



OVERSEEN DROUGHT PROBLEMS IN BERGEN OP ZOOM

The experienced effects and impacts of
droughts on the municipality

Research Bachelor (BSc) thesis



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Colophon

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“We’re the first generation to feel the impact of climate change.
We’re the last generation that can do something about it. We only
get one home. We only get one planet. There’s no plan B.”

- Barack Obama, 2015 -

Preface

For you, the thesis 'Drought problems in Bergen op Zoom'. For this thesis a research is executed at Sweco Nederland B.V. with Gemeente Bergen op Zoom as client. The final thesis is part of my Bachelor (BSc) degree Delta Management at the HZ University of Applied Sciences. This thesis is executed between January 2019 and June 2019.

The research is made commissioned by the municipality of Bergen op Zoom. They assume that they are overlooking problems and possibilities on climate adaptation. So the request arose to execute a research on the topic drought problematic of the summer of 2018. This subject satisfied my interest for climate change and climate adaptation. Moreover, it connected perfectly with my Bachelor degree.

Together with my supervisors, we come up with the research questions for this thesis. After the execution of this research I came to the answer on the research questions. During the research, my graduation lecturer, Lukas Papenborg was always able to help me. Also my in-company supervisors, Ineke Vink, Laurens van der Schraaf and Gijs Spruijt were always able to help me. They answered my questions so I could continue with my research.

In this way I would like to thank them for their support and guidance during the thesis process. In addition, I would like to thank the experts from Sweco, the municipality of Bergen op Zoom and the stakeholders involved during this research. They provide the right information and expertise. Without them, this research could not have become a success.

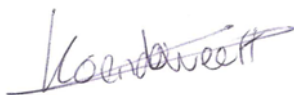
Furthermore, I would like to thank my colleagues of Sweco and Gemeente Bergen op Zoom for the fine cooperation. I often discussed with them about my research in an effective and pleasant way. Moreover, I would like to thank my parents, family and friends for their moral support during the thesis process. With their wisdom and motivating words is this thesis successfully completed.

I hope you will gain more insight in the drought problems in Bergen op Zoom and enjoy the reading of this research.

Koen de Weert

Bergen op Zoom, the Netherlands

3 June 2019



Abstract

The municipality of Bergen op Zoom is assuming to overlook climate change problems and possibilities. They are missing knowledge on how to deal with a dry period. This is the reason of the requested for a research on the drought problematic. They want to know how different departments and inhabitants experienced the dry period. Moreover, they want to know where the effects are experienced and what causes the effects in order to undertake measures to minimize the effects.

The objective of the research is to define a view of the overseen problems and possibilities related to drought. It does so by offering insight in the problems by providing an overview of which stakeholders experienced what effects and how they handle with each effect. Moreover, the causes of the effects will be researched to get to know where the problem is coming from to handle in an effective way. This objective leads to the research question: *What are the drought effects on the urban area of the municipality of Bergen op Zoom, in order to undertake measures to deal with the effects in the nearby future?*

To give an answer on the research question different methods were needed; literature research, stakeholder analysis, interviews, focus group (interview with more people at the same time), surveys and mapping. Literature research was needed to provide knowledge about the topic, research for the causes of the effects and to know which measures available are to handle the effects. For carrying out the interviews and the focus group, people were selected in the stakeholder analysis. The stakeholders need to be involved with climate effects, need to have a stake in the research problem, are target audience related to the assignment, have the means to change something related to the problem and have a stake in the urban area. With these stakeholders semi-structured open-questions interviews and a focus group were done. Five districts (Lepelstraat, De Schans, Noordgeest, Centrum & Bergse Plaat) were chosen for the 150 open and closed questions in the surveys. The districts were chosen on areas where civil servants experienced effects (result of the interviews), where they did not experience effects, villages, houses built after 1985 and houses built before 1985. The results of the interviews, focus group and surveys were mapped to give an overview of the locations. In the answers of the methods turns out that blue algae, low water level in ponds, damage to public green and the shoot up effect of tiles are the most effects experienced by stakeholders. While the most mentioned attention points are; better communication, implementing more green and citizen participation. The most experienced effects by inhabitants were low water level in ponds and damage to public green. Most of the causes of the effects happened because of the moving dry sand in the underground layer. This lead to measures which focussed on buffering water in an earlier stage and let it infiltrate in the underground to bring back the sponge capacity. Furthermore, bottom-up and diagonal communication can be used in the municipality as they also can focus more on citizen participation.

On the answers of the methods, is suggested to carry out a follow-up research for the rural area, surveys for the other districts, providing a better underground soil map and to know more about the relation of costs, effects and damage of droughts via the 'CELCIUS' tool of Sweco. Moreover, it is recommended to communicate better and to choose a responsible person to coordinate during a dry period. This person should coordinate between the different departments and make the inhabitants aware. In addition, the departments should cooperate by designing new developments and create more awareness of climate adaptation among the stakeholders of the municipality.

Table of contents

1. Introduction.....	9
1.1 Reason for this research.....	9
1.2 Problem definition.....	9
1.3 Background information.....	10
1.4 Research objective and questions.....	12
1.5 Reading guide	13
2. Theoretical framework.....	14
2.1 Scientific concepts.....	14
2.2 KNMI'14 Climate scenarios	15
2.3 Water shortage.....	16
2.4 Droughts	17
2.5 Layer approach	17
2.6 Climate stress test	18
2.7 Conceptual model	18
2.7.1 Scheme	18
2.7.2 Explanation.....	19
3. Methodology	20
3.1 Research type	20
3.2 Research strategy	20
3.2.1 Preliminary research	20
3.2.2 Main research.....	20
3.3 Summary.....	23
3.4 Materials.....	23
4. Results	24
4.1 Stakeholders experienced drought effects	24
4.1.1 Experiences of drought before 2018.....	24
4.1.2 Experienced drought effects in 2018	24
4.1.3 Efforts delivered to minimize the effects in 2018	27
4.1.4 Interest of stakeholders in drought problematic	27
4.1.5 Attention points for the future.....	28
4.2 Inhabitants experienced effects.....	30
4.2.1 Experiences of inhabitants	30

4.2.2 Expectations of the municipality	31
4.3 Locations of the effects	32
4.4 Causes of the effects	35
4.4.1 Experienced effects divided by layer	35
4.4.2 Layer approach and the locations	36
4.5 Measures available	38
4.5.1 Measures when designing developments	38
4.5.2 Other measures	40
5. Conclusion	41
6. Discussion	43
6.1 Validity	43
6.2 Results and expectations	43
6.3 The results	44
6.4 Limitations and suggestions	44
7. Recommendations	45
7.1 Communication	45
7.1.1 When is action needed?	45
7.1.2 What to do when it is a dry period?	45
7.1.3 What to do after the dry period?	46
7.2 New developments	46
7.3 Overview of the communication method	48
Bibliography	49
Appendices	53
Appendix 1: Risk of drought stress	53
Appendix 2: Maximum potential of rain shortage (1:10 years)	54
Appendix 3: Maximum potential of rain shortage (average)	55
Appendix 4: Rain in the summer	56
Appendix 5: Yearly reference evaporation	57
Appendix 6: Effects of droughts	58
Appendix 7: Stakeholder analysis	60
Appendix 8: Overview interviews questions	61
Appendix 9: Survey	64
Appendix 10: Interviews civil servants	66
Appendix 11: Interviews extern stakeholders	67

Appendix 12: Summary interviews.....	68
Appendix 13: Results survey.....	72
Appendix 14: Locations experienced effects civil servants	91
Appendix 15: Locations experienced effects fieldworkers	92
Appendix 16: Impressions possible measures.....	93

List of figures

Figure 1. The municipality of Bergen op Zoom. Source: (Heijmans, n.d.).....	11
Figure 2. Location of Bergen op Zoom. Source: Google Maps	11
Figure 3. The main roads in Bergen op zoom. Source: (Heijnen & Krouwel, 2014).....	15
Figure 4. KNMI climate scenario's. Source: (KNMI, 2015).....	16
Figure 5. Layer approach. Source: (Hidding, et al., 2002)	17
Figure 6. 'Participation ladder'. Source: (Steenvoordenoord)	40
Figure 7. Risk of drought stress in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019).	53
Figure 8. Risk of drought stress in 2050WH (Worst case scenario in 2050). Source: (Ruimtelijke adaptatie, 2019)	53
Figure 9. Maximum potential of rain shortage (1:10 years) in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019).....	54
Figure 10. Maximum potential of rain shortage (1:10 years) in 2050WH (Worst case scenario in 2050). Source: (Ruimtelijke adaptatie, 2019).....	54
Figure 11. Maximum potential of rain shortage (average) in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019).....	55
Figure 12. Maximum potential of rain shortage (average) in 2050WH (worst case scenario). Source: (Ruimtelijke adaptatie, 2019).....	55
Figure 13. The amount of rain in the summer in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019).	56
Figure 14. The amount of rain in the summer in 2050WH (worst case scenario). Source: (Ruimtelijke adaptatie, 2019)	56
Figure 15. The amount of yearly evaporation in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019)	57
Figure 16. The amount of yearly evaporation in 2050WH (worst case scenario). Source: (Ruimtelijke adaptatie, 2019)	57
Figure 17. Effects of droughts. Source: (Brolsma, et al., 2012).....	58
Figure 18. Effects of droughts. Source: (Nationale Klimaatadaptatiestrategie, 2016)	59
Figure 19. Removing tiles for green by citizen participation. Source: (Gemeente Rijswijk, n.d.)	93
Figure 20. Rain water storage via rain barrels. Source: (City of Berkeley, n.d.).....	93
Figure 21. Using green where possible in the industry sector. Source: (Borges, 2013).....	93
Figure 22. Climate proof guidelines for building a new house. Source: (Rovers, Bosch , Albers, & van Hove, 2015)	94
Figure 23. Climate proof guidelines by developing a city. Source: (Rovers, Bosch , Albers, & van Hove, 2015).....	94

Figure 24. Example of disconnecting rainwater from infiltration directly in the sewage system.	
Source: (Jonkers, n.d.)	95
Figure 25. Examples porous paving materials. Source: (Urban Green-Blue Grids, n.d.).....	95
Figure 26. Example of the function of a wadi. Source: (Gemeente Bladel, n.d.)	95
Figure 27. Infiltration crates. Source: (BPO, n.d.).....	96
Figure 28. Example of bioswales. Source: (Lotann, n.d.)	96
Figure 29. Example of parking lots with green. Source: (Build a better burb, n.d.).....	96
Figure 30. Rainwater ponds/ tanks for providing storage. Source: (Oburden, 2010).....	97
Figure 31. Example of infiltration sewage system. Source: (PVC, n.d.).....	97
Figure 32. Example of rainwater storage below a sport field. Source: (Pearl-kb, 2016)	98
Figure 33. Example of trying to buffer water. Source: (Waterschap De Dommel, 2019)	98

List of tables

Table 1. Research questions in relation to the research methods.....	23
Table 2. Overview of experienced effects per stakeholder.	25
Table 3. The effects and which efforts were delivered to minimize the effects.....	27
Table 4. Overview of attention points per stakeholder.	28
Table 5. Division of the most experienced public effects per district.	30
Table 6. Division of the most experienced private effects per district.	31
Table 7. Overview of what the inhabitants expect from the municipality and if they know the municipality did something.	31
Table 8. Experienced effects divided by layer where the effect is caused.	36
Table 9. Possible measures when designing developments.	39
Table 10. Summary of the interviews.....	71

List of graphs

Graph 1. Cumulative precipitation shortage in West Brabant. Source: (Waterschap Brabantse Delta, 2018).....	10
Graph 2. The progress of (fictional) precipitation shortage in West-Brabant between 1996 and 2018. Source: (Waterschap Brabantse Delta, 2018)	10
Graph 3. KNMI climate scenarios winter. Source: (KNMI, 2015)	16
Graph 4. KNMI climate scenarios summer. Source: (KNMI, 2015)	16
Graph 5. Overview of stakeholders that did experience drought effects and stakeholders that did not.	25
Graph 6. The amount of experienced effects by stakeholders.	25
Graph 7. Interest rate civil servants.	27
Graph 8. Interest rate extern stakeholders.....	28
Graph 9. The public effects experienced by the inhabitants.	30
Graph 10. The private effects experienced by inhabitants.	31

1. Introduction

This chapter describes the underlying thoughts of the assignment. It gives the **reason, the problem definition, background of the research** and **research** objective with the **research questions**. Afterwards the **structure of the report** is described.

1.1 Reason for this research

The municipality of Bergen op Zoom is assuming that they are overlooking problems and possibilities on climate adaptation. One of the reasons this is making clear is their 'Toekomstvisie 2025' in this vision is described that: "Climate change is a point of attention on long-term, because the impacts of it are unclear and difficult to estimate" (Gemeente Bergen op Zoom, 2008). They are especially thinking to oversee problems and possibilities in their urban area on the subject of droughts. As the effects of droughts are mostly not seen directly. It will take some time to see the effects of droughts. This created a reason to execute a research which will map the drought effects which will create more knowledge on the subject. This can lead to new challenges and possibilities.

With the scenarios of the Intergovernmental Panel on Climate Change (IPCC) (2014) in mind, it is smart for the municipality to adapt and get knowledge where necessary on climate adaptation. The IPCC is seeing an increasing risk of climate change. They describe that dry periods will happen more frequently. If the municipality is seeing more climate change patterns which lead to an increased risk of extreme weather events for society, climate adaptation can save future unexpected effects and costs. A strategy can be made to look how to deal with the problems in the future. "If the society wants to deal with climate change effects, the effects need to be known and adaptation and mitigation is required" (IPCC, 2014).

In addition, the KNMI (Dutch meteorological institute) (2015) quotes that more extreme drought periods can happen. The KNMI describes in two of the four climate scenario's that hot and dry summers will happen more frequently. Warmer temperatures (heat) will lead to more evaporation which cause a dry underground. Action must be taken to make the city, even in dry periods, robust and a pleasant place to spend time.

As a result of the IPCC (2014) and KNMI (2015) scenarios, the Netherlands has created the 'Delta Plan Ruimtelijke Adaptatie'. The goal of the Delta Plan is to accelerate and invest in adaptation measures, so the Netherlands can be water robust and climate proof in 2050 (Deltaprogramma, 2018). As a consequence is decided that every municipality needs to do a climate stress test to see the vulnerable areas within the municipality (Arcadis, 2017). The municipality of Bergen op Zoom has already executed a climate stress test.

1.2 Problem definition

As stated by the municipality of Bergen op Zoom, the results of the climate stress tests are not enough. They assume that they overlooking climate change problems and possibilities. Bergen op Zoom already faced flooding's during periods of extreme rainfall. It is therefore that they know the weak spots concerning flooding's in the municipality. What the municipality is missing, is knowledge on how to deal with a water shortage/ dry period. Because of this, the municipality has requested a research on this topic. The municipality wants to know how different departments in the municipality and inhabitants experienced the dry period. In addition, it wants to know the locations of the experienced

effects and what the causes of the effects are (causal analysis). If this is clear, measures can be taken and future damages and problems can be prevented.

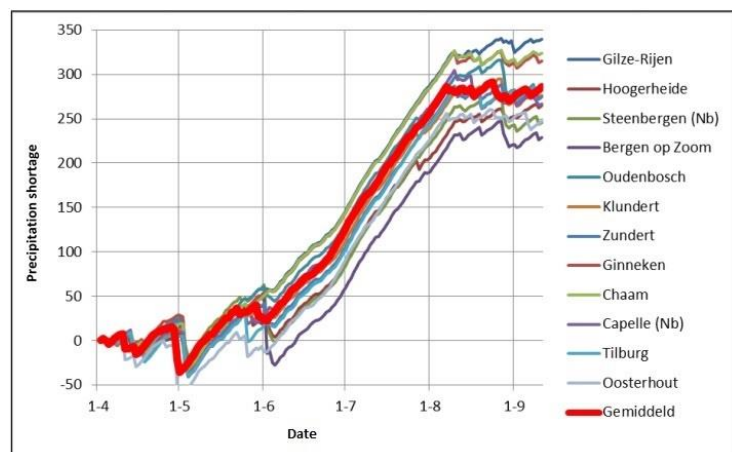
To conclude, the overall **problem definition**: *It is not clear who is affected during dry periods, how the inhabitants experienced the drought problematic, where the drought effects are, what the causes of the effects are, and how these effects can be minimized.*

1.3 Background information

During sunny weather, high temperatures and wind evaporation takes place. This results in water shortage and heat stress which will cause a dry underground (KNMI, 2015). Over a longer period, more water will evaporate compared to what will be added, this will cause a shortage in water availability (Tate & Gustard, 2000). Drought can have multiple effects, knowing the effects and locations is important to get more insight in the drought problem for the municipality. As well as, it is important to know where the effects are coming from, what the causes are of these effects (causal analysis). Knowing the causes of the effects, will help to understand the effect, find solutions and take measures.

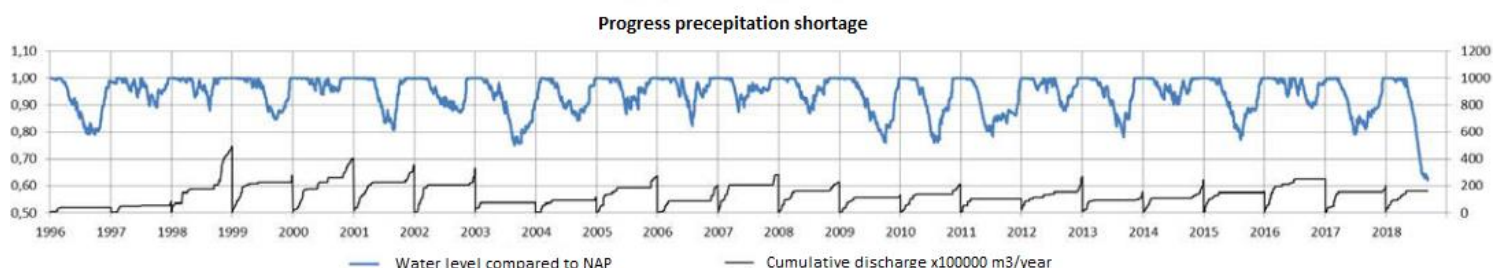
In the past there were also dry years but there is insufficient knowledge and information from that period. As the summer of 2018 was an extraordinary dry year (Waterschap Brabantse Delta, 2018). Will the summer of 2018 be used as a guideline during the research. In addition, the municipality especially requested to look into this year to gather information.

In 2018 was a precipitation shortage in Bergen op Zoom as presented in graph 1. The shortage of water is caused by high temperatures, evaporation and no rain. As reported by the KNMI was the summer of 2018 the driest summer since the last three decades and can this summer pointed out as an extreme dry year (Waterschap Brabantse Delta, 2018).



Graph 1. Cumulative precipitation shortage in West Brabant. Source: (Waterschap Brabantse Delta, 2018)

The amount of precipitation shortage was a record. The progress of the precipitation shortage between 1996 and 2018 in West-Brabant can be found in the graph 2. Graph 2 is showing that the biggest amount of precipitation shortage was in 2018 compared to other years (Waterschap Brabantse Delta, 2018).



Graph 2. The progress of (fictional) precipitation shortage in West-Brabant between 1996 and 2018. Source: (Waterschap Brabantse Delta, 2018)

Location of Bergen op Zoom

Bergen op Zoom is a city in south-west Netherlands. Bergen op Zoom is located in the west side of the province of North-Brabant and has 66.354 inhabitants (Gemeente Bergen op Zoom, 2019). Halsteren and Lepelstraat are also part of the municipality of Bergen op Zoom. Following Google Maps (2019) the municipality is bordering the province of Zeeland. The open waters located within the municipality are the Zoommeer, Markizaatsmeer and Binnenschelde. The Zoommeer is in connection with the Theodorushaven and Bergsche Diep, while this is all connected to the Schelde-Rijnkanaal and Eastern-Scheldt. One of the highways that is coming through Bergen op Zoom is the A4, this highway is crossing the municipality from north to south. Via this highway it is possible to go to the direction of Willemstad or Antwerp in Belgium. Also the A58 is crossing Bergen op Zoom, which is coming from the island Walcheren and Zuid Beveland in Zeeland. Via this highway it is possible to go to the direction of Roosendaal. Moreover, the provincial road that is connected with Zeeland is the N286 which is coming through the municipality in the north from the island of Tholen and is connected with the A4. Bergen op Zoom is also having a railway station which provide a connection to Vlissingen and one connection to Roosendaal, Rotterdam and Amsterdam.

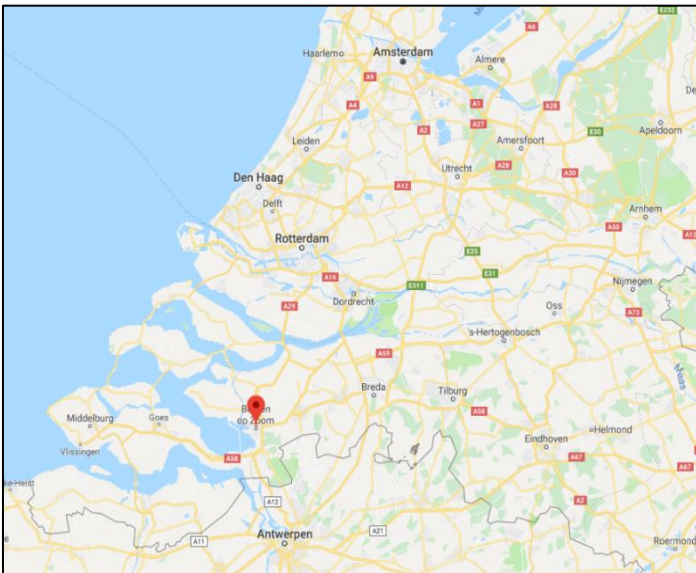


Figure 2. Location of Bergen op Zoom. Source: Google Maps

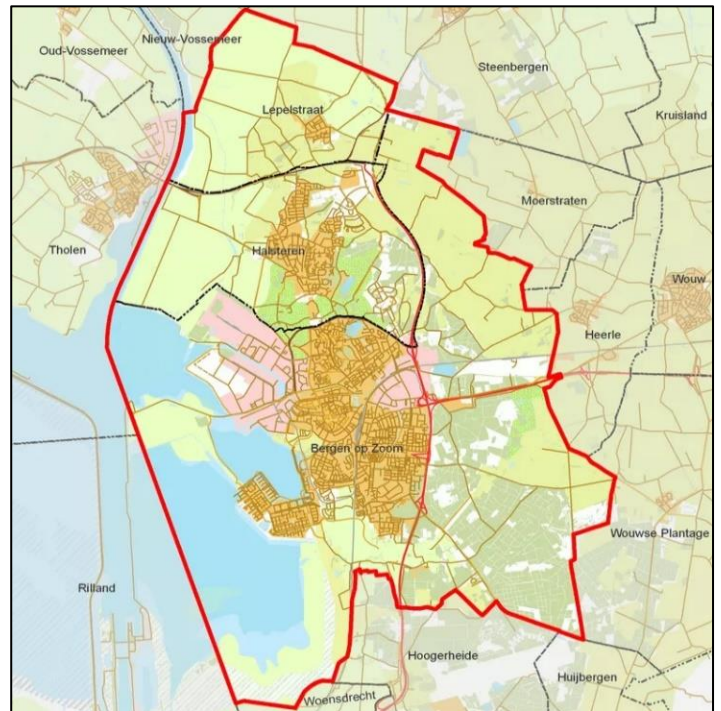


Figure 1. The municipality of Bergen op Zoom. Source: (Heijmans, n.d.)

Droughts expectations

To express the expectations of the effects of droughts for the future a climate stress test is done by Arcadis (2017) for the municipality. The stress test of the municipality of Bergen op Zoom is presenting the following results on the topic drought;

- There is a change on land subsidence in a range of 0-20cm.
- In the north-west is an area coming to attention for the peat quay.
- Salinization of the groundwater is between 300-1000 Cl/l.
- Vegetation is relatively vulnerable for drying out.
- On different locations more blue algae.

Future scenario's

In 'Appendix 1: Risk of drought stress', 'Appendix 2: Maximum potential of rain shortage (1:10 years)', 'Appendix 3: Maximum potential of rain shortage (average)', 'Appendix 4: Rain in the summer' and 'Appendix 5: Yearly reference evaporation' are possible future effects of drought shown for the municipality of Bergen op Zoom. The figures shows the possible changes from 2019 to the WH-scenario (worst case) in 2050. 'Appendix 1' describes the increasing amount of drought stress, this is especially in the higher sandy grounds on the south-east side. 'Appendix 2' express the maximum potential of rainwater shortage is increasing all over the municipality, and especially in the west side. Further, the amount of rain in the summer is decreasing in the municipality from 200-225 mm to 175-200 mm. The yearly evaporation is increasing from 590-610 mm to 630-650 mm. Moreover, the expectations are that the amount of water in Bergen op Zoom is decreasing and that the pressure of dry periods are increasing. Therefore it is important to know the drought effects and think about solutions for this. This information is based on the maps of (Ruimtelijke adaptatie, 2019).

1.4 Research objective and questions

The objective of this paper is to define a view of the overseen problems and possibilities for the municipality. It does so by offering insight in the problems and providing measures that can be taken to adapt to the effects and problems experienced with droughts. In addition, it will help to make the climate problems and possibilities clear.

The objective will be met by giving an overview with stakeholders and their experienced drought effects. This overview will be compared with quantitative data of experiences from inhabitants. This can result in different experiences and locations of the effects. Next to that the causes of the effects will be researched via the layer approach of Hidding, Brink, Heinen & Kragting (2002). This theory describes the occupation, network and underground layer. The occupation layer is the layer where people experience live and see the problem. The network layer is the system of how everything is connected with each other and the way people, water and things can transport themselves (railways, roads, etc.). The underground layer is the layer of the soil typology and geomorphology. In this way, the locations and where the problem is coming from (which ground layer) will be known. Based on these results, different recommendations and developments will be enhanced.

Following the reason, the problem definition and objective set by the municipality of Bergen op Zoom, the following research questions were formed:

Main research question:

What are the drought effects on the urban area of the municipality of Bergen op Zoom, in order to undertake measures to deal with the effects in the nearby future?

Sub questions:

To get to know which drought effects were experienced, different interviews will be done with stakeholders. This resulted in the following sub question;

Which drought effects have stakeholders experienced in the past?

- What has been experienced in dry periods before 2018?
- What is experienced in 2018?
- Which effort had the stakeholders delivered to minimize the experienced effects?
- In how far are the stakeholders interested in the drought problematic?

- What are attention points for the future?

Inhabitants can experience something different than stakeholders. This is the reason for the following sub-question;

How did the inhabitants of the municipality experience the drought effects?

- What did they experience?
- What are their expectations of the municipality?

In order to get a good overview, the locations of the effects will be mapped. This will be done based on the answers of the first and second sub-question.

Following the results of the experienced drought effects, what are the locations of these effects?

Knowing the experienced effects and the location, a causal analysis can be made based on the layer approach of Hidding et al. (2002) to get to know what the causes are of the effects.

What are the causes of the experienced effects of the stakeholders and inhabitants?

- Which effects occurred in which layers of the layer approach?

The last sub-question can be answered build on the answers of the other sub-questions. This sub-question will take into account the location and the causes of the effects.

Which measures can be taken to deal with the experienced effects in the nearby future?

- Which adaptation measures can be for use when designing developments?
- Which other types of measures can be for use?

1.5 Reading guide

After this chapter, chapter 2 will start with the relevant literature to show that this research is based on theories and concepts. Next to that, chapter 3 emphasise the methods which are used during the collection of the data. As chapter 4 presents the results with a short summary at the beginning of every paragraph. To finish the report, a conclusion is made in chapter 5 based on the results in chapter 4, as in chapter 6 the results will be discussed. Finally, chapter 7 will give recommendations for further research and methods which Sweco and the municipality can use in the future.

2. Theoretical framework

The theoretical framework describes relevant theories and models related to the subject. It will illustrate how this research is structured and which information is of importance. The chapter will start with scientific concepts. Further, climate scenario's and different theories will be enhanced.

2.1 Scientific concepts

Droughts

As reported by Tallaksen, Madsen & Clausen (2009) has drought the following meaning: "Droughts are regional in nature and critical drought conditions occur when there is an extreme shortage of water for long durations over large areas". In accordance with this, Tate & Gustard (2000) built forward on this definition: "The chief characteristic of a drought is a decrease of water availability in a particular period and over a particular area". In comparison with the definition of Maracchi (2000) is drought: "The scarcity of rainfall during the whole year and it is a climatic constant feature, caused by the general circulation pattern." The definition of Maracchi is based on a general circulation pattern which means that it is possible to adapt by techniques and lifestyles (Maracchi, 2000).

For this research, the definition of Tate & Gustard will be used. This definition fits the best in the scope of the municipality of Bergen op Zoom. Although, the definitions of Tallaksen, Madsen & Clausen and Maracchi is about a shortage of water, but according to them, drought is based on long periods, large areas and is a climate constant feature. What they exactly mean with long periods, large areas and is a climate constant feature is vague and unclear and does not fit in the scope of this research. Tate & Gustard are talking about the water availability, which can be seen as availability in groundwater and surface water. Particular area can be based on the area of Bergen op Zoom. Also particular period fits well in the problem statement, because the focus of the research is on 2018.

Climate change

According to May (2014), climate change is "a change of usual weather found in a place". This can be a change in the amount of rain in a place per year, but this can also be the change in a place temperature for a month or a season. According to the Australian Academy of Science (n.d.) climate change is: "A change in the pattern of weather, and related changes in oceans, land surfaces and ice sheets, occurring over time scales of decades or longer". The Environmental Protection Agency (n.d.) describes it as: "The climate can be seen as the average weather over a period of time. Climate change means a significant change in the climate, such as temperature, rainfall, or wind, lasting for an extended period – decades or longer".

A combination of these definitions will be used as climate change is a change in the pattern of usual weather which is related to the changes in oceans, land surfaces and ice sheets, these change can be seen as a change over a period of time. The changes can be seen in temperature, rainfall or wind. The reason to choose for a combination of the definitions is to make a broader and clearer definition.

Adaptation measures

As stated in Climate Adapt (2017) are adaptation measures aiming to manage climate risk to an acceptable level while taking advantage of any positive opportunity that may arise. These measures are possible options that can be implemented to adapt to climate change. The Delta Program (2018) is quoting that adaptation options are, measures to make the Netherlands climate proof and water

robust. This can be done because of the increasing risk of flooding's, heat stress, dry periods and sea level rise.

Both definitions are correct. Adaptation measures are measures to manage the climate risks (flooding's, heat stress, dry periods and sea level rise) and make the Netherlands climate proof and water robust. While at the same time, taking positive opportunities for possible options to implement measures.

Urban area

Confirming to Roberts, Sykes & Granger, (2017) are urban areas complex and dynamic systems. This are centres of political power and they also reflect on processes which drive physical, social, environmental and economic transition. Moreover, they are primary the generator of many changes. Correlated with the definition of Gies et al. (2005) is an urban area a term that exist of the city itself and towns. The built-up area is the urban area. Following the definition of CBS (2016) is an urban area an area of 500 by 500 meter with the density of 1500 addresses per square kilometre. They are talking about rural area if the amount of addresses is less than 1000 per square kilometre.

During this research the definition of CBS will be used. Because the definition is clear about what an urban area is and what not. Based on this definition it will become clear that villages such as Halsteren and Lepelstraat are part of the research, but hamlets like 'de Kraaijenberg' are not. This definition is supported by figure 3. Which shows the area access roads inside the built-up area and the area access roads outside the built-up area. This means that a division can be made of what urban area is and what not.

Following the definition of Roberts, Sykes & Granger and Gies, et al. is not clear where the borders exactly are in an urban area and when they talk about the rural area or the urban area.

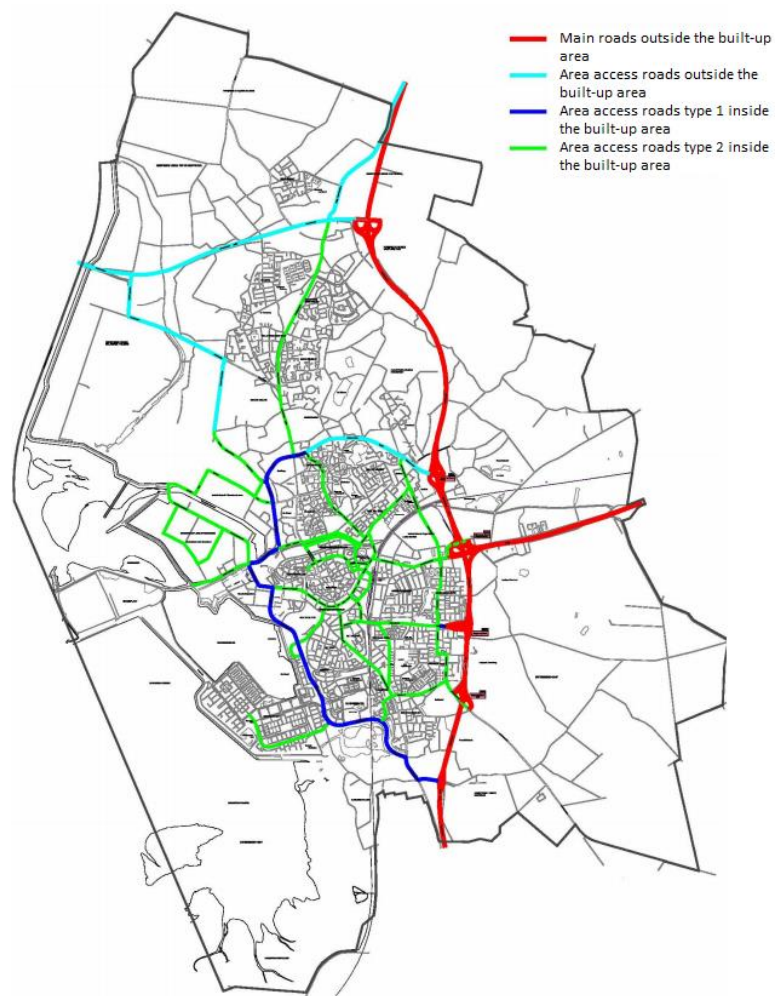


Figure 3. The main roads in Bergen op zoom. Source: (Heijnen & Krouwel, 2014)

2.2 KNMI'14 Climate scenarios

As reported by the KNMI (2015) is a climate scenario: "A plausible representation of the future climate that has been constructed for investigating the potential consequences of human-induced climate change". The WH (Warm and High value) scenario is the worst case scenario which is having a low probability but an high impact (figure 4). Graph 3 and 4 will describe that winters will become wetter and summers drier. More evaporation and less precipitation will happen. The system of the

Netherlands is mainly focussing on discharging water as quickly as possible. The system is not created to hold the water. While facing dry periods and lower amount of water supply via the rivers, the lack of sufficient proper fresh water can become an extreme problem (Biesboer, 2018).

The research will focus on the WH (worst-case) scenario. This because there is always a possibility that the worst-case scenario can happen. This is unsure. Unsure has two sides; it can be better than expected, or it can be worst. This kind of uncertainty is not symmetric. The problems by possible 'more worse' are bigger than the possible 'better than expected' (Custers, 2019). This is the reason for focussing on the worst-case scenario in this research.

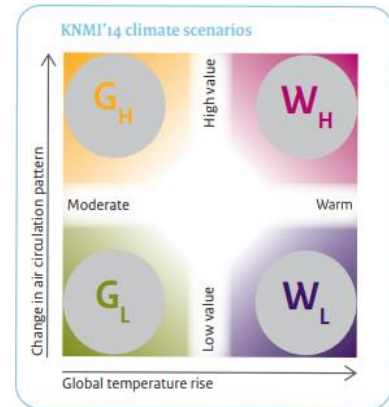
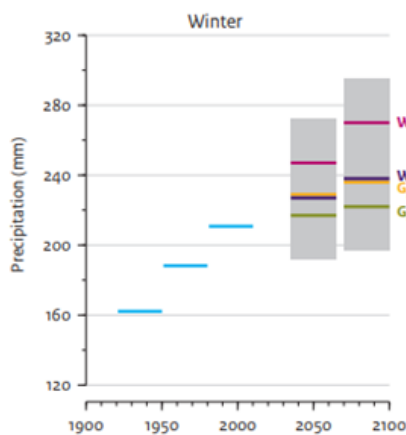
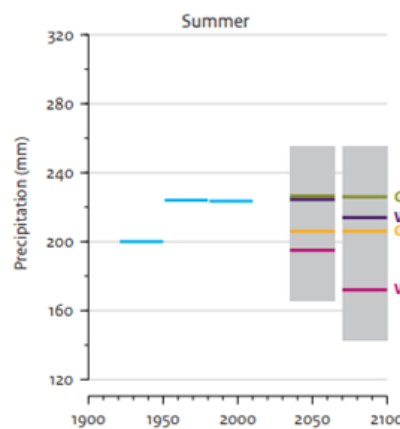


Figure 4. KNMI climate scenario's. Source: (KNMI, 2015)



Graph 3. KNMI climate scenarios winter. Source: (KNMI, 2015)



Graph 4. KNMI climate scenarios summer. Source: (KNMI, 2015)

Uncertainty

Climate change can be an uncertain matter. According to Hallegatte & Dumas (n.d.) there are four different methods for uncertainty-management which can be used for climate adaptation options and creating robustness;

- Selecting no-regret measures which will contribute to benefits, even in absence of climate change;
- Selecting safety margins for new investments;
- Soft and flexible adaptation options;
- Reducing investment lifetimes costs.

The uncertainty matters will be used in the research to show that climate adaptation measures will be useful and worthwhile to implement whatever will happen (best case or worst case scenario). The adaptation options that will be given are based on the answers of the research questions.

2.3 Water shortage

Drought is the cause of water shortages. There are two types of water shortages which are important for this research, precipitation and groundwater shortages. Precipitation shortage is defined as a condition where the precipitation is less than the normal for a prolonged period over an area (Shah, Bharadiya, & Manekar, 2015). Groundwater shortages originate from a reduced recharge of water over

a particular period of time. These shortages are associated with low groundwater levels resulting in low well yields, spring flows or even drying-up of wells and rivers. Low groundwater cause droughts. Groundwater droughts can affect the water supply and cause drought problems (van Lanen & Peters, 2000).

2.4 Droughts

Dry periods can cause the following effects; dropout of vegetation, salinization, more diseases, limiting the growth of vegetation, more growth of vegetation and a demand for water.

Due to dry periods, plants and vegetation have less water and are taking less nutrients from the ground. In addition, stomata's are closing to limit the amount of evaporation. This is resulting in limited amount of growth.

As a consequence of water absorption due to vegetation, the amount of water infiltration for the deeper aquifers is decreasing. This means that the groundwater levels are decreasing, a decrease in groundwater level can cause; damage to foundation (pile rot), land subsidence (irregular subsidence cause damage to infrastructure and buildings) and heat stress (Brolsma et al., 2012).

Drought is affecting heat stress via evaporation. Evaporation decreases heat from the surrounded area. If there is no water in dry periods, no evaporation can take place, this leads to an increasing temperature. Heat stress can increase the body temperature which results in; diseases, a bad labour productivity, behaviour of people, quality of sleeping and increasing occupational accidents (Brolsma et al., 2012).

Dry periods can cause problems with surface waters. More infiltration (the water will infiltrate to the ground water which is causing a lower surface water level), evaporation and withdrawal of water takes place. A lower water level can have the following consequences; damage to floating houses, damage to quays because of instability, nature friendly shores does not have a function because of desiccation, and a bad water quality. Short droughts can have positive effects on water plants. It will stimulate the germination of some plants. But during dry periods the water quality will decrease which is causing; smell nuisance, blue algae, botulism, dying fish and bacteria in swimming water (Brolsma, et al., 2012). In 'Appendix 6: Effects of droughts' is a division of the effects of droughts.

2.5 Layer approach

Dry periods can have consequences on different layers. To get to know what the causes are of the effects of droughts, the layer approach of Hidding et al. (2002) can be used. This approach has three different layers:

First layer: Underground layer

This is the lowest layer which is forming the soil typology, geomorphology and water system. This in relation with the natural-, landscape- and cultural values.

Second layer: Network layer

This layer consists of i.e. roads, railway, water connections (rivers, canals etc.) as well as sewage systems, pipelines and cables (electricity, telephone and ICT).



Figure 5. Layer approach. Source: (Hidding, et al., 2002)

Third layer: Occupation layer

This is the top layer which consist about living, working or recreation.

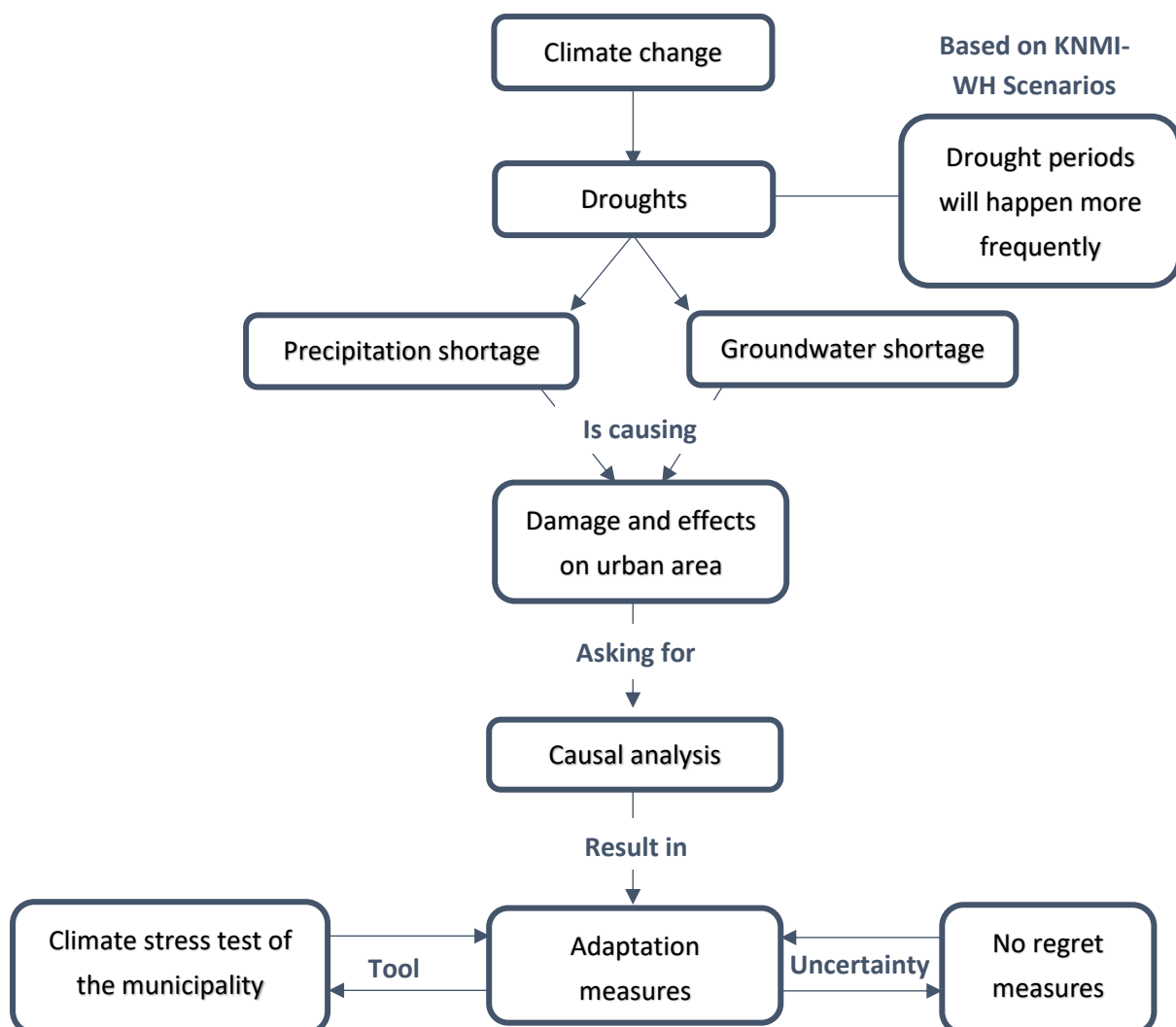
2.6 Climate stress test

A climate stress test is a climate task to figure out the vulnerable climate change spots in the municipality. Knowing these spots are forming the basis for climate adaptation options (Arcadis, 2017).

For the climate stress test of the municipality of Bergen op Zoom was Arcadis (2017) using the KNMI'06 W+ scenario. In addition, for land subsidence as an effect of droughts was the sensitivity of the foundation and the construction year of the properties used. While for the vegetation the soil type, ground level and groundwater level were measured. For this research, the latest scenarios of KNMI'14 (WH) will be used. Compared to Arcadis, in this research, the experienced effects of stakeholders will be used, both for the land subsidence and the vegetation.

2.7 Conceptual model

2.7.1 Scheme



2.7.2 Explanation

Climate change will cause dry periods. Dry periods will happen more frequently based on the KNMI-WH climate scenarios (2015). Dry periods can be described as a shortage of precipitation as well as a shortage of groundwater. These water shortages are causing effects and damages on the urban area. If the causes of the effects will be known, possible measures can be taken in a more efficient and effective way. To get to know the causes of the effects, a causal analysis can be done. The results of the analysis will give more insight into the effects and problems. Based on these results climate adaptation measures can effectively be taken. The tool 'Climate stress test' can be for use in this case to give more insight in other vulnerable spots for other climate change effects in the municipality and relations with these for adaptation measures. These measures can be based on 'no-regret measures' with safety margins and flexible options which will reduce the lifetimes investments costs. No regret measures will benefit to the area even in absence of climate change (for example, can be in a form of improving the liveability).

3. Methodology

In this section of the report the methods used during the research will be explained. The approaches and methods were taken within the limits and boundaries to perform the best possible research.

3.1 Research type

To show the comparison of the experienced drought effects of civil servants and inhabitants is a qualitative and quantitative research done. Qualitative research is done to gain an understanding of underlying reasons, opinions and motivations (de Franzo, 2011). While quantitative research is done based on numerical analysis of data collected via surveys (USC University of Southern California, 2019).

3.2 Research strategy

The research can be divided in two phases; preliminary – and the main research. A preliminary research will be a broad search for sources and gathering sufficient knowledge for executing the main research (Lumen, n.d.). During the main research the methods will provide the answer the sub-questions.

3.2.1 Preliminary research

Literature research

Literature research gave the researcher knowledge and the necessary information for the research about the topic. This method was used for finding previous conducted researches or investigations. To get more literature, the search engines Google and Google Scholar were used. Different key words were used for this (in English and Dutch). In addition, relevant papers provided by the municipality of Bergen op Zoom were used.

Field observation

This strategy was used to get a better view of the results from the literature research. This was useful for the interviews later in the main research phase.

3.2.2 Main research

Literature research

Where the preliminary research did not investigate small details, was this phase used to do so. Literature research was also used to carry out the causal analysis. The causal analysis is done after the interviews and surveys to provide an answer from the causes of the drought effects. Moreover, literature research was done to provide information for which adaptation measures are possible.

Stakeholder analysis

To get to know which effects and problems the municipality had during a dry summer, interviews were done with relevant stakeholders. A stakeholder analysis was made in order to get to know who need to be interviewed. To get different meanings and visions, different people were searched with different backgrounds and opinions. However to decide who need to be interviewed, criteria's were set up. There are too much people who might have an idea or opinion on the problem, it is too big to interview all of them. To make the research relevant and trustworthy, the amount of interviews should not be too low. The interviewees were selected on different criteria:

- If the stakeholders are involved with climate (drought) effects
- If the stakeholder is having a stake in the research problem

- If the stakeholders are target audience related to the assignment
- If they have the means to change something related to the problem
- If they have a stake in the urban area

Build on the criteria, 10 civil servants were chosen to do interviews with. Also 8 team leaders of the fieldwork department were chosen to do a focus group with.

In addition, external stakeholders were selected; Waterboard Brabantse Delta, Brabant Water and Evides Waterbedrijf were asked for interviews. The external stakeholders are also chosen on the criteria and must have a stake in the urban area.

A complete overview of the stakeholder analysis can be found in 'Appendix 7: Stakeholder analysis'.

Stakeholder interviews

After finishing the stakeholder analysis, the interviews were scheduled. The interviews were scheduled via email, phone or a walk in the office of the stakeholder to arrange a date. The contact information, was provided by the in-company supervisors to contact the interviewees. The interviews with the civil servants were held at the municipality building (Jacob Obrechtlaan 4) of Bergen op Zoom. The department economy was the only department which was not interested in the topic and an interview. The external interviews with Waterboard Brabantse Delta was held in Breda at Bouvignelaan 5 and Brabant Water in Breda at Minervum 7181. Evides Waterbedrijf was not interested in the topic and did not want an interview.

An overview of the asked questions during the interviews can be found in 'Appendix 8: Overview interviews questions'. The questions were tested and reviewed by the supervisors. As shown in the overview, semi-structured open questions were asked. Via this type of questions, the interviewees were able to form their own answers and visions. Also the interviewer was able to go more into detail about the subjects the interviewee was talking about. The duration of the interviews was between 30 – 60 minutes. All the interviews were executed between the 18th of February and the 9th of April 2019. The interviews were recorded by phone (if agreed by the interviewee) to analyse the interviews later on. After the last interview and focus group, saturation occurred. After this, no other interviews were carried out. The interviews were analysed and a report has been made of the conversation.

Of the 11 interviews, 10 of them were recorded with permission of the interviewees. As agreed with the interviewees, the recordings, their name and the report of the interviews will not be published. As the interviews were carried out without other people and in closed off rooms. It is more likely that the interviewees told the truth instead of giving 'socially correct' answers.

The information of the interviews were used for the survey and mapping of the effects.

Focus group

This method was carried out to interview 8 team leaders of the fieldwork department. The focus group lasted +/- 45 minutes. This was done at April 3, 2019 at Sportpark de Beek in Halsteren. The results of this focus group were sketched in a map of the municipality. The people in the focus group were assembled based on the stakeholder analysis.

Survey

A survey was held among the population. The research is about drought problems in the municipality, because of this, the population are the people that are living in the municipality of Bergen op Zoom. In this research the population will be 66.354 people, because this is the population of the municipality in 2018 (Gemeente Bergen op Zoom, 2019).

The questions will be partially closed this means an hybrid of open- and closed- ended formats. The survey will be done with inhabitants, this means that it can be linked to citizen participation and creating awareness. According to Irvin & Stansbury (2004) is citizen participation the belief that citizen involvement will produce more public preference decision making on the part of administrators and a better appreciation of the larger community among the public. Citizen participation will help in public trust towards government entities. In addition, the citizens know that the governmental entity is doing something on the subject.

For the survey five neighbourhoods were chosen. This because the municipality is divided in six different neighbourhoods, which are divided in different districts:

1. Bergen op Zoom-West
2. Bergen op Zoom-Noord
3. Bergen op Zoom-Oost
4. Bergen op Zoom-Outside area West
5. Halsteren
6. Lepelstraat

Number 4 'Bergen op Zoom-Outside area West' is not having inhabitants (CBS, 2008), this is the reason that this area will not be part of the research. Within these neighbourhoods five districts were chosen. These districts were chosen on different criteria as a result of the interviews;

- 3 districts were the civil servants experienced effects
- 2 districts were the civil servants did not experience effects
- Villages
- Most of the houses in the districts built after 1985
- Most of the houses in the districts built before 1985

Following this criteria, the following districts were selected:

1. Lepelstraat
2. De Schans
3. Noordgeest
4. Bergen op Zoom Centrum
5. Bergse Plaat

The amount of surveys was decided on the households of the smallest district. Lepelstraat is having 615 households, surveying 2% of the amount of households, means that 30 households needed to be surveyed. This was also done in the other districts. This means that in totally 150 surveys were carried out to make the survey trustable. The results of all the 150 surveys were statistically analysed and plotted in histograms. The survey itself can be found in 'Appendix 9: Survey'.

Mapping

Different maps were made in this research. The maps are based on the results of the interviews, focus group and surveys. The interviews, focus group and surveys provided locations of drought effects, these locations were mapped to create an overview.

3.3 Summary

To summarize, table 1 shows which methods were used for which research questions.

		Research methods (main research)					
		Literature research	Stakeholder analysis	Interviews	Focus group	Surveys	Mapping
Research questions	Experienced drought effects stakeholders (sub question 1)		x	x	x		
	Experienced drought effects inhabitants (sub question 2)					x	
	Locations of the drought effects (sub question 3)						x
	Causes of the effects (sub question 4)	x					x
	Measures available (sub question 5)	x					

Table 1. Research questions in relation to the research methods.

3.4 Materials

- Laptop with Microsoft office and ArcGIS
- Mobile phone for making pictures for field observation and recordings during interviews
- Pencils for the stakeholder meetings and interviews
- Maps of Bergen op Zoom during the focus group with the team leaders of the fieldwork department
- Tablet for the surveys

4. Results

This chapter contains descriptions of the results of the methods. The chapter starts with the **experienced effects** of the interviewed stakeholders. Further, the experiences of inhabitants will be described as a result of the **survey**. The third paragraph shows the **locations** where effects occurred and the fourth paragraph will describe **the causes of the experienced effects** (causal analysis). In the causal analysis are the effects divided by **occupation, network and underground layer**. Finally **measures** will be enhanced which the municipality can take in the in order to learn and to deal with the effects.

4.1 Stakeholders experienced drought effects

Interviews and a focus group were carried out which shows that there were no drought effects experienced before 2018. The biggest drought effects in 2018 were blue algae, low water levels and dying public green. Moreover, the common attention points for the future are better communication and focus on implementing more green.

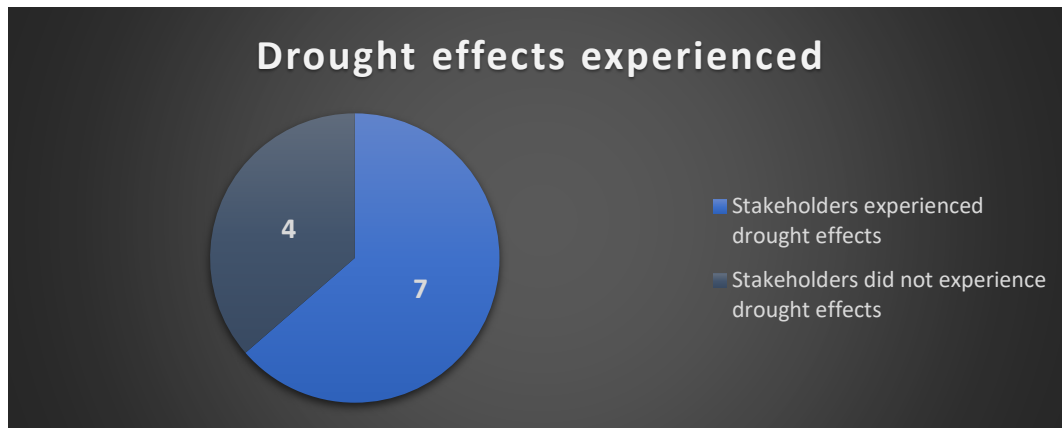
In this chapter, only the relevant information of the interviews will be discussed. A complete overview of the interviews is described in: 'Appendix 10: Interviews civil servants', 'Appendix 11: Interviews extern stakeholders' and 'Appendix 12: Summary interviews'.

4.1.1 Experiences of drought before 2018

On the question if there were drought years experienced before 2018, is answered that there were not such extreme dry years experienced as in 2018. The team leader of the fieldwork department (operational part) said during an interview: "There is definitely more effort delivered last summer. The water levels were really low. Sometimes it will happen that we need to fill the Vijverberg in the summer. But last year it was extreme. A good example are the wadi's in De Schans, normally they are filled with water, but this year they were totally dry. We were filling different ponds almost every day, it looked like if the water just disappeared" (Team leader fieldwork operational part, personal communication, February 26, 2019). In addition, during a focus group with the department fieldwork, said a team leader; "It was extremely hard to get everything done last summer. We were driving the whole time with tankers trucks to fill ponds and give water to public green. It looked like we were doing it for nothing. I never experienced so much problems as last year" (Team leader fieldwork, personal communication, April 3, 2019).

4.1.2 Experienced drought effects in 2018

To make clear if stakeholders experienced effects of the dry period in 2018, is asked during the interviews if they experienced something. If yes, what did they experience. Four stakeholders did not experience problems or effects: department municipality buildings, department city; area development & mobility, department cables and pipes and Brabant Water. In graph 5 is an overview of the amount of stakeholders that experienced effects, and the amount of stakeholders that did not. Out of the 11 stakeholders interviewed, 7 of them plus the fieldworkers during the focus group experienced effects. Only this 7 stakeholders and the fieldworkers of the focus group will be taken into account during the formation of the results on '4.1.2 Experienced drought effects in 2018' and '4.1.3 Efforts delivered to minimize the effects in 2018'.

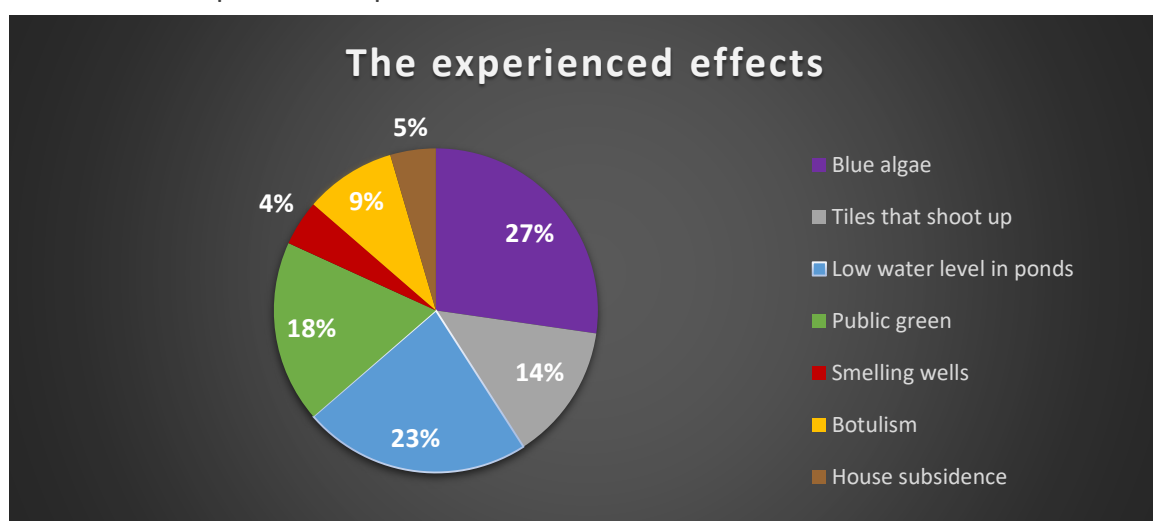


Graph 5. Overview of stakeholders that did experience drought effects and stakeholders that did not.

The overview in table 2 describe which effects were experienced by the seven stakeholders and the fieldworkers of the focus group.

	Blue algae	Tiles shoot up	Low water level ponds	Public green	Smelling wells	Botulism	House subsidence
Leisure economy – advisor water and climate adaptation	x					x	
Roads and civil works		x					
Fieldwork – Operational part	x	x	x	x			
Leisure economy – strategic policy advisor/ advisor water	x		x	x		x	
Public green				x			
City water and sewage system	x		x		x		
Waterboard Brabantse Delta	x		x				
Fieldworkers focus group	x	x	x	x			x

Table 2. Overview of experienced effects per stakeholder.



Graph 6. The amount of experienced effects by stakeholders.

Blue algae

During an interview with the department leisure economy – water and climate adaptation, a respondent said: “I need to say that we had more blue algae and botulism last summer compared to other years. Blue algae and botulism is bad for the water quality.” (department leisure economy – water and climate adaptation, personal communication, February 2, 2019). This effect is confirmed by department leisure economy – strategic policy advisor/advisor water, department fieldwork – team leader operational part, department city water & sewage system and Waterboard Brabantse Delta.

Tiles that shoot up

The department roads and civil works said: “We had problems, especially with cycle paths. We had the so called ‘shoot up’ effect of tiles. Due to a low groundwater level, roads will get burned, dry out and pulverized.” (department roads and civil works, personal communication, February 26, 2019). Department roads and civil works is not the only department that was facing these effects, also the department fieldwork – team leader operational part, had this effect.

Low water level of ponds

The department fieldwork – team leader operational part, was saying: “Different ponds had a low water level where we needed to add water to.” (department fieldwork – team leader operational part, personal communication, February 26, 2019). Moreover, also the department leisure economy – strategic policy advisor, department city water & sewage system were having these problems and Waterboard Brabantse Delta.

Public green

Department public green experienced effects. This respondent was saying: “Last year we got weird messages about drought. I experienced that public green close to hardening was dying. Even small trees in forests were dying, while lawns were unable to recover from the period without water. Sometimes it was looking so dry, that it looked like we did not gave water at all.” (department public green, personal communication, March 7, 2019). This effects also occurred by department fieldwork – team leader operational part and department leisure economy – strategic policy advisor/advisor water.

Smelling wells

One department had an effect of drought with smelling wells. The department city water & sewage systems. The respondent was saying: “We had problems with smelling wells. We do not know the exact locations, but we gave advice to the inhabitants to throw a bucket of water on it.” (department city water & sewage systems, personal communication, April 4, 2019).

Botulism

There is an increase in botulism. The department leisure economy – strategy policy advisor/advisor water said: “Ponds become dry, there is not enough water anymore. Blue algae and botulism are increasing, this is bad for the water quality.” (department leisure economy – strategic policy advisor/advisor water, personal communication, February 28, 2019). This is confirmed by department leisure economy – water and climate adaptation.

House subsidence

During the focus group, the fieldworkers mentioned that they got two notifications from inhabitants that experienced house subsidence which caused cracks in their house. (fieldworkers, personal communication, April 3, 2019).

4.1.3 Efforts delivered to minimize the effects in 2018

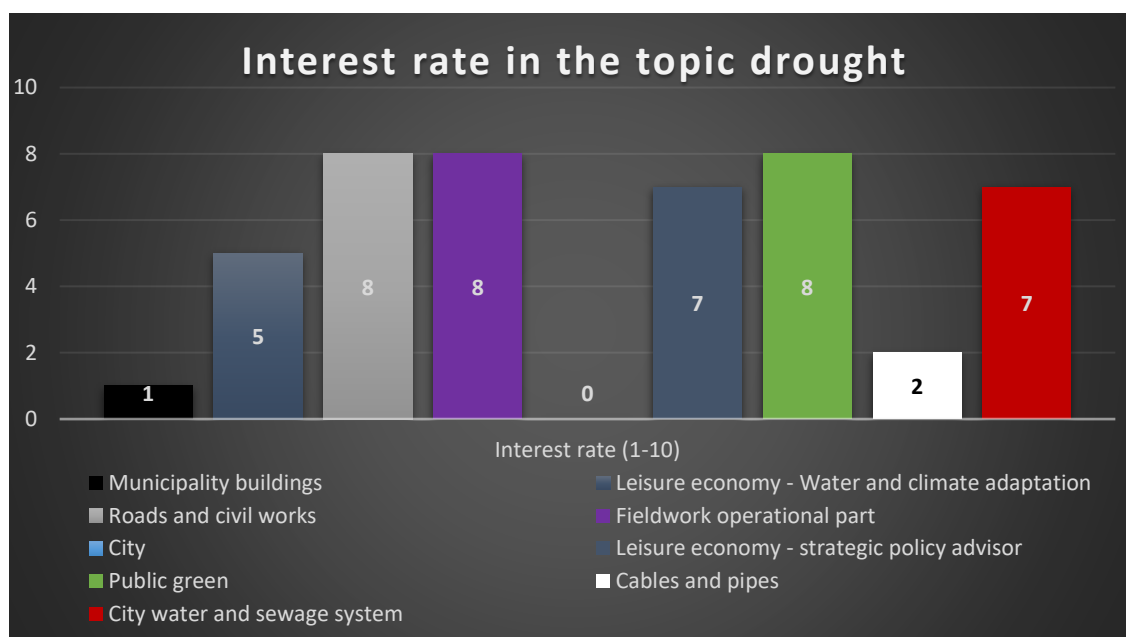
Different measures were taken to minimize the experienced effects of droughts. Measures taken are divided under the effects occurred.

Blue algae	Acceptation, when there is no possibility to flush the water, it is hard to do so
Tiles that shoot up	- Spraying water on the tiles - Removing tiles and placing them back
Low water level in ponds	- Filling the ponds with just enough water so the fishes were able to swim - Farmers got planks to place in ditches to retain water - Specific way of mowing to move the water slowly - Acceptation, there was not enough water - Abrogation bans for surface waters - Implementing sluices to hold water
Public green	- Giving water to young trees - Making choices which green is getting water and which not - Giving advice to inhabitants to remove stones and implement green
Smelling wells	Giving advice to inhabitants to throw a bucket of water in the smelling well
Botulism	Removing high vegetation
House subsidence	Nothing done

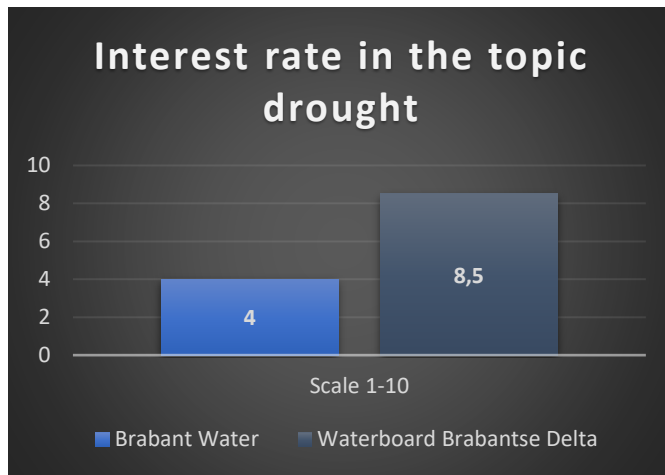
Table 3. The effects and which efforts were delivered to minimize the effects.

4.1.4 Interest of stakeholders in drought problematic

During the interviews, the stakeholders were asked what their interest is in the drought problematic. This is based on a scale from 1-10 (1 = no interest, 10 = a lot of interest). An overview of the interest of different departments from the civil servants can be found in graph 7 and from the extern stakeholders in graph 8.



Graph 7. Interest rate civil servants.



Graph 8. Interest rate extern stakeholders.

4.1.5 Attention points for the future

Different attention points came for discussion during the interviews. In table 4 is an overview of which stakeholders had which attention points for the future.

	Communication about climate adaptation	Placing asphalt	Implementing more green & infiltrate locally	Starting to give water in an earlier stage	Work and create awareness with inhabitants
Municipality buildings	x				
Leisure economy – Advisor water and climate adaptation	x		x		x
Roads and civil works		x			
Fieldwork – operational part	x	x	x	x	
City; area development & mobility	x				x
Leisure economy – strategic policy advisor/ advisor water	x		x		
Public green	x		x		x
Cables and pipes					
City water and sewage system	x		x		x
Brabant Water			x		x
Waterboard Brabantse Delta	x		x		x
Fieldworkers focus group	x		x		x

Table 4. Overview of attention points per stakeholder.

Respondents were saying that communication about climate adaptation is an attention point. This is communication between the civil servants as well as to external parties. One respondent was saying: “During the dry period, every department was acting in their own tunnel vision and solved their own

drought problems. We did not communicate at all.” (department city water & sewage systems, personal communication, April 4, 2019). In addition, another respondent was saying: “We lost a lot on the point of participation and awareness among inhabitants”. (Brabantse Delta, personal communication, April 9, 2019).

Another attention point that arose when one respondent said: “We destroyed the natural balance in the Netherlands. We did this because we build everywhere, because of this we destroyed the ‘sponge’ capacity of the ground. We do not hold the water long enough. Causes for this are that we discharge the water quickly and in cities the water is not able to infiltrate in the ground anymore.” (department leisure economy – water and climate adaptation, personal communication, February 2, 2019).

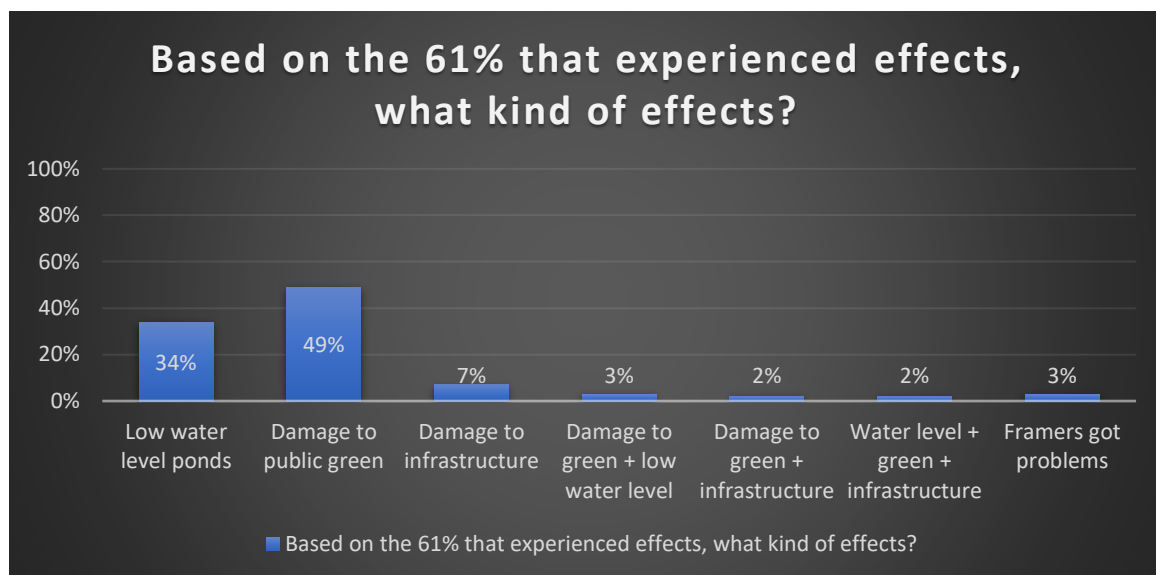
4.2 Inhabitants experienced effects

*Surveys were carried out to see what the inhabitants experienced. As showed, most of the inhabitants are aware of the drought problematic. **Damage to green** and **low water level of ponds** are the most mentioned effects. However, the inhabitants are not aware if the municipality did something to solve the effects.*

Within the results of this chapter, only the relevant information of the surveys is described. A complete overview of the results from the survey can be found in 'Appendix 13: Results survey'.

4.2.1 Experiences of inhabitants

In the survey is tested what the experiences of the dry summer in 2018 were by the inhabitants. First is asked if the inhabitants are aware of the drought problem in common. **85%** of the surveyed knows that there is a drought problematic. In total **61%** of the surveyed had experienced effects in the public area. Graph 9 describes what the 61% of the inhabitants had experienced. Table 5 shows the most experienced effects per district.

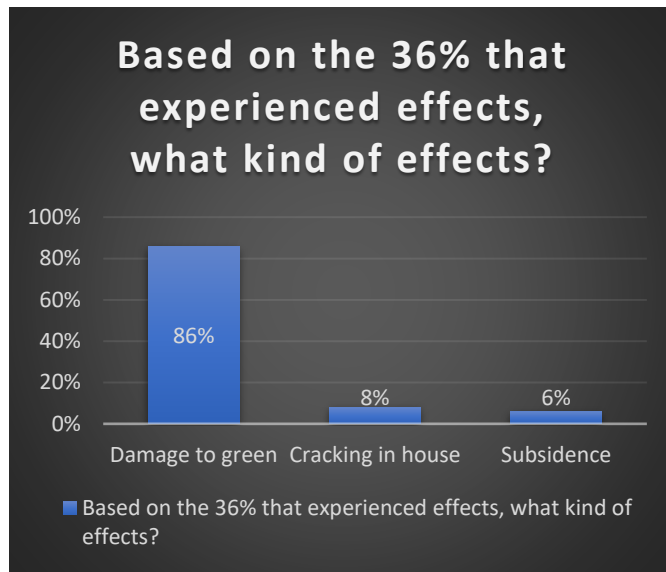


Graph 9. The public effects experienced by the inhabitants.

District	Percentage that experienced a public effect	Most mentioned effect (based on the percentage that experienced an effect)
Bergse Plaat	75%	Low water level ponds (47%) Damage to green (40%)
Bergen op Zoom city centre	35%	Damage to green (86%)
Noordgeest	55%	Damage to green (64%)
De Schans	95%	Low water level ponds (52%) Damage to green (42%)
Lepelstraat	45%	Low water level ponds (33%) Damage to green (33%)

Table 5. Division of the most experienced public effects per district.

36% of the surveyed stated that they had experienced drought on their private terrain. Graph 10 describes what kind of effects the 36% of the inhabitants had experienced. Table 6 shows the most mentioned effects that inhabitants experienced on their private terrain.



Graph 10. The private effects experienced by inhabitants.

District	Percentage that experienced a private effect	Most mentioned effect(based on the percentage that experienced an effect)
Bergse Plaat	45%	Damage to green (78%)
Bergen op Zoom city centre	30%	Damage to green (86%)
Noordgeest	35%	Damage to green (71%)
De Schans	35%	Damage to green (86%)
Lepelstraat	35%	Damage to green (33%)

Table 6. Division of the most experienced private effects per district.

4.2.2 Expectations of the municipality

During the surveys is tested how the inhabitants think and what they expect about the municipality. This is done to get to know the relation of the municipality with the inhabitants.

In average **47%** of the surveyed expect that the municipality will solve the effects of drought. A majority is not expecting that the municipality will solve the effects. **4%** of the surveyed knows that the municipality did something to solve it. Table 7, displays what the expectations of the different districts are and if they think the municipality did something to solve an effect.

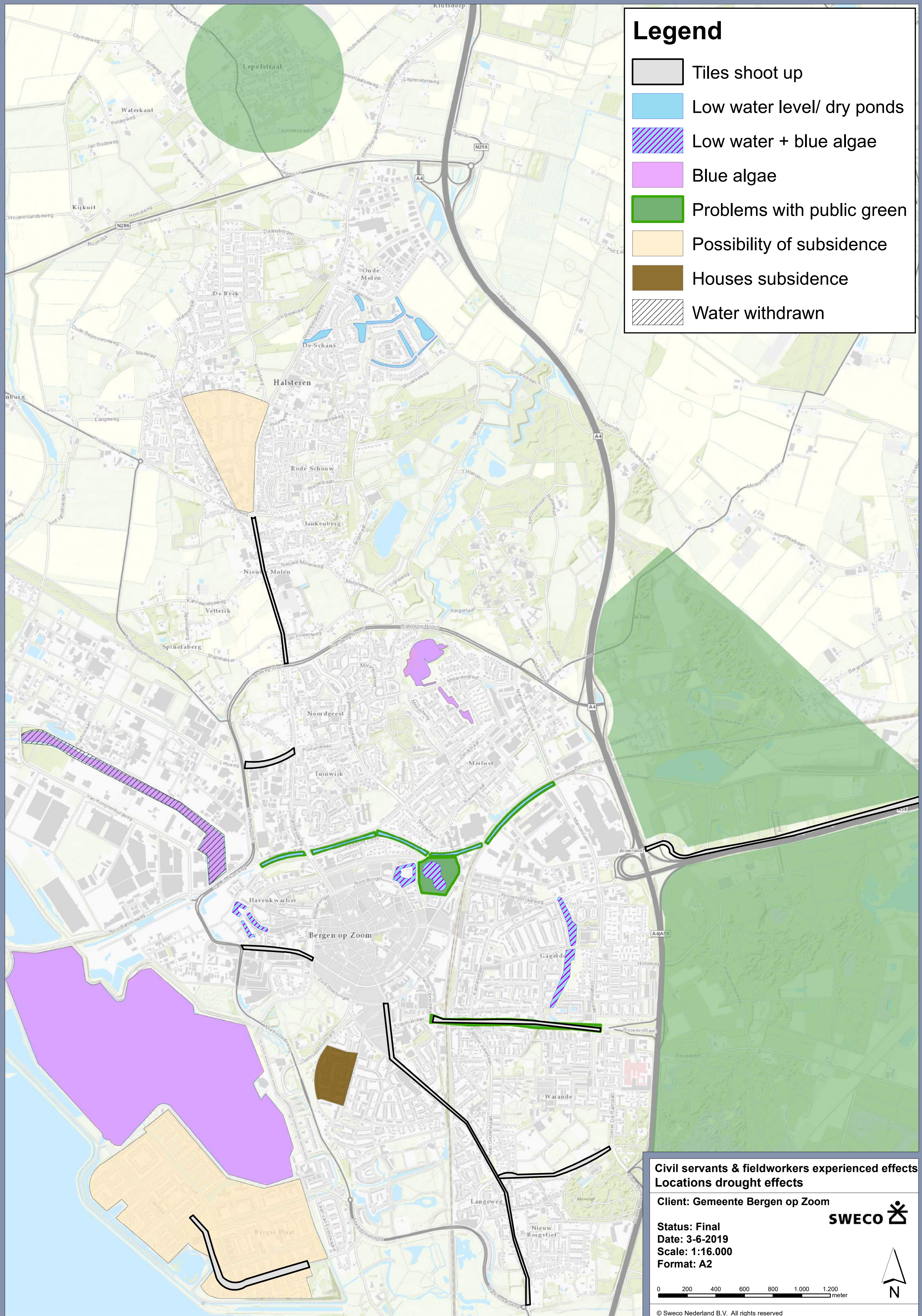
District	Do you expect the municipality will solve the effects?	Did the municipality do something on the mentioned effects?
Bergse Plaat	Yes 35%	Yes 0%. No 45%. Maybe 35%
Bergen op Zoom City centre	Yes 45%	Yes 0%. No 15%. Maybe 25%
Noordgeest	Yes 60%	Yes 5%. No 35%. Maybe 30%
De Schans	Yes 60%	Yes 15%. No 20%. Maybe 55%
Lepelstraat	Yes 35%	Yes 0%. No 20%. Maybe 20%

Table 7. Overview of what the inhabitants expect from the municipality and if they know the municipality did something.

4.3 Locations of the effects

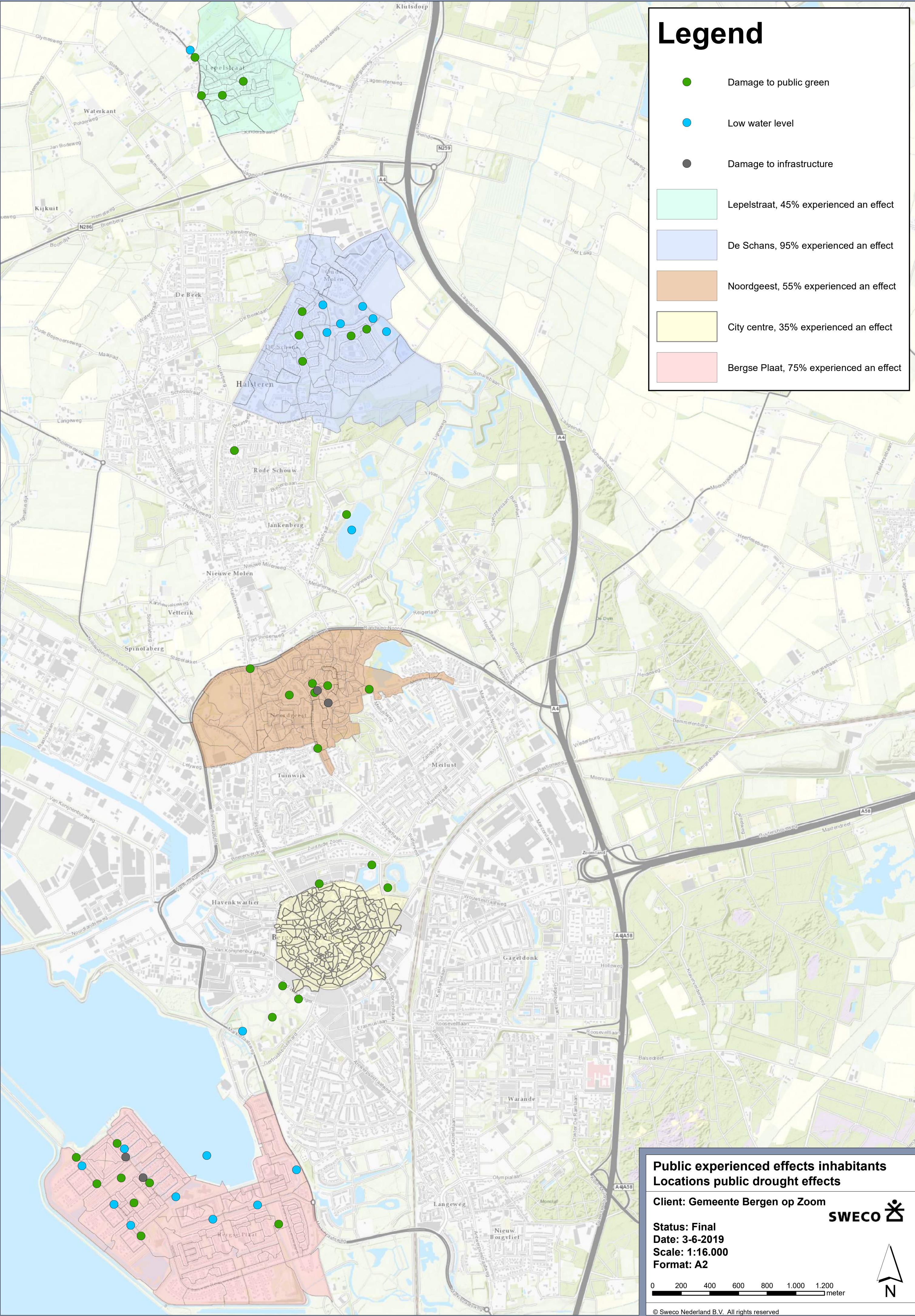
The locations of the effects which were under discussion during the interviews, focus group and surveys were mapped. There is an overlap in locations of the experienced effects, as there are also differences. The biggest difference noted is that the fieldwork department saw (potential) subsidence while the civil servants did not.

The effects experienced by the civil servants and fieldworkers are combined in one map. Separate maps can be found in 'Appendix 14: Locations experienced effects civil servants' and 'Appendix 15: Locations experienced effects fieldworkers'.



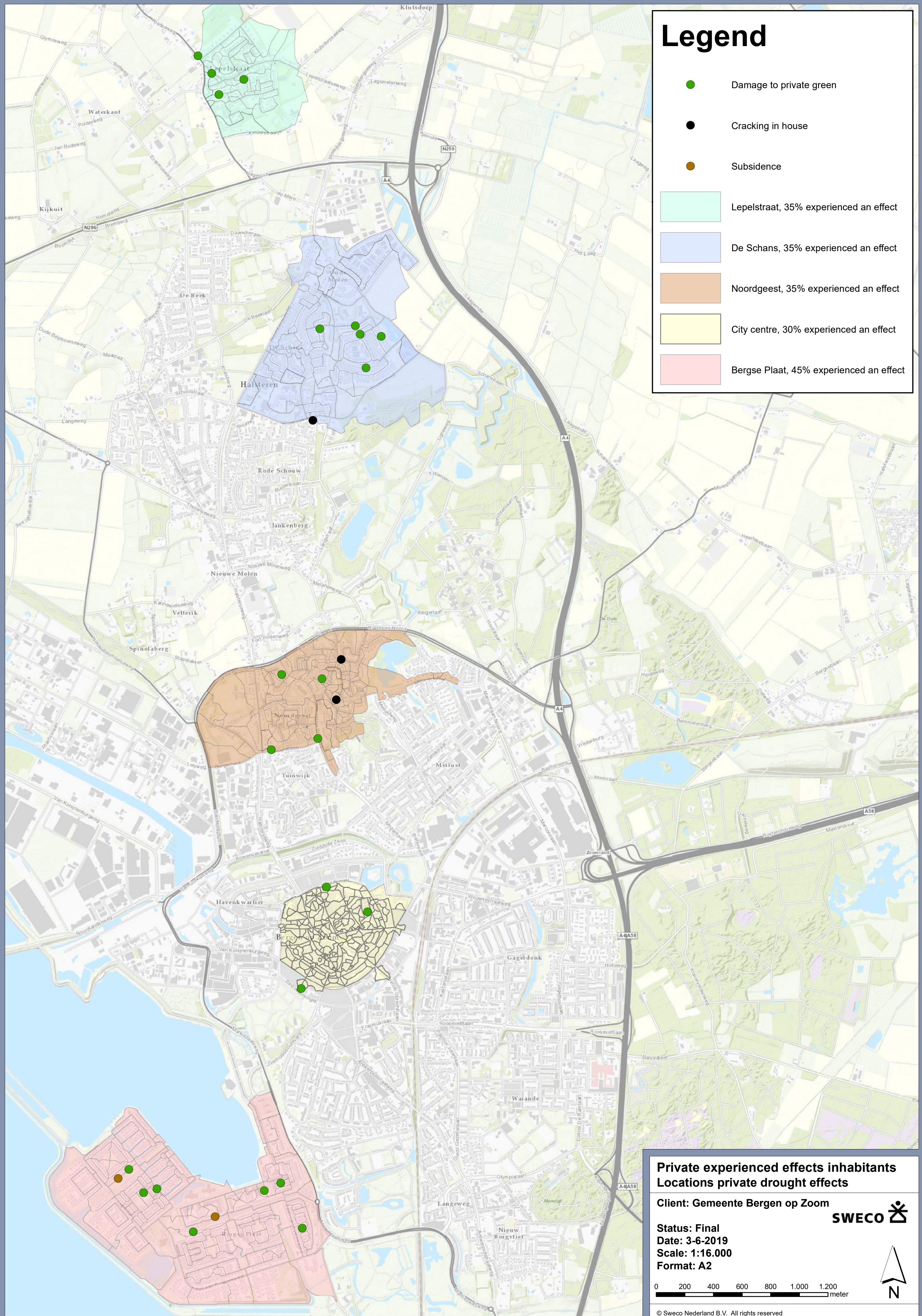
The map 'Public experienced drought effects by inhabitants' displays the streets where the citizens experienced an effect in the public area. The effects visible are divided in the districts within the scope of the research. Some of the streets selected might outside the district, this is an effect that the inhabitant saw in that specific street/ area.

Public experienced drought effects by inhabitants



The map 'Private experienced drought effects inhabitants' shows the locations of the streets where inhabitants experienced a drought effect on their private terrain. The effects on the map are divided in the districts within the scope of the research.

Private experienced drought effects by inhabitants



4.4 Causes of the effects

*This chapter describes what the exact causes are of the effects. **Blue algae** is an effect of a dry period, because there is not enough clean water available to flush or mix the water to deal with it. While **loose tiles**, **dying public green** and **house subsidence** is an effect of a dry sandy underground where water is not available.*

4.4.1 Experienced effects divided by layer

Blue algae

Blue algae mainly come from a surplus of nutrients load in the form of nitrogen and phosphorus. The load can come from agriculture, settlements, industry and septic systems. This can end up in the underground or the nutrients can be transported via canals or rivers (Furman, Pihlijamäki, Välipakka, & Myrberg, n.d.). As blue algae may affect the light conditions, water plants disappear and algae are dominating more. Blue algae is harmful for humans and animals as it can cause diseases. Blue algae may affect the bathing conditions as bathing prohibitions can occur (Gemeente Bergen op Zoom, n.d.). To solve the problem of blue algae ponds can be dredged or water can be flushed through the ponds. There must be enough clean water to mix with the water of blue algae. During the dry period there was simply not enough water to flush the blue algae away. (department city water & sewage systems, personal communication, April 4, 2019).

Tiles that shoot up

As a consequence of a long dry period, the underground will become dry. The moisture in the underground during a dry period is gone. Tiles will come loose from the foundation because dry sand is moving easier than wet sand. Loose tiles cause dangerous situations for cyclists and walkers. (department roads and civil works, personal communication, February 26, 2019).

Low water level in ponds

A dry period cause evaporation of water in ponds. The evaporation is bigger than the amount of water that will be added. As there is not enough supply of water via rivers/canals or precipitation. More water will go out than water is coming in which can cause a low water level in ponds. This is the cause of an underground that do not hold the water properly. (department city water & sewage systems, personal communication, April 4, 2019).

Public green

As a consequence of a long dry period public green died. Public green is searching for moisture in the underground which is not available. Roots will shoot up and more weeds will grow back when it start to rain. (department public green, personal communication, March 7, 2019).

Smelling wells

Smelling wells are caused by a dry sewage system. During a dry period it is hard to prevent this effect as we do not want to flush water the whole time through a dry sewage system. (department city water & sewage systems, personal communication, April 4, 2019).

Botulism

Botulism is caused by toxins. This is produced by a bacteria. Botulism is mostly caused by dead fish and water birds, via swimming water it is possible that people will get affected by it (Rijksinstituut voor Volksgezondheid en Milieu, 2018). Botulism is acting as best when; water temperature is between 20 and 25 degrees Celsius, less oxygen is available and enough proteins are available. During a dry period, in average the water temperatures are increasing, which will results in a lower water level and less

oxygens available for fish. Consequently it will lead to more dead fish, which provide proteins for the botulism bacteria to grow (clostridium botulinum). So during a dry period, the botulism bacteria get perfect conditions to grow (Venhuizen, 2018).

House subsidence caused cracks

This effect came up for discussion during the focus group with the fieldworkers on April 3, 2019 at Sportpark de Beek in Halsteren. They said “We got some notifications of house subsidence which caused cracks. This can probably be an effect of the dry period”. A dry period will cause expansion and shrinkage in the walls which can lead to a crack (Eigenhuis, n.d.). The underground can also play a role because the underground is sand. Dry sand will move easier than wet sand. (department roads and civil works, personal communication, February 26, 2019).

In table 8 is a summary of the of the causes of the experienced effects made divided by layer.

	Occupation	Network	Underground
Blue algae		x	x
Tiles that shoot up			x
Low water level in ponds			x
Public green			x
Smelling wells		x	
Botulism	x		
House subsidence caused cracks			x

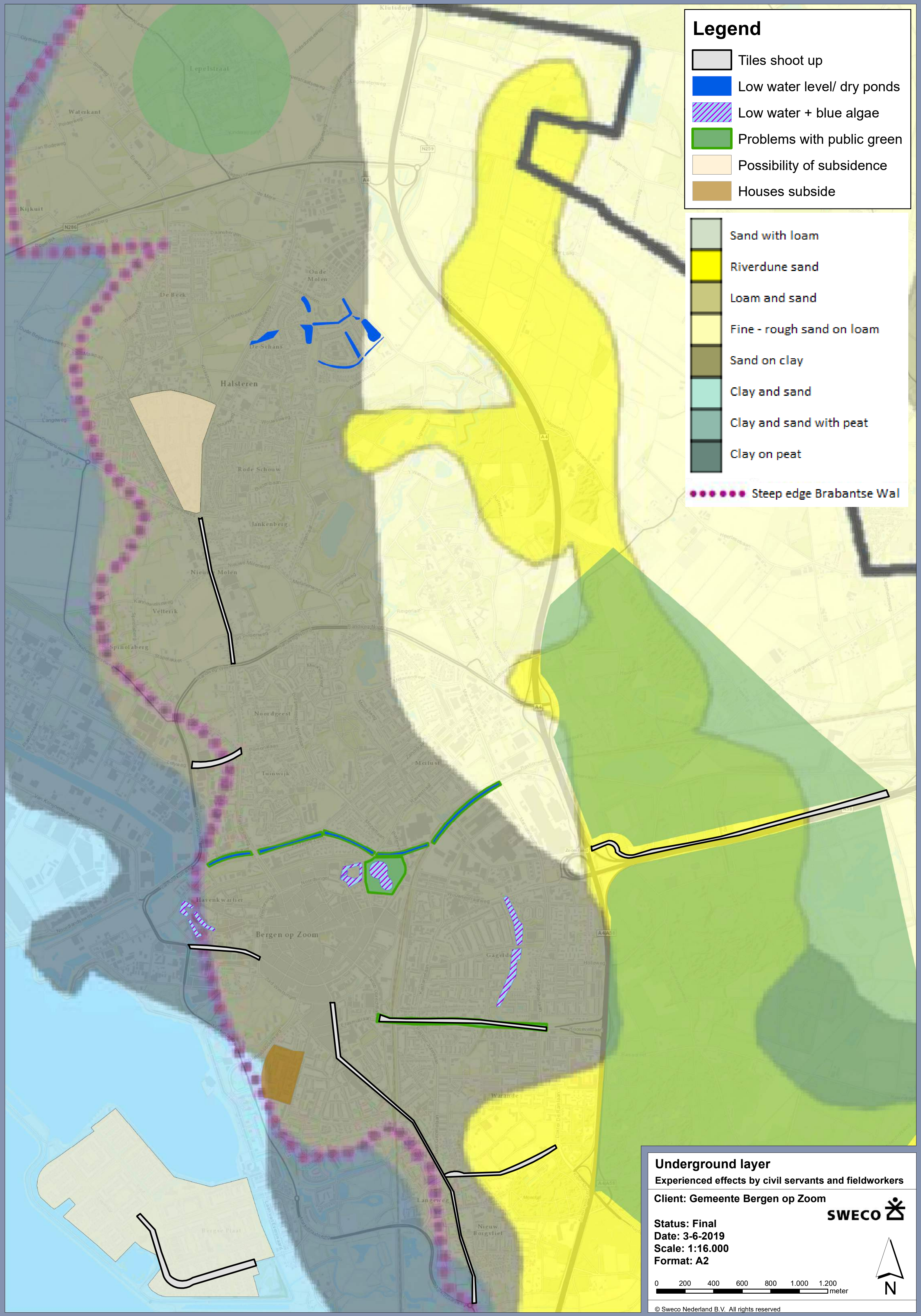
Table 8. Experienced effects divided by layer where the effect is caused.

4.4.2 Layer approach and the locations

This paragraph shows the experienced effects of the stakeholders and their relation with the layer the effect was coming from. As it was not clear for the municipality where the locations of **smelling wells** and **botulism** are, were this effects not worked out in this paragraph. The effects experienced were visible and part of the occupation layer, as this is the layer of living, working, recreation and perception. However, the occupation layer is already worked out in ‘4.3 Locations of the effects’.

Underground layer

This layer shows the underground with the experienced effects.



Legend

- Tiles shoot up
- Low water level/ dry ponds
- Low water + blue algae
- Problems with public green
- Possibility of subsidence
- Houses subside

- Sand with loam
- Riverdune sand
- Loam and sand
- Fine - rough sand on loam
- Sand on clay
- Clay and sand
- Clay and sand with peat
- Clay on peat

Steep edge Brabantse Wal

Underground layer

Experienced effects by civil servants and fieldworkers

Client: Gemeente Bergen op Zoom

Status: Final
Date: 3-6-2019
Scale: 1:16.000
Format: A2

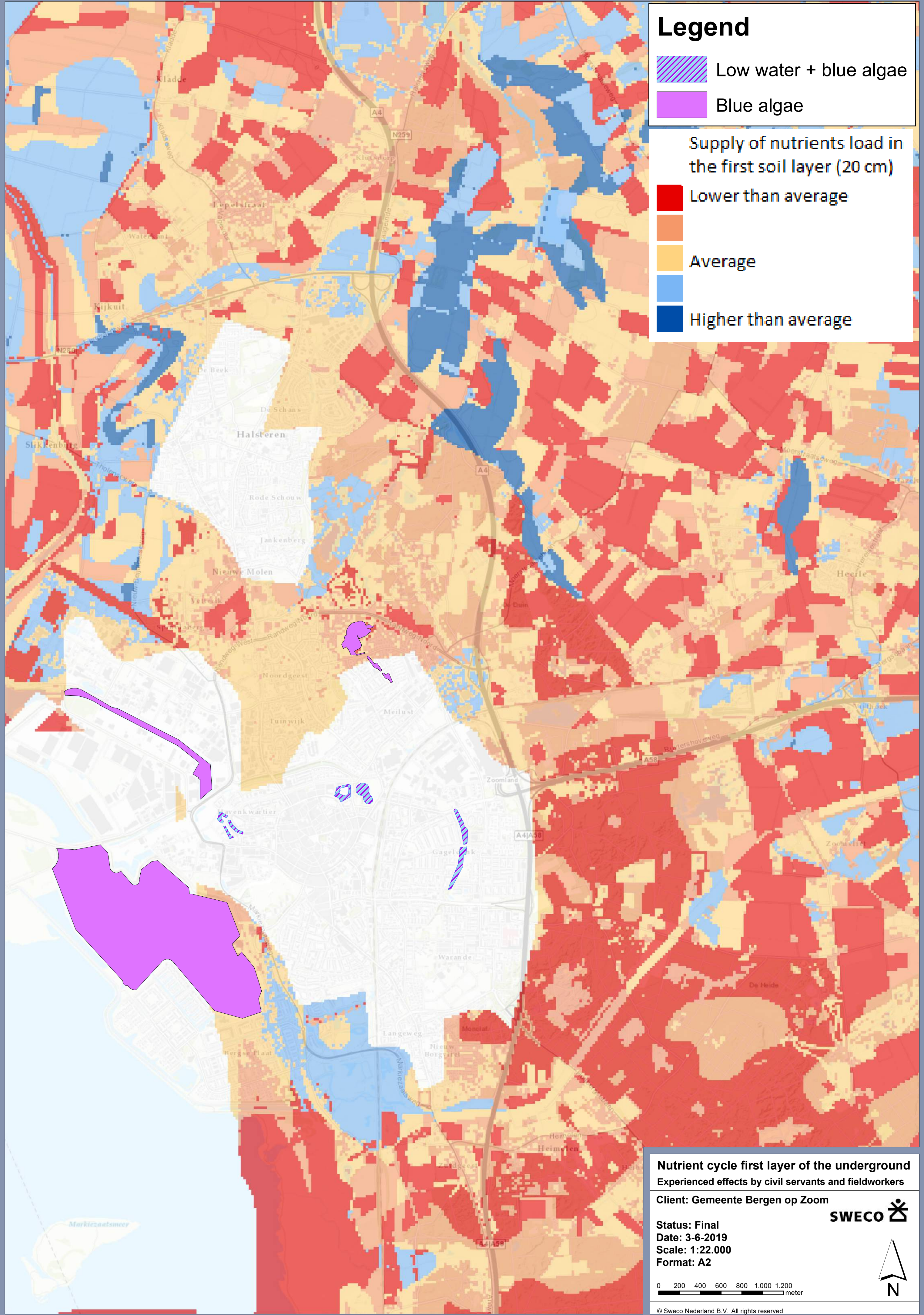
SWECO

0 200 400 600 800 1.000 1.200 meter

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Underground/ network layer

Blue algae is caused by a load of nutrients in the form of nitrogen and phosphorus. The load mainly comes from agriculture, settlements, industry and septic systems. This ends up in the underground (underground layer) or it can be transported via rivers and canals (network layer).



4.5 Measures available

To deal with a dry period, water need to be stored and buffered at an earlier stage. Different measures are available which can solve the effects experienced. These measures can be implemented directly or can be used as a guideline during new developments. In addition, measures are given regarding the communication within the municipality.

4.5.1 Measures when designing developments

Climate adaptation is an overarching principle to make the Netherlands climate proof as more departments of the municipality must sit together to deal with effects of drought. Climate change is an uncertainty (Hallegatte & Dumas, n.d.), this is the reason that the measures described will be at any time worthwhile to implement, this are the so called 'no regret' measures. The measures will improve the climate ability of an area while at the same time, it will increase the liveability of the area. The measures can be implemented directly as they can also be implemented by new projects.

As described in chapter '4.4 Causes of the effects' are the effects caused by a shortage of water. Drought is defined as "a decrease of water availability in a particular period and over a particular area" (Tate & Gustard, 2000). Department leisure economy – water and climate adaptation, said during an interview on February 2, 2019: "We destroyed the natural balance in the Netherlands. We did this because we build everywhere, because of this we destroyed the 'sponge' capacity of the underground. We do not hold the water long enough. Causes for this are that we discharge the water quickly and in cities the water is not able to infiltrate in the underground anymore.". During the interviews it became clear that water need to be stored in an earlier stage to deal with a dry period and that the sponge capacity of the underground need to be restored. If water is buffered earlier and infiltrated in the underground, the dry period can cause less effects because water is available. This paragraph will give inspirations of how water can be stored in an earlier stage or in what way the sponge capacity of the underground can come back.

Table 9 gives an overview of possible measures which can be taken when designing new districts or when developments within the municipality occur. These measures can replace old structures or give an idea of what can be done while making a plan for new developments. An overview with inspirations of the possible measures can be found in 'Appendix 16: Impressions possible measures'.

Measure	Will help	Solves
Swapping tiles for green by inhabitants	Make people aware that they can get subsidy. Infiltration of water will improve the sponge capacity of the underground (Gemeente Rijswijk, n.d.).	Tiles that shoot up Public green
Storage of water via rain barrels	Water buffer during dry periods, inhabitants do not need to use drinking water or water from ditches (City of Berkeley, n.d.).	Public green
Subsidy for green by industry	Giving subsidy if companies implement green. More green will result in better infiltration which will improve the sponge capacity (Borges, 2013).	Public green
Climate proof guidelines for every new developments	Every type of climate change problem. Guidelines can be set up by constructing new districts as guidelines can be set up for the industrial area (Rovers, Bosch, Albers, & van Hove, 2015).	Tiles that shoot up Public green Low water level in ponds

		Blue algae Botulism House subsidence
'Disconnect coach'	Giving advice to inhabitants to disconnect their pipes where possible. Some inhabitants want to disconnect but simply do not know how to do it. It will bring back the sponge capacity for the underground (Gemeente Renkum, n.d.).	Tiles that shoot up Public green
Porous paving materials	Types of materials that infiltrate slowly in the underground which is better for the sponge capacity (Urban Green-Blue Grids, n.d.).	Tiles that shoot up Public green
Wadi	Water storage/buffering, the water will infiltrate slowly in the underground (Gemeente Bladel, n.d.).	Public green
Infiltration crates	Water storage/buffering under the ground (BPO, n.d.).	Tiles that shoot up
Bioswales	Infiltration of water will improve the sponge capacity (Lotann, n.d.).	Public green
Car parking's with green	Infiltration of water will improve the sponge capacity.	Public green Tiles that shoot up
Rainwater ponds/tanks without fish	Water storage/buffer, when needed, water can be used.	Low water level in ponds Public green
Infiltration and transport sewage system	Infiltration of water will improve the sponge capacity (PVC, n.d.).	Public green Tiles that shoot up
Rainwater storage where possible (for example, below sport fields)	Water storage/buffering (Pearl-kb, 2016).	
Closing sluices in canals/ ditches	Water storage/buffering (Waterschap De Dommel, 2019).	Blue algae Low water level in ponds
Green able to absorb water and handle dry summers	Drought tolerance. Public green is able to survive a dry period.	Public green Tiles that shoot up
Tile tax	Removing tiles. More sponge capacity of the underground.	Tiles that shoot up Public green
Different types of trees	Some of them might survive the dry period, some not. When having different types of trees, not all of them will die at the same time from the same effect.	Public green

Table 9. Possible measures when designing developments.

4.5.2 Other measures

During the interviews it became clear that the interviewees are seeing communication as an attention point. Improving the communication will help the municipality to not miss out opportunities and make employees aware of climate adaptation. In this paragraph, a communication method is described which can be for use for the municipality. In addition, it is important to communicate to the inhabitants, so different ways of communication to the inhabitants will be enhanced as well.

Communicating within the municipality

During a dry period, communication is essential to get through this period and to get to know what every department is doing. The called 'bottom up' approach can be for use during such a period. By a bottom-up approach need the management (municipality case; managers) to listen and not only send information. The employees closer by the work process and problems (municipality case; the fieldworkers) mostly know how the problem can be handled. From these people you get; information of the problem, ideas about the way to solve the problem and feedback on the communication way. Bottom-up approach is about security, the management need to be able to listen and the fieldworkers need to talk. In addition, diagonal communication can be used. This type of communication is crossing the organogram in different levels. This is on the one hand on hierarchy division and on the other hand on task specific divisions. In this way, different departments from different hierarchy levels are able to communicate to each other (Nelemans, 2017).

Communicating to inhabitants

When involving inhabitants a broad used concept is citizen participation. Citizen participation is a form of active citizenship. By citizen participation there is a relationship between the governmental body and the citizens. Citizen participation is indispensable by bringing the municipality on the right way. What is the municipality doing well and what can be improved? Inhabitants are having the knowledge and experiences about their living area. Optimal using the knowledge, experiences and creativity of inhabitants will cause in a better maintenance and execution. There are different ways of participation in which the inhabitant can be involved. In figure 6 are the different ways of participation described in the 'participation ladder' (Steenvoordenoord).

The lowest step is important when designing a new district. Citizens need to be informed where the functions of the public space are for. With the step consult the municipality is showing their plans to citizens and is asking for feedback, the feedback is not necessary to take into account. In the third step giving advice, is the inhabitant acting as an advisor on the ideas of the municipality. By co-produce is the inhabitant co-decision maker within the boundaries of the assignment/project. On the top of the ladder, the citizen is the initiator for a specific assignment/project (Steenvoordenoord).



Figure 6. 'Participation ladder'. Source: (Steenvoordenoord)

5. Conclusion

In this research is searched for an answer on the question; ***What are the drought effects on the urban area of the municipality of Bergen op Zoom, in order to undertake measures to deal with the effects in the nearby future?*** For this a qualitative and quantitative research is executed which will show the experienced problems and possibilities on the topic drought for the municipality of Bergen op Zoom.

Stakeholders experienced effects

A majority experienced effects of droughts. Seven interviewees and the fieldworkers of the focus group experienced effects of droughts. The effects experienced of droughts were **blue algae**, **low water level in ponds**, **dying public green**, tiles that shoot up, **smelling wells**, **botulism** and **subsidence**. This shows the municipality was overlooking effects. The climate stress test did not describe the following effects; infrastructure effects, smelling wells and botulism. During the dry period it was hard to minimize the effects. The stakeholders tried to do so, however, there was not enough water available. The interviewees which experienced effects showed their interest in the drought problem (for their working field) by giving in average high grades (based on a scale 1-10). In addition, most of them said that attention points for the future are better communication, implementing more green and doing more on citizen participation.

Inhabitants experienced effects

A majority (85%) of the surveyed said that they know about the drought problematic in the Netherlands. 61% (majority) of the inhabitants experienced effects during the dry period of 2018. During this period, the most experienced effects were **low water level in ponds**, **damage to public green** and **damage to infrastructure**. There is a difference in the amount of experienced effects per districts. In the city centre (most of the houses built before 1971), with almost no green and water, experienced 35% (minority) an effect. While the relatively new districts (most of the houses built after 1971 and 2001) with more public green and water, Bergse Plaat and De Schans experienced 75% and 95% (majority) an effect. A minority (36%) of the districts experienced drought on their private terrain. **Damage to public green** is the most mentioned effect the inhabitants experienced on their private terrain. The inhabitants do not expect much of the municipality, a minority (47%) expects the municipality to solve the effects. Furthermore, 4% of the surveyed knows the municipality did something to solve the effects. These results shows that inhabitants are not aware about the activities of the municipality.

Location of the effects

The effects experienced were mapped. Effects are visible over the whole municipality. However, differences can be seen between the experienced effects of civil servants, fieldworkers and inhabitants. Civil servants noted less effects than the fieldworkers. While fieldworkers saw **subsidence** and noted possible areas of subsidence. Yet fieldworkers saw less **blue algae**. Inhabitants only noted visible effects (naked eye) in the public area, **damage to public green**, **low water level**. Some of them experienced **damage to infrastructure**.

Causes of the effects

During the causal analysis based on the layer approach, is found out that most of the effects are caused by an effect in the underground. Most of the effects occurred on the east side of the Brabantse Wal, this is the sand layer in Bergen op Zoom. On the west side of the Brabantse Wal is clay, less happened

in this area. The effects in the sand area are caused by dry sand. Dry sand is moving easier than wet sand. This can cause damage to infrastructure and subsidence. In addition, sandy ground is already having a low groundwater level because the water can infiltrate easily. During a dry period the groundwater level will decrease more, this can cause the effects as well. While blue algae may have been caused by a surplus of nutrients load in the network layer. On the map are some spots visible which shows that there is a higher than average surplus of nutrients in the first soil layer (20 cm).

Measures available

The municipality can take several measures to deal with the experienced effects. Spatial measures are focussing on buffering water in an earlier stage, water need to be buffered and stored in order to have water available during a dry period. This was the biggest problem in the summer of 2018. During this period, not enough water was buffered which resulted in the effects. In addition, other measures which are available for the municipality is to focus more on communication during a dry period. This were possibilities the municipality was overlooking and came as an attention point during the interviews. A better communication can results in less effects occurring. The municipality can use a bottom-up and diagonal communication approach. The effects occurred are mostly the results of a dry underground layer. This shows that more disciplines must work together as the effects are caused by the same layer. Moreover, more communication to inhabitants is possible. The surveys concluded that inhabitants have a lack of knowledge about functions in the public space (i.e. wadi's in De Schans). Or they do not know if the municipality is doing something. The participation ladder can be used to get to know what kind of communication form need to be used.

What are the drought effects on the urban area of the municipality of Bergen op Zoom, in order to undertake measures to deal with the effects in the nearby future?

Drought is for the municipality when there is a water shortage. A water shortage depends on the decrease in 'normal' ground water levels and surface water levels. If this decreases over a longer period, a dry period can be the consequence. Dry periods will cause blue algae, low water level in ponds, dying public green, tiles that shoot up, smelling wells, botulism and subsidence. This research shows the municipality is having different ways to deal with the experienced drought effects. For these effects spatial measures can be used. The municipality should focus more on storing water in an earlier stage and bringing water back in the underground. The most important measures for this are to remove tiles, buffer water and placing back public green. Moreover, the research displays that the municipality should focus on the bottom-up and diagonal communication methods.

6. Discussion

In this chapter are the results interpreted and the limitations described. The research is evaluated and a critical review of the used methods and results is given. In this research different methods were used to get to know if the municipality is overlooking problems and possibilities. To do so, interviews, a focus group and a survey is done with stakeholders and inhabitants.

6.1 Validity

The interviews were carried out with 11 stakeholders. The stakeholders interviewed are aware of the drought problematic and know what the definition drought means. This is so, as the stakeholders interviewed were selected on criteria which are based on the research scope. The questions during the interviews were asked in such a way that the researcher will get the answer it is looking for. The validity of the questions increased when the questions were tested and checked by the supervisors of the researcher. A stuck interview scheme was used and the interviews were carried out under the same circumstances (without other people and in separate rooms). By a repetition of this method, the interviewees will say the same which will give the same results. This makes the results of the interviews valid.

A focus group is done with 8 team leaders of the fieldwork department. During the focus group it is possible that people gave 'socially correct' answers. As there were colleagues and the head of the department present. The researcher tried to keep it central and let everyone speak and give their answers and views on the research topic. This method is not valid because of the possibility that people gave 'socially correct' answers. However, this method is trustable as the respondents will probably give the same answers when different researchers in the same circumstances carry out this method.

Surveys were carried out with 150 inhabitants. This is based on a sample of the population in 2018. The surveys were carried out in different districts which were selected on criteria. As the surveys were carried out face-to-face by the researcher and the inhabitant. The researcher was able to tell the definition of drought and the reason of the research. This made the surveyed aware about what drought is, this made their answers trustable. By a repetition of this method the surveyed will probably give the same answers. This made the method valid.

6.2 Results and expectations

The results of the interviews showed that 4 stakeholders did not experience an effect. This does not meet with the expectations. The expectations were that all the departments interviewed had something experienced. The expectations were more effects experienced and more problems with subsidence. By the question of attention points for the future had the researcher no expectations. It was good to see that the interviewees lighted almost the same attention points on communication, implementing more green and awareness among inhabitants. So it was possible to work this further out in the research. An explanation of the not expected results could be that Brolsma, et al. (2012) quoted much more effects of droughts. Moreover, Nationale Klimaatadaptatiestrategie (2016) came with a complete overview of effects, also positive effects. Positive effects were not lighted out during one of the interviews. A cause could be that people only remember negative effects, negative effects will be better remembered than positive effects.

The focus group with the fieldworkers did meet the expectations. The focus group provided more locations of experienced effects. It did meet the expectations as the researcher expected that interviewing people closer to the effect (as this is so by people working in the 'field') will lead to more results.

The experienced effects by inhabitants showed that **damage to green** and **low water level in ponds** were the most experienced effects. Moreover, a majority of the surveyed said that the municipality did not do something on the effects or they did not know what the municipality did. These results met the expectations, as it was expected that the inhabitants only see **damage to green** and **low water level** as an effect of drought. Moreover, it was expected that bad communication between the municipality and the inhabitants came as a result of the survey. It was expected as a consequence of the interviews, this made clear that the communication between the municipality and citizens is not well organized.

6.3 The results

The research is an addition on the existing literature for the municipality of Bergen op Zoom. As the existing literature is describing already the effects. The municipality did not know which departments experienced which effects and which attention points they had for the future. Moreover, the municipality had not clear how the inhabitants think about the topic and the municipality. The research made clear that the effects occurred are related to the same layer, this means the municipality can improve on internal communication.

Climate change is still an uncertainty that it will happen, so it is unsure if dry periods will happen more frequently. However there is a probability that it will happen more frequently (Hallegatte & Dumas, n.d.). This is the reason that the measures described are worthwhile at any time to implement. This shows that this research is worthwhile at any time. The results light something new and the measures which can be taken are worthwhile to implement.

6.4 Limitations and suggestions

Herby need to be taken into account that this study only focused on the urban area of Bergen op Zoom. It is possible that the rural area experienced different effects, another research could show this. More external parties will be involved, which can lead to new findings and possible communication strategies between the municipality and external parties about what to do during a dry period. In addition, the surveys were limited to five districts in the municipality. It is possible that surveys over the whole population of Bergen op Zoom will give extra or different results. Moreover, a limited underground map was available which could have an influence on the result. An expansion and improvement of the underground map will probably result in better conclusions.

Despite the promising results, questions remain. A similar follow-up research can be carried out to get to know the experiences in the rural area. Further, other districts can be surveyed to get to know which effects inhabitants of other districts experienced. Moreover, a better underground map can be made which will make the causes of the effects clearer. In addition, the 'CELCIUS tool' of Sweco can be used which to research the relation of costs, effects and damage of droughts if adaptation measures are not taken by the municipality.

7. Recommendations

In this chapter, an advise will be given to the client. How they can improve their climate ability and how to continue with the results. During the research it became clear that the municipality of Bergen op Zoom had drought effects last summer. The research made visible which effects were experienced by which departments. In addition, it appears that the municipality is overlooking other problems, it became clear that there are improvements possible on communication.

7.1 Communication

7.1.1 When is action needed?

As an advise during a dry period it is necessary to communicate. To get to know when the municipality is facing drought, they need to know or monitor the groundwater and surface water levels¹. This information need to be up-to-date and known when the levels are decreasing. The municipality will then know if they are going to face a dry period. This data need to be compared to the data of the summer of 2018 (extreme dry year) and the data of the standard water levels. A responsible person (drought coordinator municipality) need to be selected. By preference not a person from the department 'Maintenance & Advice'. This person need to control the surface- and groundwater levels of the urban area regularly (depending on the situation how many). This information need to be compared with the water levels mentioned in an earlier stage. By controlling this and knowing the weather forecast, actions can be undertaken in an earlier stage. Water can be buffered, stakeholders and inhabitants can be made aware. From this moment, the municipality can handle more efficient.

When the data of water levels is not available, the departments need to be informed when one department had a drought effect. The drought coordinator should take the lead and inform the other departments and Waterboard Brabantse Delta. From this moment the departments should work together and dates for meetings need to be scheduled. By discussing together what to do during the dry period, the municipality can handle the dry period more efficient.

7.1.2 What to do when it is a dry period?

If the municipality is facing a dry period, the essential thing to do is communicating. When the drought coordinator of the municipality is saying a dry period will come, bottom-up and diagonal communication can be used (explanation see '4.5.2 Other measures').

The first thing that need to be done is the drought coordinator of the municipality need to communicate with Waterboard Brabantse Delta. The Waterboard is also having a 'drought coordinator'. This person knows exactly what is going on and how effects of droughts can be minimized. An important topic to discuss is where water needs to come from and what the locations of possible water withdrawal are.

The second step that needs to be done is that departments need to work together. Department 'public green', 'City water and sewage system' and 'Roads and civil works' need to discuss together how they are going to deal with the dry period. All of them experienced effects in the summer of 2018. They probably are going to face these effects again. Work and discuss together how every department is going to operate and deal with the dry period. Where water is available and where not, where is a

¹ Based on a scenario that the data of groundwater and surface water levels are weekly available

bigger potential of dying public green, what are the consequences of this for the surface water. More root shoot up, what are the consequences for this on the roads.

The third thing that needs to be done is organizing a meeting with the department 'Maintenance & Advice' (department 'roads and civil works', 'public green', and 'city water and sewage system'.) and the 'Managers of the fieldwork department'. In this meeting, the drought coordinator should take the lead. Weak locations will be discussed based on the maps in '4.3 Locations of the effects'. All the departments should deal with their own responsibilities. However as they are dealing with the effects caused in the same underground layer they need to cooperate, they should discuss how each other is dealing with the effect. The fieldworkers should give regular updates to the drought coordinator, as the drought coordinator should note the updates. Communicate this locations regularly with the specific department responsible for this. Later on, create a new overview and compare this overview with the overviews of previous year(s). The different departments should note their extra costs made during this period. Do not only think about costs in money, but also costs in effort.

The last but not least, communication to the inhabitant should be done. This should be done by the drought coordinator. The inhabitant also experienced effects, this is the reason that they need to know what the municipality is doing. Communicate in the local newspaper, website and on social media what the municipality is doing and what not. In what way the municipality need to communicate to outside need to be discussed with the communication department.

7.1.3 What to do after the dry period?

The dry period is over depending on the water levels. After the dry period it is important to come together once again ('Maintenance & Advice' and 'Managers of the fieldwork department'). The drought coordinator should organize this meeting. Evaluate what went well and what went wrong. The drought coordinator should note this. In addition, it should present the map which is made of the locations of the effects. Further, an overview of the extra costs made will be discussed. It is important to get to know if extra costs were made or not. The amount of damage need to be decided and how to recover from the dry period. Department public green should decide which vegetation need to be removed. Important in this case is when the department is deciding the vegetation is dead and needs to be replaced. By replacing, use other type of vegetation which can withstand dry periods.

Following this recommendations will lead to a more efficiency during a dry period. People will not only act in their 'tunnel vision' but they see that cooperation is essential. The recommendation will lead to less effects and problems as it will be known when a dry period is coming.

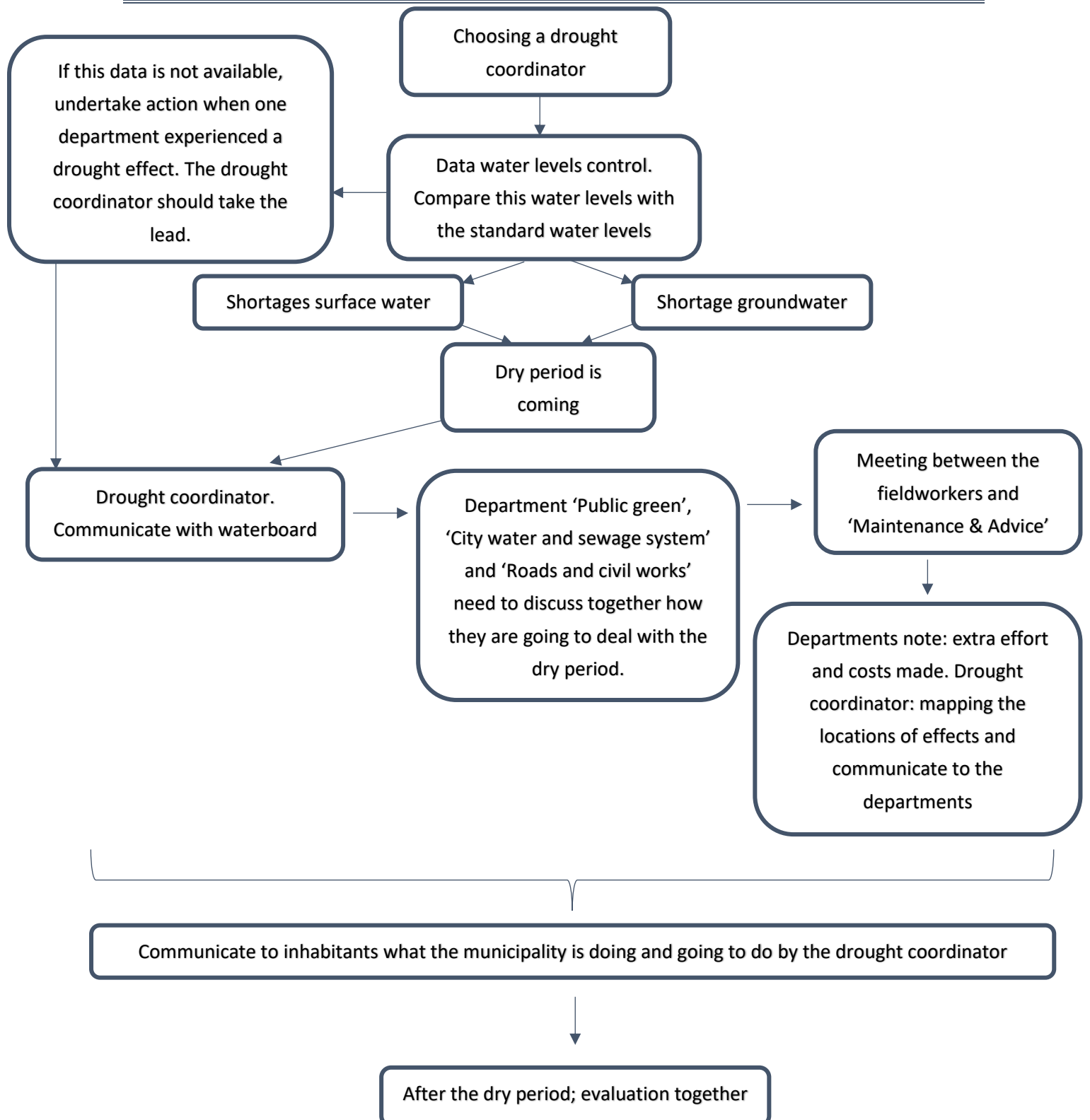
7.2 New developments

During new developments departments 'Leisure economy', 'Roads and civil works', 'Public green', 'Cables and pipes' and 'City water and sewage system' should discuss together about how to arrange the area that need to be developed. In addition, the inhabitants can be of importance as well, this is the reason to use the participation ladder (described in '4.5.2 Other measures'). As it is difficult to let all the departments sit together on a specific date. Can a document be used where the plans made need to be added to. The document need to be checked by the different departments. The departments need to sign this document if agreed with the plan, if not leave comments or discuss this with the plan makers. Moreover, department 'City water and sewage system', 'Roads and civil works', and 'Public green' should cooperate more, because they have more in common than they might think.

Removing tiles for green (department 'Roads and civil works' and 'Public green') will lower the amount of water for the sewage system ('City water and sewage system').

The municipality should focus for every new development on the measures described in '4.5.1 Measures when designing developments' and 'Appendix 16: Impressions possible measures'. To deal with dry periods it is important to bring the sponge capacity of the underground back and to focus more on buffering water. If water is buffered earlier and infiltrated in the underground, the dry period can cause less effects because water is available. As these measures described are 'no regret' measures are they always worthwhile to implement. It will not only improve the climate ability but also the liveability of the area. During the process of new developments, Sweco can give advice of which measures can be for use.

7.3 Overview of the communication method



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Appendices

Appendix 1: Risk of drought stress

Drought stress according to the 'klimaateffectatlas' (Ruimtelijke adaptatie, 2019).

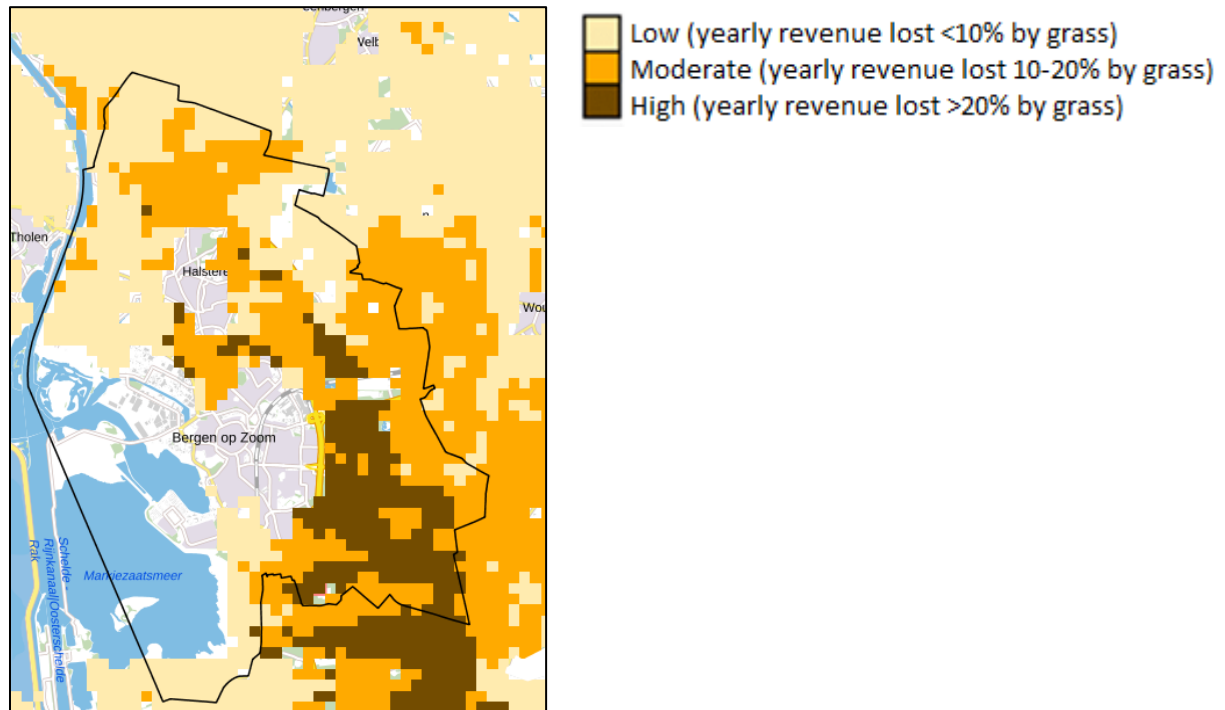


Figure 7. Risk of drought stress in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019).

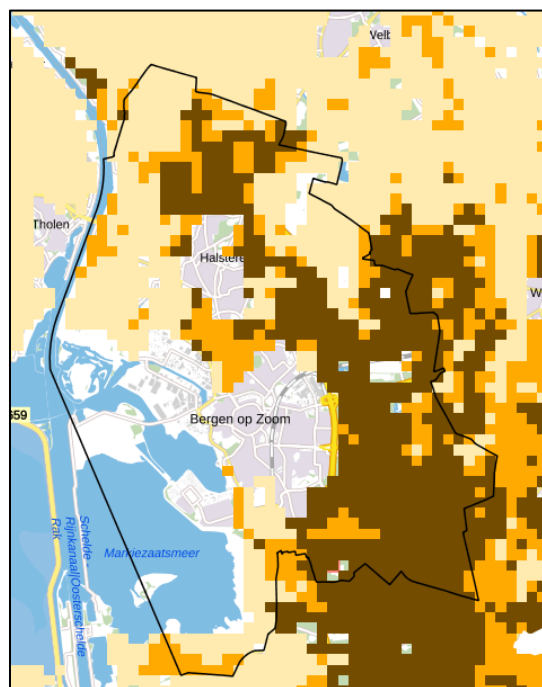


Figure 8. Risk of drought stress in 2050WH (Worst case scenario in 2050). Source: (Ruimtelijke adaptatie, 2019)

Appendix 2: Maximum potential of rain shortage (1:10 years)

Maximum potential shortage of rain once in ten years according to the 'klimaateffectatlas' (Ruimtelijke adaptatie, 2019).

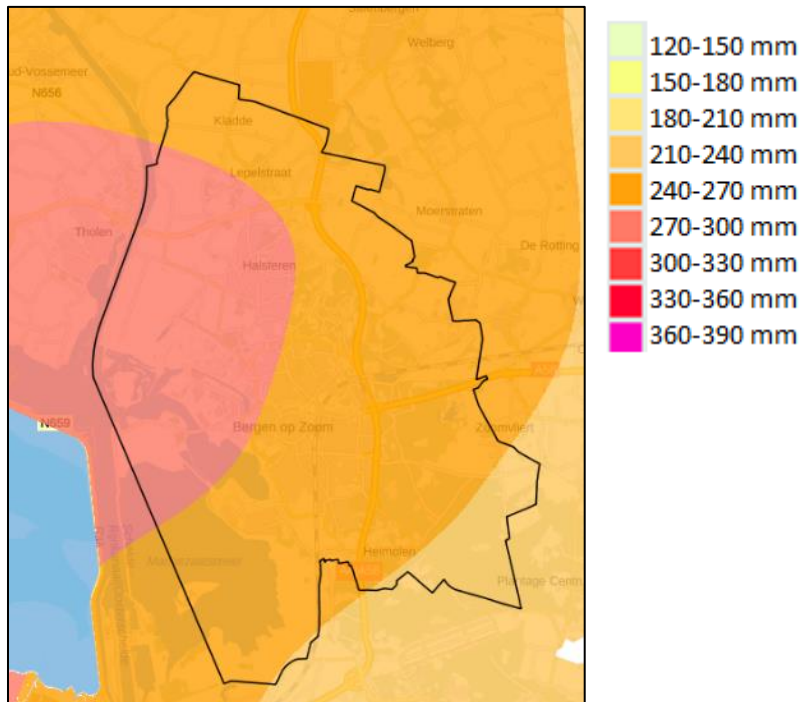


Figure 9. Maximum potential of rain shortage (1:10 years) in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019)

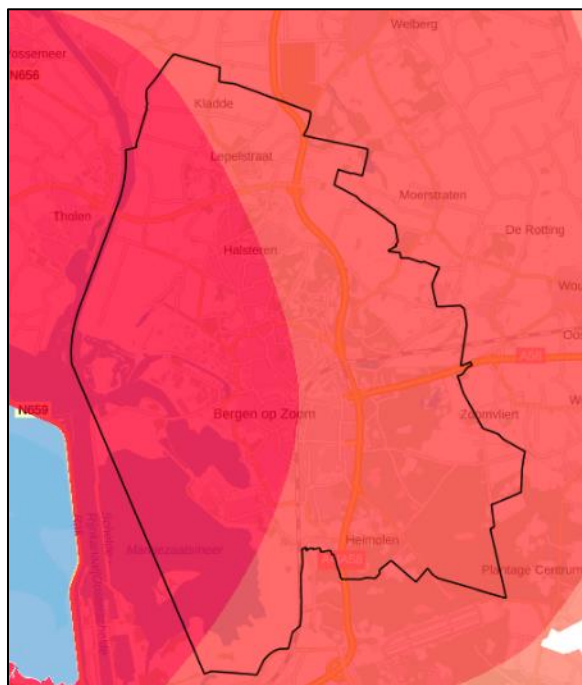


Figure 10. Maximum potential of rain shortage (1:10 years) in 2050WH (Worst case scenario in 2050). Source: (Ruimtelijke adaptatie, 2019)

Appendix 3: Maximum potential of rain shortage (average)

Maximum potential of rain shortage in average, according to the 'klimaat-effectatlas' (Ruimtelijke adaptatie, 2019).

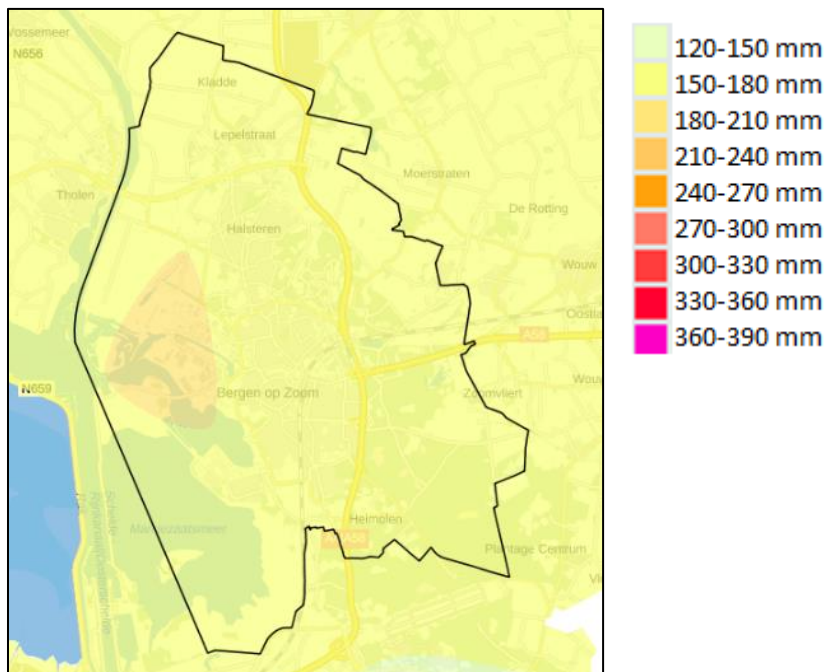


Figure 11. Maximum potential of rain shortage (average) in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019)

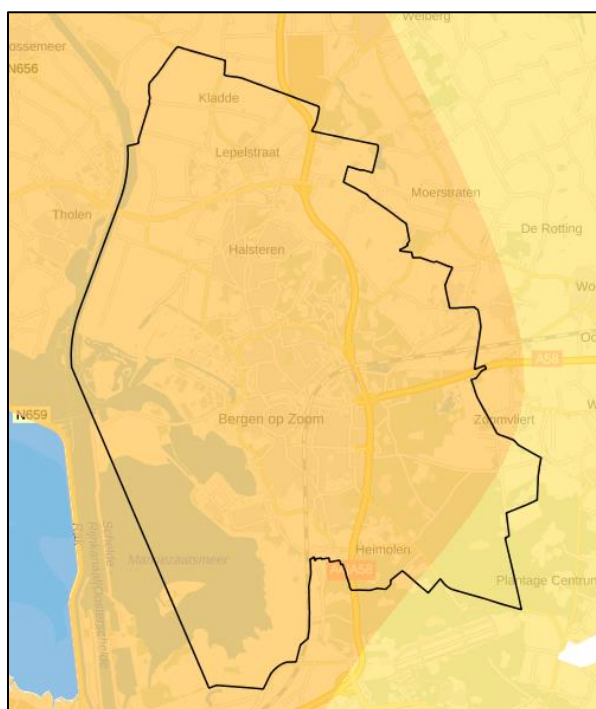


Figure 12. Maximum potential of rain shortage (average) in 2050WH (worst case scenario). Source: (Ruimtelijke adaptatie, 2019)

Appendix 4: Rain in the summer

The amount of rain in the summer period according to the 'klimaat-effectatlas' (Ruimtelijke adaptatie, 2019).

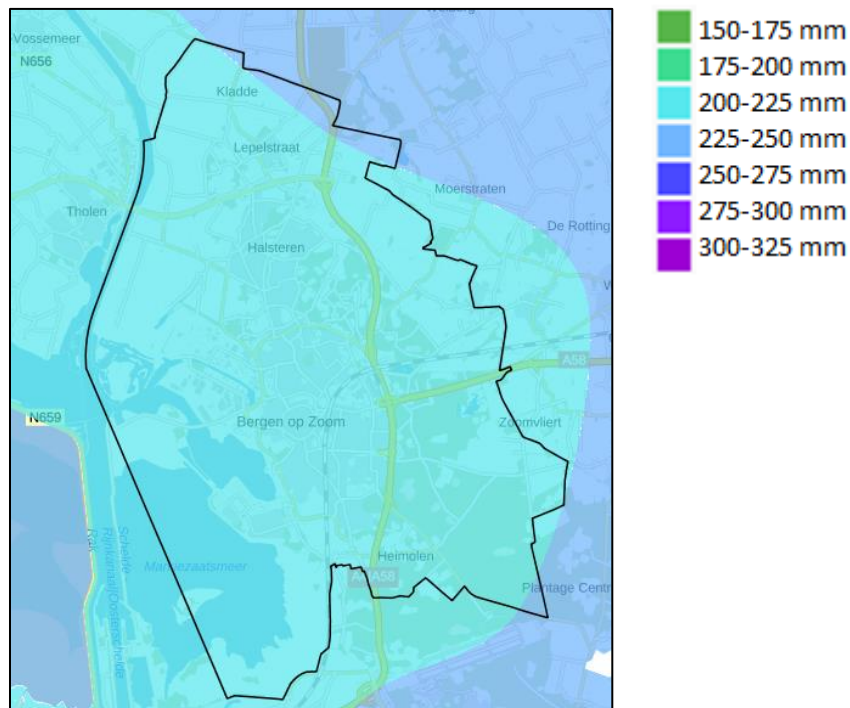


Figure 13. The amount of rain in the summer in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019).

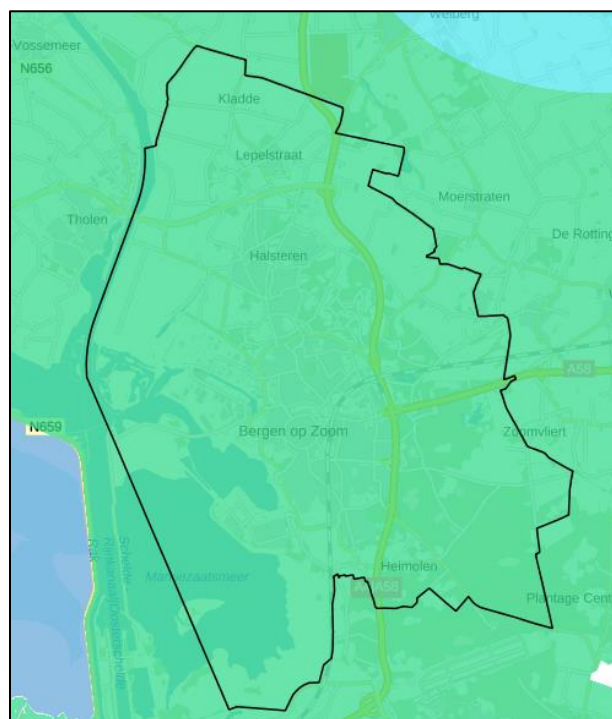


Figure 14. The amount of rain in the summer in 2050WH (worst case scenario). Source: (Ruimtelijke adaptatie, 2019)

Appendix 5: Yearly reference evaporation

The amount of yearly evaporation according to the 'klimaat-effectatlas' (Ruimtelijke adaptatie, 2019).

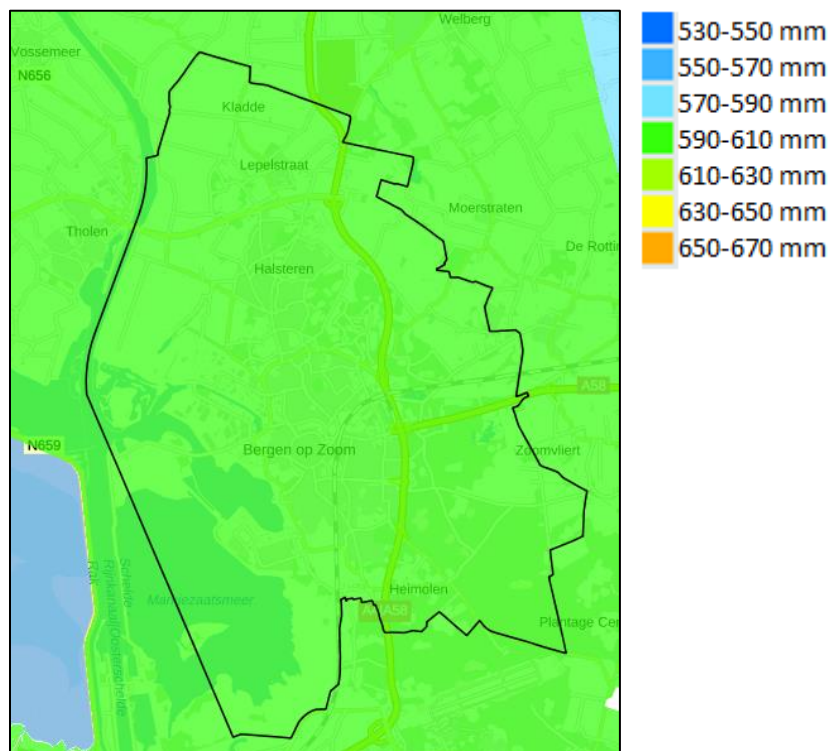


Figure 15. The amount of yearly evaporation in the current situation (2019). Source: (Ruimtelijke adaptatie, 2019)

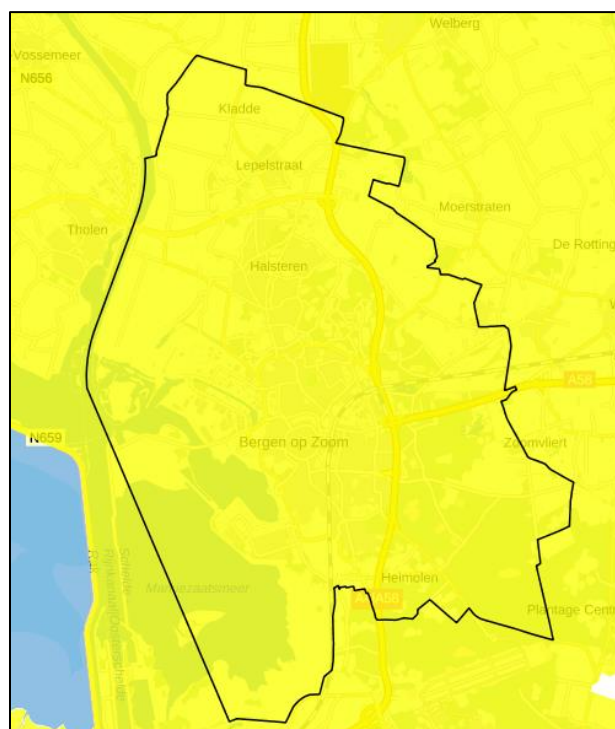


Figure 16. The amount of yearly evaporation in 2050WH (worst case scenario). Source: (Ruimtelijke adaptatie, 2019)

Appendix 6: Effects of droughts

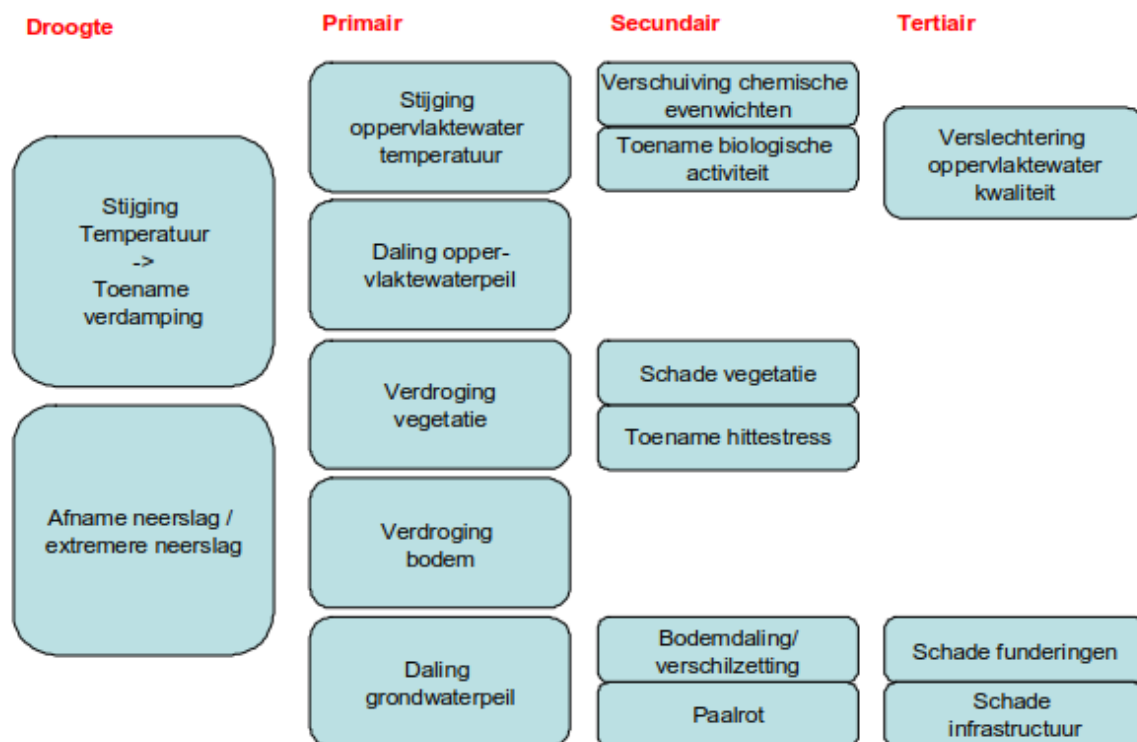
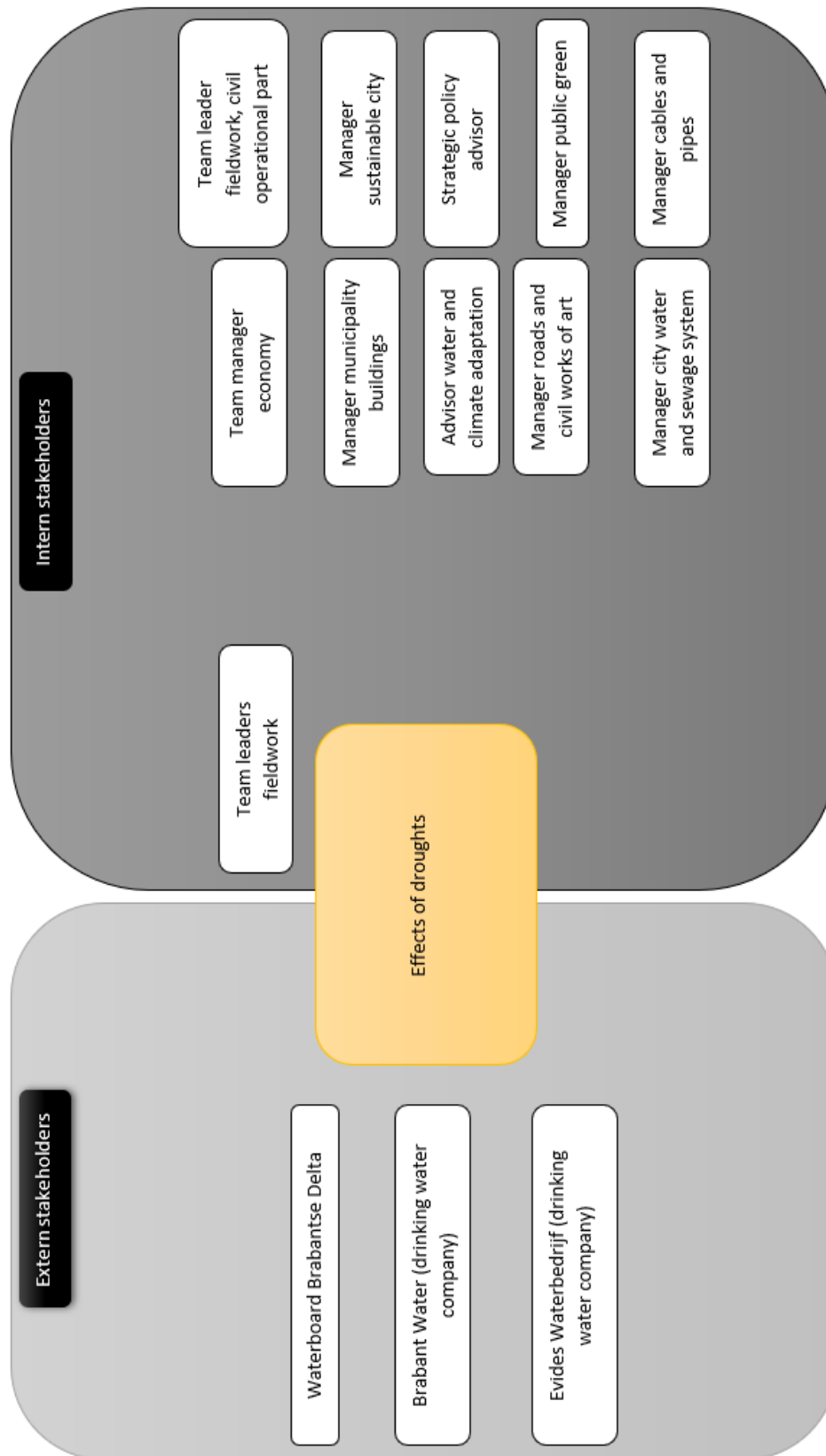


Figure 17. Effects of droughts. Source: (Brolsma, et al., 2012)



Appendix 7: Stakeholder analysis



Appendix 8: Overview interviews questions

Civil servants

Allereerst starten met een onderzoeken naar de achtergrond van de geïnterviewde. Deze informatie helpt om de context van de geïnterviewde te weten te komen.

- Waar bent u verantwoordelijk voor? Wat zijn uw taken binnen de gemeente?
- Wat zijn uw ervaren droogte effecten in 2018?
- Zijn deze effecten meer in vergelijking tot 2017?
- Wat zijn de locaties van deze effecten?
- Hoe weet u dat deze effecten zijn veroorzaakt door droogte?
- Heeft u gegevens van de antwoorden die u geeft over de problematiek?
- Wat zijn attentie punten/gebieden om aandacht aan te besteden met betrekking tot droogte?
- Is er iets gedaan om de effecten te minimaliseren?
- Wat is in uw ogen een oplossing voor de genoemde effecten?
- Wat is in uw vakgebied de interesse, gebaseerd op een schaal van 1 tot 10, voor de droogte problematiek?
- Wat denkt u over de toekomst? Dat uw interesse voor droogte groter is? Gebaseerd op een schaal van 1 tot 10.
- Welke afdelingen binnen de gemeente zijn bewust van de droogte problematiek en welke niet?
- In hoeverre wordt er samengewerkt op het onderwerp klimaatadaptatie binnen de gemeente?
- Zijn er dingen die ik ben vergeten te zeggen of heeft u nog interessante informatie?
- Heeft u interesse in een focus groep in mei 2019?

Gebaseerd op de context van de geïnterviewden, kunnen meer vragen gesteld worden die niet onderdeel uitmaken van dit format, maar wel nuttig kunnen zijn voor het onderzoek.

Overzicht dat gecreëerd wordt op basis van de interviews:

Stakeholder	Interest rate (1-10)	Problem(s)/ effects experienced	Attention points and/or areas	Effort to minimize effects

Waterboard Brabantse Delta

- Waar bent u verantwoordelijk voor? Wat zijn uw taken binnen Brabantse Delta?
- Wat zijn volgens u ervaren droogte effecten binnen Brabantse Delta, gemeente Bergen op Zoom in 2018?
- Zijn deze effecten meer ervaren dan in 2017? Wat zijn de locaties van deze effecten?
- Hoe kunt u aantonen dat deze effecten gerelateerd zijn tot droogte? Waren het niet gewoon incidenten?
- Waren de grondwater standen te laag? Waar? Onttrekking verboden? Zijn hier gegevens van?
- Zijn er gegevens van de huidige grondwater standen?
- Zijn er attentie punten/gebieden met betrekking tot droogte?
- Waren er stoffen gevonden in het water die er niet in thuishoorde?
- Waren er zorgen over de waterkwaliteit?
- Zijn er maatregelen genomen om de ervaren effecten van afgelopen jaar te minimaliseren? Zo ja, welke maatregelen en waar?
- Wat is in uw opzicht een oplossing voor de effecten?
- Moeten we wel maatregelen nemen? Dat extreme droogte vaker voor gaat komen weten we, moeten we hier iets aan doen, waarom?
- Op een schaal van 1 tot 10. In hoeverre speelt droogte op dit moment een rol in uw vakgebied. Waarom?
- Op een schaal van 1 tot 10. Wat wordt de interesse binnen uw vakgebied in de toekomst? Waarom?
- Wie kan hoofdzakelijk wat doen om de problemen met droogte tegen te gaan?
- Hoe gaat de samenwerking met andere externe partijen en gemeentes?
- Wie kan ik nog meer meenemen in mijn onderzoek?
- Zijn er dingen die misschien nog interessant zijn om in het onderzoek mee te nemen? Ben ik iets vergeten? Heeft u misschien nog andere nuttige informatie?
- Heeft u interesse in een focus groep in mei 2019?

Gebaseerd op de context van de geïnterviewden, kunnen meer vragen gesteld worden die niet onderdeel uitmaken van dit format, maar wel nuttig kunnen zijn voor het onderzoek.

Overzicht dat gecreëerd wordt op basis van de interviews:

Stakeholder	Interest rate (1-10)	Problem(s)/ effects experienced	Attention points and/or areas	Effort to minimize effects

Brabant Water (drinking water company)

- Waar bent u verantwoordelijk voor? Wat zijn uw taken binnen Brabant Water?
- Wat zijn volgens u ervaren droogte effecten binnen Brabant Water in 2018 of andere jaren?
- Zijn deze effecten meer ervaren dan in 2017? Wat zijn de locaties van deze effecten?
- Hoe kunt u aantonen dat deze effecten gerelateerd zijn tot droogte? Waren het niet gewoon incidenten?
- Waren de grondwater standen te laag waar Brabant Water water onttrekt? Waar precies?
- Waren er problemen met het water op de juiste temperatuur te houden? Dit kan misschien eerder gelinkt worden aan hitte?
- Wat waren attentie punten/gebieden?
- Waren er stoffen gevonden in het water die er niet in thuishoorde?
- Waren er zorgen over de waterkwaliteit?
- Zijn er maatregelen genomen om de ervaren effecten van afgelopen jaar te minimaliseren? Zo ja welke maatregelen en waar?
- Wat is in uw opzicht een oplossing voor de effecten?
- Moeten we wel maatregelen nemen? Dat extreme droogte vaker voor gaat komen weten we, moeten we hier iets aan doen, waarom?
- Op een schaal van 1 tot 10. In hoeverre speelt droogte op dit moment een rol in uw vakgebied. Waarom?
- Op een schaal van 1 tot 10. Wat wordt de interesse binnen uw vakgebied in de toekomst? Waarom?
- Wie kan hoofdzakelijk wat doen om de problemen met droogte tegen te gaan?
- Hoe gaat de samenwerking met externe partijen en gemeentes?
- Wie kan ik nog meer meenemen in mijn onderzoek?
- Zijn er dingen die misschien nog interessant zijn om in het onderzoek mee te nemen? Ben ik iets vergeten? Heeft u misschien nog andere nuttige informatie?
- Heeft u interesse in een focus groep in mei 2019?

Gebaseerd op de context van de geïnterviewden, kunnen meer vragen gesteld worden die niet onderdeel uitmaken van dit format, maar wel nuttig kunnen zijn voor het onderzoek.

Overzicht dat gecreëerd wordt op basis van de interviews:

Stakeholder	Interest rate (1-10)	Problem(s)/ effects experienced	Attention points and/or areas	Effort to minimize effects

Appendix 9: Survey

Enquête droogte problemen 2018 in gemeente Bergen op Zoom

Deel 1. Introductie

In de zomer van 2018 is droogte problematiek ervaren bij de gemeente Bergen op Zoom. De gemeente wilt hier meer over te weten komen en is een onderzoek over droogte problematiek gestart. Verschillen droogte en hitte: *Droogte: Langdurig watertekort. Hitte: Warme periode.*

Deel 2. Persoonlijke gegevens

Datum					
Straatnaam en wijk					
Leeftijd					
Samenstelling huishouden	1 persoons	2 persoons	3 - 4 persoons	≥ 5 persoons	
Koop / Huur	Koop		Huur coöperatief		Huur particulier
Type woning	Appartement	Portiek	Hoekwoning	Meer-ondereen-kap	Vrijstaand
Bouwperiode	< 1930	1930 - 1950	1950 -1970	1970-2000	> 2000

Deel 3. Vragen ervaren droogte problemen in 2018.

1. Bent u in het algemeen bewust van de droogte problematiek in Nederland?

Ja	Nee

2a. Heeft u afgelopen zomer droogte ervaren in uw buurt/straat?

Ja	Nee

2b. Indien **ja** ingevuld te hebben bij vraag **2a** (anders deze vraag openlaten). Wat heeft u ervaren?

Laag waterpeil vijvers/beekjes	Schade aan groen	Schade aan infrastructuur	Anders, namelijk....

2c. Antwoord ingevuld bij 2b. Wat is uw toelichting hierop? Wat voor soort schade/ effecten?

3a. Heeft u droogte ervaren op uw privé terrein?

Ja	Nee

3b. Indien **ja** ingevuld te hebben bij vraag **3a**. (anders deze vraag openlaten) Wat heeft u ervaren?

Schade aan groen	Scheurvorming in/aan uw huis	Verzakking van uw perceel	Anders, namelijk....

3c. Antwoord ingevuld bij 3b. Wat is uw toelichting hierop? Wat voor soort schade/ effecten?

Z.O.Z

4a. Verwacht u dat de gemeente de effecten oplost?

Ja	Nee

4b. Heeft de gemeente iets gedaan aan de genoemde effecten in vraag 2 en 3?

Ja	Nee	Misschien	Geen problemen ervaren

5. Heeft u iets gedaan aan de genoemde effecten in vraag 2 en 3?

Ja	Nee	Geen problemen ervaren

6. Kunt u de locatie(s) (straatnaam, kruising, gebied) benoemen waar effecten beschreven in vraag 2 en 3 ervaren zijn? Welke problemen zijn hier dan ervaren?

7. Overige aanmerkingen:

Appendix 10: Interviews civil servants

The results of the interviews are confidential and private information. As agreed with the interviewees will their names and a full written report of the interview not be published. The full written report is available and can be requested by the researcher.

Appendix 11: Interviews extern stakeholders

The results of the interviews are confidential and private information. As agreed with the interviewees will their names and a full written report of the interview not be published. The full written report is available and can be requested by the researcher.

Appendix 12: Summary interviews

Stakeholder	Interest rate (1-10)	Problem(s)/ effects experienced	Attention points and/or areas	Effort to minimize effects
Department municipality buildings	1	At this moment there are no drought effects on municipality buildings. There could be effects of droughts in the future, which can cause cracks in buildings. Another problem that can happen is that there is a water shortage and/or flooding's in public buildings.	Within four years they will know the attention points due to the multiannual plan. There are attention points in the way of communication on climate adaptation.	Multiannual plan, to know within four years which problems there are. To deal with the water shortage problems. A basin can be implemented in houses and old buildings that are having drought/flood problems.
Department leisure economy - Advisor water and climate adaptation	5	More blue algae and botulism. Blue algae in Vijverberg, Binnenschelde, Ganzenvijver and the Kleine Melanen, compared to other years.	Seeing more relations between drought and heat. Implementing more green will cause more evaporation which cause a cooling effect. The ground will not dry out quickly, because the 'sponge' effect will return. In the field of climate adaption, 'turn on more buttons' instead of just one.	Kleine Melanen; Dredging, nature friendly shores, removing high vegetation. Ganzenvijver; removing high vegetation.
Department roads and civil works	8	Tiles in cycle paths shoot up as an effect of a dry underground layer locations: Ruytershovenweg, Rooseveltlaan, Olympialaan and Antwerpsestraatweg. This happened more than in 2017. Problems with wooden bridges, accelerated wear.	For the wooden bridges are the attention points to use other materials than wood (fiber glass, composite and recycled plastics). For the cycle paths is mainly the focus on placing asphalt.	Spraying water on the tiles. Removing tiles for asphalt. More maintenance for wooden bridges.
Department fieldwork, team leader operational part	8	Wadi's (at the Schans) got dry, while fishes were swimming in the wadi's. Different pounds were having a lower water level (or where dry) Vijverberg, Anton van Duinkerkenpark and the Ravelijn. Floor tiles in cycle paths (Halsterseweg and Ruytershovenweg) shoot up as an effect of a dry underground layer. Different young trees needed	Do not fill wadi's with water in dry periods, 'wadi's are full when there is a surplus of water and dry during dry periods' but the fish need to be removed that is in there. Giving trees earlier water. Filling the ponds just enough that fishes are able to swim.	The wadi's and pounds were filled with just enough water so the fishes were able to swim. The water came from the Theodorus haven. Different cycle paths were sprayed with water, but the effect was minimal. The ground under the tile, was still dry. This because the water infiltrated in the spaces between the tiles and evaporated quickly.

		water , what they got via a water drain.	Focus with tiled cycle paths on placing asphalt. Try to catch the rainwater locally and let it infiltrate locally. There is no collaboration on climate adaptation.	Different young trees got water via a water drain. This was not possible by old trees, because they did not have a water drain anymore.
Department city; area development, mobility	0	There are no direct problems of drought in this field. This department get information and guidelines from other teams about what they need to change. Climate adaptation is part of this. We follow this guidelines and actually at the same time, implementing climate adaptation measures.	Attention points are that the information from other teams. Need to be transparent, true and complete. If this is not the case. Than there are not the right guidelines which can cause problems in the implementation phase or final phase. 'Operatie steen bree' inhabitants get subsidy to remove stones in the city centre and placing back little gardens.	In this working field were no direct measures taken to minimize effects. This field just followed guidelines which were set up by other departments.
Department leisure economy - Strategic policy advisor/ advisor water	7	Blue algae were present. On the sandy grounds were the biggest problems. Dry pounds . Increasing botulism . Dead trees in the Zoom. Nature dies in the Brabantse Wal. The Zoom, the Molenbeek and the Blaffert, became dry . All these effects were consequently more compared to 2017.	Farmers are not aware of the consequences of pumping too much ground water, they just think about their crop money. Water storage in city centre. Close all the sluices and hold the water. Efficient use of drinking water. Working more together in the municipality of Bergen op Zoom.	In polders the water level was controlled. Maximum amount of water letting in from the Wilhelmina Kanaal. Pumping maximum amount of water from the Hollandse Diep. Stows were pulled up. Farmers get planks to place in ditches to retain water. Specific way of mowing to move the water slowly.
Department public green	8	Public green was dying . Especially green close to hardening. Small trees (rowans and birches) were dying in forests. Lawns were unable to recover. This all was more compared to other years. Rhododendrons died in the Anton van Duinkerkenpark. More messages from inhabitants, it was so dry, that it looked like we did not give water to anything.	The first thing that started to grow were weeds. Giving trees water, it is hard to give everything water. Especially if the ground is dry. It is sometimes cheaper to let the green die and plant new green. Implementing more green.	Which green are we going to give water and which not. By old trees it is difficult to give them water, by young trees is it possible via a water drain. By old trees they dropped water on the ground around the trees and after a few hours they were giving the tree water. This to give the ground the 'sponge' work back.

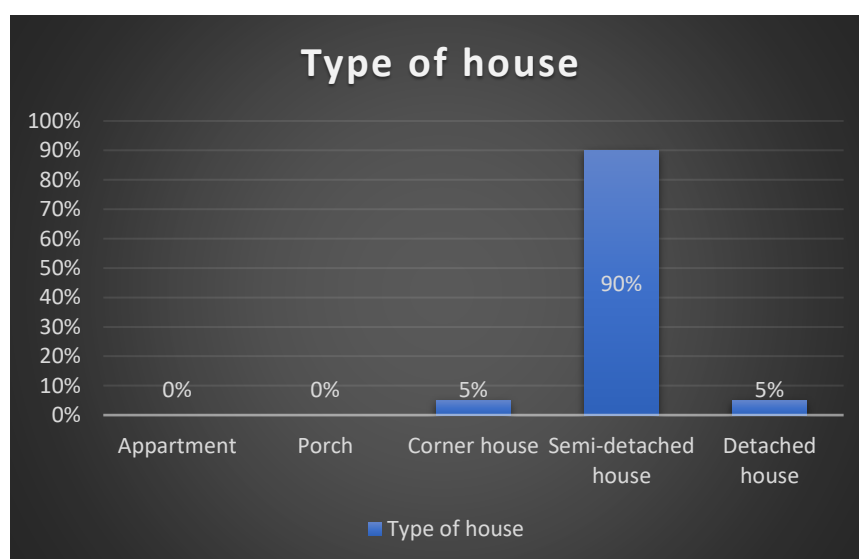
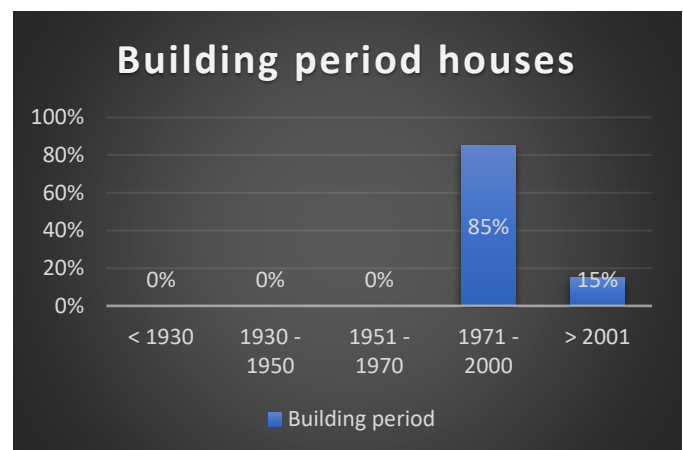
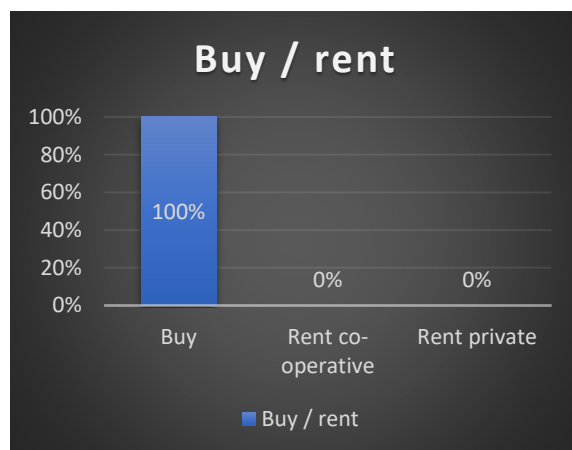
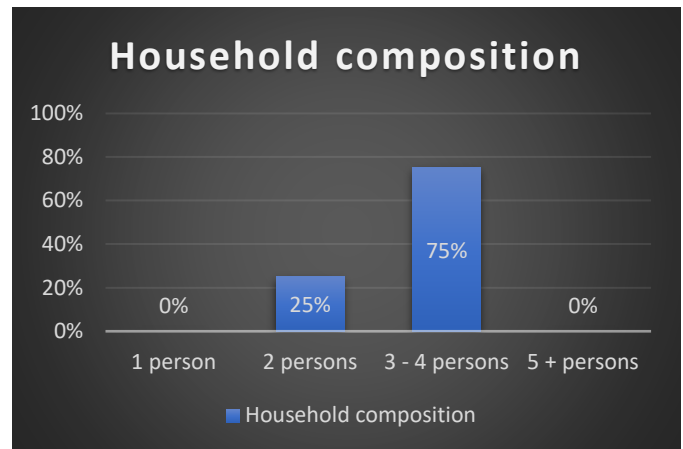
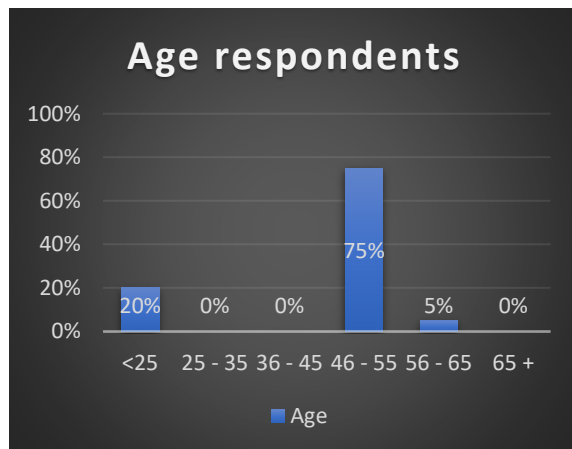
		More root shot as a consequence of less mowing.	More effort for climate adaptation. More surface water storage, not only in the sewage system. Possibilities in industrial areas.	It is difficult to give some green water, because of the dry soil will all the water flush away. Façade planting. Giving advice to inhabitants for implementing a rain barrel.
Department cables and pipes	2	Cracks in asphalt which were never seen before. In the past, heat was good for asphalt because than the asphalt did recover from small cracks caused by heavy vehicles. Drought is for cables and pipes a positive effect because you can still go on with your work activities and add water where necessary.	For this department, there are more positive effects than negative effects of drought for this work field.	There is no effort delivered to minimize cracks in asphalt. The asphalt is 'old' and need to be replaced. While at the same time you can think about implementing asphalt with other concentrations, like asphalt in 'hotter' countries, so this cracks will not happen again.
Department city water and sewage system	7	Problems with surface waters, blue algae , dry pounds . Vijverberg, Schansbaan, Ravelijn, Parkvijver, oude Binnen haven, Ham haven, oude visershaven. It was not possible to create a water buffer, because simply, there was no water. Smelling wells . Bad communication between different departments in the municipality as well as bad communication to the inhabitants.	Surface waters. Where do we need to get the water from? Were we efficient with efforts to minimize the effects? Finding possibilities to buffer water on the surface. Communicate better to the inhabitants as well as better communication between intern departments. Project plans, let every department decide on every project, if they are seeing possibilities there or not. Find possibilities to demand a 'x' amount of green in each district that will help in case of a dry period.	Acceptation. There was not enough water, we could not do anything. It was hard to create a water buffer to flush the water and prevent it from blue algae.
Brabant Water	4	Not really drought effects. This is because we are pumping water from a deep ground layer. The groundwater that we are pumping is so deep that it does not contribute to drought. The problems in the summer of 2018 mostly occurred in the first groundwater layer.	Creating awareness among the inhabitants that we do not have infinite amount of water. Brabant Water do not necessarily need to take measures. This because they are pumping water from deep ground layers.	Creating awareness among inhabitants and companies that need to use water efficiently. Try to use less energy and become self-sufficient.

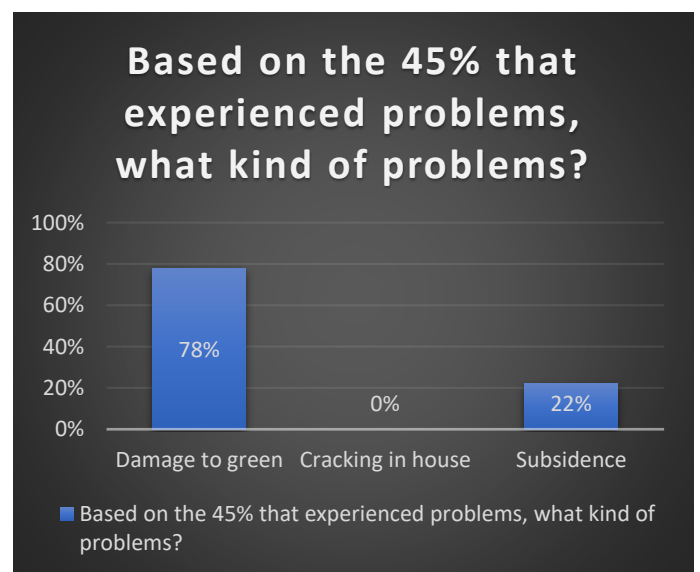
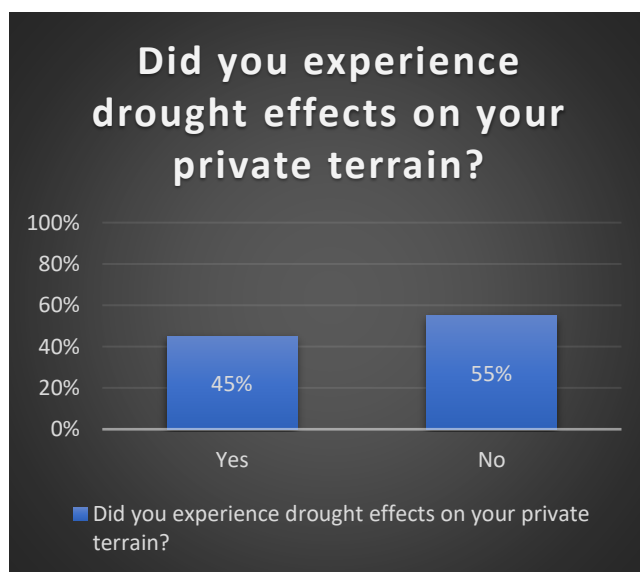
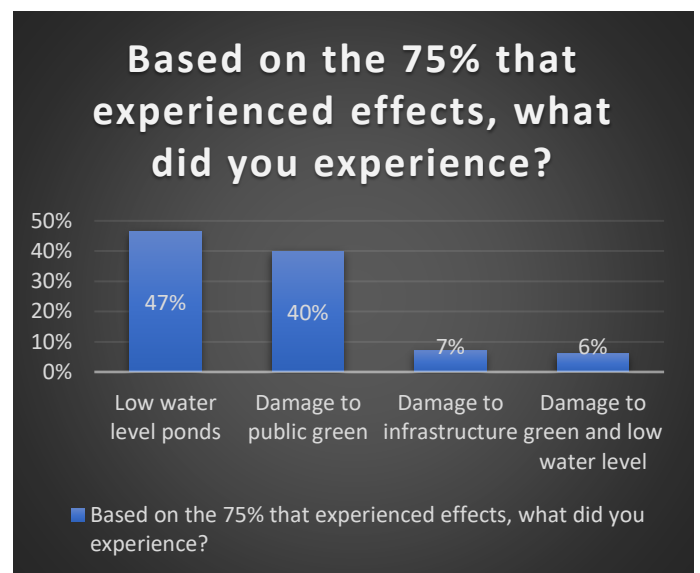
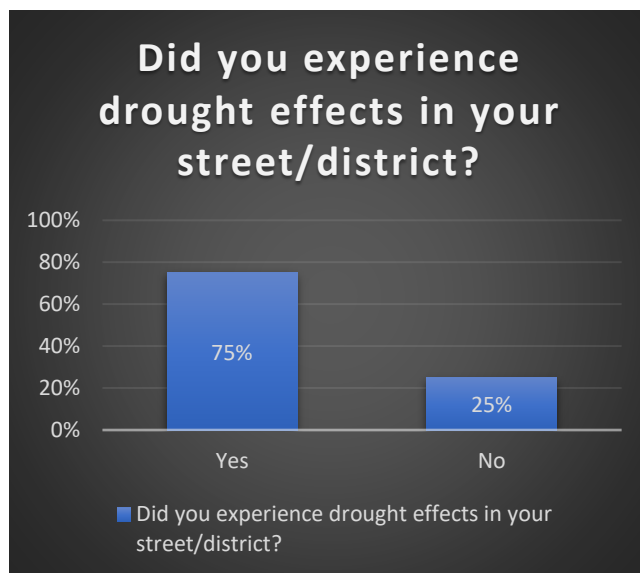
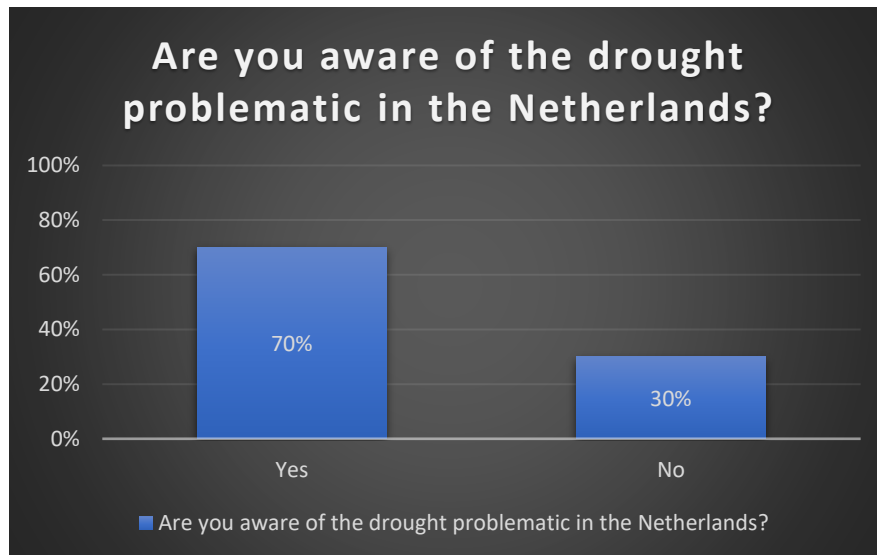
		We only got some problems with heat, to hold the water under the demanded temperature to prevent it from getting bacteria's.	Let water infiltrate locally to deal with drought.	
Waterschap Brabantse Delta	8,5	Mainly problems in areas where the waterboard cannot control the water . In polders we controlled the water and had almost no problems. The Brabantse Wal was relatively wet because of seepage pressure. More blue algae .	Considering the whole time. What is more important and what is not. This is hard and difficult. Because of this, it is important to communicate correctly why this choice is made. Do this to the inhabitants as well as to the municipality. Store the water, this is the reason that we gave farmers planks to hold water in ditches.	Surface water abrogation bans. But no groundwater abrogation bans, because farmers also need to have access to water for their crops. Implementing a sluice to hold water.

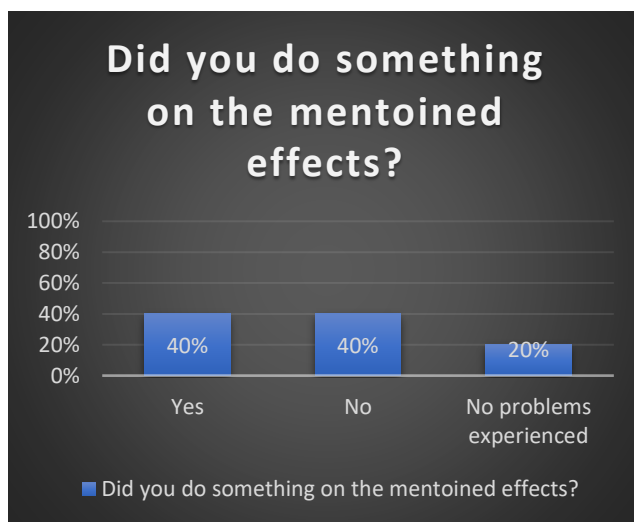
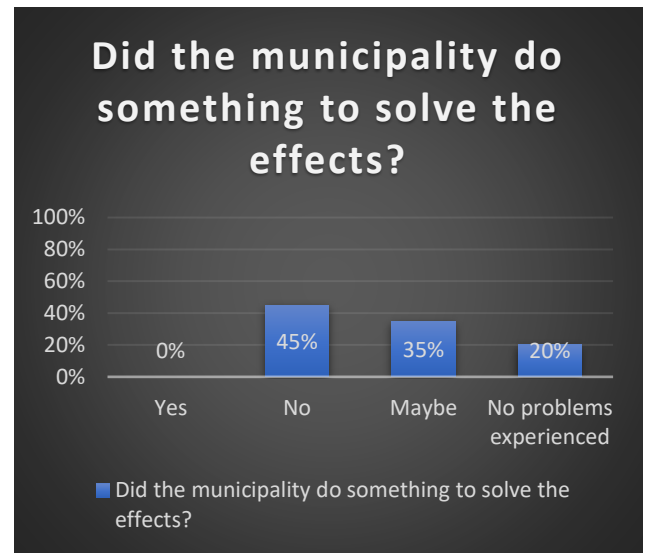
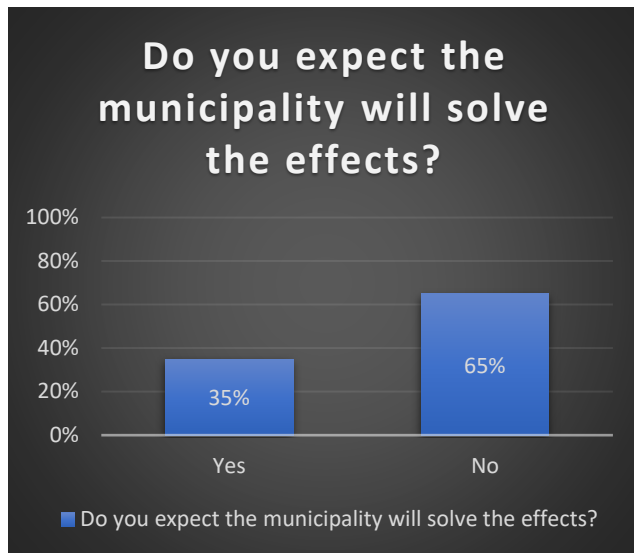
Table 10. Summary of the interviews.

Appendix 13: Results survey

De Bergse Plaat



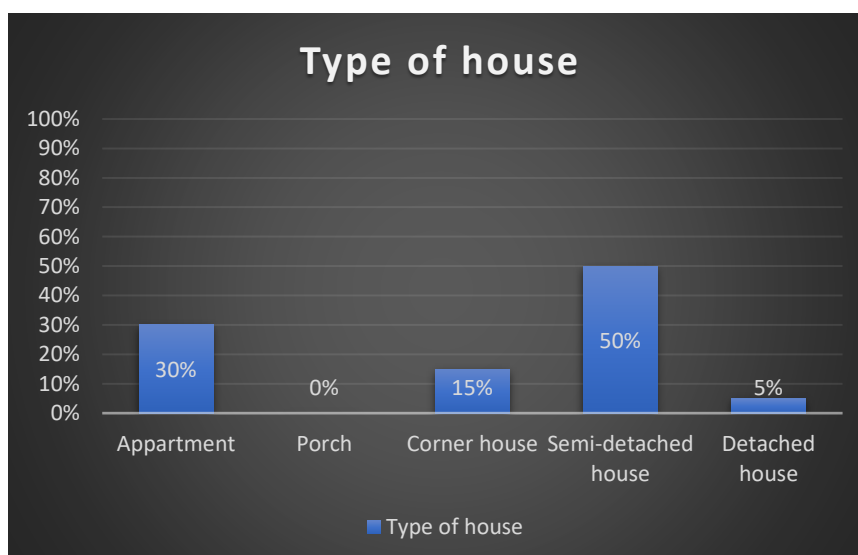
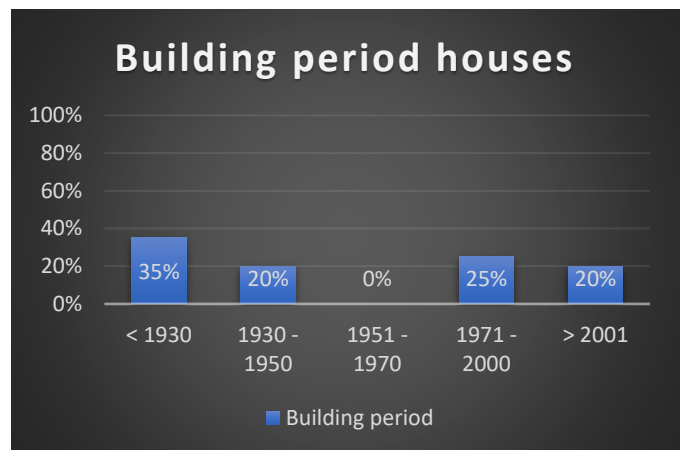
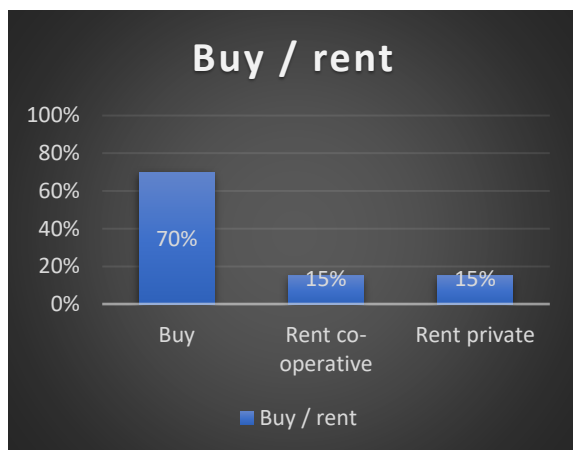
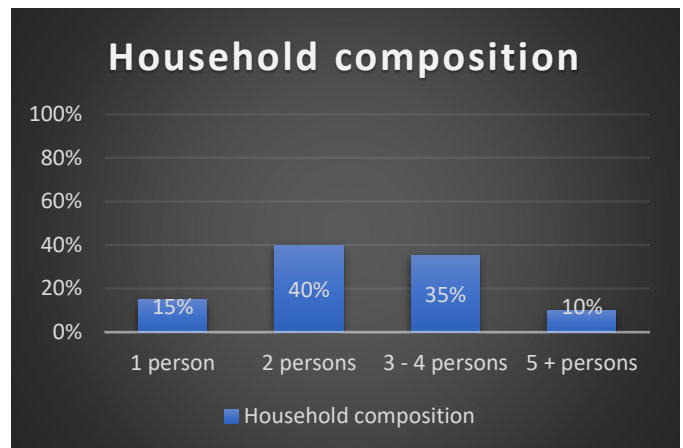
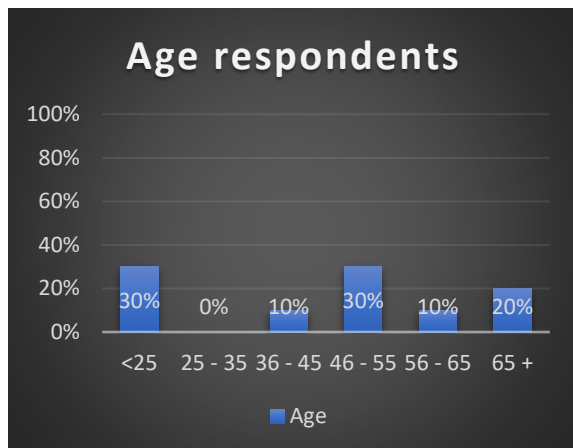


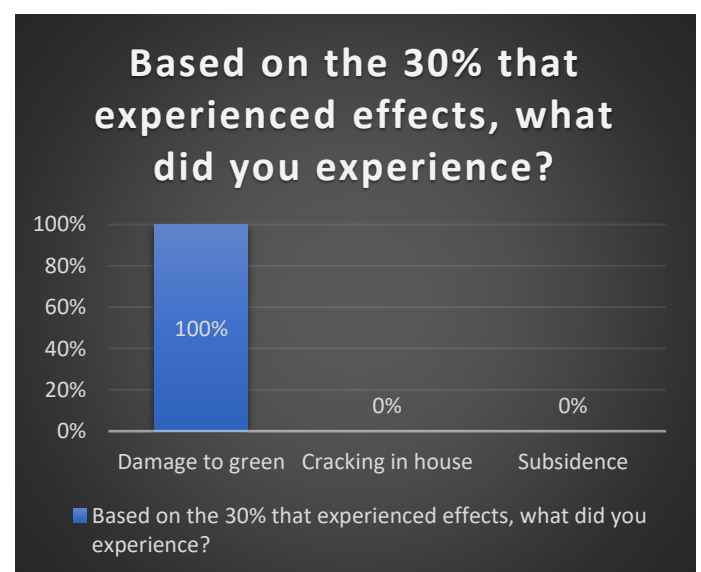
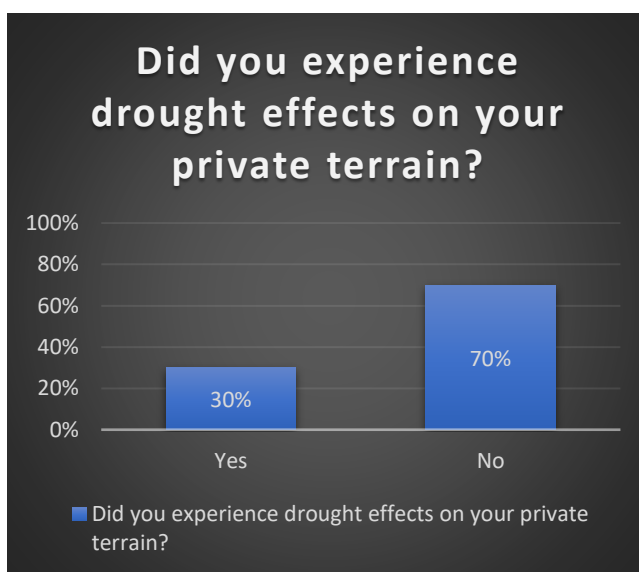
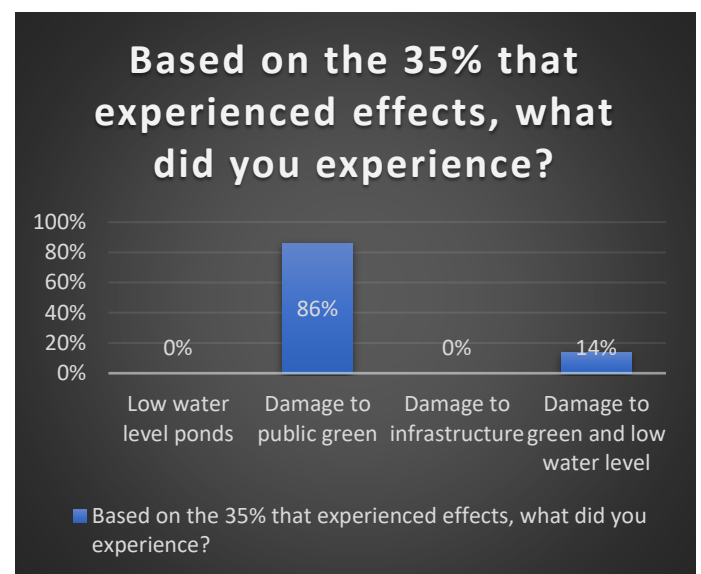
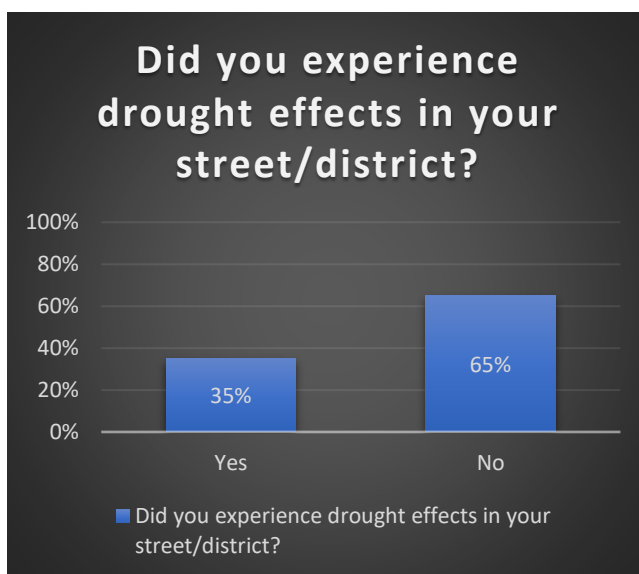
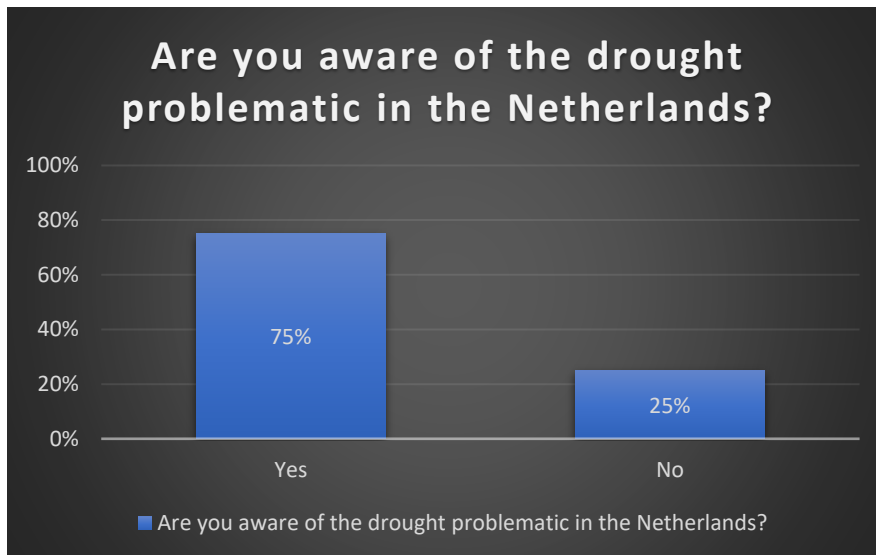


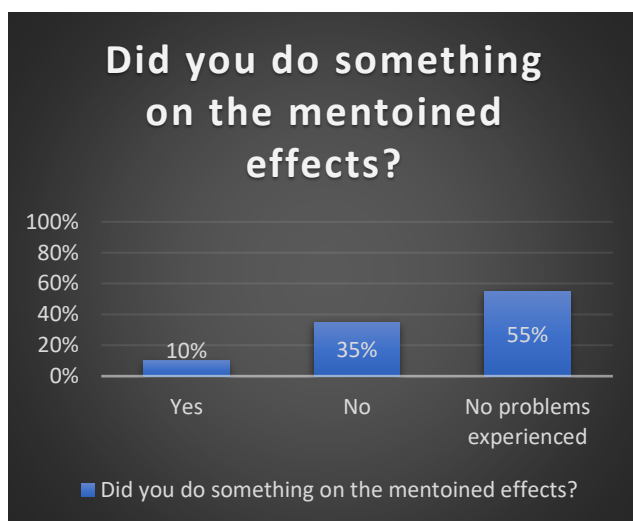
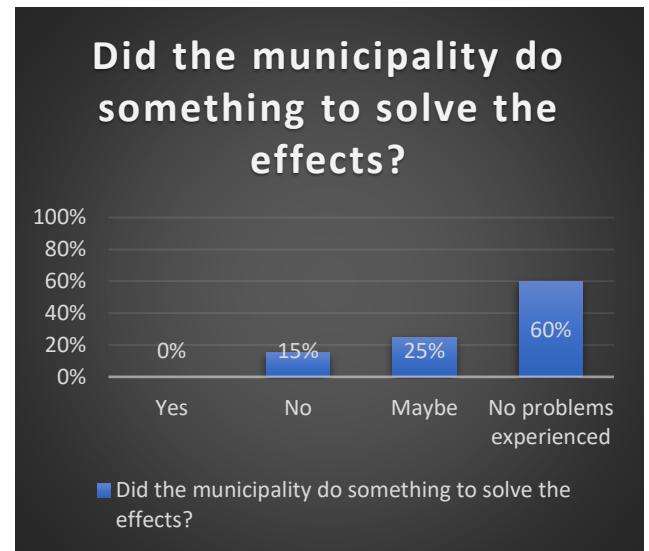
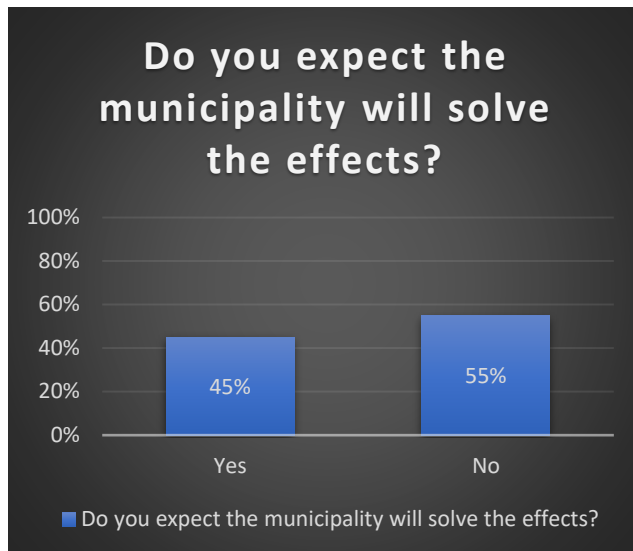
Public effect	Location
Low water level ponds	Lepelaar, Waterloop by Oostplaat, Fuut, Tureluur, Laan van Hildernisse Zuid, Lemmerhengst, Binnenschelde & Molenplaat
Damage to public green	Strandplevier, Zilverplevier, Speelman, Beiershil, Fuut, Meerkoet & Lepelaar
Damage to infrastructure	Fuut (tiles shoot up)

Private effect	Location
Damage to green	Speelman, Beiershil, Fuut, Laan van Hildernisse Zuid, Geepstraat & Kiekendief
Subsidence	Strandplevier (subsidence) & Laan van Hildernisse Noord (sinkhole)

Bergen op Zoom city centre



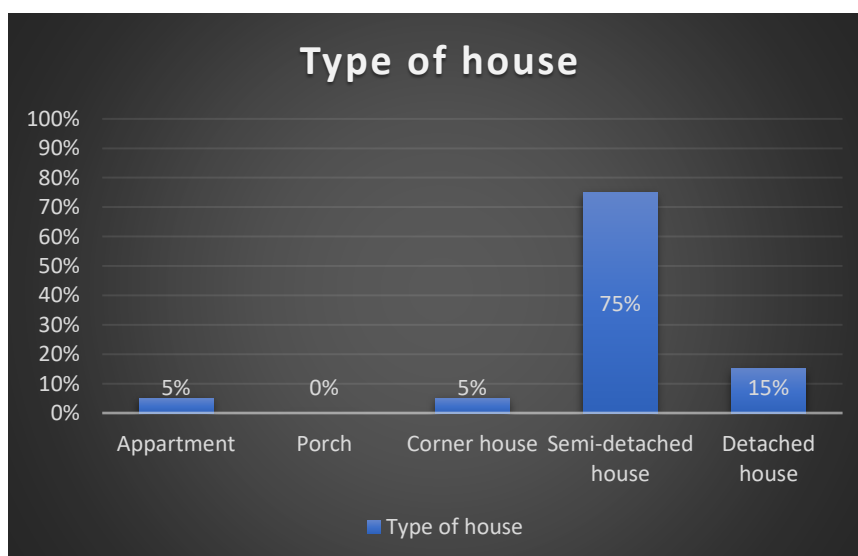
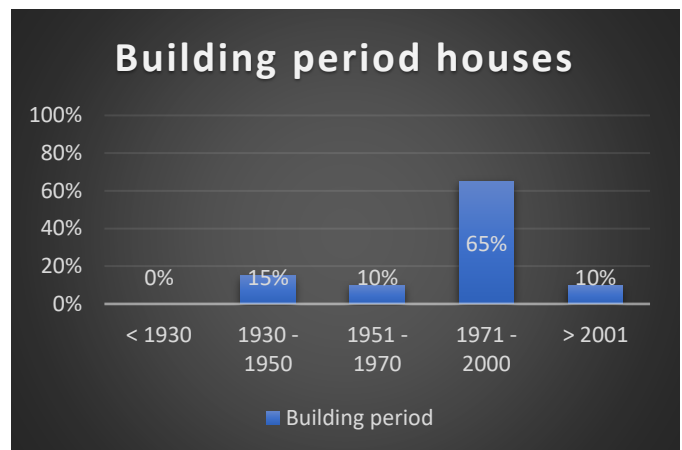
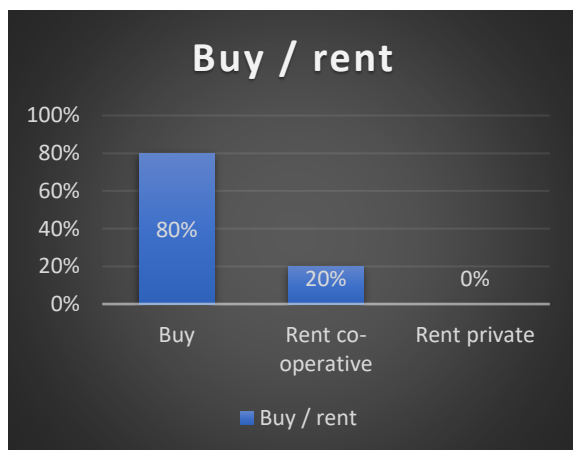
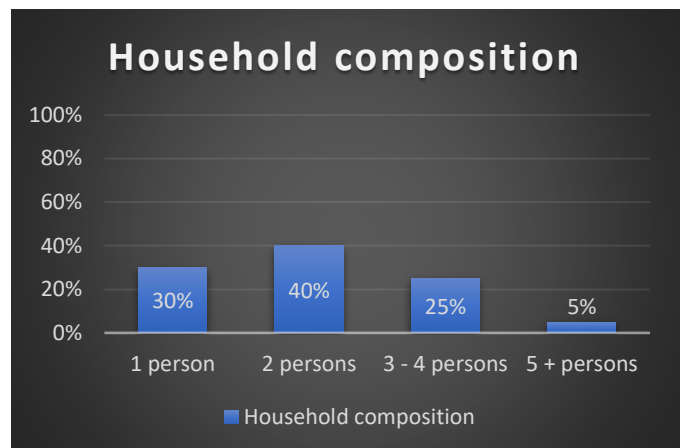
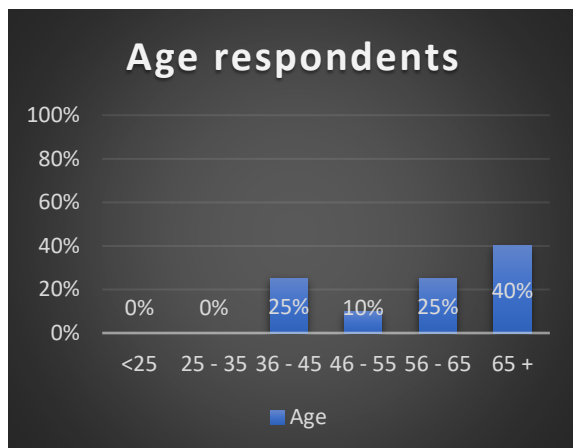


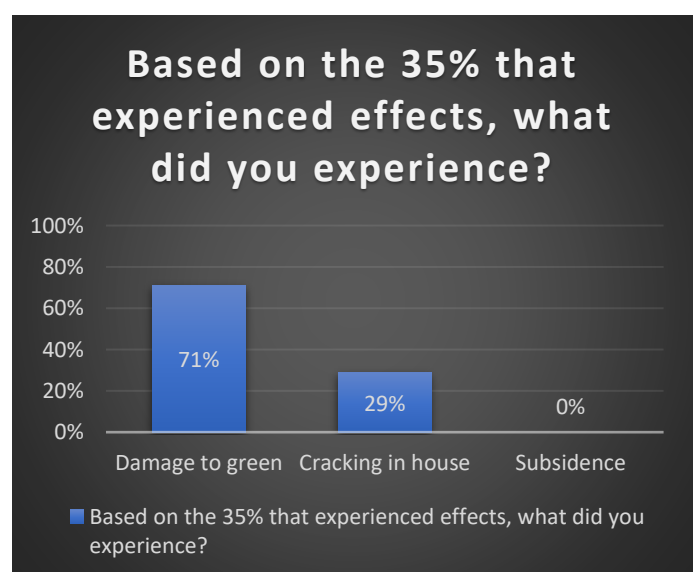
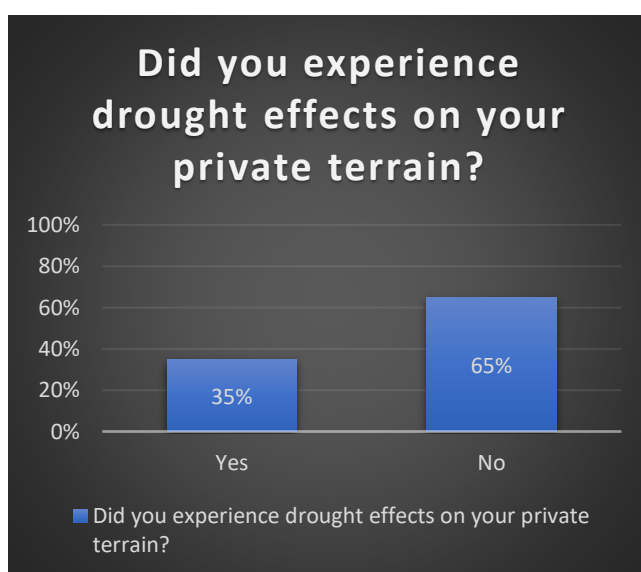
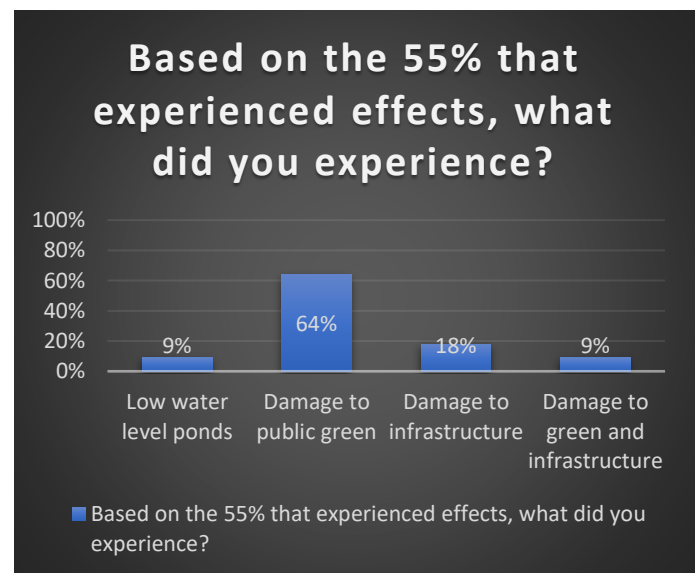
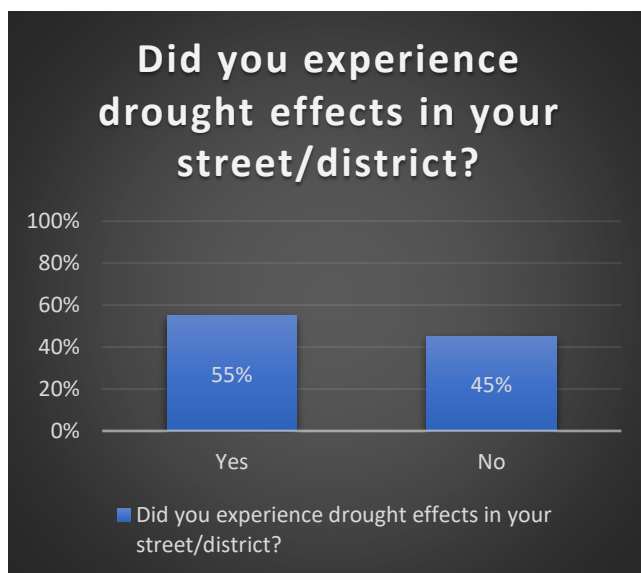
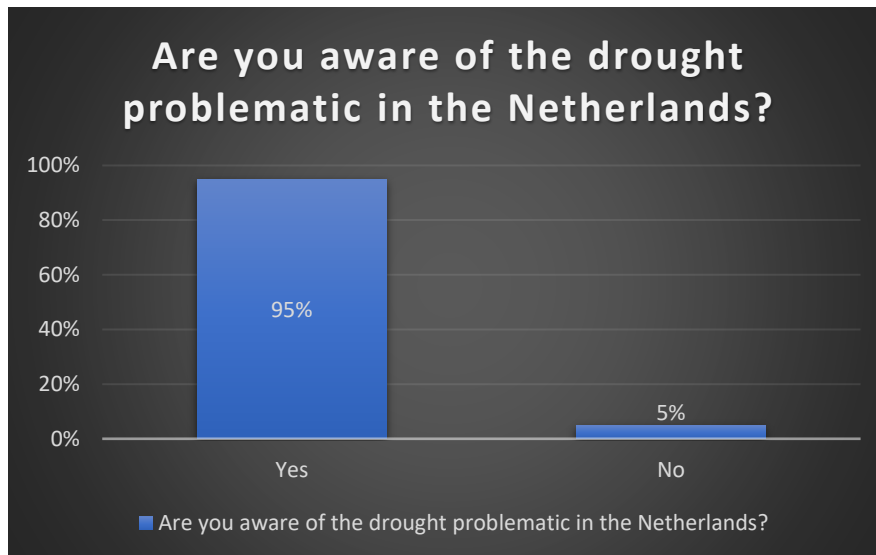


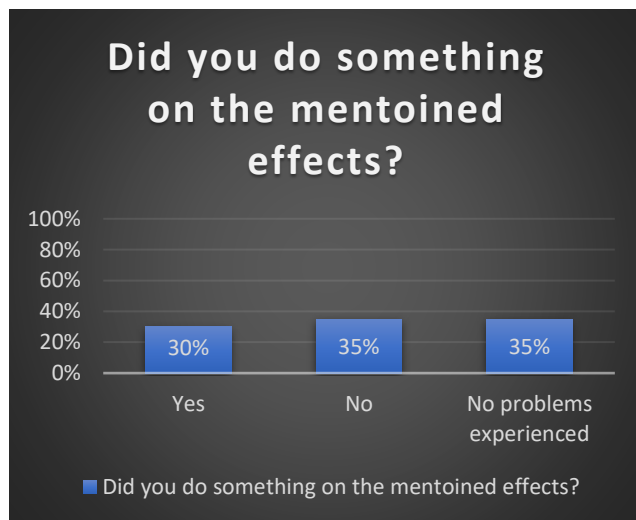
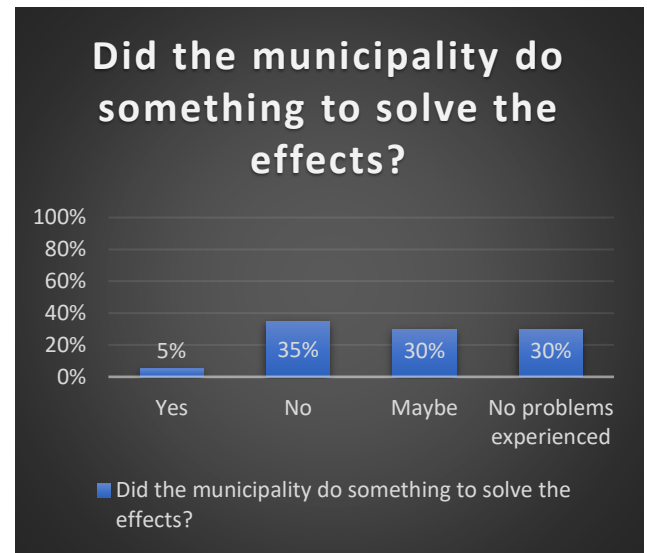
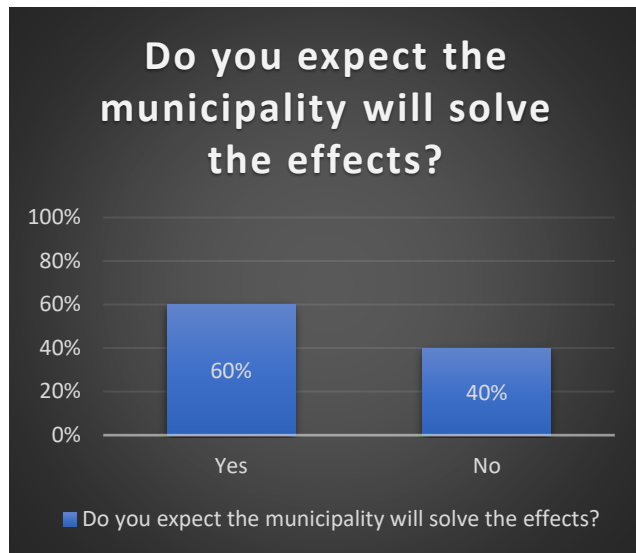
Public effect	Location
Low water level ponds	Kijk in de pot park
Damage to public green	Zuid-Westsingel, Thomas de Roukstraat, Bolwerk zuid, Scheldelaan, Kijk in de pot & Anton van Duinkerken park

Private effect	Location
Damage to green	Korenbeurstraat, Abeelstraat, Zuid-Westsingel & Thomas de Roukstraat

Noordgeest



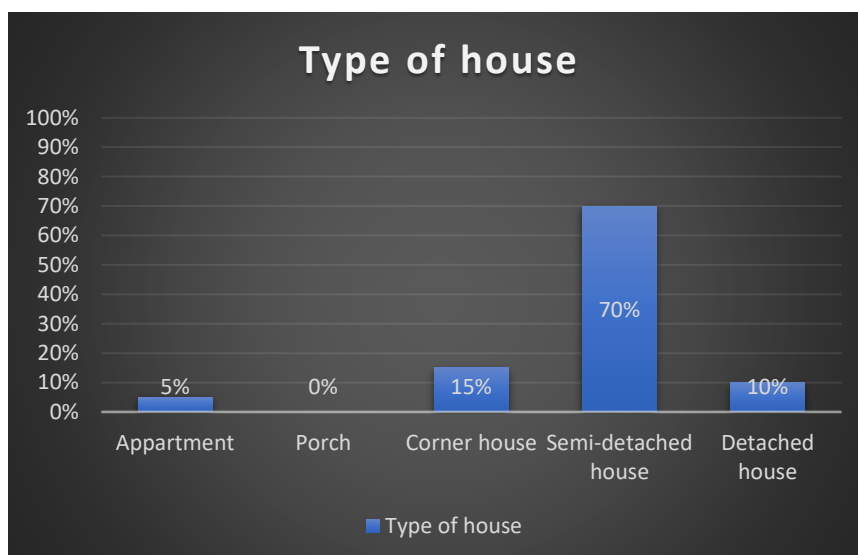
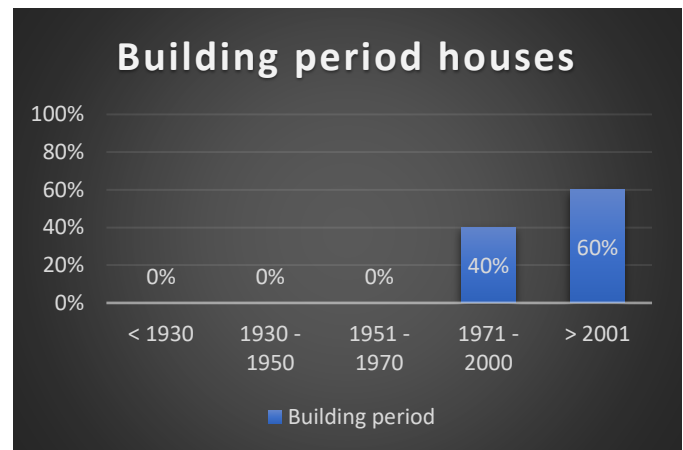
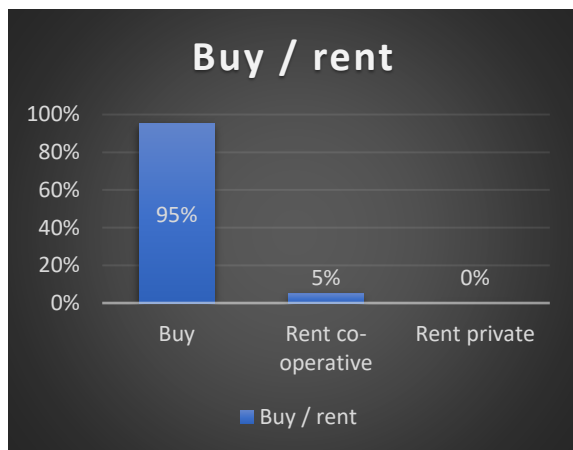
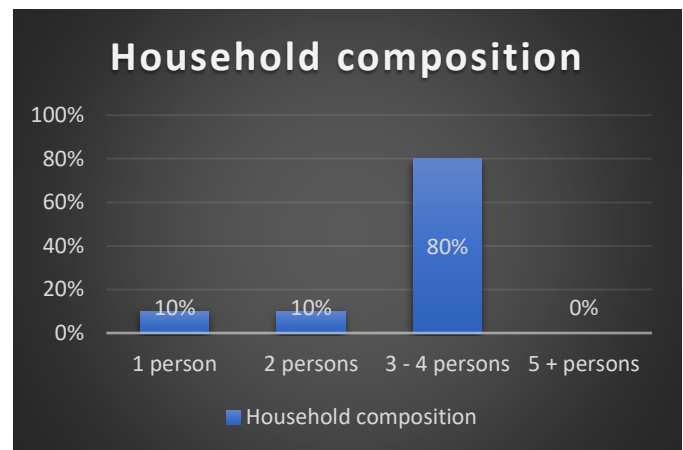
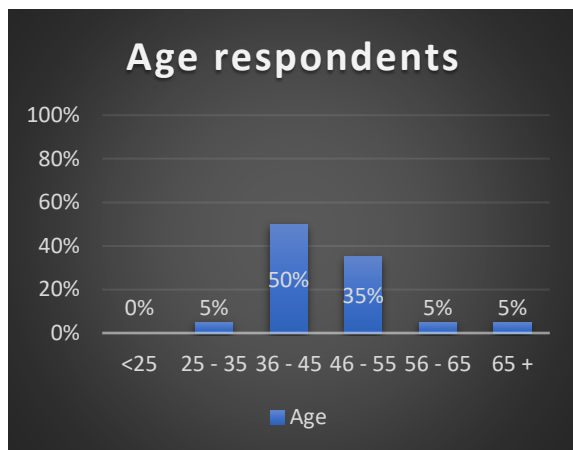




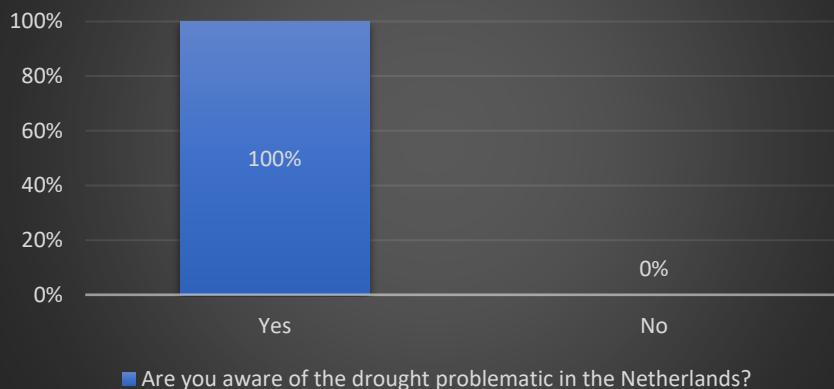
Public effect	Location
Low water level ponds	Binnenschelde
Damage to public green	Scandinavië straat, Ierlandstraat, Halsterseweg, Lupineveld, Asterstraat, Florastraat, Tuinderspad, Dirk & Groenplaats
Damage to infrastructure	Asterstraat (tiles shoot up), Duitslandstraat (tiles shoot up) & Dirk (tiles shoot up)

Private effect	Location
Damage to green	Scandinavië straat, Lupineveld, Tuinderspad, Gladiolstraat & Akkerhoef
Cracking in house	Kriekbos & Europaplein

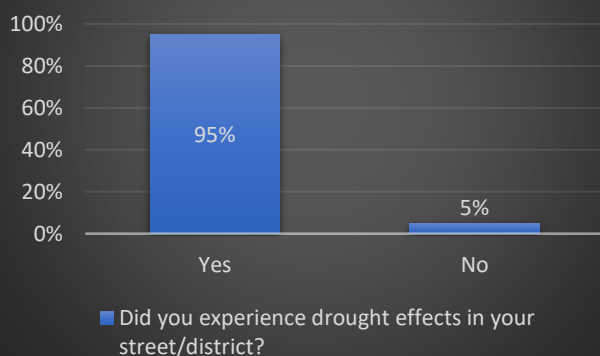
De Schans



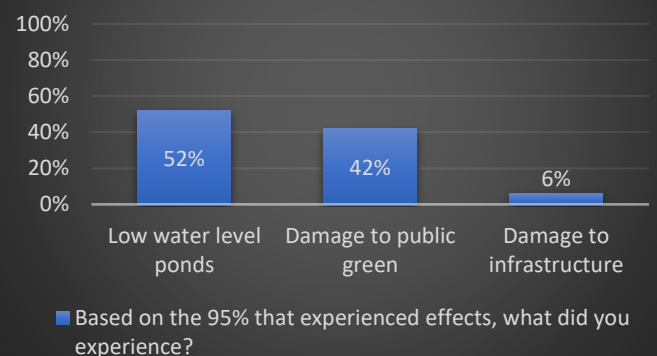
Are you aware of the drought problematic in the Netherlands?



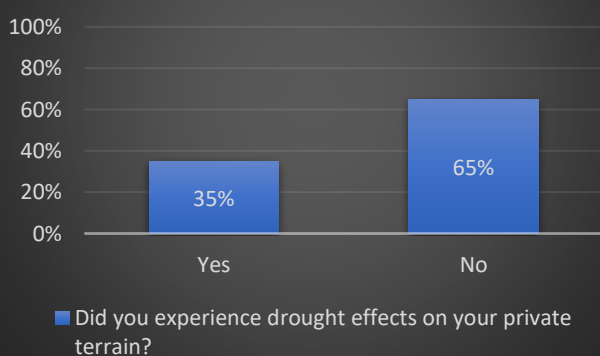
Did you experience drought effects in your street/district?



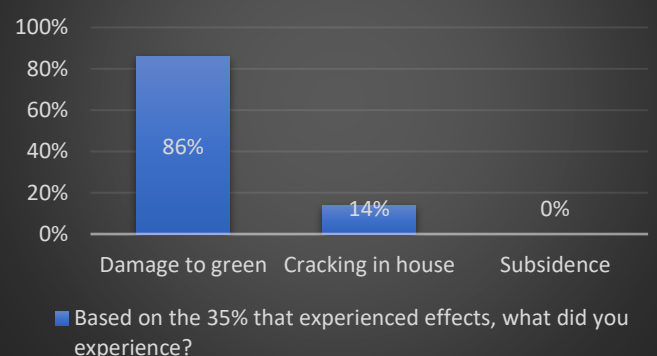
Based on the 95% that experienced effects, what did you experience?

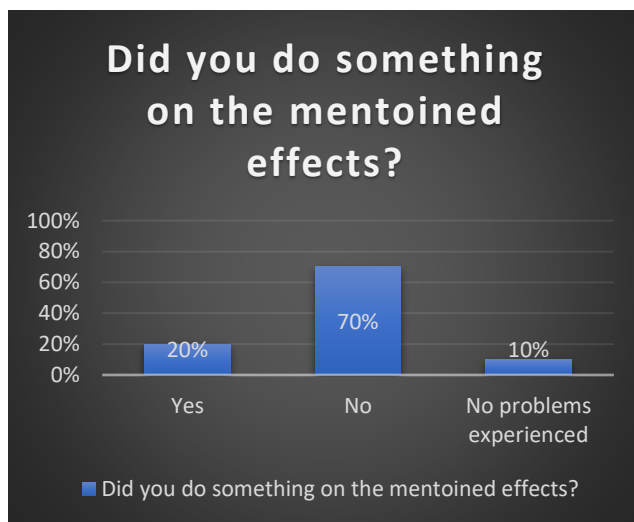
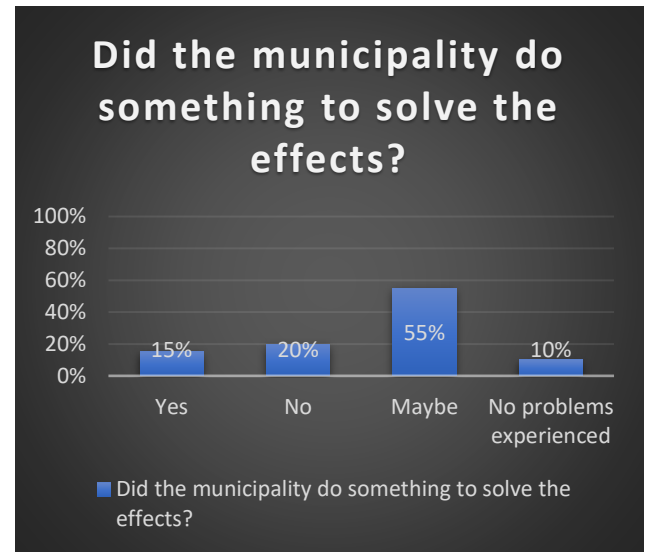
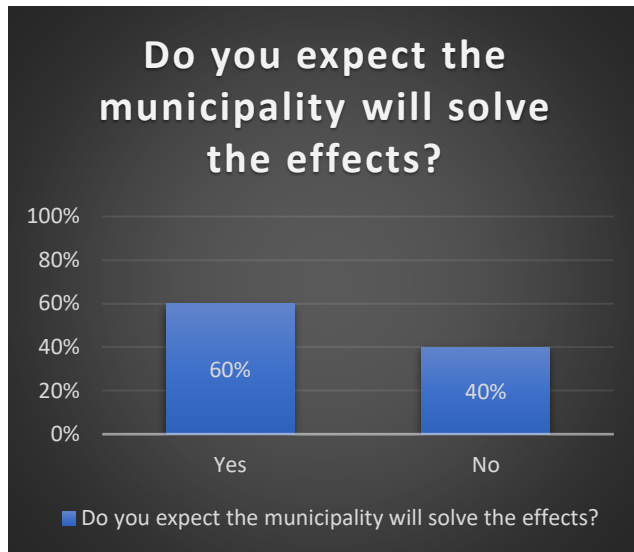


Did you experience drought effects on your private terrain?



Based on the 35% that experienced effects, what did you experience?

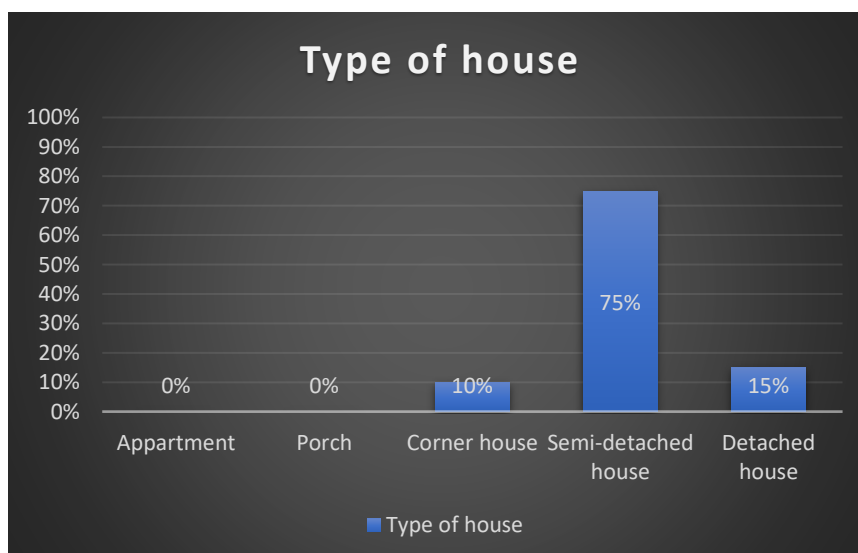
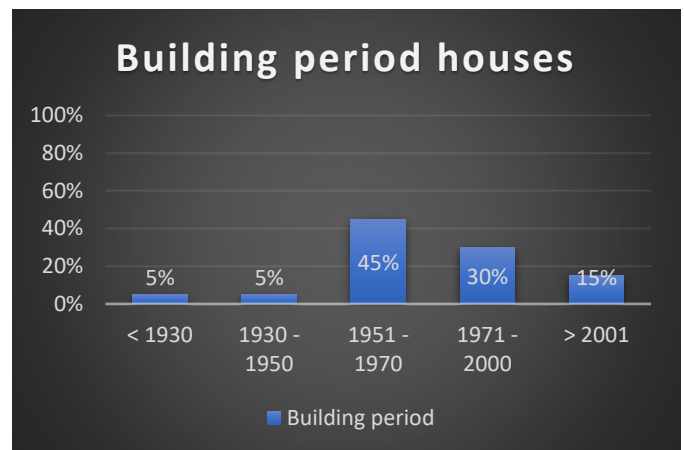
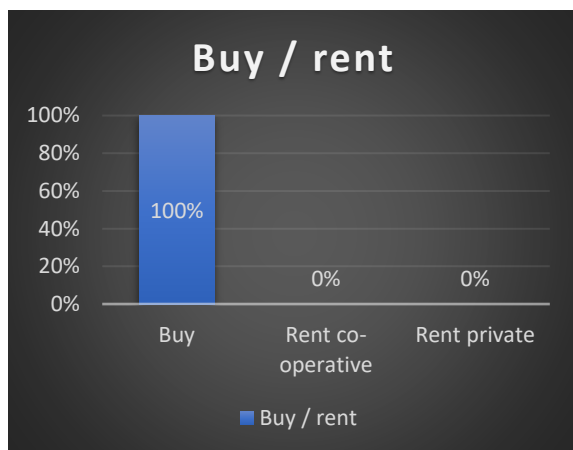
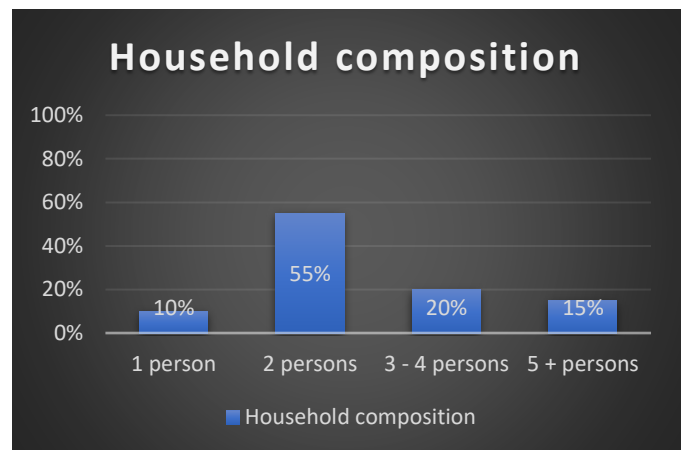
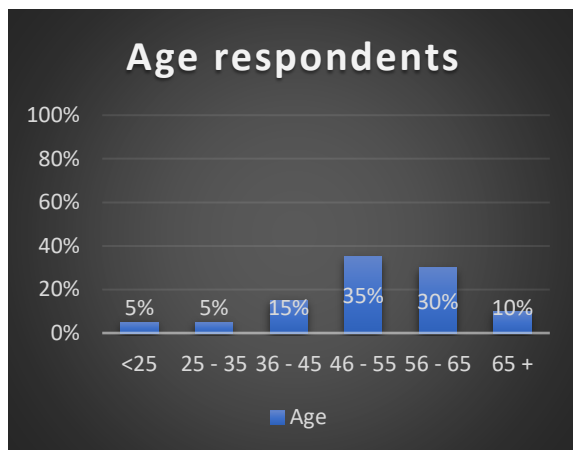


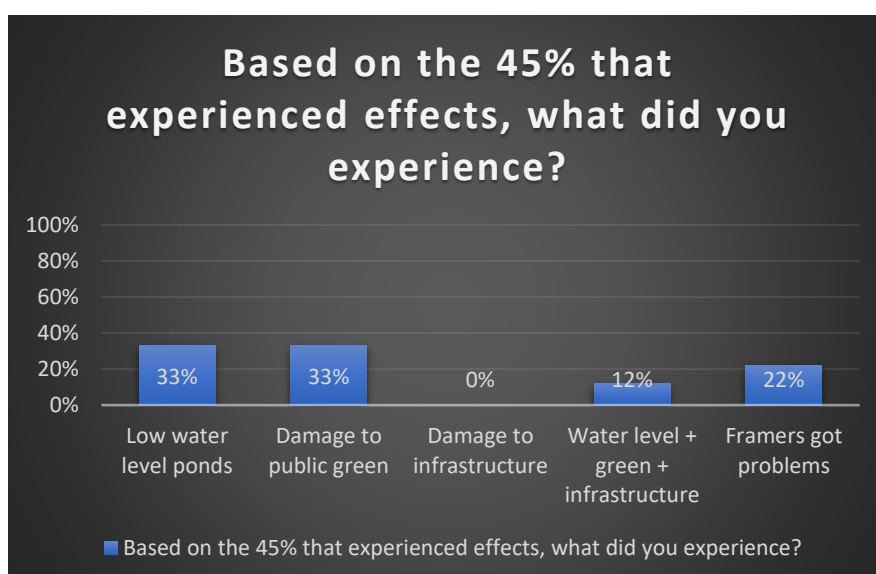
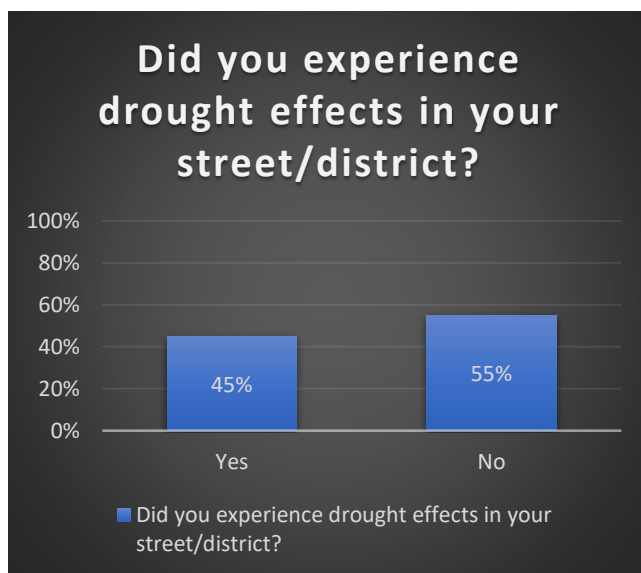
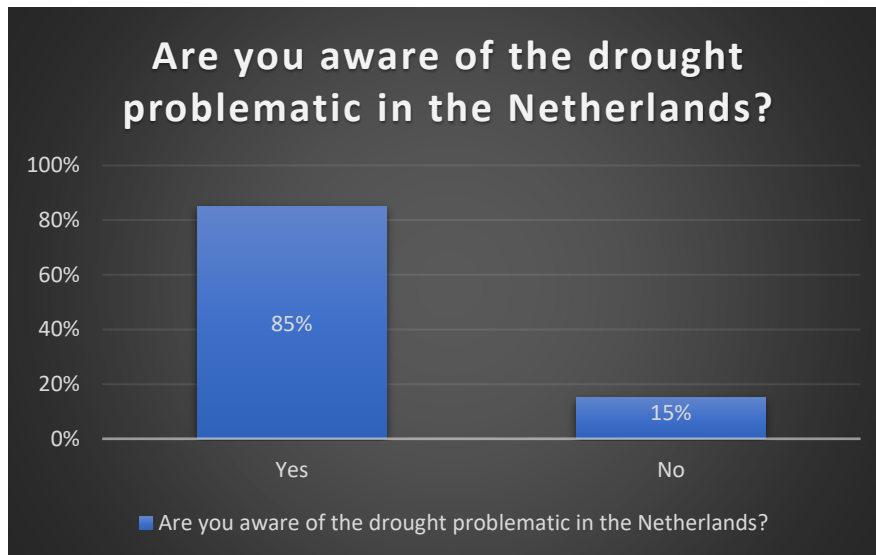


Public effect	Location
Low water level ponds	Kapitein Vinkesteinstraat, Gulden Roede, Kapitein Lentensingel, Kapitein Perrotstraat, Recreatie gebied de Melanen, Vijver Toermalijnschool & de Schansbaan
Damage to public green	Kastanjelaan, Raemdonck, Kapitein Wielmanlaan, Melanen, Gripkeshof, Eenlandsweg & Klaverblad
Damage to infrastructure	Klaverblad

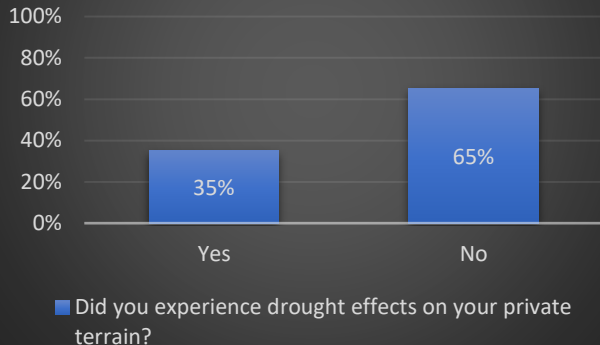
Private effect	Location
Damage to green	Kapitein Wielmanlaan, Gulden Roede, Kapitein Lentensingel, Kapitein Perrotstraat & Kapitein Vinkesteinstraat
Cracking in house	Klaverblad

Lepelstraat

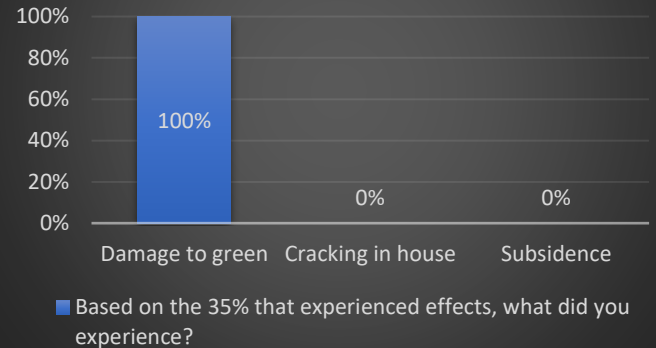




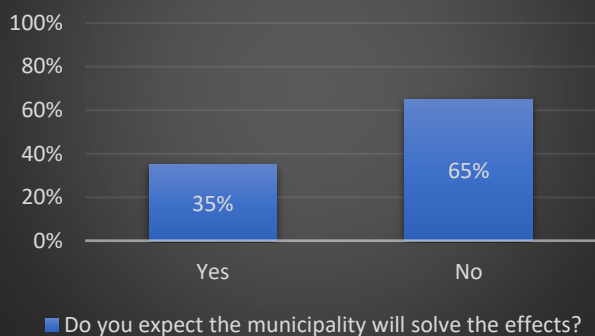
Did you experience drought effects on your private terrain?



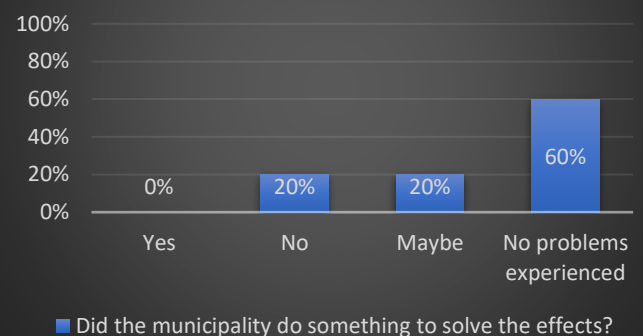
Based on the 35% that experienced effects, what did you experience?



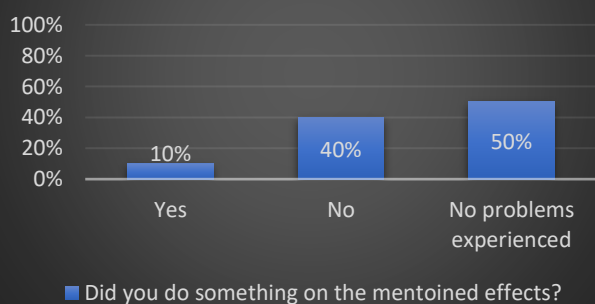
Do you expect the municipality will solve the effects?



Did the municipality do something to solve the effects?



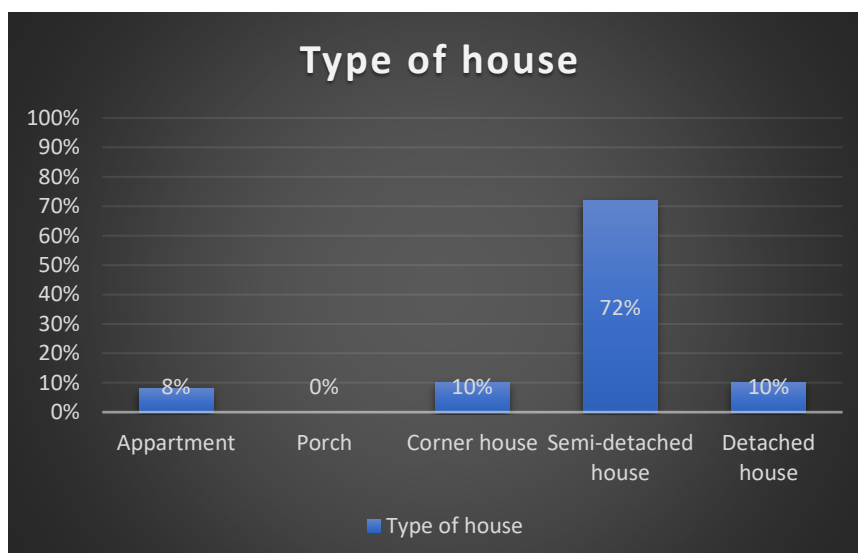
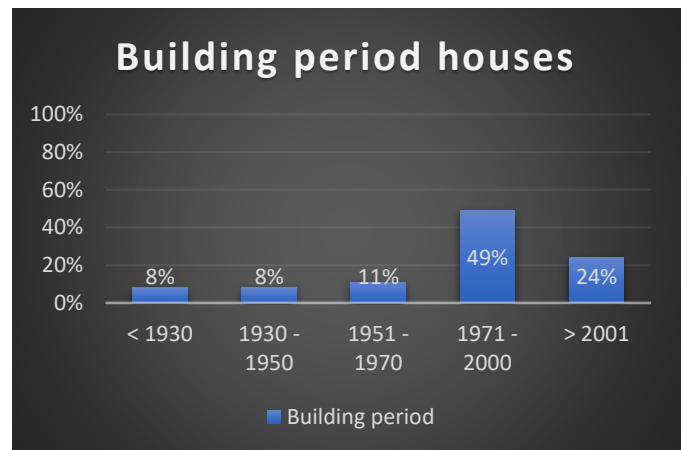
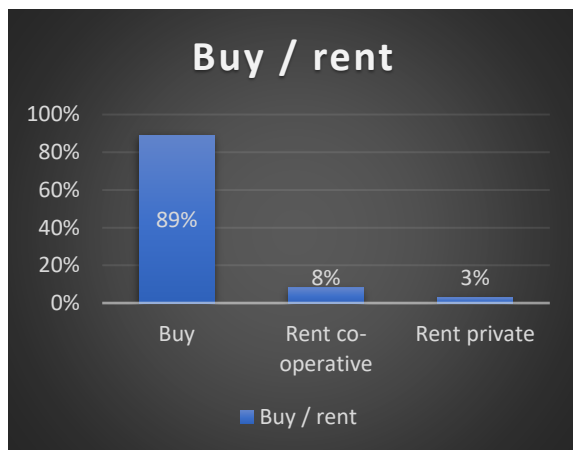
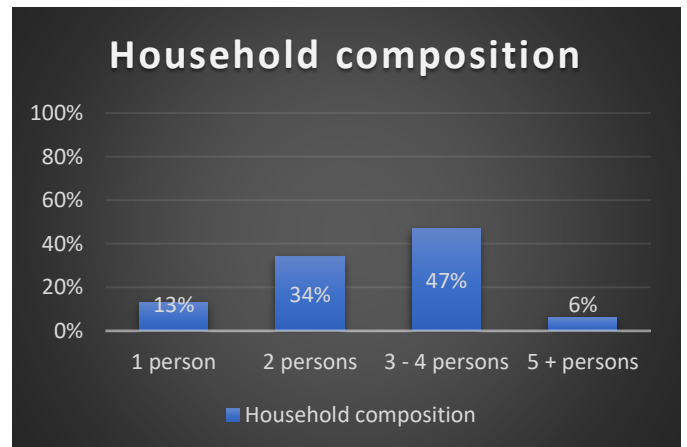
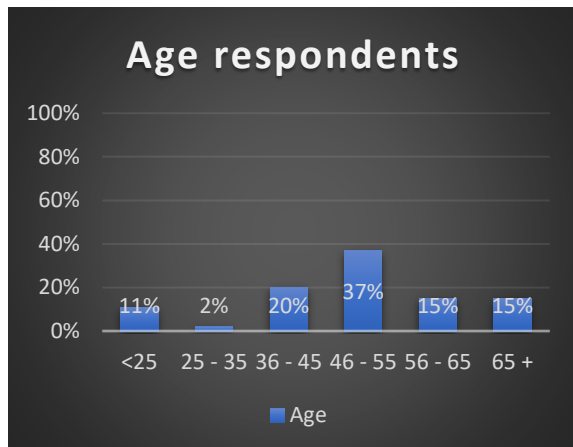
Did you do something on the mentioned effects?

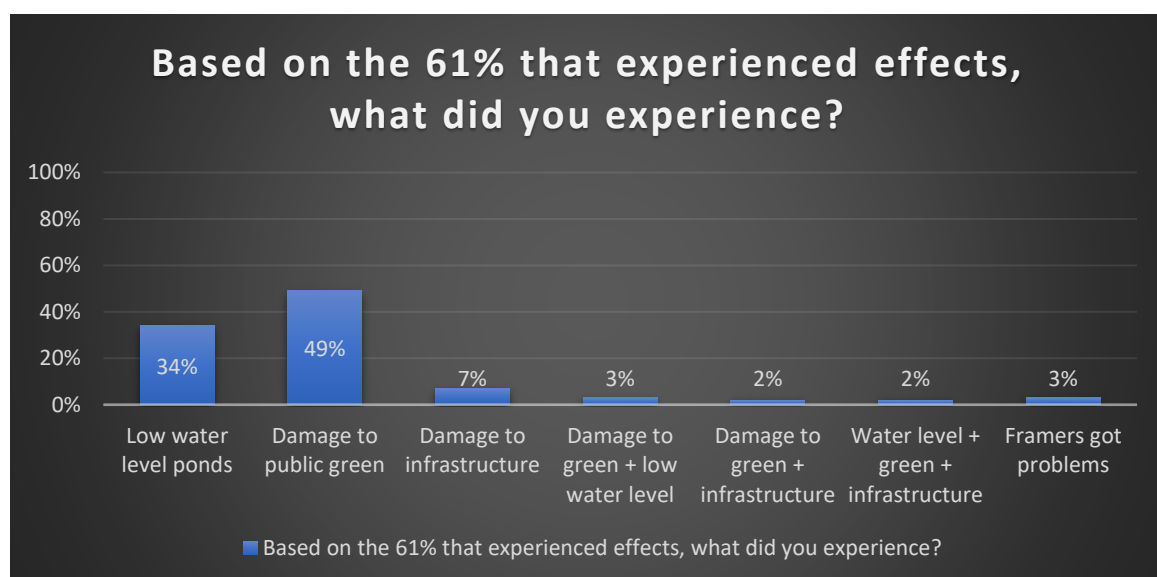
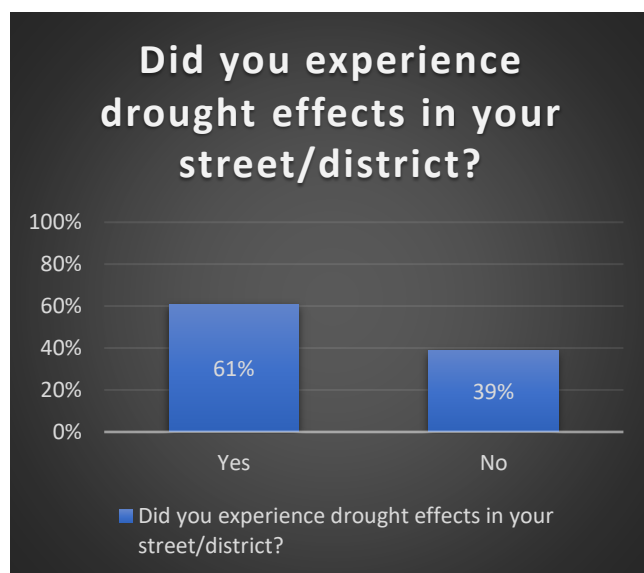
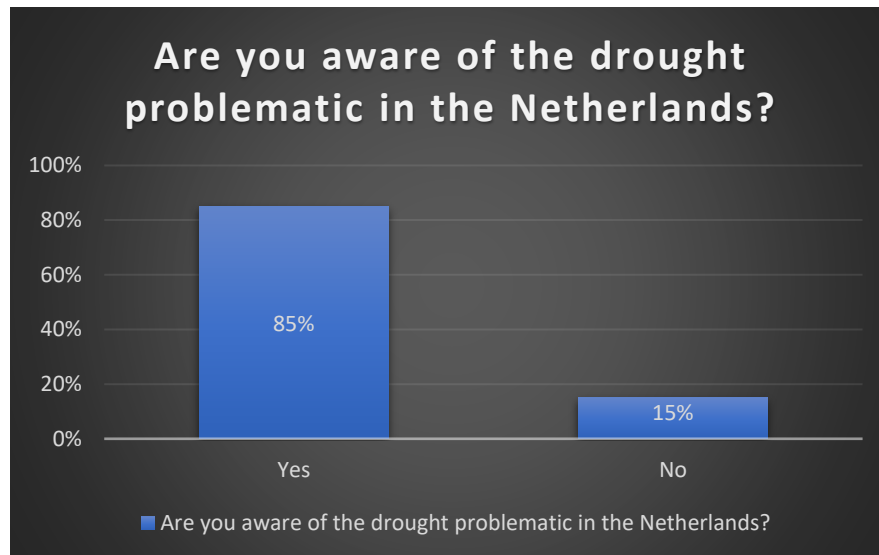


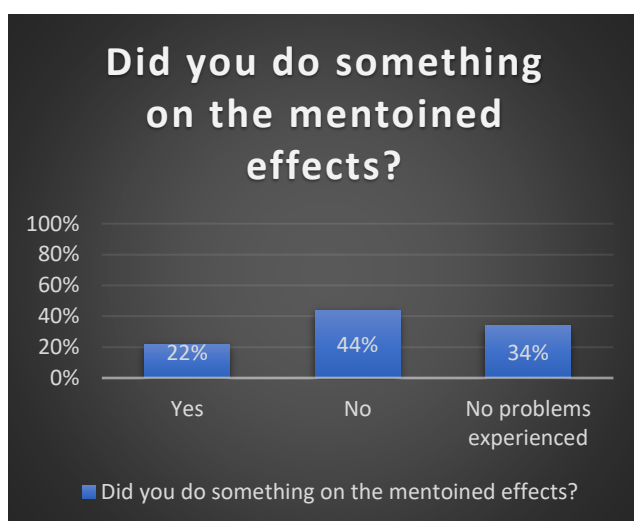
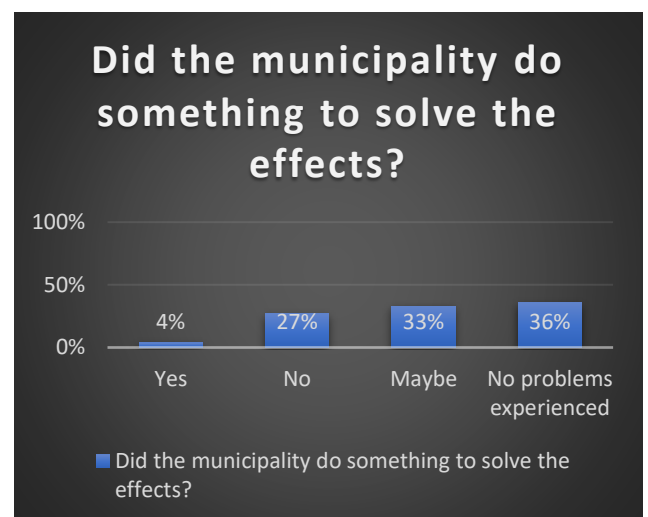
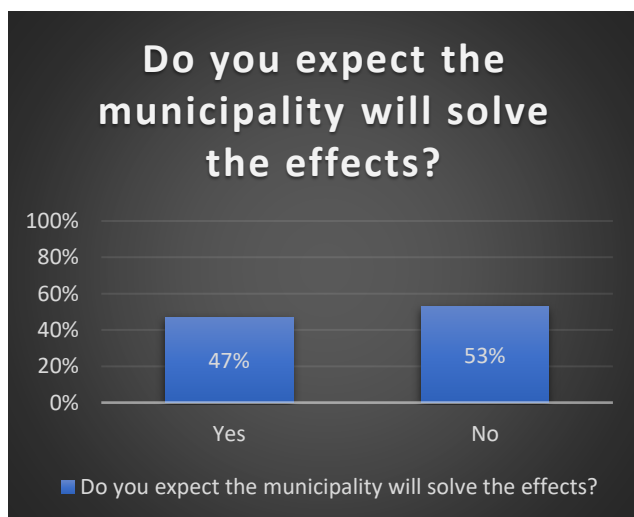
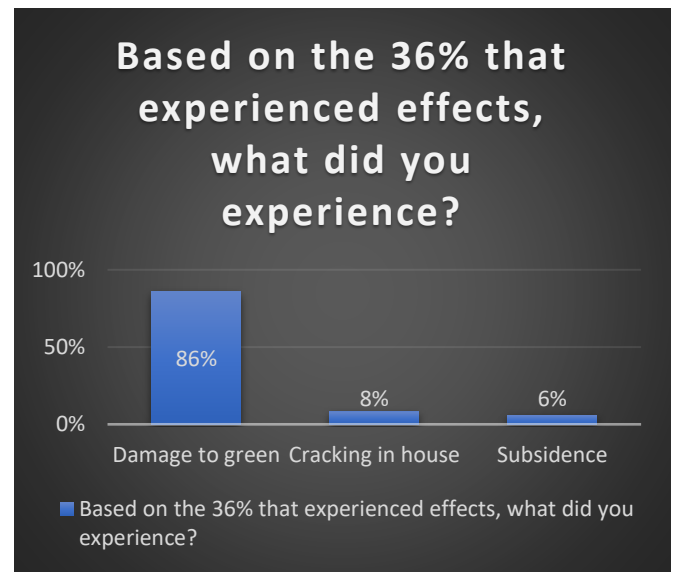
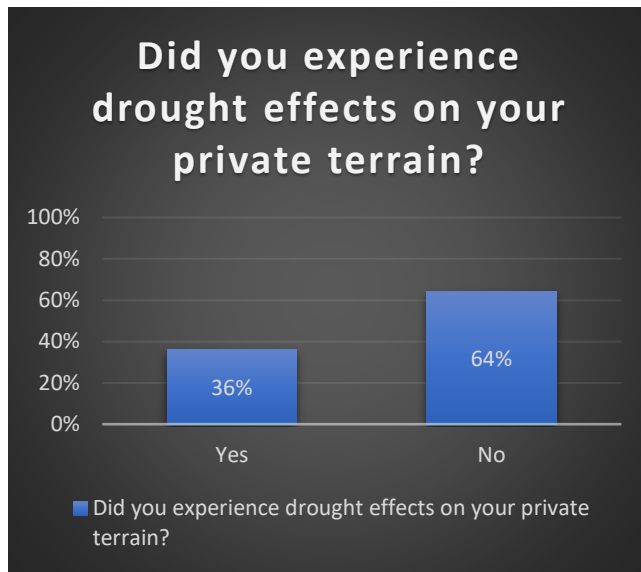
Public effect	Location
Low water level ponds	Kladseweg
Damage to public green	Schoutenpad, Kladseweg & Bloemendaalseweg
Farmers got problems	Kladseweg (not enough water for the trees and horses)

Public effect	Location
Damage to public green	Schoutenpad, Kladseweg, Bloemendaalseweg & Kerkstraat

All districts together



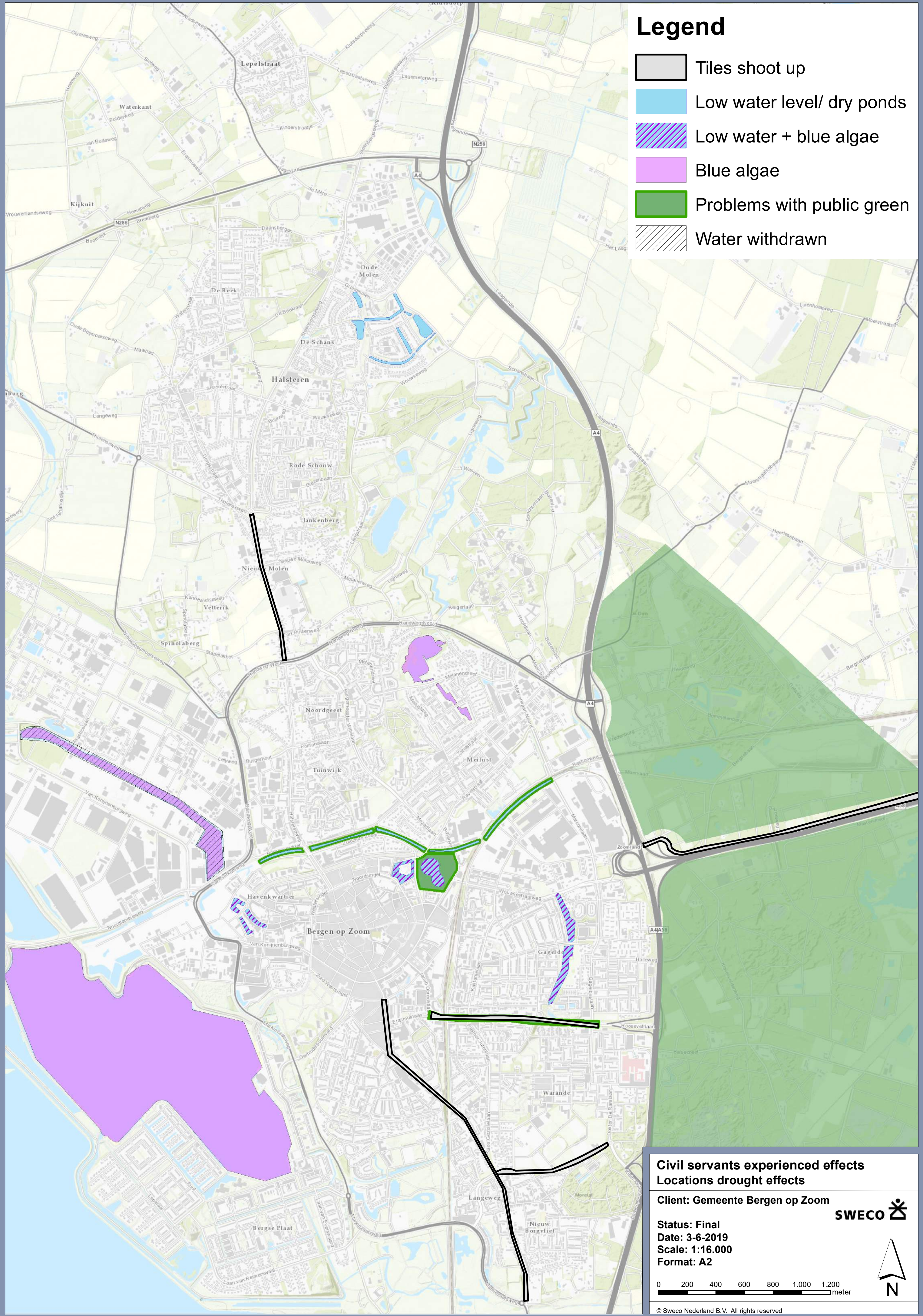




Appendix 14: Locations experienced effects civil servants

Legend

- Tiles shoot up
- Low water level/ dry ponds
- Low water + blue algae
- Blue algae
- Problems with public green
- Water withdrawn



Civil servants experienced effects Locations drought effects

Client: Gemeente Bergen op Zoom

Status: Final
Date: 3-6-2019
Scale: 1:16.000
Format: A2



0 200 400 600 800 1.000 1.200 meter



Appendix 15: Locations experienced effects fieldworkers

Lepeelstraat



Legend

- Tiles shoot up
- Low water level/ dry ponds
- Low water + blue algae
- Blue algae
- Problems with public green
- Possibility of subsidence
- Houses subsidence
- Water withdrawn

Fieldworkers experienced effects
Locations drought effects

Client: Gemeente Bergen op Zoom

Status: Final
 Date: 3-6-2019
 Scale: 1:16.000
 Format: A2

SWECO

0 200 400 600 800 1.000 1.200 meter

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SWECO



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Appendix 16: Impressions possible measures

Swapping tiles for green by inhabitants

Give subsidy and create awareness to convince everyone to remove tiles.



Figure 19. Removing tiles for green by citizen participation. Source: (Gemeente Rijswijk, n.d.)

Storage of water via rain barrels

Creating a water buffer will provide water available during a dry period. Via rain barrels, inhabitants do not need to use water from ditches or drinking water during dry periods.

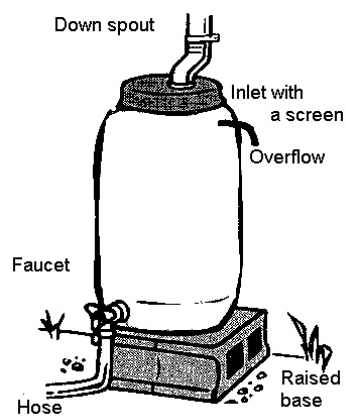


Figure 20. Rain water storage via rain barrels. Source: (City of Berkeley, n.d.)

Subsidy for green by industry

Industry are normally a place with a lot of heat stress. If they implement more because it is attractive via subsidy will this result in a better sponge capacity of the underground.



Figure 21. Using green where possible in the industry sector. Source: (Borges, 2013)

Climate proof guidelines for every new development

Following guidelines by every new development will improve the climate change capacity on the long term.

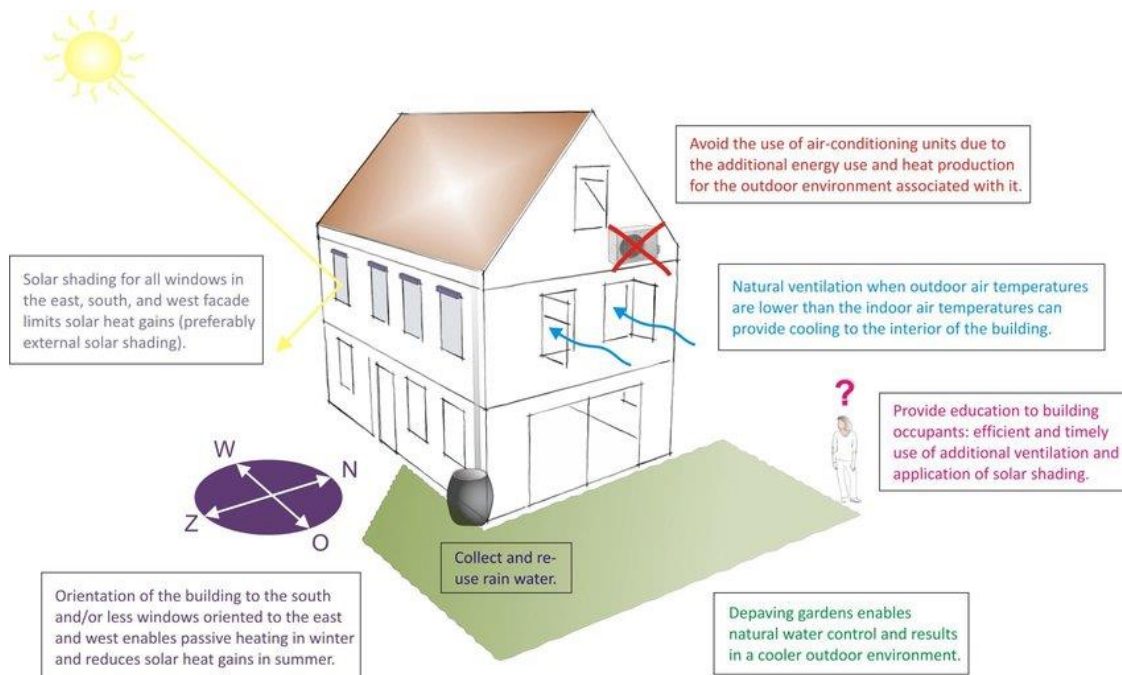


Figure 22. Climate proof guidelines for building a new house. Source: (Rovers, Bosch , Albers, & van Hove, 2015)

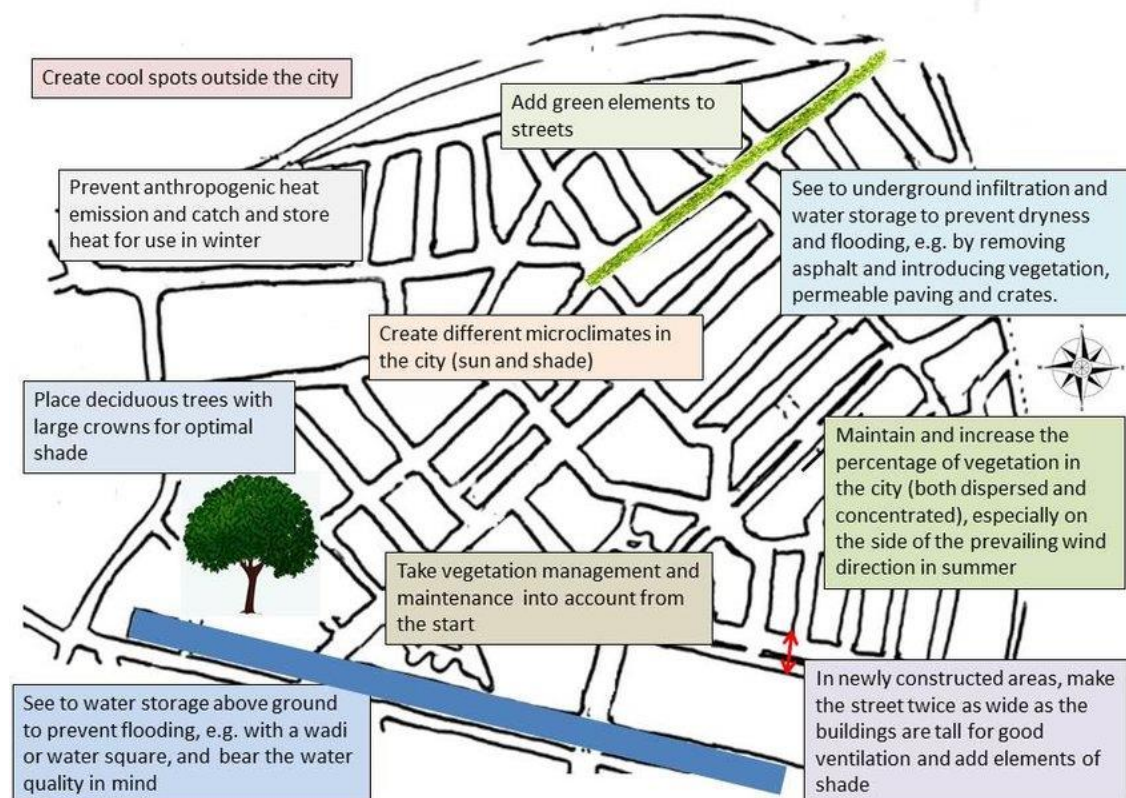


Figure 23. Climate proof guidelines by developing a city. Source: (Rovers, Bosch , Albers, & van Hove, 2015)

Disconnect coach

Giving advice to inhabitants how they can disconnect and how the water can infiltrate in the underground.



Figure 24. Example of disconnecting rainwater from infiltration directly in the sewage system. Source: (Jonkers, n.d.)

Porous paving materials

Types of materials that is infiltrating rainwater slowly in the underground.



Figure 25. Examples porous paving materials. Source: (Urban Green-Blue Grids, n.d.)

Wadi

A wadi provide water storage and will let the water infiltrate slowly in the underground.



Figure 26. Example of the function of a wadi. Source: (Gemeente Bladel, n.d.)

Infiltration crates

Infiltration crates can be implemented under i.e. parking lots. This will provide water storage under the ground. A tap can be connected to the crates and can be used, for example, to give water to vegetation.

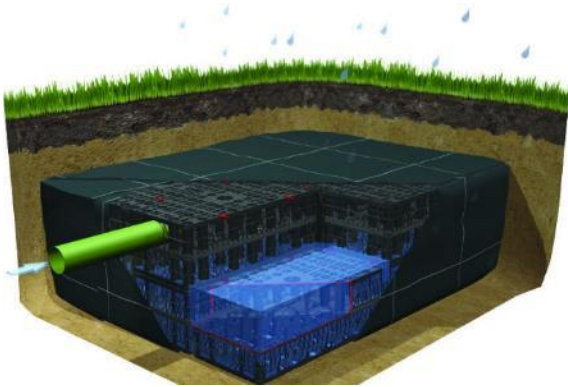


Figure 27. Infiltration crates. Source: (BPO, n.d.)

Bioswales

Infiltration of water will improve the sponge capacity. As it is also having a nice view and it will clean the water.



Figure 28. Example of bioswales. Source: (Lotann, n.d.)

Car parking lots with green

More green will provide more infiltration of water in the underground which will improve the sponge capacity.



Figure 29. Example of parking lots with green. Source: (Build a better burb, n.d.)

Rainwater ponds/ tanks without fish

Water storage and buffering, when water is needed, it can be used. Water do not need to be added during a dry period, as there are no fish in it.

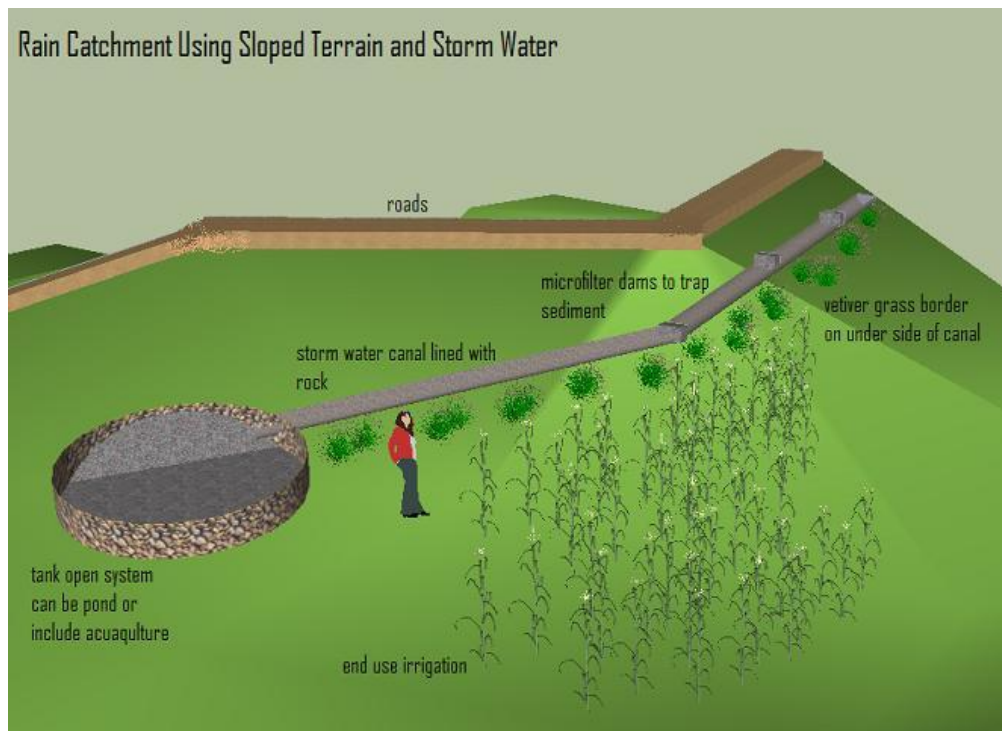


Figure 30. Rainwater ponds/ tanks for providing storage. Source: (Oburden, 2010)

Infiltration sewage system

Infiltration of water slowly in the underground will improve the sponge capacity of the underground.



Figure 31. Example of infiltration sewage system. Source: (PVC, n.d.)

Rainwater storage where possible (for example, below sport fields)

Always think about solutions to store rainwater.

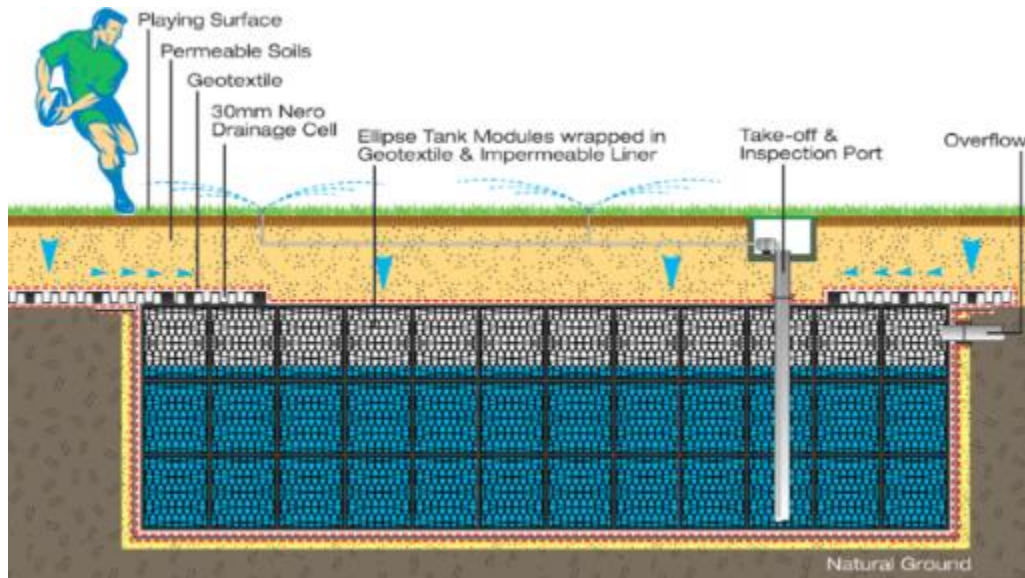


Figure 32. Example of rainwater storage below a sport field. Source: (Pearl-kb, 2016)

Closing sluices/ placing planks in canals/ ditches

Buffer water where possible.



Figure 33. Example of trying to buffer water. Source: (Waterschap De Dommel, 2019)