require physical monitoring efforts to verify whether the models are a correct representation of the situation. While municipalities have less experience with heat related problems, still, monitoring methods could be distinguished, which mainly aimed to measure the temperature either before or after the implementation of a certain measure. Another example of heat-related monitoring is the transpiration of vegetation: *“There is currently research being done on the transpiration of trees. By measuring how much water is being used by certain types of trees within the city, as well as determining how much of that is being released through evapotranspiration by the tree. That’s got a connection with heat.”* - Anonymous respondent [9]. With regard to drought, the monitoring method most used by municipalities is the continuous monitoring of groundwater levels. With one respondent showing how their groundwater data is used to observe the vitality of trees: *“We have maps with the mean high and the mean low groundwater levels. Which you can use to compare it with the overall quality of the trees”* - Anonymous respondent [7].

## Use of feedback

One aspect on monitoring procedures is how the feedback which is generated through the different methods is used within the adaptation policy of the municipalities. Overall, the use of feedback amongst municipalities involves a systematic way: in cases where monitoring procedures are performed, the outcomes of the procedures are either evaluated and used within the next policy cycle, or direct actions are taken. As the examples show: *“Yes, there are moments upon which we evaluate the policy, which is something that is stated when we set up the policy. After three years, we will evaluate to see whether we are still on the same track, whether everything is going as planned, and how to continue from this. This is something which is planned in advance, so on that moment we also look at the monitoring results. Certainly after a pilot for the functioning of an infiltration sewage, we will look at the results, and sometimes it raises more questions than it solves. Which makes for a difficult change in policy”* – Anonymous respondent [1]. According to multiple respondents the outcome of monitoring procedures are used to identify problems, which are then linked to certain spatial projects to tackle these issues. [7, 8, 9, 10, 11, 12, 13]: *“We monitor, and we always have an action after, when groundwater levels are low we look at the cause, and whether we can do something about it - Anonymous respondent [13].* However, related to this, one respondent [5] mentioned that it takes a long time for something to be realised due to the planning process taking a long time within the municipality. Another respondent [4] mentioned that the use of monitoring within the adaptation policy is also dependent on being able to communicate with colleagues: *“Because monitoring is on spot A, and the policy is on spot B. How do you bring these two together? That’s the point at which we are at now. About how you are going to organise that. And which aspects of your policy should you adjust. That’s part of our strategy, being able to make sound agreements on this.”* – Anonymous respondent [4].

## Summary

To summarize, all respondents which were interviewed stressed the fact that their respective municipalities do currently not possess a structured monitoring protocol. However, municipalities still engage in certain monitoring procedures for each of the climate risks of water nuisance, heat and drought. A clear distinction is made between the use of qualitative monitoring methods and quantitative. Qualitative involving the experience value of among which residents on the social and physical environment, which includes observations; complaints- and notifications from citizens. Where water nuisance and drought are more tied to the overall state and experience value of the physical system, and heat is more tied to the social and health aspects. Quantitative involve the use of hard data such as models; measurements; datasets; calculations; maps; etc. Overall, municipalities engage most in the use of models for both water nuisance and heat, while drought-related monitoring is mostly done through the monitoring of groundwater levels and an assessment of the quality of the vegetation and trees. Models in this sense are used to simulate a certain situation such as rainfall/heat and how it affects the area, and/or showing the overall temperature of certain areas. Models are used more than physical monitoring efforts due to them being more cost-effective and time-efficient. However, it was noted that physical monitoring efforts can aim to verify these models as they are not always a perfect representation of reality. Also, through technological development and the use of pilot projects, municipalities would experiment or engage in new monitoring methods. It was noted that the collection and sound usage of data is important to substantiate decisions. With regard to the use of feedback within the municipalities’ adaptation policy, it



was noted that in cases where monitoring was performed, the results of the monitoring are evaluated ex post during an overall evaluation of the policy. And/or in cases where monitoring results show the need for action, they are directly used to implement measures in current or future projects.

## 4.5 Participation

Participation is a concept which came up during the interviews. Which is mainly about monitoring through collaboration with residents, or by the resident themselves. Through the interviews, the following themes and sub-themes could be distinguished:

Theme	Sub-themes
Citizen participation	- Bottom-up initiatives - Collaboration
Participatory monitoring	
Awareness	- communication

Table 16: Themes and sub-themes participation

### Citizen participation

Throughout the interviews, citizen participation was widely discussed. The argument was that in order for a municipality to become climate resilient, citizen participation is important because of the large share of space being owned by private households [3, 5, 9, 12].

**Bottom-up initiatives** – Throughout the interviews, the distinguishment in relation to citizen participation can be made between so-called bottom-up initiatives, which are initiatives started by the citizens themselves, and collaborations, during which public authorities work together with citizens to monitor climate effects and adaptation. One respondent [2] mentioned the fact that such a bottom-up initiative was set up which aimed to inform, and stimulate citizens to act upon adaptation. Such as applying more vegetation and plants in their gardens.

**Collaboration** – One aspect of citizen participation which was widely mentioned was collaboration between citizens and the municipality [1, 6, 9, 11]. During which the municipality would either help and/or stimulate citizens to apply climate adaptation measures within their private setting or in public. One of the main actions in which the municipalities collaborate with the citizens is the reducing of paved surface. In which citizens and municipalities work together to take out paved surface such as tiles and replace it with vegetation. Which in turn can add a positive effect on the climate resilience. This aspect was mentioned by multiple respondents. [1, 6, 9, 11]. During this, it was stressed by one respondent [3] that building trust and a good relationship with the inhabitants is key to achieve their goals. As is exemplified through the following quote: *I think it is important that everyone who lives in the area experiences that it is not only the governments which should act. We are in this together. That is something in which we put a lot of energy. That is the only way to make a city climate resilient. Due to the fact that a large share of the space is in private hands. That is a very important part which has to be part of your strategy, which is involving the citizens.* – Anonymous respondent [3].

### Participatory monitoring

During the interviews, different examples of practices in which citizens monitored climate related aspects were mentioned. Ranging from measuring temperatures, [4, 8, 10, 12] to

measuring the air quality [3] in a certain neighbourhood, and even the moisture in the soil [10], as was exemplified by one respondent. It is heavily tied to what is known as citizen science, where citizens engage in practices of measuring certain elements: *Within [location] we have a neighbourhood where citizens measure the temperature within their own garden. During which you can see how their garden, which is greener has a lower temperature than their neighbour who has a largely paved garden. Those are interesting findings.* – Anonymous respondent [4]. One important aspect with regard to participatory monitoring and citizen science which was stressed by one respondent [10] is the privacy aspect. Because the data which is generated by the monitoring practices will need to be safeguarded by someone.

## Awareness

Awareness is one theme which throughout the interviews is not only an important outcome of the municipalities efforts, but also a goal in itself.

**Communication** – For municipalities it is important to communicate the projects which they execute, to not only inform the inhabitants of their projects, but also to create a certain awareness of the importance of those projects [1, 2, 6, 11]: *“If we are executing certain projects in the public space, in for instance certain streets or neighbourhoods such as for instance adding vegetation or adjusting the water system. It can function as a trigger to come into contact with inhabitants, during which we explain what we are doing, and telling them what they can do to contribute positively.”* – Anonymous respondent [8]

## Summary

Overall, citizen participation was mentioned as an important aspect for a municipality in order to reach their climate change adaptation goals and increase the overall climate resilience. Mainly due to the fact that the largest share of space is privately owned. It was stated that sound communication with citizens is important in order to create awareness on the importance of climate change adaptation. Consecutively, an increase in awareness can prompt citizens to perform participatory monitoring tasks which overall could lead to an increase in motivation due to the fact that monitoring can produce tangible results. This could in the result in citizens investing in climate change adaptation. All the while, good communication and collaboration between the citizens and municipalities is seen as the two most important aspects with regard to citizen participation.

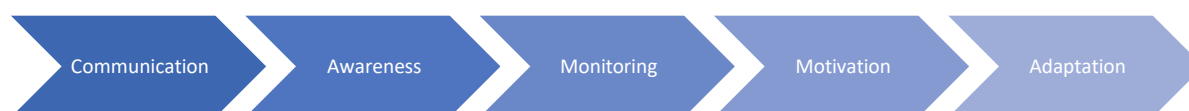


Figure 12: Participation process (own work)

## 4.6 Single- and double loop learning

Learning is at the core of the climate change adaptation policy cycle in which monitoring is used as a method to produce learning outcomes. As such, throughout the interviews, questions were asked based on this process, and how the respondents perceived it. Single- and double loop learning herein is only focused on the internal learning processes within the municipality. However, not all municipalities which were interviewed engaged in monitoring practices,

which made asking questions related to learning outcomes more difficult. During the analysis, the following themes and sub-themes could be distinguished:

Theme	Sub-themes
Single-loop learning	<ul style="list-style-type: none"> <li>- Organizational learning</li> <li>- integrality and communication</li> <li>- pilots and experiments</li> <li>- climate themes</li> <li>- Effect on policy</li> </ul>
Double-loop learning	<ul style="list-style-type: none"> <li>- monitoring goals</li> <li>- difference between theory and reality</li> </ul>

Table 17: Themes and sub-themes learning aspects

## Single-loop learning

**Organizational learning** – The main theme with regard to single-loop learning is that of learning within the municipal organisation itself. Which includes the acquisition of knowledge and experience to apply it in the next policy cycle. Which happens internally, where experiences and findings are shared amongst the departments. Which include aspects which do, and do not work. [1, 10, 13]: *“Yes I think that it is basically acquiring knowledge, that way more knowledge is produced which we can share with our colleagues, with different experiences being generate with different data, not about the data itself, but about the climate adaptation measures and how they work, through this, we will adjust something slightly differently the next time. Which means either using a different technique, or finding a new one. That’s quite an organic process I think, this way we can follow wat we have learnt from this effect. Trough measurements you simply get more insights.”* - Anonymous respondent [1]. One respondent [9] mentioned the fact that they have developed a so-called educational design or courses on climate change adaptation for internal use. In order to enhance the understanding of the subject amongst other colleagues. Of which he mentioned that monitoring is part of. The same respondent [9] mentioned their municipalities desire to standardize as much as possible and that the findings from monitoring were used in a sort of manual which is used to provide information on the functioning of certain spatial or technical constructions. Which is then used within the public space. Another respondent [2] stressed that the learning process can be characterized as ‘learning by doing’ which should be substantiated not only emotionally but also scientifically. However, when asked the same question to another respondent [5] stressed the fact that it is not learning by doing, but rather carefully analysing a certain problem and determining actions based on this. The acquisition of knowledge and experience is not only performed through internal actions, it also includes getting into contact with the citizens and gaining their input [3]. A final aspect in relation to learning within the organization is the willingness to do so. One respondent [7] mentioned that in order to be able to learn, it is important to show a certain willingness to take action in performing monitoring tasks: *“You need the right people who also have that drive. Which is something you get when you notice that other people exist who also want to know more about a certain thing.”* - Anonymous respondent [7].

**Integrality and communication** – Following up on organizational learning within the municipality is the theme of integrality. An integral way of working is one theme which was widely mentioned by some respondents, in relation to the learning aspect [2, 6, 11]. As it was

mentioned by two respondents [2, 11] that the cooperation between them and urban designers / landscape architects in relation to the integration of climate could be better. As is explained through this quote: *“You also need to think about how you will apply your vegetation, because one thing you see all too often is urban designers and landscape architects applying the vegetation on a higher level than the street for a better appeal. Which has no effect. You need to apply it lower than the street for it to be able to store water and have an effect.”* – Anonymous respondent [2]. Another aspect related to the integrality is the influence of politics on the policy process. As civil servants are tied to the demands coming from the political side of the municipality. Accountability towards politics proved important [2]. The following quote aims to summarize this aspect in a clear way: *“Look, the challenge with climate change adaptation is the integrality of it. Which many municipal organisations find difficult, because they are not organised in that way. That is quite a challenge, to work integrally. For bigger municipalities it is extra difficult than for smaller ones. Because, bluntly said, within smaller municipalities, you’ll find each other at the coffee machine. And yeah, smaller municipalities work way faster and easier. A larger municipality is just way more difficult. Also in a legislative way, aldermen always need to be accounted for, that is how our political system is organised. You need to profile yourself because you want to win elections”* – Anonymous respondent [6].

**Climate themes** – Related to the four climate themes of water nuisance, heat, drought and flooding, multiple learning outcomes could be identified. For water nuisance it was mentioned by one respondent [2] that related to heavy rainfall, standardizing is difficult to do, because every rainstorm may be different: *“There is no single standard. There is not one rain shower. You can choose which shower you take, but just know in the back of your mind that climate change can always cause an even more severe shower. That sounds like an unanswered remark, but it does mean that you just have to think carefully and not attach yourself too much to a certain value or a number or whatever. We can take a shower of I this many millimetres, but it does not explain that much”* – Anonymous respondent [2]. Different respondents [2, 3, 5, 6] also stress the fact that while water nuisance is very dependant on the location, heat is not. Which makes the topic of heat more abstract and less easy to apply policy to: *“Water nuisance is manageable. But drought and heat, that's just a slightly more difficult matter. And I also notice within the country that many governments are still struggling with this”* – Anonymous respondent [5]. When asked about the way in which their municipality is currently monitoring, one respondent [5] stressed the fact that water nuisance is much easier to fit into what he deemed as SMART goals. While drought and heat is more difficult to adhere to these goals. He stressed that if it is not possible for drought and heat to adhere to the SMART goals another solutions should be found like establishing easy to measure indicators. Municipalities have the most experience with water nuisance, which is why related to heat and drought, experimenting with monitoring methods is more in order [7].

**Pilots and experiments** – In order for municipalities to learn from the implementation of adaptation as well as monitoring, multiple municipalities engage in the use of pilots and experiments: *“We perform different pilots. We are doing all sorts of pilots around these sort of things (around monitoring). Soon we will have a pilot with satellite data, with which you can use satellite images and infrared to see where the vegetation is, and where it is cooler. Along with where it more warm due to paved surface. But the question is whether we are going to do it structurally. These are all types of pilots with which you can gather data.”* – Anonymous respondent [4]. In relation to pilots, it was mentioned by one respondent [9] that aside from assessing the effectiveness of the measure, it is important to determine the cost in relation to

the maintenance after implementation as well as the overall need for maintenance after implementation. Also, in relation to pilots, the same respondent [9] mentioned that monitoring the effectiveness of such a pilot can prove to be difficult due to the lack of concrete indicators: *“I have to say that we have a lack of concrete indicators. So... does it work? You will need to have certain indicators to know what you are about to measure. That is something which is not always clear. So yes, monitoring practices have been going on for a while. But a real consistent set of indicators upon which you can measure.. to my knowledge we do not possess these yet.”* – Anonymous respondent [9]. Another respondent mentioned that monitoring is also tied with experimenting, to see which effect a certain measure will have. By monitoring this, you will have more proof and a better substantiation for the effort which is put into it [7]. Lastly, it was mentioned [10] that a pilot can grow into a larger and stable yearly investment programme.

**Influence on adaptation policy** – In some cases, it was mentioned [1] that monitoring is used to assess whether a certain project is deemed successful or not, and whether it is wise to continue with that process: *“Yes there are moments upon which the policy is evaluated, which is also determined within it when we set it up, that after three years we want to evaluate whether we are still on the right track, has everything been going on like expected and how do we proceed. That is something which is planned beforehand, during which we also look at the monitoring results, but also after a test with the functioning of the infiltration sewage can we look at the results and determine what our opinion is on it, sometimes it results in more questions than answers which makes it difficult to make an adjustment in policy.”* – Anonymous respondent [1]. Another respondent [2] mentioned that learning happens in a continuous way, by assessing whether the costs are still properly related to the benefits, learning is about finding the best solution. However, the same respondent [2] mentioned that the overall plan-process within a municipality takes too long. Which means that the measures which are monitored are for the most part implemented before climate change adaptation became an issue. The first measures who are developed in an integral and climate adaptive way, still need to be developed. Monitoring is also used to determine the functioning of certain measures, as is explained by the following quote: *“I have seen it happen with other municipalities, where a type of pavement is used in which rutting took place. So you’re assets which you have as a municipality which are your roads, you will need to adapt them, because you want to be climate adaptive. And if you were to monitor this, it seemed that certain pavement silt up as a consequence. And because you are monitoring, you can conclude that you need to take action. Meaning you are going to research what the problem is. So you if it does function as intended, you can scale it up”* – Anonymous respondent [9]. One respondent [10] stressed the fact that with regard to the learning process it is about being able to determine what the initial investment towards a project has yielded. And monitoring can be used to verify this. Because you have certain goals opposite to your investment. When asked about what the learning process in relation to monitoring looks like one respondent [13] mentioned that due to the fact that they are a small municipality they do not have their own experts. Which is why they hire these when setting up policy.

## Double-loop learning

**Monitoring goals** – One aspect related to double-loop learning to determine whether municipalities are doing the right things is the determination of their monitoring goals [3]. Because monitoring in itself can have multiple goals, in order for municipalities to learn through a double loop means determining which monitoring goals they need to become climate resilient are most important for their specific context: *“The question is mainly, what are you going to*

*measure, what do you want to measure, for what and for whom? We are planning to develop an approach for that, which would mean that we are going to monitor in what way the city will become climate resilient.” – Anonymous respondent [3].* This aspect which throughout the interviews is something many municipalities still struggle with. Mainly because climate change adaptation is still a relatively new subject, along with the fact that many municipalities have little experience with heat and drought related adaptation. The overall adaptation goals are strongly linked to the goals to which there is monitored as well. The following quote is a good example of this: *“Offcourse you can ask yourself, how can we do this in a smart way? Are we doing things in the right places, with the right type of vegetation. What are the side-effects? These are all questions which you can answer. However, that means you need to... we are thinking of an approach which gives aim to that question. And yes, the art is not to make it too big. Because offcourse you can measure a lot within such a big city. Which is also expensive, so you will need to really think about what you want to measure in order to make sound conclusions about it.” – Anonymous respondent [3].* Another respondent [11] mentioned that they did not use monitoring as they try to execute each project to their best ability, meaning that you can monitor the effect. But if you did the best you could, there is no need to do so.

**Difference between theory and reality** – One other aspect related to the a reflection on the methods used by municipalities is the difference between theory and reality. Mainly in the form of models and physical monitoring. As many municipalities [2, 3] use models as a means to substantiate decisions. However, as is explained by one respondent, there is a clear difference between a theoretical model based on calculations and reality: *“Because a computer model stays a tool. Reality is always different from theory because these cobblestones are situated differently than the model suggests. I have seen a couple of cobblestone in an area of the road which are situated differently which means that the water does not go straight like the model suggests, but took a left turn, taking another road. Yeah, those computer models are nice, but they are not as detailed as you would want them to be” – Anonymous respondent [2].* The same respondent [2] mentioned that it is important to ensure that the input for these models is correct, because if your input is incorrect it means the output wont be correct either. As such, two respondents [2, 3] mention that physical monitoring can be used as a tool to verify these models.

## Summary

Overall, aspects of single- and double-loop learning are performed by municipalities, but are difficult to identify. Mostly because municipalities see learning as an ongoing element, and not so much a goal in itself. As such, learning for municipalities means to improve upon their practices after an analysis of these practices. Learning is also very much related to a reflection on the overall goals related to adaptation as well as monitoring in itself. With the questions related to ‘are we doing the right things’ (double-loop learning) is strongly tied to a clear definition of ones goals. Because if these goals are not clear, it is difficult to assess whether you are in fact doing things the right way.

## 4.7 Social learning

Next to internal learning processes in single- and double loop learning are social learning processes. Which are learning processes amongst multiple actors, in which the municipalities work together with other actors to learn more about the overall monitoring process. In which the following themes could be distinguished:



Theme	Sub-themes
Collaboration	<ul style="list-style-type: none"> <li>- Knowledge institutes</li> <li>- Conferences</li> <li>- Educational institutions</li> <li>- Public organizations</li> <li>- Private organisations</li> <li>- Civil society</li> </ul>

Table 18: Themes and sub-themes social learning

## Collaboration

In relation to the social learning aspect, the respondents were asked in what way they collaborate with other organizations to learn from climate adaptation and the monitoring in general. During which, multiple ways of sharing knowledge and collaborating were mentioned:

**Knowledge institutes** - Knowledge institutes play an important role in the sharing of knowledge and the overall collaboration related to the topic of monitoring. This is mainly due to the fact, as one respondent mentioned [10], that municipalities are executive organisations and not scientific ones. Which means that collaboration between the two is very important. Another respondent [9] supports this by mentioning that knowledge institutes can hand them the tools necessary, as a stepping stone, such as certain indicators and methods which they can use and develop further.

**Educational institutions** – Similar to collaboration with knowledge institutes is the collaboration with educational institutions such as universities and universities of applied sciences. Three respondents [1, 2, 8] mentioned that such a collaboration where students of such institutions would engage in a measurement campaign to collect data for the municipality. As well as research on the for instance the use of certain vegetation in relation to the climate risks. All and all, the collaboration with educational institutions can help municipalities to collect data as well as provide knowledge which can help support certain decisions.

**Conferences** - Certain conferences tied to topics of climate change adaptation and monitoring are very worthwhile to attend according to multiple respondents [1, 4, 5, 10]. Due to the fact that these conferences can create learning outcomes and networking opportunities. However, one respondent [5] mentioned that attending such conferences requires time and the opportunity to do so. Something which civil servants working in the municipality not always possess.

**Public organizations** – Social learning practices within public organizations happen inside the municipality itself amongst civil servants, as well as between other municipalities, health organisations (GGD) and waterboards. Where health organizations are collaborated with due to the fact that they possess a lot of data with regard to health [1, 4 6]. Related to social learning inside the municipal organizations, two respondents reflect on this, where one [7] mentioned the fact that they are busy with informing designers within the municipality. To slowly enhance their awareness with regard to climate related topics. Another [11] mentions the fact that they have a so-called climate team, where different departments such as urban design, soil, and living environment engage in weekly meetings to collaborate and share knowledge related to climate. Not only do municipalities engage in social learning practices inside the municipality, they also engage with other municipalities [4, 9, 13]. One of such is what one respondent named a core group [4]. Who engage in activities with regard to measurements and data, and also to see how



other municipalities engage in those practices: *“It’s a leading group consisting of five municipalities who are leaders within the Netherlands with regard to data, and the use of monitoring, that’s something you learn a lot from. Not necessarily seeing whether something goes right or wrong, but about the application of your resources. That is something you learn a lot from, by working together with other municipalities. And at the same time, it’s the art of finding your colleagues. That is also an important one. Because monitoring is on spot A, and the policy is on spot B so to say. It is about how to bring those two streams together.”* – Anonymous respondent [4]. Related to the same topic of collaboration amongst municipalities, one respondent [13] mentioned that their municipality engage in the monitoring practices on their own, but that there are certain ambitions to work together in the region. Due to the fact that they are the leading municipality on adaptation, and smaller municipalities do not have the same capacity, they share information with them, about what they do, and which approach they are taking. Which those municipalities use to learn from, however, she mentioned that monitoring is not involved in this learning process. The same respondent [13] mentioned that it is mostly exchanging knowledge between the different municipalities. Along with the fact that it is mandatory by means of the Deltaprogramme for municipalities to work together. Although collaboration can be difficult due to the fact that it is a slow process, also mainly because you need to work together with organizations that do not understand one another due to the fact that they are so different: *“Most municipalities deal with those struggles, so the municipality says we do not need to work together. It is nice to extract knowledge, however we do not want to collaborate because we can not come to certain agreements. That’s kind of how you do it, the learning curve means getting to know and trust one another, only to not work together.”* – Anonymous respondent [13]. One respondent [9] mentioned that the collaboration between municipalities happens on a provincial level in which all the municipalities surrounding their own are part of. Where they engage in a dialogue to discuss the lessons which they have learnt. Another respondent [12] mentioned that when engaging in dialogues they outsource it on a regional scale through the province, not on a local scale, because it is less efficient if municipalities were to do it on their own. In doing so, multiple municipalities in that region can benefit from it: *“So... monitoring is such a subject which you are better off working on in a collaborative way. Rather than each on their own.”* – Anonymous respondent [12].

**Private organizations** – In relation to the climate risk of heat, multiple respondents [1, 2, 6] stress the importance of working together with housing corporations. In order to facilitate knowledge on constructing housing in a climate-proof way. Two other types of private organisations which were mentioned were consultancy and engineering firms [6] and drink water companies [9]. Because they possess a certain knowledge which the municipalities can use in their development towards a climate resilient environment.

**Civil society** – Lastly, social learning occurs within a collaboration between the municipality and the civil society such as the local neighbourhood watch [6] with which one respondent mentioned. And a so-called community of practice. According to the respondent [7] the community of practice consists of a collaboration between multiple parties among which the municipality itself; a collection of volunteer organisations; the local health organisations; waterboard and a couple of other organisations. Where he stressed that bringing knowledge from different organizations together means that more progress is made than if you were to do it individually. Lastly, with regard to the overall learning process, one respondent [12] had the following to say: *“Ofcourse, the learning process is about conversing with one another, from a standpoint of ‘we have a shared task’. Another aspect is, which I have not talked about is,*

*yes.. we can think of all sorts of things. But we will have to work together with the citizens. The other day I saw a quote of: 'if you do something for me, without involving me, are you against me?' So yes... we are laying the foundation right now. Because society is not only governments, housing corporations, public-health organisations and so on. No, it is everyone! Everyone participates. In that sense it is optimal inclusion. How to accomplish that? I do not know yet. But it is something we need to do together, again, I contribute to the development of such a basis, such a starting point. But I realise that I am not going to do it with only the governments. The largest share of property is private property. So they need to participate as well." – Anonymous respondent [12].*

## **Summary**

To summarize, social learning is an aspect which is already widely used within the municipalities in which the respondents function. There is however a clear difference between clearly organised programmes to share knowledge on adaptation and monitoring, and the incidental acquisition of knowledge. Related to learning within their own public organization, some respondents mentioned that there are clear goals to internally improve the knowledge base of their colleagues through certain programmes. While other respondents are more keen on learning through other means such as attending conferences. Overall many examples of collaboration for the purpose of learning and the generation of knowledge were given, which indicates that while monitoring may seem an underexplored subject, municipalities do put effort into their knowledge production.

## 5. Results: focus group

The main purpose of the focus group was to test the initial results of the interviews, and to provide fuel for further discussion on each concept. During the focus group, a total of eight people were present in a Microsoft-Teams meeting, among which included two interviewees and six participants in different organizations with each having an affinity and experience with the topic of climate change adaptation monitoring. The focus group was organized in the following way:

- A presentation on the research and the initial results.
- One statement per research concept as fuel for discussion through menti-meter.
- One ending statement to act as a summary on the overall importance of the topic.

The results of the focus group are discussed per research concept, in which single/double-loop learning and social learning are grouped together in what is named as learning aspects. For an overview of each answer to each statement, see appendix x. The results are explained in a narrative way in accordance with the interview results.

### 5.1 System of interest

*The main goal of the monitoring of climate change adaptation policy is to assess the effectiveness of the measures and indicate the progress of policy*

The answers to the statement show that from the eight answers given, four agree with the statement. While one respondent mentioned learning as an important goal. Another mentioned: “both is necessary. In the end, the effect on the ‘real world’ is most important. There is no need to check of lists. There is however the need to learn and adapt”. Along with an assessment of the effectiveness of measures, showing the politics and the citizens that progress is being made towards becoming climate resilient by 2050 is one of the major goals with regard to monitoring. It was mentioned by one respondent [1] that throughout the development towards a climate resilient city in a certain timeframe. That through the years of development, the goals and priorities can change. Which means that the data which you gather from monitoring might not be usable anymore, which means it is important to ensure that the data remains operational even though your goals change. He also adds to this that it can work in the opposite way, when data which in the past was not usable, can all of a sudden become relevant. Another element which was stated by the same respondent [1] was the fact that it is not only important to assess the physical effectiveness of a measure, but also the overall experience value from citizens, stating that the focus should start with the citizen instead of the physical system.

Overall the main conclusion with regard to this concept is that the respondents agree that assessing the effectiveness of climate change adaptation measures is important, however, it should be done with the overall goal in mind, which is becoming climate resilient by 2050. Which is not only tied to the physical system, but also the social one. Meaning that choices need to be made to which elements of the system, monitoring has the most benefit in achieving this goal. Along with the fact that if the impact of a certain measure is high in achieving the goal, monitoring can aid in assessing how that particular measure functions in the whole system [3].

## 5.2 Responsible organisations

*The responsibilities for monitoring of the climate change adaptation policy and measures should lie with the department in charge of management and maintenance.*

With regard to this statement, there were mixed reactions. Two out of the eight responses said yes while six others did not agree on this statement. With one [6] stating that the one who makes the policy should not be the one to assess it. Because the monitoring should in his eyes have a certain degree of independence to it. Also due to the fact that it is an unpopular activity, making it independent from management and maintenance should be a good thing, so monitoring keeps being practiced. Another respondent [3] mentioned that it is also possible to outsource monitoring practices to a third party. Also reflecting on the importance of independence. Another respondent [5] who was part of a smaller municipality stressed the fact that due to smaller capacity they may not have the time themselves to monitor, agreeing with the previous statement that if your goals in relation to monitoring are clear, you can outsource it. The last respondent [1] also adds that outsourcing can be beneficial if one has a clear formulation of their monitoring goals as long as the municipality stays in charge.

To conclude, most respondents do not agree with the statement and agree that outsourcing is a viable option if the municipality itself does not have the time or capacity to perform monitoring tasks. However, in doing so, the objectives and goals for monitoring should be clear.

## 5.3 Indicators

*The indicators which are used for the monitoring of climate change adaptation are focussed on the physical measures and not the implementation process.*

With regard to this statement, the respondents agreed that currently the overall focus is mostly on indicators tied to the physical system, rather than that of the process. With one respondent [1] mentioning that while there is room for process monitoring, in practice the learning effect of process monitoring disappears due to lack of time and other activities being more important. Another respondent [2] agrees that while currently the current focus is too much on the physical system, with regard to indicators, the overall experience value of citizens should also be taken into consideration. One respondent [1] agrees with this stating: “I am in favour of both. Make sure that you can monitor the physical system along with the experience of the citizens. Say, the experience is negative, and your physical system also shows it, it means you will need to take measures. And if they do not match, then you will get interesting affairs meaning you will need to deal with it differently than having to depend on one of the two.” The two participants agreed with one another on this aspect. Finally, one respondent [6] mentioned that it is important to have basic indicators for the physical system as this can show a certain trend. With regard to the monitoring of the process, a more less strict approach can be used adding: “we have the tendency to, every once in a while do everything all over again. Yeah, that’s not very helpful.”

To conclude, the respondents seem to agree that currently the focus is very much on the physical system and less so on the process. During which the emphasis should not only be on the physical system, but also on the social system. Which should be reflected in the use of indicators.

## 5.4 Procedures

*Every municipality should possess a climate change adaptation monitoring protocol, which serves as a feedback mechanism for policy and implementation/maintenance.*

Overall, all respondents seem to agree that it is important for municipalities to possess a sort of monitoring protocol. Although there are certain nuances to be made. As one respondent [6] mentioned that it should be beneficial to have a certain base level agreements made with regard to monitoring amongst municipalities, all the while making sure that it does not become too big, and unmanageable. However, he added that finding out what the essentials are for this base level can be difficult. Another respondent [3] mentioned that even though the overall goal is to become climate resilient, there is not much input from the board to monitor this. Adding that when thinking about monitoring the cost in relation to the benefits should be balanced. Two respondents [3, 6] mentioned the use of so-called climate labels which can be used as a means to monitor which are based on model calculations of extreme rainfall. Although in practice, while using these models, one respondent [3] mentioned that these calculations are not monitored in practice to verify them, as this is difficult to do.

Overall the respondents seem to agree that municipalities should possess some form of monitoring protocol which should be easily manageable. Which should contain a balance between the cost and benefits of the monitoring. However, in practice this is still lacking. When physical monitoring is not feasible, models which are based on calculations are used as a baseline for input. When physical monitoring is feasible, it should aim to validate these models. In the end, the respondents find the transition towards technical measurements and policy difficult.

## 5.5 Participation

*Participatory monitoring with citizens is essential to make their environment aware of the importance of climate change adaptation and their role/task within it.*

Unfortunately due to time restraints, this statement was skipped from being answered. However, during the focus group itself, regarding this concept, some insights were provided. Many respondents stressed the fact that a large part of the space is in private hands, with one respondent [2] mentioning that municipalities have a large influence on public space but not so much on private space, meaning that it is important for a municipality to create awareness and trigger a behavioural change in citizens. Which he thinks participatory monitoring is a good tool to achieve this. Another respondent [3] mentioned that within their adaptation programme, citizen participation is one of their goals. A third respondent [5] mentioned that it is important to keep in touch with citizens as well as engage in participation to make sure that you do not lose contact with them.

To conclude, throughout the focus group, the aspect of citizen participation was mentioned a few times as being an important aspect within the municipalities' climate change adaptation policy, however unfortunately due to a lack of time. The participatory monitoring element was not elaborated on further.

## 5.6 Learning aspects

*The main goal of monitoring is to learn and based on this adjust: why do we learn exactly?*

Related to learning aspects and monitoring, different outcomes were identified per respondent. One respondent [3] stressed that learning is not so much the goal of monitoring but an important side effect. He added to this by stating that after implementing policy, you should monitor it, and adjust the policy accordingly, which in turn means learning automatically. Which is an important secondary purpose. Another respondent [4] mentioned that it is important to keep into consideration how you spend your money, if you were to spend it on a pilot project without knowing whether the funding are well spent, it could signal to the citizens that their tax money is not being spent well. A third respondent [1] mentioned that the word learning is a crux in the context of monitoring. Because monitoring in itself means collecting data which needs to be processed into understandable information, which then is turned into knowledge. Meaning that monitoring can aid in the learning process if the data is well processed. Another respondent [3] supported this claim by stating that after monitoring you have not learned anything yet. Learning takes place after adjustments are made based on the monitoring. Lastly, one respondent [6] mentioned that it is important to determine who learns in the end, people or organizations? Noting that the internal mobility of people disrupts the learning process. Mainly because people tend to be very mobile, which is also stimulated, it can result in people trying to 'reinvent the wheel'. Adding that in order for an organization to learn it should note information down. Also, climate change and adaptation requires working in an integral way between different sectors. Which is part of the learning process, meaning that it requires a kind of culture change: "it is more related to attitude than content. Which is why I find the whole learning story quite difficult" [6].

To conclude, the respondents agreed that learning should not be the main goal, but an important side effect of monitoring. Also, monitoring in itself does not directly result in learning, learning takes place after information from monitoring is processed, interpreted, and leads to changes in the physical space from which learning outcomes can be derived.

## 5.7 Conclusion

To conclude the overall focus group, one last ending statement was provided which aimed to summarize the importance of climate change adaptation monitoring now and in the future:

*What is the importance of the monitoring of climate change adaptation now and in the future? Which developments do you see in the coming 10 years?*

During the last statement, seven different answers were given based on how the respondents see the developments in the coming years related to climate change adaptation monitoring. The answers included the following:

- importance of participation
- the challenge in setting up a relatively simple monitoring protocol which is used over a long period of time to be used to adjust policy
- the use of model-based monitoring as a baseline, which needs to be validated and changed based on experiences of citizens, asset-managers, designers etc.
- Information driven decision making with smart systems.
- Further automatization, continuity measurements, water quality, exchange of information to create insight.
- More collaboration is necessary in order to create a broad integral image of the climate resilience of the city.
- It would be nice if there were a kind of national comparable indicators were introduced.

To conclude, the focus group session gave room to verify the results which were derived from the interviews, along with provide more information. Overall, the interviews and the focus group yielded similar data, along with some extra insights.



## 6. Conclusion

This chapter includes an overall conclusion on the study and the main- and sub-questions which are tied to it. This thesis is based upon the initial preference from Deltares as well as a background study on the gap of the implementation of climate change adaptation monitoring both in practice and in literature. This study used an explorative approach to determine the status with regard to climate change adaptation monitoring on a local scale within the Netherlands, related to the overall adaptation goals set by the Deltaplan of Spatial Adaptation. Seen as though through the literature, the learning effect of this topic is at the centre, the main emphasis was on this aspect. From which the following main research questions was defined:

***Main research question – “To what extent does climate change adaptation monitoring result in improved adaptation policy in Dutch municipalities, and how can principles of learning be implemented to improve this process?”***

In order to systematically answer this question, multiple sub-questions were set up, in an explorative way. Which aimed to distil parts of the main question related to the essence of the topic itself, its current implementation in Dutch municipalities, the role in which it is used in adaptation policy, and the learning outcomes which can be derived from climate change adaptation monitoring. As such, each sub-question is answered individually in a chronological manner:

***Sub question 1 – How is climate change adaptation monitoring defined, and what are known principles according to the literature?***

Climate change adaptation monitoring is the systematic collection of qualitative or quantitative data with pre-defined indicators which is performed either in a continuous or periodic timeframe (Lamhauge et al., 2012). During this process, agreements are made on the system of interest; the responsible organisations; the indicators and the procedures. As such, monitoring practices are performed within the system of interest, which is related to specific sectors and functions as well as geographically specific areas which are bound in space and time. Within these areas, the monitoring goals will need to be determined, along with the timeframe in which monitoring takes place. Second, sound and comprehensible indicators will need to be set up which function as measurable indicators to indicate the progress towards achieving the monitoring goal set by the organisation. Which can focus on the input; process; output or outcome of certain climate change adaptation related activities. Third, the organisations which are held responsible for performing monitoring tasks should be identified, with a clear indication of the effort which is required from them. Fourth, a monitoring protocol should be set up which include step-by-step instructions on the procedures related to methods of data collection; analysis; reporting and other activities related to monitoring. Lastly, the activities within climate change adaptation monitoring are heavily tied to learning principles focussed on problem solving (single-loop learning); process reflection (double-loop learning); and learning between actors who are also engaged in (participatory) monitoring tasks (social learning). These three learning outcomes are performed through the monitoring tasks, which aim to improve and adapt upon the overall adaptation goals. After adapting these goals, the cycle is repeated in an iterative way. Which is known as adaptive management.

### ***Sub-question 2 – How do Dutch municipalities currently monitor climate change adaptation measures?***

In cases where monitoring is performed, the focus on the parts of the system of interest that are chosen for monitoring are mostly performed on a project-basis, on a neighbourhood scale, and on vulnerable areas which suffer from water nuisance; heat; drought; and flooding related climate risks. The timeframe in which monitoring procedures are performed is dependent upon a municipalities' capacity to perform them. As continuous monitoring is deemed more costly than periodically. It is noted that a zero-measurement is important to have to compare the monitoring outcomes with. The indicators which municipalities use are mostly tied to input indicators such as cost, and output indicators such as the degree of implementation of adaptation projects. Overall, an outcome indicator is more difficult to determine as an assessment of a municipalities' climate resilience remains a difficulty. The organisation(s) responsible for performing monitoring tasks differ strongly per municipality, as it is highly dependent on whether monitoring is clearly defined as a task within the adaptation policy. The monitoring procedures are related to qualitative and quantitative monitoring methods. Qualitative methods include observations and feedback from citizens. A difference exists between monitoring of the physical system, as well as the social system. Where water nuisance and drought related climate risks are mostly tied to the physical system. Because of the fact that water nuisance is mostly tied to inundation of (vulnerable) areas. And drought is reflected in the overall quality of vegetation and trees. Heat-related monitoring is more tied to the social system, as heat affects the health of inhabitants. Which is why municipalities assess the overall experience value of inhabitants in relation to qualitative monitoring methods and the three climate themes. Quantitative methods include measurements; datasets; models; calculations; maps; and other methods of quantitative data collection. Related to this, the use of models is widely used throughout the municipalities in order to predict water nuisance and heat-island effects. As such, it was mentioned that physical monitoring procedures can function as a means to verify these models. Drought-related monitoring is mostly tied to the measuring of groundwater levels and the moisture-level of vegetation/trees. Overall, municipalities have more experience in monitoring water nuisance related climate risk, while heat and drought related monitoring is less performed due to the fact that municipalities have less experience with it and due to the fact that it is less tangible than water nuisance. Flooding related monitoring is not performed by municipalities because it is seen as the task of the waterboards.

### ***Sub-question 3 – What role does monitoring play in the municipalities' adaptation policy?***

The results show that monitoring practices are still very much performed incidentally by the municipalities, mainly because of the following reasons: none of them possess a concrete monitoring protocol in which clear objectives and procedures are defined; the responsibilities to whom should be in charge of the monitoring is not always clear, and due to the fact that a lot of the times, the municipalities lack the time, capacity or funding to perform monitoring procedures. Another large reason for inadequate monitoring was the fact that it is difficult for municipalities to determine sound goals for monitoring. The fact remaining that through the DPRA the goal is to become climate resilient by 2050, for many municipalities it still remains difficult to determine when their municipality is considered to be climate resilient. Which makes it difficult to monitor when certain goals are not clear.

Even though monitoring is included in some of the municipalities' adaptation policy, it is not seen as a solid stand-alone subject. Mostly because of the fact that because the main emphasis lies on the implementation of adaptation related projects, and monitoring is seen as a side-task which only is performed when a municipality has the time, capacity and funding to do so. The role which monitoring plays in the municipalities' adaptation policy differs per municipality. Mostly between monitoring the effectiveness of the adaptation measures and the degree of implementation of those measures. While some municipalities value to know how their adaptation measures function, meaning assessing the effectiveness, others are more inclined to know how many adaptation measures they have implemented, and their progress towards a certain goal. This is also reflected in the use of indicators. The indicators which these municipalities use are mostly based on an indication of the degree of implementation, and less on the effectiveness of measures. One reason for this is that for municipalities, indicators on the degree of implementation are easier to use than the effectiveness, mostly because for many municipalities knowing when something is defined as effective is difficult. Another reason is the role of monitoring as a communication tool to political figures. A large reason for this is the fact that civil servants need to substantiate the effective use of tax money to their political superiors, during which the implementation of projects is seen in higher regard than an assessment of the effectiveness. One function in assessing the effectiveness of climate change adaptation measures is the creation of awareness with regard to climate change adaptation. Both for internal uses within the organization as well as external through citizens and other actors. Meaning that using monitoring to provide an evidence based argument for the use of a certain adaptation measure after assessing that it indeed has effect, can increase the overall awareness and incentivize actors to take action. Also, when a municipality is not capable of monitoring on a large scale due to the lack of capacity or funding, it was stated that the use of monitoring is a good way to complement and further verify types of models which are used to assess risks and base adaptation measures on. Lastly, citizen participation is seen as a vital element in achieving climate adaptation related goals, mostly because a large share of space is privately owned, meaning that creating awareness to incentivize citizens to take action is seen as an important aspect for municipalities.

#### ***Sub question 4 – How are principles of learning applied during the monitoring process?***

Municipalities strongly engage in social learning practices with citizens, the private sector, the public sector and other municipalities. Where the main aim of learning is the exchange of experiences and knowledge from municipalities which have more experience with monitoring and adaptation practices to other municipalities, private sector and citizens who have less experience. Single-loop learning is based on an improvement of practices based on the insight and knowledge produced from monitoring practices as well as knowledge which is provided through different platforms and programs. These learning outcomes are either used to take action on a project level when the need is high, or are used within the next cycle of policy adoption. Double-loop learning concerns a critical reflection on the process itself, in which the determination of the policy goals in relation to climate change adaptation and monitoring are assessed. Which is mainly reflected in the use of models. Where respondents would mention that even though models are widely used by many municipalities, they still do not reflect reality in the best sense. The main conclusion which is given is that municipalities are struggling with a clear determination of the policy goals, which as such has an influence on whether monitoring procedures are performed and whether learning outcomes are produced as a result of this.

***Sub question 5 – How can principles of learning improve the adaptation and monitoring processes for Dutch municipalities?***

Through monitoring, knowledge on an aspect of the system of interest is produced, which can help substantiate certain decisions, and as such can yield learning outcomes for further development. During this process, learning is not seen as a goal, but more as a means to an end. Learning takes place after making adjustments based on monitoring procedures, and not during the monitoring process itself. As the data which is collected through monitoring itself does not provide any insights into the functioning of the system, it is only after analysing the data, turning it into usable information, and adapting accordingly, can learning outcomes be produced. As such, by learning to reflect upon your process, it can help municipalities to identify the bottlenecks within their organisation. And as to whether changes need to be made within their organisation to become able to monitor more effectively, as well as improve upon their overall adaptation policy. In order to do so, collaboration between other actors along with an open attitude is important. As such, principles of learning can improve the adaptation and monitoring process when monitoring is based on clearly defined goals, with procedures aimed to gather and process information which can serve as a base for learning.

***Answer to the main research question – “To what extent can climate change adaptation monitoring result in improved adaptation policy in Dutch municipalities, and how can principles of learning be implemented to improve this process?”***

The degree to which climate change adaptation monitoring can result in an improvement of a municipalities’ adaptation policy is dependent on multiple factors, which includes the following:

- A municipalities’ capacity to perform monitoring tasks, which includes sufficient amount of funding, time, personal and other resources.
- The most important factor is a clear formulation of adaptation goals. As monitoring is strongly tied to monitoring the system of interest in relation to the goal to become climate resilient in 2050. If municipalities were to formulate these goals with clear and easily to understand indicators on when such a goal is achieved, monitoring can help to assess the degree to which a municipality becomes climate resilient. As monitoring procedures aim to measure these indicators. After the collection of relevant data, its analysis, and use. Learning outcomes can determine to what extent the input which is provided results in improved adaptation policy.

In order to produce learning outcomes there are some factors which need to be included, among which include the following:

- The capacity of an organization to engage in monitoring practices, which again, include funding, time, personal and other resources.
- The capacity of an organization to learn in an integral way. Which entails that proper communication is needed with regard to the subject of climate change adaptation (monitoring) across all departments within the municipal organization. Which in turn can increase the overall awareness on the subjects. Which can result in generation of learning outcomes, which would ultimately benefit the climate change adaptation policy.

- The willingness to do so. Which means that a certain degree of leadership and general interest on the subject of climate change adaptation monitoring is needed with the people that are working within the climate change adaptation policy.
- The capacity to cooperate with other actors and share learning outcomes. Which requires a good relationship between organisations and other actors, where trust and the capacity to share knowledge are important factors.
- The ability to have a critical reflection on the overall climate change adaptation policy.

If a municipal organization possesses these qualities, can climate change adaptation monitoring result in learning outcomes which can improve the overall climate change adaptation policy, which in turn can improve the way in which a municipality becomes climate resilient.

## 7. Discussion

This section contains a critical discussion on the following aspects of the study: the results; the use of methodology; the use and contribution to the theory; and the limitations of the study. As such, choices will be substantiated along with a critical reflection for each part.

### **Discussion on the results**

In order to answer the research questions, thirteen interviews were performed with civil servants from Dutch municipalities who were involved in climate change adaptation and have an affinity with the monitoring subject. Consecutively, a focus group was organised with six respondents of similar backgrounds. These two methods yielded different but also comparable results which were discussed in both results sections of the interviews and focus group.

Starting with the interviews, the choice was made to analyse the findings of the interviews based on the concepts which were set-up in the conceptual model. As such, the results were analysed using the theory as a means to find certain conclusions for each of the concepts. This choice was made to provide a coherent and easy to follow results section in which certain themes and sub-themes could be identified per concept. In doing so, multiple quotes were used to further substantiate and highlight practical examples. However, due to the fact that each of the concepts is addressed individually, it was less easy to find patterns throughout the data. Also an important point to make is the fact that the research questions were formulated with the intention of analysing municipalities who engage in monitoring practice. However, as became clear through the interviews, the amount of municipalities who engage in such practices is relatively limited, even though the choice was made to choose municipalities who are considered to be one of the frontrunners in climate change adaptation within the Netherlands. As such, it was difficult to get the results which were desired. Especially with regard to the topic of learning, which was difficult to identify throughout the data.

The focus group provided a deeper insight into the different concepts and the stance of the respondents towards them. All participants agreed that determining sound climate change adaptation goals is most important to determine how monitoring procedures should be carried out. With regard to the responsible organisations, there were some differences which include the desire for a third-party to perform monitoring tasks, and the desire for the municipality to do it themselves. Overall the difference with the interview result was the fact that within the focus group it was mentioned that outsourcing monitoring tasks is seen as a viable option, while this was not discussed within the interviews. Another aspect which was discussed in the focus group that was not discussed in the interviews is the need for process-related interviews. Where it was concluded that alongside monitoring of the physical system, a monitor on the process is just as important. Overall, the participants of the focus group seemed to agree with each other on their conclusions. However, due to technical implications and time constraints, the amount of data which was gathered from the focus group proved to be limited. As such, more time or a second focus group could have provided more data.

### **Methodological discussion**

In order to collect data, the researcher used a literature review, semi-structured interviews and a focus group.

Starting with the literature review. This method was used to get an initial impression of the subject, as well as gain an understanding of it. Due to the fact that climate change adaptation monitoring is considered a relatively new subject, it was difficult to find a lot of information on the subject. However, through an extensive search using different key words, as well as a snowball-method to find more relevant literature, an extensive list of literature was made to serve as a base for this research. The overall library of literature was saved within the programme Zotero. Within this list, a clear distinction between climate change adaptation monitoring; adaptive management; and literature on learning was made. In the end, the choice was made to use the framework of Klostermann et al., (2015) as the basis for the analysis. This framework was chosen because the authors of this paper have a great affinity with the topic, being able to identify them in other papers related to the same topic. Along with the fact that within the literature, this was one of the only clearly formulated and easy to understand frameworks about climate change adaptation monitoring. The use of literature related to learning is based upon literature which is tied to the monitoring phase within the adaptation policy cycle. Overall, the researcher aimed to support the different concepts with different types of literature consisting of different authors to make the theoretical framework as grounded as possible.

The choice for semi-structured interviews was made to ask questions which were formulated based on the literature, but also to give room for an inductive way of data collection. Because of the fact that the topic is relatively new, both within the literature as well as in practice, collecting extra information was desirable. The choice of municipalities and respondents was based on a report by Stichting Cas (2021) which contained a list of municipalities which were considered to be frontrunners on the subject of climate change adaptation. As such, the bulk of the respondents were chosen from this list. Overall the type of respondent consisted of a fairly homogenous group, not so much in the sense that everyone had the exact same function, but in the fact that the respondents seemed to possess similar types of knowledge on the topic of climate change adaptation and monitoring. Mainly because all the respondents were in some way tied to the municipal climate change adaptation policy.

The focus group was performed to further validate the results which came out of the interviews as well as provide an opportunity for the collection of new data. However, due to Covid-19 and the lack of time for each respondent, the choice was made to perform a meeting within Microsoft Teams, which resulted in several technical problems. Also, the statement with regard to participatory monitoring was not treated due to a lack of time. Overall, if more time was possible, a more in-depth discussion on each concept without the fear of running out of time could have resulted in more data.

### **Theoretical discussion**

The theory which was used was that of the climate change adaptation monitoring framework from Klostermann et al., (2015) along with theory on learning aspects such as single- and double loop learning, and social learning. These three types of learning aspects were chosen based on the fact that the literature on adaptive management, of which monitoring is an important aspect, widely contained aspects of each of these three learning types. As such, the type of theoretical development was based on the use of these learning aspects within the process of climate change adaptation monitoring. The conclusion showed that while initially



difficult to identify through the analysis, some aspects with regard to this connection could be answered. Which includes:

Monitoring and learning are closely linked together. The process in which learning outcomes can be derived from monitoring is the following: after collecting data through monitoring procedures, the data needs to be analysed in accordance to the overall climate change adaptation goals which are set by that respective organization. After doing so, choices need to be made based upon this analysis. Learning outcomes are derived after decisions are made based on this analysis. The fact that learning takes place in the end and not during the process itself is due to the fact that the steps of data collection and analysis is important in order to give meaning to it. Only after giving meaning to it in relation to the goals, can learning outcomes be derived.

To critically reflect on the contribution for further development of theory related to this concept. Overall, assessing concepts of learning within monitoring practices were difficult, mainly because there was a lack of clearly defined monitoring protocols, along with the fact that municipalities have a very pragmatic approach to the production of knowledge, which is mostly about problem solving, and less focussed on an overall reflection on the process itself. Mostly because municipalities are more concerned with the implementation of projects rather than the learning process itself.

### **Limitations of the study**

As was previously stated in the results section of the discussion. One of the main limitations was the fact that none of the municipalities which were interviewed possessed a clearly thought out monitoring protocol for climate change adaptation. Which made analysing the topic difficult at times. Also, another limitation was the fact that even though the data collection process was considered a success, it was still difficult to find respondents. Mostly due to the fact that civil servants have a busy schedule and are not as easily approachable at times. Another limitation was the fact that with regard to the climate risk indicator of flooding, not many insights could be given with regard to monitoring, as flooding is a subject heavily tied with waterboards, which, due to the scope of this project, were not interviewed. This research focussed on the monitoring of the effectiveness and the degree of implementation of the adaptation measures, and less so on process related monitoring. Which meant that producing results in line with the research questions could have been better. Also, while there were clear geographical differences between the municipalities, these were not acknowledged within this study, mostly because monitoring practices were lacking, as such, it made making a conclusion based on geographical differences insignificant. Which is why the choice was made to maintain a broad sense of the topic rather than focus on these differences in municipalities. Lastly, because this study focussed on the local scale, an assessment on the importance of monitoring on regional and national scales was not included. Which means that the interaction between the three with regard to the subject is not included.

## 8. Recommendations

The recommendations section includes arguments for recommendations both in the academic sense as well as a more practical sense.

### **Academic recommendations**

Within the introduction of this research, multiple knowledge gaps were identified with regard to climate change adaptation monitoring which include a lack of a systematic approach and common standard for adaptation monitoring. The aim of this study is to provide a certain baseline for further research on this topic. As such, it is recommended that further research should focus on the definition of success with regard to climate change adaptation. As it was proven that the determination of success with regard to adaptation was considered to be difficult. Which in turn was tied to the degree in which monitoring procedures could be performed. Consecutively, a deeper understanding of climate change adaptation monitoring related procedures, as well as the identification of clear to use indicators can aid in the process of determining when adaptation is deemed to be successful. As such, a smaller case study analysis of cases who possess a monitoring protocol should provide a deeper understanding on the subject and the relation to certain physical and social differences between cases. As of yet however, such a deep analysis was not possible due to the lack of monitoring protocols analysed. Another recommendation to give is the fact that due to the fact that this study only focussed on the local scale, a study on the importance of climate change adaptation monitoring on the regional and national scale can help gain insight into its functioning on different scale levels.

### **Practical recommendations**

The main aim of this study was to create insight into the degree in which climate change adaptation monitoring procedures were performed on a local scale in municipalities that were considered frontrunners with regard to climate change adaptation. One of the most important recommendations which can be given to other municipalities is the fact that it is important to make a clear determination of ones climate change adaptation goals. As monitoring practices can help determine when these goals are reached through the indicators. The four climate risks are very location-oriented, meaning that municipalities should determine sound goals in tackling each of the risks in the way that benefits their area the most. This in turn makes determining monitoring indicators more easy. However, a municipality should determine for themselves whether performing climate change adaptation monitoring procedures is in their best interest, as it was shown that many municipalities may not have the time, funding or capacity to perform these tasks. An argument should therefore be made for which parts of the system monitoring procedures are performed, and for which parts it is not necessary. Which can include for instance the focus on vulnerable areas in relation to the outcomes of the climate stress-test.

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# Appendix 1: interview guide

**Doel van het interview:** inzicht krijgen in hoeverre de gemeenten de klimaat adaptatie monitoren, wat gebeurt er met de feedback, en hoe wordt er van de feedback geleerd om keuzes in het beleid en de adaptatie maatregelen bij te sturen.

## Hoofdvraag:

“Op welke wijze monitoren Nederlandse gemeenten de effectiviteit van klimaat adaptatie maatregelen, en wat is de toegevoegde waarde van het promoten van leerprincipes tijdens dit proces?”

## Opening

- algemene opening
- doel van het onderzoek
- duur van het interview
- verwerking van de data
- anonimiteit
- audio opname interview t.b.v. transcript en analyse
- vragen vooraf

## Algemene introductievragen over adaptatie

1. Waar houdt u zich vooral mee bezig op het gebied van klimaat adaptatie?
2. Welke klimaat thema's: wateroverlast, hitte, droogte en overstroming zijn het meeste van belang in uw gemeente?
3. Welke maatregelen zijn hier volgens u voor nodig en welke zijn er al geïmplementeerd?

## Definitie

4. Wat verstaat u onder het monitoren van klimaat adaptatie?

## Monitoren

5. Monitort de gemeente de klimaat adaptatie?
  - a) zo nee, sectie 2
  - b) zo ja, sectie 3

## Sectie 2: De gemeente monitort niet



6. Waarom monitort de gemeente niet?
7. Wat zijn volgens u algemene knelpunten?
8. Hoe zou het volgens u het beste gemonitord kunnen worden? Wat vindt u belangrijk?
9. Wat voor soort indicatoren zijn voor u belangrijk?

[ga naar sectie 4]

## Sectie 3: De gemeente monitort wel



### **Procedures (procedures)**

- 10. Hoe monitort de gemeente het effect van de adaptatie maatregelen? (methodes)
- 11. Hoe lang is de gemeente hier al mee bezig?

### **Organisaties (Responsible organisations/participatory monitoring)**

- 12. Wie monitort er?
- 13. Wordt er met partijen samengewerkt?
- 14. Hoe belangrijk is het monitoren van de klimaat adaptatie voor de gemeente?

### **Indicatoren (indicators)**

- 15. Wat voor soort indicatoren worden er gebruikt om de adaptatie te monitoren?
  - a) input (tijd, geld, middelen, etc.)
  - b) process (besluitvormingsproces)
  - c) output (wat het beleid oplevert/wat er wordt geproduceerd: klimaatadaptatie maatregelen)
  - d) outcome (of hiermee het beleid wordt behaald t.b.v klimaat resistentie)

### **Feedback loop (procedures)**

- 16. Wat voor soort informatie komt er voort uit het monitoren?
- 17. Hoe wordt deze informatie geanalyseerd?
  - a) wie analyseert de data?
- 18. Wat wordt er met deze informatie gedaan?

### **Leerproces (Single-loop learning)**

- 19. Hoe ziet het leerproces over monitoren er uit binnenin de gemeente?
- 20. Hoe wordt deze informatie gebruikt om het monitoren en de adaptatie te verbeteren?

### **Gezamenlijk leren (Social learning)**

- 21. In hoeverre werkt de gemeente samen met andere actoren om meer kennis op te doen over het monitoren?
  - a) en zo ja: met wie?
  - b) en zo ja: hoe ziet de samenwerking er uit?
  - c) en zo ja: in hoeverre zijn deze mensen bereid inspanning te leveren om de situatie te verbeteren?
  - d) en zo nee: waarom werkt de gemeente niet samen met andere actoren?

### **Reflecteren over het proces (Double loop learning)**

- 22. Want vindt u van de wijze waarop er gemonitord wordt?

## Sectie 4: Afsluiting



### Afsluitende vragen

23. Tot slot, hoe ziet volgens u uw gemeente er uit als deze 100% klimaat robuust is?
24. Dan zijn we aangekomen aan het einde van dit interview, heeft u verder nog aanvullingen/opmerkingen die u wilt geven met betrekking tot het monitoren?

### Afsluiting

- controle transcript
- eindproduct
- dankwoord

## Appendix 2: coding scheme

Concept	Variable (property of the concept)	Indicators (measurable)	Q nr.
System of concern	The share of understanding of the concept	The definition of the concept	4
	The system of concert in space and time	Agreements on what is to be monitored	5
Procedures	Measuring methods	The methods which are used to monitor	10
	Timespan	The timespan to which there is monitored	11
Responsible organisations	Responsible organisations	The actors who engage in monitoring practices	12
	Cooperation between organisations	The degree to which there is cooperation of organisations in the monitoring process (participatory monitoring)	13
	Importance	The degree to which monitoring is seen as important or embedded within policy	14
Indicators	Use of context specific indicators	Input, process, output, outcome	15
Procedures: Feedback loop	Feedback	The information which is received from monitoring either qualitative or quantitative	16
	Analysing methods	The methods which are used to analyse the data	17
	Use of data	The degree to which the data which is analysed results in an improvement of the monitoring system	18
Single-loop learning	Learning process	The overall learning process which a municipality uses to learn about monitoring	19
	Improved techniques of efficiency	The extent to which adaptation and monitoring interventions/practices are improved	20
Social learning	Collaboration	The degree to which actors are involved and collaborated with during the learning process	21
	Outcome of mutual trust	The extent to which social learning improves the willingness of actors to share knowledge and information and the willingness to take risk	21
	Outcome of shared frame	The extent to which social learning improves a shared problem statement and mutual understanding between actors	21

	Outcome of commitment	The extent to which social learning improves: financial contribution, provision of labour, provision of time, public statements of adhesion to the projects' goals and ambitions of actors	21
	Open attitude	Transparency between actors	21
Double-loop learning	Frame reflection	The degree to which a critical debate on the process itself is present	22

Table 19: Coding scheme

## Appendix 3: monitoring methods

Amt	Water nuisance-related monitoring methods and feedback
14	<b>Rainfall model</b> Inundation in a certain area
11	<b>Perception research</b> How citizens experience the quality of everyday life
10	<b>Observations</b> Observation on inundation and/or the state of vegetation
7	<b>Citizen complaints</b> Complaints on either water nuisance, heat and drought related issues
6	<b>Stress-test</b> Identification of potential vulnerabilities related to water nuisance, heat, drought and flooding related climate risks
5	<b>Infiltration capacity</b> The degree to which water is able to inundate into the soil
3	<b>Flooding map</b> Inundation in a certain area
2	<b>Calculations</b> To predict an outcome
2	<b>Water level measurements</b> The water level in a certain area
2	<b>Overflow measurements</b> The degree to which there is overflow
2	<b>Rainwater data</b> Data on precipitation levels
1	<b>Sewage flow measurements</b> The flow-capacity of a part of the sewage system
1	<b>Sewage inspection</b> A qualitative inspection on the quality of a part of the sewage system
Amt	Heat and air related monitoring methods and feedback
11	<b>Perception research</b> How citizens experience the quality of everyday life
10	<b>Heat map</b> Temperature levels per location
7	<b>Air temperature measurements</b> The air temperature in a certain area
7	<b>Citizen complaints</b> Complaints on either water nuisance, heat and drought related issues
6	<b>Stress-test</b> Identification of potential vulnerabilities related to water nuisance, heat, drought and flooding related climate risks
5	<b>Infrared camera/pictures</b> The impact of vegetation/removal of pavement on the surrounding area

4	<b>Heat perception research</b> How citizens experience heat
3	<b>Heat models</b> Calculations on the temperature levels per location
3	<b>Satellite data</b> Temperature levels per location
Amt	Drought and soil-related monitoring methods and feedback
11	<b>Groundwater measurements</b> Groundwater levels in a certain area
11	<b>Perception research</b> How citizens experience the quality of everyday life
10	<b>Observations</b> Observation on inundation and/or the state of vegetation
7	<b>Citizen complaints</b> Complaints on either water nuisance, heat and drought related issues
6	<b>Stress-test</b> Identification of potential vulnerabilities related to water nuisance, heat, drought and flooding related climate risks
2	<b>Crop/vegetation observation</b> Observation of the vitality of crops and vegetation
1	<b>Soil moisture sensor</b> Measurements of the amount of moisture within the soil
1	<b>Tree moisture sensor</b> Measurements of the amount of moisture within a tree
Amt	Other non-climate related monitoring methods and feedback
6	<b>Air quality measurements</b> The air quality in an area
2	<b>Biodiversity</b> Amount of biodiversity in an area
1	<b>Citizen panels</b> Panels in which citizens discuss on certain topics

Table 20: Monitoring methods



# Appendix 4: focus group results

## System of interest



Figure 13: Focus group: system of interest answers

## Responsible organizations



Figure 14: Focus group: responsible organisations answers

## Procedures

**Elke gemeente zou over een klimaatadaptatie-monitorprotocol moeten dat dient als feedback mechanisme voor beleid en uitvoering/beheer**

Ja, maar niet te uitgebreid (anders sterft het in schoonheid ...)

Ja, beleidsevaluatie is belangrijk.maar toch doen we het te weinig

Ja

et klinkt logisch, en toch, om daar iets groots aan op te tuigen, heiligt dat het doel dan...

Ja maar het zou mooi zijn als we enigszins vergelijkbare indicatoren hebben

Figure 15: Focus group: procedures answers

## Indicators

**De indicatoren die worden gehanteerd voor het monitoren van klimaatadaptatie zijn gericht op fysieke maatregelen en niet op het implementatieproces**

Je kunt ook

Je kunt ook participatiegraad burgerz monitoren

...of gedrag van mensen bij hittegolven

Te vaak nog alleen op fysiek

Output monitoring is vaak gericht op proces

Focus zit vaak op fysiek

Er is wel ruimte voor procesmonitoring, maar in de praktijk verdwijnt het leereffect van procesmonitoring in de waan van de dag.

Figure 16: Focus group: indicators answers

## Learning aspects

**Monitoren moet als doel hebben om te leren en op basis daarvan bij te sturen: waarom leren we nu eigenlijk?**

Beter andersom, leren is belagrijk neveneffect

voor de toekomst voor realisatie van nieuwe verbetermaatregelen

En wie leert er eigenlijk? Interne mobiliteit verstoort het leren. Leren mensen of organisaties?

Data levert informatie op voor kennis, met kennis kun je nieuwe maatregelen treffen

Figure 17: Focus group: learning answers

## Ending statement

**Wat is het belang van het monitoren van klimaat adaptatie nu en in de toekomst? Welke ontwikkeling ziet u voor de komende 10 jaar?**

Participatie wordt super belangrijk

Grootste uitdaging is het opzetten van een relatief eenvoudige monitor (zowel inhoud als proces) en dit vooral lang volhouden én er gevolgen aan verbinden (bijsturen).

modelmatig monitoren als "basislaag", gevalideerd en getweaked aan de hand van een laag van ervaringen van bewoners, assetbeheerders, ontwerpers, etc.

Informatie gestuurde besluitvorming met smart systems (als belangrijke aanvulling, valkuil is data leidend maken)

verdere automatisering, continumetingen, waterkwaliteit, uitwisseling info-lagen om inzicht te krijgen

Er zal meer samengewerkt worden omdat alleen dan je een breed integraal beeld krijgt van klimaatbestendigheid van de stad

Het zou mooi zijn als er enigszins landelijk vergelijkbare indicatoren komen

Figure 18: Focus group: ending statement answers