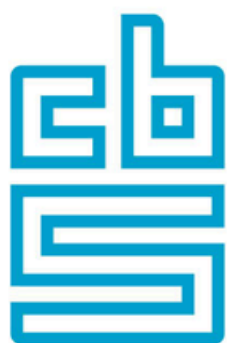

Concise Research Report

Climate Change Adaptation: Data-needs in the Agricultural Sector

Harm Jan Haasjes - 28 May 2018



**Centraal Bureau
voor de Statistiek**



Zwolle

Executive Summary

This research report describes the outcomes of the conducted research concerning climate change adaptation in the agricultural sector and the data-needs that are connected to it. The research uses the National Adaptation Strategy (2016) and the Regional Adaptation Plan (2017) as a framework. These reports describe a total of 33 climate change effects that influence the agricultural sector. In order to set a clear scope, these effects have been narrowed down to the top 5 effects that are perceived as most 'urgent'. Using focus group discussions and an online survey, the five most urgent effects in the agricultural sector were determined. These are the following:

1. Decrease of freshwater availability
2. Increase of infectious diseases and plagues
3. Lower crop yields
4. Change in ecosystem/shift in species
5. Decrease of water quality

Using experts that are specifically chosen beforehand, I conducted semi-structured interviews. The interviews were analysed thoroughly, and components and data-needs of these five effects were determined. The main findings (per determined effect) are as follows:

1. *Decrease of freshwater availability* - Most participants of the research perceive this effect as important. As weather extremes are increasing, long periods of drought can cause a lot of damage to crops and livestock. It is important to keep monitoring ground and surface water levels. The importance of long-term weather forecasting can increase, as it is important to foresee years of drought.
2. *Increase of infectious diseases and plagues* - Most participants of the research also perceive this effect as important. This effect is strongly linked to the fourth effect, as new species can bring new plagues and diseases. Current plagues and diseases should be monitored closely. The agricultural sector in the Netherlands can learn from other countries with a warmer climate.
3. *Lower crop yields* - According to the participants, this effect is a result of many of the other climate change effects. Not everyone saw this as particularly urgent, but it is important to take into account. The participants of the research recommend to keep monitoring the different parcels that farmers have, and to register this.
4. *Change in ecosystem/shift in species* - Most participants consider this effect as urgent. A changing ecosystem could mean that farmers have to switch to other crop varieties or other species. It is important that current crops in the region will be monitored. In order to introduce new varieties or species, it is important to conduct effect studies.
5. *Decrease of water quality* - This effect was considered less urgent by most participants. Due to all kinds of regulations, the water quality is generally improving. Algae-formation is a serious concern that is climate change related, but it is not yet particularly urgent. Here again, monitoring is key. It is important to not only measure the water quality once every now and then, but it should be monitored constantly. With salinisation being a serious problem in the Netherlands, this monitoring should also contain measuring salt levels in the water.

Conclusion

Monitoring is considered key in data-needs concerning climate change adaptation in the agricultural sector. This is the case for all covered effects in this research. Another thing that is recommended is that data-generating authorities collaborate more effectively and efficiently.

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1. Introduction & Background

Currently, the climate is changing rapidly. The weather extremes in the Netherlands, and the sea level is rising. There are a lot of risks connected to these changing circumstances, which include floods, food shortages due to bad yield, and the extinctions of species. It is crucial for us to adapt to these changes, but in order to do so, there is a necessity of certain measures. In order to determine what kind of adaptations would fit the current circumstances, there is a need for statistical data on the effect of climate change. There is already a lot of data available, but it is yet unknown whether these statistics are sufficient to come to fitting solutions. In order to draw relevant conclusions, the gathered data should be as complete as possible.

According to Statistics Netherlands (Denneman, personal communication, January 22, 2018) and the Municipality of Zwolle (Van Rooijen, personal communication, January 29, 2018), there is a general lack of understanding what kind of data is still needed. Therefore, this research is going to function as an inventory of data-needs. The National Adaptation Strategy (2016), and the Regional Adaptation Plan (2017) are the baseline of this research. The inventory of data-needs is based on the effects that are described in these two reports. Due to the limited time frame that we had to work with, we made the decision, together with Arthur Denneman (Statistics Netherlands), to only focus on one of the nine sectors, in my case the Agricultural sector. Another student, Pascal Kist, focused on the sector 'Water and Spatial Management'. Moreover, we made the choice to focus the research on the region of Zwolle.

The results of the research will be analysed and discussed in this research report. Based on this report, an advisory report for Statistics Netherlands and the municipality of Zwolle will be written. This advisory report will contain data-needs that were identified during the research concerning the agricultural sector. Moreover, this research report includes recommendations. The results will be beneficial for data-generating authorities, as it gives some concrete data-gaps that need to be filled, and it will be beneficial for the agricultural sector, as effective climate change adaptation can be implemented after proper research.

2. Literature Review

This literature is written with the purpose of gathering more knowledge about the topic of climate change (adaptation) in the agriculture sector on a global scale.

Agriculture is an important sector to take into account when thinking of climate change adaptation. Agriculture is one of the main land uses across the globe. Moreover, a significant part of the earth's surface is used for fisheries (Easterling, et al., 2007). Because agriculture is such a big part of the world, it is a major economic, social and cultural activity. As a balanced, stable ecosystem is crucial for agriculture, the sector is extremely vulnerable to potential effects of climate change. If proper adaptations to these effects of climate change are not implemented, there could be negative consequences in the agricultural sector (Howden, et al., 2007). Wiebe et al. (2015) argue that the effects of climate change on the agricultural sector are even worse than initially thought.

As there are still a lot of farmers who have not yet adapted to these changing circumstances yet, early adopters can definitely benefit by implementing adaptations to gain a comparative advantage (Meinke, Stone, 2005). Howden et al (2007) describe a number of benefits that agricultural adaptations can have:

- Climate change adaptations in the agricultural sector could make harvest more sustainable and efficient.
- It could prevent malnourishment in the future, as it prevents general poor yields from happening.
- Evaluating these adaptations could help improving the general policy and strategy concerning agriculture.
- Even though these adaptations could be a huge initial investment, they can make the harvest more cost-efficient over-time. Already adapting to climate change can also prevent drought and soil-degradation, as the risk of exhausting the soil is lower with proper adaptations (Power, S., et al., 2005). Moreover, more cost-efficient harvests also benefit the consumer, as the surplus of crops is potentially bigger. This generally means cheaper products for the consumer.
- Early adapters are necessary to conduct long-term research on the effectiveness of the adaptation measures (Howden, M., et al., 2003).

According to Howden (2007), relatively easy adaptations concerning water management, altering crop varieties and timing, improving weed management, and using climate forecasting can already have a significant effect in the long term. It is not yet fully known, however, what effects these climate change adaptations have on for example air pollution (Tubiello, F., et al., 2007).

In conclusion, Howden et al. (2007) argue that one of the most important things at the moment is that there should be more research on the impact of climate change on the agricultural sector. Only with proper knowledge about current effects of climate change and the potential of climate change adaptations, some current uncertainties about these topics can be resolved. In order to respond as effectively as possible to climate change, proper research is key. For proper research to be able to happen, a number of farmers worldwide have to 'pilot' some of these adaptation techniques. This could be a big risk for these individuals, as these pilot projects can cost a lot of money (United Nations, 2016), and success is not always guaranteed. But only if farmers adopt these new techniques, scientists will be able to do proper research on the topic. In order to make it more appealing for these farmers, government-subsidised projects are an option

According to Davies et al. (2009), inhabitants of rural countries suffer greatly from climate change, as a stable ecosystem is so important for their harvest. They rely on their food production as a form of income and thus survival. However, these fluctuations do not necessarily mean that there will be negative impact. Farmers usually have to cope with changing seasons, which improved their adaptability and time management. But the potential fluctuations due to climate change could be very severe and have a big impact on the rural areas.

Therefore Davies et al. (2009) suggest that disaster risk reduction and climate change adaptation are necessary in order to sustain the crops and cattle. According to him, disaster risk reduction is important for farmers to implement, but it might not be sufficient on the long term, as it aims on reducing risks on the short term. Therefore, climate change adaptation should be implemented, which aims more on improving the situation in the long term. Because more is known about climate change than before, climate change adaptation has grown from a minor concern to a major environmental challenge (UNPD, 2007).

According to Fischer et al. (2002), climate change and climate change adaptations are a global and intergenerational issue. It involves a complex interaction between environmental, economic, political, social, and technological processes. The adaptability of the agricultural sector depends on factors such as population growth, arable land, water management, and infrastructure. As challenges within the agricultural sector are increasing (due to climate change), and populations (and thus food demand) are growing worldwide, adapting to this is crucial in the near future. Fischer et al. (2002) propose that policies should be implemented that reduce the pressure on natural resources, improve the management of environmental risks, increase the welfare of developing countries, and advance sustainable development within the sector. Even though implementing these policies can be challenging, it could be a crucial step towards reduction of vulnerability to climate change.

In the report of Nelson et al. (2009), they determine a number of impacts that climate change will (or could) have on the agricultural sector:

- Yield on crops will generally be lower. Most hard-hit countries will be the developing countries, with irrigated rice production in southern Asia being most hard-hit, as already suggested by Davies et al. (2009). Due to the increasing temperature, the water demand will also be higher. Areas with less access to water, will have to adapt to these changing circumstances.
- Prices of the most important crops worldwide (wheat, rice, maize, and soybeans) will increase in between 2000 and 2050.
- The average calorie availability per world citizen from crops will decrease in between 2000 and 2050, due to lower yield and increase of the world population. This is especially a problem in the developing world, where child-malnutrition will also increase due to the lower availability of calories.

Due to growing knowledge of the effects that climate change can have on the agricultural sector, climate change adaptations are increasingly important on the political agenda. These adaptations are mostly based on making the rural population more resilient to the negative effects of climate change. As some of these worldwide climate change adaptations will cost billions of dollars, it is crucial that proper research leading to these adaptations will be done beforehand. Therefore, Nelson et al. (2009) suggest that national research and global data collection and analysis should be improved to conduct proper research before actually implementing climate change adaptations. It is therefore crucial to determine the data-needs, in order to do research more effectively and efficiently. This stresses the importance of this research. The last thing that is recommended is to increase the funding for climate change adaptation worldwide. Investing in adaptations may cost a lot of money now, but it can save a lot of money in the future (United Nations, 2016).

3. Research Objectives

The effects that climate change has on the agricultural sector in the Netherlands, are already described in the National Adaptation Strategy (2016). As these are already available, it will be used as the theoretical framework for this research. The complete schemes are included in Appendix I. The main objective of this research is to find out whether the current amount of data and statistics is sufficient to come up with and implement proper climate change adaptations to the agricultural sector. If the current available data is not sufficient, an objective of this research is to find out what data is still needed. This will be tested on each individual effect that was covered during this research, in order to get a complete overview of the amount of data that is available at the moment, and especially the data-needs that are present.

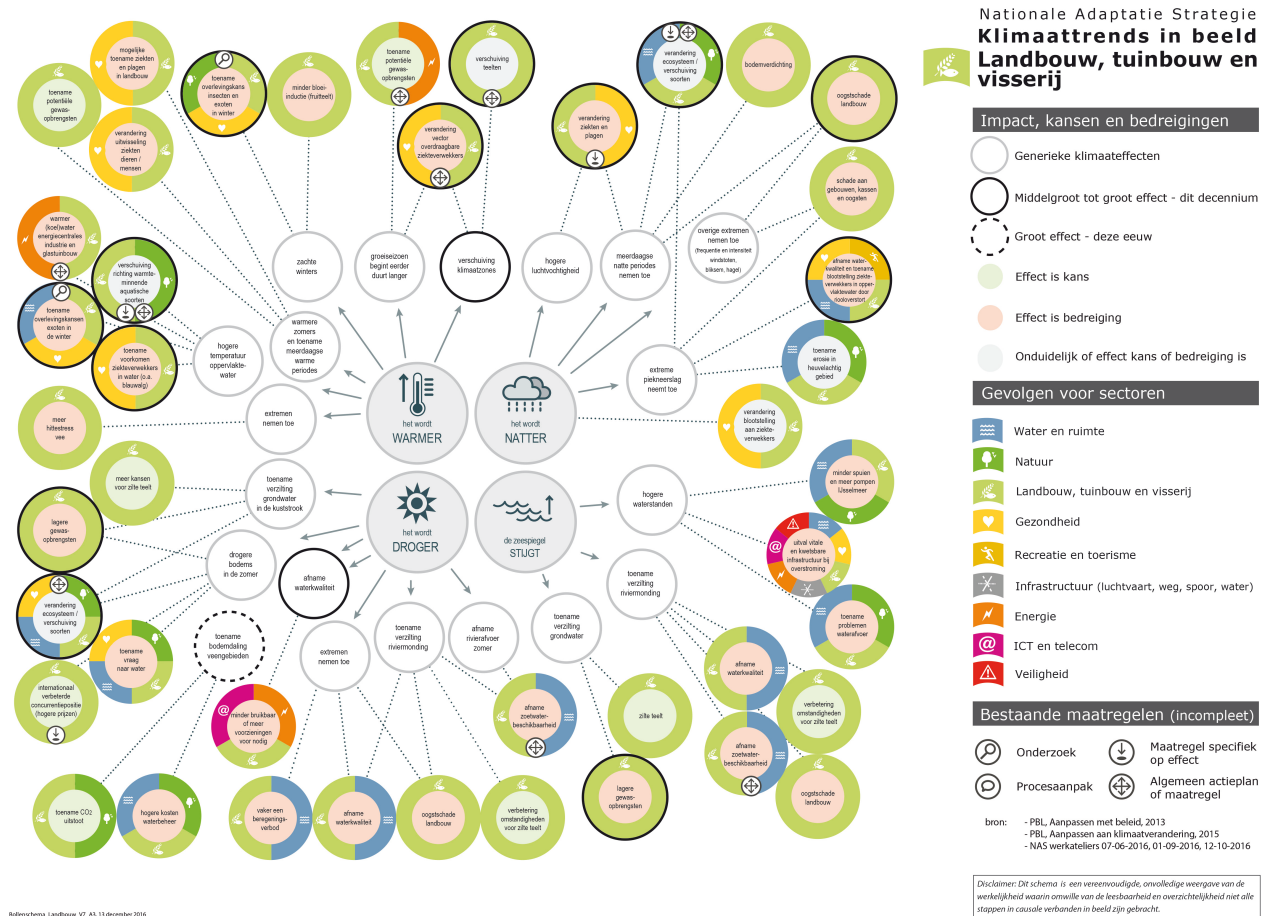


Figure 1. National Adaptation Strategy: Agricultural Sector (Meijs, S., et al., 2016).

Howden et al. (2007 and Nelson et al. (2009) already described that it is key to conduct proper research before actually implementing climate change adaptation on a large scale. Currently, it is unknown whether the data that is available at the moment is sufficient. Therefore, it is important to get more clarity on this. The objective of this research is providing an inventory of data-needs that seeks to assess the available data connected to the top 5 most urgent climate change effects in the agricultural sector. The research will then try to identify what crucial data is not available. Based on this, there are a number of recommendations included.

The main research question is based on the general data-needs and the sub-questions are based on the individual issues within the main research question. This will mainly be on the regional scale, in this case the region of Zwolle, Overijssel. The covered research questions are as follows:

Main research question

What data is already present, and what data is required in order to implement effective and efficient climate change adaptations to the agricultural sector in the Netherlands?

Sub-question 1

What are the five most important climate effects concerning the agricultural sector that are described in the theoretical framework?

Sub-question 2

What data concerning implementing effective and efficient climate change adaptations to the agricultural sector in the Netherlands is already available?

Sub-question 3

When is data qualified as sufficient to implement effective and efficient climate change adaptations to the agricultural sector in the Netherlands?

Sub-question 4

What data concerning implementing effective and efficient climate change adaptations to the agricultural sector in the Netherlands is required?

Sub-question 5

Who can supply this data concerning implementing effective and efficient climate change adaptations to the agricultural sector in the Netherlands?

4. Research Design

The research consists of three main parts, namely a survey (and focus group discussions), interviews, and desk research. The main purpose of the survey was to narrow down the number of effects of climate change on the agricultural sector. There were 33 effects described in the schemes provided by the Regional Adaptation Plan (RAP, 2017). By using this survey and three focus group discussions, the five most urgent effects of climate change on the agricultural sector were identified. The survey was distributed amongst carefully chosen experts of the agricultural sector, using the selective sampling method. Experts included:

- Employees of Statistics Netherlands in the Department of agriculture and environment.
- Experts from governmental institutions including municipality of Zwolle, province of Overijssel, regional water authorities, and the cadaster.
- Lecturers from Adres Hogeschool Dronten (University of Applied Sciences for Agriculture).
- Experts from consultancy bureaus.

The objective of the survey was to narrow down the 33 effects to the five most urgent (as perceived by the experts) climate change effects on the agricultural sector. It is important to note that 'urgent' could have different meanings in this context, including the impact that the effect has on the sector, or the potential lack of data about the effect. The description of the survey made this clear. The survey is included in Appendix II. The participants had to make a top 5 of effects that they perceive as most urgent. The order of the top 5 was important as well, in order to make sure that five effects can be distinguished, and to lower the chance of the outcomes ending up in a tie between different effects. The participants were also asked to give a short explanation of their choices. This is done in order to gain some insights in the thinking processes of the participants, and it gives more information which can be used in the next phase (interview) as well.

On 12 March 2018, a focus group discussion with a working team concerning climate change adaptation in the region of Zwolle was initiated. The purpose of this focus group discussion was to test the survey that was created beforehand. In this focus group discussion, we asked the participants to complete the survey (that is normally done online, as a self-completion questionnaire), and if there were any questions, we were able to answer these. Moreover, if there was any feedback on the survey, we could take this into account before actually distributing the online survey amongst the chosen participants. During this focus group discussion, the participants identified some unclarities, and provided further feedback. Not only were there quite a lot of participants who completed the survey, there were also some in-depth discussions about the topic, as there was a round-table discussion after completing the survey. Because this focus group discussion was such a success, we decided to also apply this method with the participants of Statistics Netherlands. We held two more focus group discussions on 21st and 22nd of March with six participants each that completed the survey. initiated with each six participants that completed the survey (held on 21 and 22 March). The focus group discussions were also recorded in order to improve reliability and use the information that was shared during these sessions. During these sessions, the participants completed the survey, and had discussions about their choices afterwards. The discussions were valuable, and we acquired quite a lot of good information.

As the other chosen participants have various backgrounds, it was difficult to complete the survey in such a group setting, thus we chose to distribute it online. Unfortunately, the response rate of the online survey was low, even though we sent a reminder a week after the initial invitation. This was probably due to the complexity of the survey, which the participants that did complete the survey was also mentioned. Nevertheless, a total of 25 people completed the survey, which was a sufficient number to make a top 5 of most important climate change effects on the agricultural sector. The questions in the next part of the research, the semi-structured interview, were based on this top 5.

5. Sampling

For all the different parts within the research, we used a selective sampling method, which means that the participants were specifically chosen beforehand. We did this to make sure that the participants of the research had sufficient knowledge of the topic.

Because agriculture is quite a broad topic, there were some requirements to be met by the participants of the survey, focus group discussions, and the interviews. These are:

- Participants should have sufficient knowledge of the topic agriculture, especially in the context of climate change adaptation.
- Participants should have knowledge of the region of Zwolle, as the research has a regional focus.
- Participants from different disciplines should be included in the research, in order to gather data from multiple perspectives.

In order to find participants for first the focus group discussions and the online survey and interviews, we used the network of both Statistics Netherlands and the municipality of Zwolle. The focus group discussions and online survey had a total of 25 participants. There were eleven experts that participated in the semi-structured interviews. The background of these participants of the interviews are included below (table 1). The availability of this network of both Statistics Netherlands and the municipality of Zwolle hugely contributed in the success of the research.

Table 1. Participants of the semi-structured interviews

Part.	Date of interview	Function
1	3 April 2018	Statistics Netherlands, department of environmental accounting
2	3 April 2018	Statistics Netherlands, department of agriculture
3	3 April 2018	Statistics Netherlands, department of environmental accounting
4	4 April 2018	Province of Overijssel, Regional Adaptation Plan
5	4 April 2018	HKV Lijn in Water, Research and Development
6	5 April 2018	Aeres Hogeschool, lecturer
7	10 April 2018	Statistics Netherlands, department of environment
8	10 April 2018	Statistics Netherlands, department of agriculture
9	11 April 2018	Aeres Hogeschool, lecturer
10	12 April 2018	Royal Haskoning DHV, Professional Water Resilience
11	13 April 2018	Kadaster Zwolle, Project Manager

6. Data Collection and Summary of Research Results

6.1. Survey and Focus Group Discussions

On the basis of the results of the survey, we determined a top 5 of most urgent climate change effects. The survey had a total of 25 respondents (focus group discussions and online self-completion questionnaire combined). As participants in the focus group discussions already pointed out, some of the effects are exactly the same or are very similar. Therefore, some of the effects are combined. From the 25 surveys that were completed, a clear top 3 of most important effects could be determined. Number four and five were closer to some others, but after analysing the outcomes of the survey and the explanations for this, four and five could also be determined. The outcomes of the survey, and thus the top 5 of the most urgent climate change effects on the agricultural sector are as follows (in order):

1. Decrease of freshwater availability
2. Increase of infectious diseases and plagues
3. Lower crop yields
4. Change in ecosystem/shift in species
5. Decrease of water quality

Table 2. Survey ranking of climate change outcomes

Rank	Climate change outcomes	1	2	3	4	5	Total
1	It is getting wetter	13	12	12	9	7	53
2	It is getting dryer	14	14	8	8	4	48
3	It is getting warmer	6	7	9	9	5	36
4	The sea level is rising	7	6	8	8	2	31

Note: The amount of times that the effects within the main climate change outcomes (as described by the National Adaptation Strategy from 2016) have been mentioned is included here. The numbers on top of the table mean the amount of times the climate change outcome was ranked as number 1, 2, 3, 4 or 5.

In the table above (table 2), a short summary of the outcome of the survey is visualised. The main climate change outcome that was mentioned in the survey is 'it is getting wetter', followed by 'it is getting dryer', 'it is getting warmer', and finally 'the sea level is rising'. According to some of the participants, the sea level is rising is the climate change outcome that is the least applicable of the four to the region of Zwolle. This region is relatively safe from the rising sea level; the other climate change outcomes are of a bigger concern for this area. The reason that this outcome still was mentioned quite a lot of times is because it includes two top 5 effects, namelijk: 'decrease of freshwater availability' (which is also included in 'it is getting warmer'), and 'decrease of water quality' (which is also included in 'it is getting wetter', and 'it is getting dryer'). A more complete result of the survey is included in Appendix III.

In the next section, some of the explanations that the participants of the focus group discussions and online survey gave for choosing the top 5 effects are shortly discussed.

Climate change effect 1. Decrease of freshwater availability

The main reason for choosing this effect for most participants is a supply/demand equation. One of the trends that also was mentioned by the participants (but did not make the top 5), is that the demand for water is increasing in the agricultural sector. At the same time, there will be more extremes in the weather (especially in the summers), meaning that there will be more and longer dry periods. In these periods there is less supply of water, simply because of the absence of it. This climate change effect also goes together with the effect 'decrease of water quality'. A lot of the water that might be accessible is becoming less usable, which makes it harder to irrigate crops properly for example. This decreasing availability of freshwater could lead to another effect which has been mentioned, namely 'lower crop yields'.

Climate change effect 2. Increase of infectious diseases and plagues

According to some of the participants of the survey, this climate change effect is important to take into account, and has two main causes. The first cause is that winters are generally warmer. This means that a lot of insects that have negative impact on the crops do not die in winter, which causes problems in the growing season. This also partly leads to another climate change effect that has been mentioned quite often in the survey, namely 'change in ecosystem/shift in species'. A lot of the natural enemies of species that are harmful for the crops are not present anymore in the habitat of these species. This means that they can reproduce freely, which leads to more potential plagues on crops. The second cause is that there will be more and longer wet periods. These wet periods cause certain infectious diseases and harmful fungi in the crops. An increase of infectious diseases and harmful fungi call for the use of pesticides. But according to some of the participants, the increasing use of pesticides also has a lot of downsides, including the negative effect it has on important insects such as bees, and the impact it has on the water quality.

Climate change effect 3. Lower crop yields

In the survey it became clear that this climate change effect is the result of a lot of the other (negative) effects on the agricultural sector. The most important cause of this effect that a lot of the participants mentioned was that there will be more extreme weather. The main climate change outcomes 'it is getting wetter' and 'it is getting dryer' are for example causes for problems in the agricultural sector, because both too dry and too wet are generally bad for crop yield. The fact that there is a decreasing availability of freshwater, and there is an increase of infectious diseases and pesticides (effect 1 and 2) also contribute to lower crop yields. According to some participants this will affect the quantity and quality of the products that are produced. This is especially the case in regions with sandy soils, as it is more difficult to irrigate these areas.

Climate change effect 4. Change in ecosystem/shift in species

Not all the described effects in the Regional Adaptation Plan (2017) are necessarily perceived as negative. There are also effects of which it is unknown whether it has a negative or positive impact on the agricultural sector. The fourth climate change effect that is chosen by the participants is an example of this. The change in ecosystems and shifts in species could mean that it is necessary to either grow different crops or different crop varieties that are more resistant to the changing circumstances. Growing different crops that are being grown today might be an opportunity for the economic position of the Dutch agricultural sector. It is, according to the participants, important to learn the exact impact, both economically and ecologically, that the change in ecosystem and shift in species will have on the agricultural sector.

Climate change effect 5. Decrease of water quality

On recommendation of many of the participants of the focus group discussions, and online survey, three climate change effects are combined. These effects are so similar that it is more relevant for the research to cluster them. The effects that will be clustered are:

- Decreasing water quality due to swilling.
- Worse water quality due to rising, erosion, and overflow of sewage.
- Decreasing (swim)water quality.

This effect made it to the top 5 partly because some of the participants think that there is not enough data available about the quality of water, and is therefore perceived as 'urgent'. A component of this effect is that there will be an increasing amount of algae in the surface water. Another component that has been mentioned is that changing circumstances could lead to an increasing use of pesticides, which is bad for water quality. However, not all participants agreed on the urgency of this effect.

6.2. Semi-Structured Interviews

Based on the outcomes of the online survey and focus group discussions, an interview protocol was constructed. I conducted a total of 11 interviews over a period of two weeks (from 3 April to 13 April 2018). The interviews were semi-structured, and the purpose was to determine the most important components of the top 5 most urgent climate change effects on the agricultural sector in the region of Zwolle. Moreover, the participants of the interviews were asked if they agree with the top 5 effects, and what the demand of data connected to these effects are. At the end of the interviews, the participants had the opportunity to mention factors that are not covered by the five discussed effects. This was done in order to make sure that all important factors are taken into account in this research. I chose a semi-structured interview in order to gather as much information as possible, using probing techniques. The complete interview protocol is added in Appendix IV.

The interviews were all recorded (with the permission of the participants), and transcribed afterwards. The transcriptions were coded, in order to better analyse them. The amount of information gathered from the semi-structured interviews was satisfactory, as most participants had a lot of knowledge about the topic, and most of the interviews lasted for at least 40 minutes. By using selective sampling of the interview participants, the quality of the gathered information was also assured. In the section below, the outcomes of the semi-structured interviews are analysed.

Climate change effect 1. Decrease of freshwater availability - components

During the interviews, it became clear that the effect 'decrease of freshwater availability' is one of the most important effects on the agricultural sector. 10 out of 11 participants agree with this effect being in the top 5 most important effects, as they perceive it as a serious risk for the future. This has a couple of reasons. First of all, the extremes of weather are increasing. This on the one hand means that there will be more long wet periods, which causes difficulties on its own, but contradicts the 'decrease of freshwater availability'. On the other hand, it means that there also will be more long dry periods, in which the 'decrease of freshwater availability' is a serious issue. Secondly, according to most participants of the interviews, salinisation is becoming more problematic for the Dutch agricultural sector. Even though this is not (yet) the case in the region of Zwolle, it is important to take into account. Salinisation is roughly a consequence of the decreasing availability of freshwater (Statistics Netherlands, personal communication,

April 3, 2018). If the salinisation level of the soil is too high, it could mean that the area cannot be used for agriculture anymore. Moreover, a high level of salinisation can be a hazard to the supply of drinking water.

According to some participants the annual precipitation is not going to change, but there will be longer wet and dry periods. In the longer wet periods, there will be water nuisances in a lot of places in the Netherlands (Statistics Netherlands, personal communication, April 10, 2018). In the longer dry periods, there will be a shortage of water. One of the main problems here is that there is not enough water stored. In areas with clay soil, it is easier to store water than it is with sandy soil. A good solution to this problem could be implementing more water buffers throughout the regions. These water buffers can be implemented in cities, lakes, farms, etcetera (Aeres Hogeschool, personal communication, April 11, 2018).

Climate change effect 1. Decrease of freshwater availability - data-needs

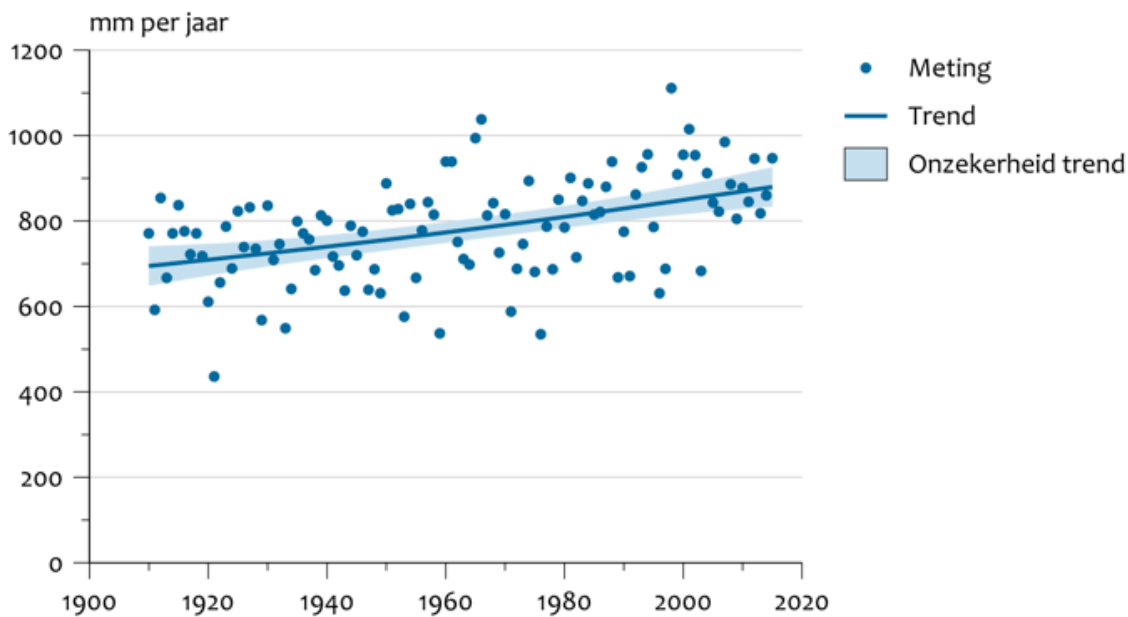
First of all, according to the participants, it is important to know how much freshwater is available in the Netherlands at any given time. By monitoring the quantity of available freshwater in the Netherlands (or in a certain region), trends can become visible, which can be used to base climate change adaptation on. Moreover, it is important to keep track of the amount of water that is used for the agricultural sector. This should not only be done on the national scale, but also on more regional scales. As different regions have different circumstances, the water use can differ. Another factor that could be taken into account here is the form of agriculture, as the usage of water in the different forms differ as well.

Moreover, it is important to monitor the groundwater level. This should also be done both nationally and regionally, as this number could differ per region. It is important to know where the soil is able to hold water well, and where the soil is not able to hold water well. By monitoring this closely, certain 'risk regions' can be identified after some time. These are the regions with a groundwater level that is structurally too low. These regions rely on freshwater supply from different regions that have a surplus of freshwater (Cadaster, personal communication, April 13, 2018). This brings another data-need; how can this water transition between different regions in the Netherlands go as efficiently and effectively as possible.

As the freshwater availability is mainly an issue in long dry periods, it is important to have a framework of weather data. This includes predicting when dry periods will occur and monitoring precipitation data (Statistics Netherlands, personal communication, April 10, 2018). A lot of this data, however, is already available at organisations such as KNMI, but it is not all collected and put together well. Farmers need to know whether the following year will be a wet or a dry year, or whether it will be a warm or a cold year. Even if the farmer knows that a dry period will occur in a couple of weeks, it will be useful information. This helps them with implementing short-term adaptations. Farmers need to know the longer-term climate forecasting as well, in order to implement proper long-term climate change adaptations (RHDHV, personal communication, April 12, 2018). One of the participants of the interviews, a farmer in the region of Zwolle, suggested that this data can be combined in a kind of 'climate dashboard', which is explicit and clear. Organisations that have these statistics available should discuss these possibilities with each other in the near future (Statistics Netherlands, personal communication, April 10, 2018).

Figure 2. Amount of annual precipitation (PBL, 2016)

Hoeveelheid neerslag



Bron: PBL.

PBL/mrt16
www.clo.nl/nl050806

The amount of water that falls from the air in the form of precipitation is not getting lower annually, but according to a study from PBL (2016), it is actually getting higher (see figure 2). Therefore, the freshwater availability should not be a problem in the Netherlands, the dry and wet periods should balance each other out over time. According to some participants of the interviews, more water buffers should be implemented. These could take the form of big water reservoirs, like the IJsselmeer, but farmers themselves can also collect water locally. There are already some farmers that collect rainwater in wet periods, that they then use to irrigate their crops, or what they use for their livestock in dry periods. Another option is to collect water in urban areas, which some of the participants highlighted. A thing to take into account here is that the water then still has to be distributed to the areas in need of it (RHDHV, personal communication, April 12, 2018). There is still a lot of research to be done connected to water buffering and its effects.

Table 3. Recommendations and data-needs effect 1: Decrease of freshwater availability

Recommendations and data-needs:

- Constant water-monitoring.
- More water-use measurements.
- More weather data on short and long term.
- Experiments with drought-resistant crops.
- More data concerning water buffers.

Climate change effect 2. Increase of infectious diseases and plagues - components

The second climate change effect is the increase of infectious diseases and plagues. 9 out of 11 participants agree with this effect being in the top 5 most urgent effects. This climate effect has multiple components. According to some of the participants of the interviews, the increasing temperature and wetter conditions cause some harmful bacteria and fungi to reproduce faster. If the natural balance, which is present at most places in the region of Zwolle, is affected by an expanding species, it can disrupt the local ecosystem (Statistics Netherlands, personal communication, April 3, 2018). A disrupted ecosystem can lead to the disappearance of crucial species for the agricultural sector, which would be disastrous, and thus can lead to bad harvest.

Another component of this effect is linked to the fourth effect; Change in ecosystem/shift in species. If the global temperature rises, the Dutch climate becomes more appealing for species that are currently native to southern Europe for example. These species could bring different kinds of viruses and plagues with them, which we are not familiar with, and could disrupt the crops. This is already the case in some other countries, according to some of the participants of the interviews (Overijssel Province, personal communication, April 4, 2018).

If diseases and plagues will increase in the agricultural sector, due to the previously mentioned factors, farmers have to intervene. This could mean using more pesticides, which is not a desired outcome, as pesticides affect the soil and water quality (Overijssel Province, personal communication, April 4, 2018). If the Dutch agricultural sector does not respond correctly to these changing circumstances, it could harm the export-position (Aeres Hogeschool, personal communication, April 5, 2018). As the export of agricultural products is a key form of income for the Netherlands (Statistics Netherlands, 2018), it should be conserved. As organic cultivation is getting increasingly popular over the years (CLO, 2013), the use of natural crop protection could increase in the near future according to some of the participants.

Climate change effect 2. Increase of infectious diseases and plagues - data-needs

As this climate change effect is, like the ecosystem, pretty complex, it is hard to quantify. First of all, it is important to keep track of current plagues and diseases. This applies to both crop farming and livestock farming. If certain plagues or diseases occur in a certain crop, this should be registered. If there is a disease amongst cows in a certain region, this should be registered as well. After detecting a plague or disease, it is important to identify the cause of the problem (Statistics Netherlands, personal communication, April 3, 2018). In order to get to the root of these potential problems, relevant data contains what the perfect growing conditions are for fungi, plagues, and diseases. The big question, as with many other effects, is whether the effect is related to climate change. If the ecosystem is disrupted, it is important to know how to get it to a desired state again. There is certainly a data-need on how to effectively do this in all the different circumstances (Statistics Netherlands, personal communication, April 3, 2018).

With this effect, it is important to gather some data on parcel-level. Examples of data-needs on parcel-level are: crop species that you grow, crop variety that you grow, yield when there are no serious plagues or diseases, yield when there are serious plagues or diseases, pesticides that you use on the parcel, type of soil, average temperature, and total precipitation. The more you know about a certain parcel, the easier it is to establish causal links between different factors. If you know some of the causal links, it is easier to combat the issue of for example a plague on the crops (Statistics Netherlands, personal communication, April 10, 2018). Another thing that the participants of the interviews mentioned is that the role of these

kinds of microdata can change in the near future. It becomes more important that individuals generate data about their own crops, which can be combined with other farmers in order to gather knowledge about certain issues in the agricultural sector.

Another thing that the participants mentioned during the interviews, is that it might be smart to learn from practices from the southern European countries, as species are shifting north. The climate that is currently in southern France could be the climate that will be here in 50 years. As they are already dealing with it, we can learn from their practices, so we do not have to 'invent the wheel' ourselves. We can observe the things that they are struggling with, and the things that they use to combat vermin, plagues, and diseases. Moreover, it would be relevant to find out what the correlation is between the rising temperature, and the native species that currently live here (Overijssel Province, personal communication, April 4, 2018). How will it affect them? What is the effect of the changing circumstances on the insect populations on and around crops?

There are some plagues and diseases that we cannot prevent from happening. We can adapt to this by using more pesticides. But since pesticides are bad for soil and water quality, it might be right to look for alternatives. A data-need in this context is to look for other alternatives for the chemical pesticides. In case chemical pesticides will be used, it must be completely clear beforehand, what kind of side effects they have.

Table 4. Recommendations and data-needs effect 2: Increase of infectious diseases and plagues

Recommendations and data-needs:
<ul style="list-style-type: none">• Constant monitoring of current plagues and diseases.• More data regarding effects of plagues and diseases.• More data on parcel-level.• Determine perfect growing conditions.• Look at southern countries.• Effect studies on alternatives for pesticides.

Climate change effect 3. Lower crop yields - components

The third climate change effect, lower crop yields, is mainly perceived as a result of some other climate change effects. First of all, the weather extremes are increasing, which means that there will both be longer dry and longer wet periods. Longer dry periods can, without proper adaptation, lead to drought damage to the crops, which would lead to lower crop yields. This is the same with longer wet periods, which can lead to water damage, which would also lead to lower crop yields (Statistics Netherlands, personal communication, April 3, 2018). Another example of an effect that might affect the crop yield is the decreasing availability of freshwater. This will especially be a problem in the longer dry periods, on sandy soil. The increase of temperature is another factor that is important to take into account. A rising temperature could mean the end of the cultivation of a specific crop, which could, in some cases, also mean a lower total crop yield.

As farmers live off crop yields, it is crucial that these will be sustained in the future. In order to prevent lower crop yields from happening, there are some adaptations that farmers can implement. One of these adaptations is switching to a crop variety that is specifically resistant to drought or wetness for example. Another example is switching to an entirely different crop (Cadaster, personal communication, April 13, 2018). This could especially be the case in a scenario in which the temperature will increase with quite a few degrees. In this scenario, the Dutch climate might be sufficient to grow currently mediterranean crops. An important thing to take into account is that there should be a market for the newly grown crops, otherwise there would be an oversupply of a certain crop, which would mean a lower price that farmers get for their crops.

Modern-day farmers in the region of Zwolle and elsewhere in the Netherlands are entrepreneurs. This is the very reason why most participants of the interviews expect that the farmers will adapt, and change with the current changing circumstances. They have to adapt; they basically put their money in the ground. As the agricultural sector is not changing rapidly due to climate change, farmers typically have enough time to adapt (Cadaster, personal communication, April 13, 2018). It should be noted, however, that this is something that should be taken very seriously.

Climate change effect 3. Lower crop yields - data-needs

First of all, it is crucial to monitor yields per parcel. By monitoring yields, and differentiating per crop, soil-type, and climate, trends may be visible on the longer term. If a downward trend is visible on the longer term, some sort of intervention should be implemented to prevent this problem from worsening (Statistics Netherlands, personal communication, April 3, 2018). If a particular parcel has a bad year, it might be due to a certain event or reason. By monitoring the situation closely, the chances of detecting these events or reasons are higher. If these causes can be determined, selective adaptation can be implemented to the parcels.

Moreover, so-called 'good practices' should also be taken into account. If a year's yield is relatively good, you want to know what set of factors made it a good year. This is knowledge that a farmer can use to potentially improve yield in the future as well. Therefore, this crop monitoring is key in developing good strategies for the future in the agricultural sector (Statistics Netherlands, personal communication, April 3, 2018).

Another thing that is important to know is which foreign crops farmers can and which they cannot grow here in the future. If the temperature rises, the circumstances for growing certain crops change. The bigger the rise of the temperature, the bigger the change of circumstances are as well. Therefore it is important to know which crops can be grown in the future climate (Statistics Netherlands, personal communication, April 10, 2018). It is, for example, relevant to know if farmer should only grow other crop varieties, or if they have to grow entirely different sorts of crops. It is recommended by some of the participants of the interviews, to look at what is currently going on in other countries. Especially the circumstances in southern European countries like France, Spain, Portugal, and Italy should be monitored closely. As our climate will most likely be comparable in the future with their current climate, we can learn from their good and bad practices (Overijssel Province, personal communication, April 4, 2018).

There are a lot of factors that could potentially affect the farmers' yield. In order to tackle a problem as well as possible, we should solve it at the root. If the root of the problems is not yet fully identified, there is a

data-gap. The root of these problems is certainly something that is not fully known at the moment (Overijssel Province, personal communication, April 4, 2018).

Not all factors that could affect the farmers' yield are climate change-related. Therefore it is important to know what the most important cause of the potential yield loss is. If it is a climate change-related issue, climate adaptation can be a solution, but if it turns out that it is not climate change-related, implementing climate adaptation would be a loss of resources (Cadaster, personal communication, April 13, 2018).

Table 5. Recommendations and data-needs effect 3: Lower crop yields

Recommendations and data-needs:

- More monitoring on parcel-level
- Take domestic good practices into account.
- More scenario planning concerning climate change.
- Look at current practices abroad.
- Determine whether the cause is climate change.

Climate change effect 4. Change in ecosystem/shift in species - components

If this fourth effect occurs, it could have a huge impact on the biodiversity that is currently present. If something changes in nature, it has impact on the agricultural sector, and if something in the agricultural ecosystem changes, it has impact on nature. If the global temperature will rise, this will certainly affect the regional ecosystem. Species will either migrate north, or they will go extinct. This means that species that currently live south of our regions could be introduced here. This could have a positive effect, but these species could also bring new diseases and plagues, currently unknown in this region, with them (Statistics Netherlands, personal communication, April 3, 2018). Taking these factors into account, most participants of the interviews think that this is an important and urgent climate change effect.

This effect, however, could also have positive influences on the agricultural sector. If the temperature rises with a couple degrees, the Dutch climate could be sufficient to grow different crops. This means that certain products that now have to be imported, can be grown here. An example of this that has been mentioned a couple of times is soy. At first, this only grew in southern European countries, but it now also grows in the Netherlands. It could help us being more self-sufficient concerning growing different crops. Therefore, it is important to keep experimenting with new crops or new varieties, in order to determine the effectivity of the newly introduced crops (Aeres Hogeschool, personal communication, April 5, 2018).

According to some of the participants of the interview, it is undesirable to switch to a monoculture on a large scale. The more diverse the cultivation is, the better it is for important insects such as bees, and spiders that hunt harmful insects. Therefore participants recommend to prevent a monoculture from happening as much as possible, and implement mixed cultivation (Statistics Netherlands, personal communication, April 3, 2018). It should be noted, however, that the participants generally trust the entrepreneurship and innovativity of the farmers; they will adapt to the changing circumstances, as it influences their yield.

Climate change effect 4. Change in ecosystem/shift in species - data-needs

First of all, it is very important that the ecosystems that we have will be monitored closely. It should be known what kind of species live where, and in what numbers they live there. As the change in ecosystem and shift in species is a relatively slow process, this should be monitored over numerous years. This monitoring should be done per ecosystem, as this phenomenon is region-bound. By monitoring over a long time, trends could potentially be identified, which can help adapting to the changing circumstances (Statistics Netherlands, personal communication, April 3, 2018).

It is important to know what the current situation is for the ecosystems in the region, and how this situation can be improved. One participant recommended to form a kind of basic framework of actors in ecosystems. It is important to know the basic needs for an ecosystem to function properly. If this knowledge is present, and if close monitoring of ecosystems happens, adaptations can be implemented if it not going so well with a certain ecosystem (Cadaster, personal communication, April 13, 2018).

Another thing that should be taken into account are the components of newly introduced (or yet to be introduced) crops. It should be clear what its effects are beforehand, to prevent ecological disasters from happening. One way of doing this is, as previously mentioned, to look at ecological systems of other countries with a warmer climate. They have been coping with the concerning species for some time now, so there is knowledge that can be transferred. In order to validate this, observations in another country should be done in the same way as they are done in the Netherlands. Otherwise it can be hard to compare both countries (Statistics Netherlands, personal communication, April 3, 2018).

With this effect, it is also important to do some forecasting studies. Most participants of the interviews are not too concerned that key insects such as bees will disappear, but if something disastrous would happen, they could disappear. Important things to know here are:

- What does it mean for agriculture if species disappear or ecosystems change?
- What does it mean for the soil fertility?
- What does it mean for other species?

Table 6. Recommendations and data-needs effect 4: Change in ecosystem/shift in species

Recommendations and data-needs:

- Monitoring per ecosystem is key.
- Create a basic framework of actors in ecosystems.
- Effects of newly introduced species should be known.
- Conduct forecasting studies on ecosystems.

Climate change effect 5. Decrease of water quality - components

The last climate change effect of the top 5 effects is not very urgent according to most participants of the interview. First of all, a big part of the decrease of water quality is not an effect of climate change, but mostly a human-related effect (Statistics Netherlands, personal communication, April 3, 2018). A big culprit of this problem is, for example, the agricultural sector. Due to the wide use of pesticides, parts of it end up in the water, which decreases the quality of the water.

It should be noted that this effect used to be way worse than it is now. Due to all kinds of regulations concerning the use of pesticides, and close monitoring of the freshwater quality in the Netherlands, the quality is actually improving (Aeres Hogeschool, personal communication, April 5, 2018). Therefore, the main players that can solve this problem are the policy makers. They can make sure that harmful pesticides will be prohibited, and will make place for less harmful pesticides. Not only is this better for the (ground) water quality, it is also better for the soil quality. According to one of the participants of the interviews, we still do not comply with the water quality norms that we agreed to in Brussels. Even though the amount of pesticides that ended up in water has decreased with 95%, we are still not there; there is still room for improvement (Cadaster, personal communication, April 13, 2018).

There are, of course, some climate-related components to the potential decrease of the water quality. An example of this is the salinisation. Because the sea level is rising (which is one of the main climate change outcomes), more salt water will flow into the Dutch rivers. This could mean that parts of the current river systems in the Netherlands will not be usable in the future. This would especially be a problem near the coast, but not so much in the region of Zwolle (yet) (Aeres Hogeschool, personal communication, April 11, 2018). Another example of the impact that climate change could have on the water quality is algae formation. Due to the increase of temperature, algae populations could grow faster, which would be bad for the water quality. This is something that needs to be taken into account.

The main concern connected to this effect is a combination with the first effect; the decrease of freshwater availability. If, due to climate change, there would be less freshwater available in certain periods, and groundwater and surface water levels will be lower, it is important that the water is of sufficient quality. Low water levels are especially vulnerable to the impact of high temperature, and pesticides that end up in the water. As the total volume of the water bodies is lower in these periods, it warms up faster, so algae can grow faster, which is a concern. Moreover, if pesticides end up in water bodies with a lower volume than usual, the water quality decreases faster (Statistics Netherlands, personal communication, April 10, 2018).

Climate change effect 5. Decrease of water quality - data-needs

Even though this climate change effect is not perceived as particularly urgent, there are certainly data-needs connected to it. As is the case with most of the other effects, monitoring is key in measuring the water quality. Currently, a report concerning water quality should be delivered every three or four years, but that is quite a long period in terms of water quality. As the quality can fluctuate due to numerous reasons, some of the participants recommended to write these kinds of reports with shorter intervals (for example every year) (Statistics Netherlands, personal communication, April 3, 2018). Due to warmer periods, or heavier use of pesticides in particular regions for example, the water quality can be very different between regions, and over time. Moreover it is important to know who the main pollutants of the water are. If it is known that a particular company has a big concentration, the problem can be tackled at the root; the pollution of the company.

Another thing that is important to know is the salt variations in the water. This is especially the case close to the coast, where salinisation is a big problem. If you know where the rivers are getting saltier for example, you know the places where some sort of adaptation should be implemented in order to improve the overall water quality there (Statistics Netherlands, personal communication, April 3, 2018). Due to all kinds of new techniques, it is becoming easier to constantly monitor the water quality, rather than taking

samples of the water now and then. By using sensors, it is really easy to determine potential fluctuations in the water quality. If these fluctuations are determined in an early stage, a potential intervention can be done sooner, to prevent worsening of water quality from happening.

Table 7. Recommendations and data-needs effect 5: Decrease of water quality

Recommendations and data-needs:

- Monitor water quality more closely.
- Find out who the polluters are.
- Monitor salt variations.
- Make more use of sensors.

Other factors & recommendations

Apart from the top 5 climate change effects, there were also some other factors that were mentioned by one or multiple participants, which they perceive as relevant. These factors are shortly discussed in the following section.

One of these factors, the role of insurance companies, was already mentioned during the focus group discussions. Due to the increase of extreme weather, like heavy rain or heavy drought, costs for farmers could increase. According to some of the participants of the interviews, more farmers will insure themselves against extreme weather rather than adapt (Statistics Netherlands, personal communication, April 3, 2018). This is mainly because there are a lot of things that can lead to bad yield, and adapting to all of these things is simply too expensive. But if more of these extreme events occur, the insurance premiums will rise, which would be a problem as well.

Another factor that a lot of the participants of the interviews mentioned is important in the context of climate change (adaptation). In a lot of effects it is unknown whether climate change is the main cause. Before implementing all kinds of expensive climate change adaptations, it is recommended that the causality between climate change and the effects is confirmed. The bad water quality is, according to some of the participants, not really climate change-related, but more due to industrial pollution. Therefore, conducting studies that could either confirm or deny the causality between climate change and the described effects is recommended.

An effect that did not make it to the top 5, but is considered very important by some of the interviewees was the risk of water nuisance and floods (Overijssel Province, personal communication, April 4, 2018; Aeres Hogeschool, personal communication, April 11, 2018). Not enough water is certainly a problem, but due to extreme weather, too much water can be disastrous as well, and can cause a lot of damage. As the extreme weather is increasing, this problem is increasing too. This is certainly the case in the Netherlands, where the battle against water has been going on for centuries already.

Some thoughts and recommendations that came up during some of the interview sessions were connected to new forms of agriculture. As the agricultural areal could decrease in the future due to some climate-related effects, we have to look for new forms of agriculture to be able to sustain ourselves. Suggestions

that came up were linked to urban farming and sea farming (RHDHV, personal communication, April 13, 2018). As this part of agriculture is in an early stage, there are still a lot of data-needs. Participants recommend to conduct research on these forms of agriculture.

One of the key findings of this research is linked to all covered climate change effects of the agricultural sector. A lot of the participants of the interviews mentioned that there is not enough collaboration between the numerous data-generating authorities. According to one of the interviewees, there has been a lot of decentralisation when it comes to data generation over the last couple of decades (Cadaster, personal communication, April 13, 2018). On the one hand this can be a good thing; the more competition, the more these parties push each other to achieve, the better their research must be to keep existing. But on the other hand, this has negative impact as well. During the interviews, it became clear that a lot of the participants did not know a lot about the operations of other organisations. According to some of the interviewees, there is a lot of room for improvement here; these parties should work together more frequently. By using their own strengths, collaboration between different data-generating authorities can be more efficient and more effective. Therefore, one of the main recommendations is to work together in order to tackle the problem that affects us all; climate change.

A last thing that is recommended by one of the participants of the interviews is connected to the National Adaptation Strategy (2016) and the Regional Adaptation Plan (2017). On the one hand, it is very nice that there are working groups that are covering this issue. On the other hand, the schemes including the climate change effects that were covered during this research are the result of brainstorm sessions. There are a lot of effects that were included in both the National Adaptation Strategy and the Regional Adaptation Plan, but it is financially impossible to implement proper climate change adaptation that cover them all. Therefore, it is recommended by one of the participants that these effects will be quantified in the future (HKV Lijn in Water, personal communication, April 4, 2018). The norm that can be used to quantify these effects is for example in potential costs. This is a way of comparing impacts that these effects potentially have. If you quantify these effects, you can create a clear list including the effects that have the highest priority. In this way, more cost-effective climate change adaptation can be implemented.

7. Conclusion

During this research, a sufficient amount of data has been gathered by using both the survey and the interviews. With this information, most research questions could be answered. In this section, I will shortly discuss all research questions.

Sub-question 1

What are the five most important climate effects concerning the agricultural sector that are described in the theoretical framework?

An online survey and three focus group discussions were used to answer the first sub-question of this research. The participants of both the focus group discussions or the online survey had to make a top 5 most urgent climate change effects concerning the agricultural sector. The effects that they could choose were described in the Regional Adaptation Plan (2017). Even though the response of the online survey was a bit disappointing, enough data was gathered to form a top 5 to base the interviews on. The interviewees

were asked whether they agree with the top 5. Most participants agreed with the top 4, but the fifth effect, the 'decreasing water quality', was not perceived as urgent by most participants of the interviews. The top 5 of most urgent climate change effects is as follows:

1. Decrease of freshwater availability
2. Increase of infectious diseases and plagues
3. Lower crop yields
4. Change in ecosystem/shift in species
5. Decrease of water quality

Sub-question 2

What data concerning implementing effective and efficient climate change adaptations to the agricultural sector in the Netherlands is already available?

In order to answer this sub-question, the interviewees were asked what data is already available concerning the top 5 climate change effects on the agricultural sector. Some of the participants knew that there was data available concerning a specific effect. The water quality and quantity for example, is monitored closely, so there is a lot of data available. But the biggest problem concerning this sub-question is that a lot of that is unknown by a lot of people what data is available, and where it is available. As a matter of fact, this was one of the main conclusions drawn from the interviews. A lot of the data-generating authorities have a lot of data available, but they often do not know what everyone has available, as the collaboration does not seem optimal. A lot of the interviewees desire a better collaboration between the different authorities. Participants recommend that some sort of collaboration network between these authorities should be created, that makes it easier to find each other's available data. As Howden et al. (2007) argue, the more is known, the better climate change adaptations can be implemented.

Sub-question 3

When is data qualified as sufficient to implement effective and efficient climate change adaptations to the agricultural sector in the Netherlands?

This sub-question was meant to form indicators with which data can be tested whether it is perceived as sufficient to implement effective and efficient climate change adaptations to the agricultural sector in the Netherlands. Looking back, however, it was not realistic to form a set of indicators, as there was not enough time to do so. I recommend that there will be follow-up research to create a set of indicators that can properly test data sufficiency. Statistics Netherlands or the municipality of Zwolle can conduct this follow-up research in the future, for example. In order to do a comparable inventory in the future, creating a set of indicators could make the process more efficient and effective. As these indicators are general, they can be used by different inventories of different organisations.

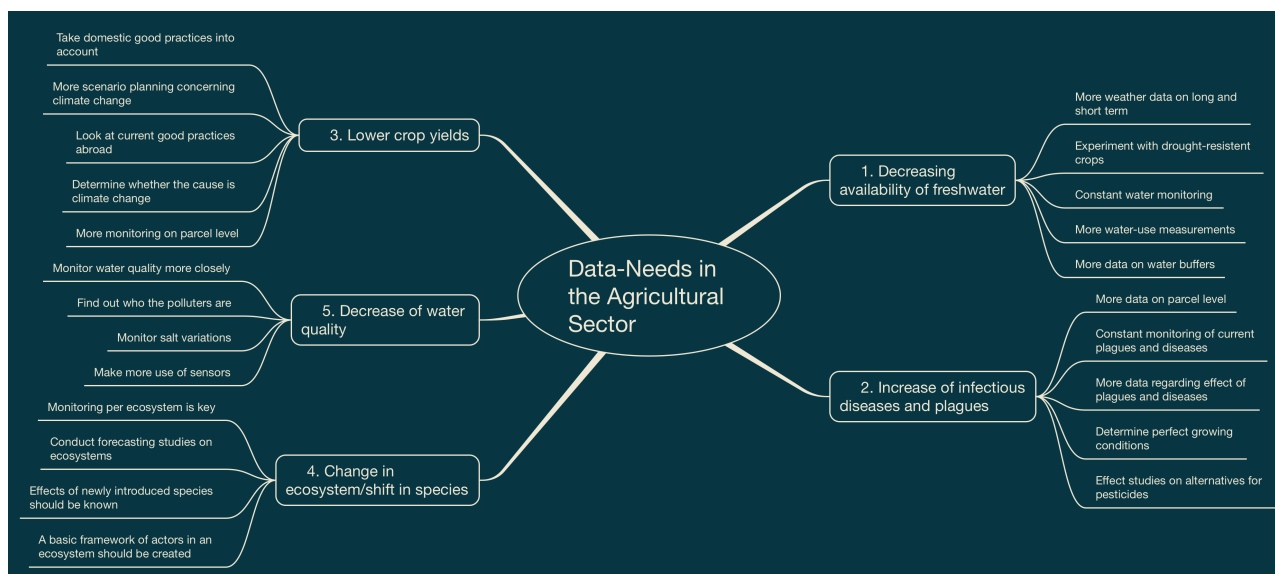
Sub-question 4

What data concerning implementing effective and efficient climate change adaptations to the agricultural sector in the Netherlands is required?

One of the main outcomes of the research was that monitoring is key in the discussed climate change effects. In the case of the first and fifth effect (freshwater quantity and quality), monitoring the amount and quality of ground and surface water is crucial. This should happen at any point in time. In case of the

second effect, the increase of diseases and plagues, it is also important to monitor the different parcels or livestock. By continuously monitoring this, it is easier to identify potential trends, and potential diseases or plagues. According to the participants, the earlier a problem (or bad trend) is identified, the better. With the third effect, the lower yield, it is also key to monitor the parcels or livestock. In case of bad yield, it is crucial to identify potential causes, and to monitor this. In this way, things can improve in the future. Moreover, it is important to monitor ecosystems. It should be clear what kind of species live where, and in what numbers they live there. This should be monitored over numerous years. As climate change is a relatively slow process, data from a lot of years is necessary to be able to identify certain trends. If these trends are identified, certain interventions are possible in form of climate change adaptation. Particular data-needs are visualised in the mind-map below (figure 3).

Figure 3. Mind-map of data-needs in the agricultural sector.



Sub-question 5

Who can supply this data concerning implementing effective and efficient climate change adaptations to the agricultural sector in the Netherlands?

As there are a lot of organisations that generate specific data, it is impossible to say that it should be Statistics Netherlands' task, or that it should be the task of another data-generating authority. A thing that should be improved in the future, however, is the collaboration between these organisations. A lot of the participants of the interviews have mentioned that they do not know exactly what the other organisations are researching for example. If these parties know more about each other's operations, a more efficient network of data-generating authorities can be created, which would not only benefit them, but it would also benefit the Dutch citizens. A better collaboration would lead to a better framework of data. The better the framework of data is, the more potential climate change adaptations have, as they are based on a better, more complete set of data. For the specifics on which party can supply what data-needs, I can refer you to the advisory report on the same topic.

8. Relevance of Research Results for the Work Field

This research functions as an inventory of data-needs. These data-needs do not only apply to either Statistics Netherlands or the municipality of Zwolle, but they apply to the whole region of Zwolle, or the whole Netherlands in some cases. Some data-gaps may be filled by Statistics Netherlands, but others may be filled by other data-generating authorities. As explained earlier by Howden et al. (2007), proper research on climate change adaptation is crucial. Climate change is happening one way or the other, and depending on the impact that it will have on the sectors described in the National Adaptation Strategy (2016), climate change adaptation should be implemented. Providing the data that is still needed is a task for data-generating authorities (like Statistics Netherlands), but proper adaptation to the changing climate is of everyone's interest, which stresses the importance of this inventory of data-needs.

9. Contribution of Research Results for Professional Product

The professional product is an advisory report with recommendations that are based on the conducted research that is included in this concise research report. The research results that were presented in this research report will be used to give advice to Statistics Netherlands and the municipality of Zwolle. It first gives a short overview of the components of the climate change effect. After that, a list of data-needs per effect will be presented. Combined with that, if applicable, there will be a short overview of potential next steps. Moreover, a chapter with other suggestions in form of a discussion will be presented. These suggestions contain ideas and thoughts that came up during the interviews with the experts.

10. Quality Assurance

Different quality criteria as described in the project plan for this research were assured as follows:

- *Credibility* - In order to ensure credibility in this research, I used a method triangulation. In order to come to conclusions, I used multiple methods and data sources. Examples of these methods were desk research, online survey, focus group discussions, and semi-structured interviews. During interviews, I used member-checking as well, in which already gathered data was shared with the participants in order to try to correct errors.
- *Dependability* - I discussed findings of the research with other experts, in order to either confirm or deny them. Moreover, I acted objectively, as specific outcomes did not have any benefits for me personally.
- *Transferability* - I clearly wrote down how, where, and with whom I conducted the interviews. In this way, a potential new research can be conducted in the same setting. It is also easier to evaluate if everything is properly documented.
- *Consistency* - I ensured consistency by first selecting one sector (agriculture), and afterwards narrowing down from twenty to fewer factors. After this, I used the same approach on all participants to assure consistency.
- *Relevance* - As the research is fully based on Statistics Netherlands' concern of not knowing whether there are any data demands, relevance for the organisation is assured. Moreover, we planned weekly meetings with the in-company mentor, to ensure that the research would be kept relevant.

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- *Usability* - The deliverable of this research is an advisory report written for Statistics Netherlands. This report contains recommendations on potential further research on the topic. This makes it usable for Statistics Netherlands. Since it is mostly based on the region of Zwolle, this research is also relevant for the municipality of Zwolle.

The additional 'Nice to Have's' that were included in the quality assurance plan were assured as follows:

- *Interest for an international audience* - To make the outcomes of this research interesting for an international audience, the research report and advisory report were written in English. In this way, an international audience will be able to read it and gain knowledge. As climate change is a global phenomenon, this research can be of use for other countries as well. It should, however, be taken into account that effects of climate change could differ per region.
- *Usable for the next person to work on the topic* - As there was limited time during this research, we decided to only focus on a couple of factors linked to climate change effects on the agricultural sector. Together with experts on the field, we chose the most important effects. This means that a lot of effects will stay untouched by this research. This can be picked up in the future by other researchers, which makes it usable for the next person to work on the topic.
- *Positive media coverage on the topic* - The effects of climate change have been a hot topic in the media lately, which stresses the importance of this research. This research can therefore be very important for the agricultural sector.

10. Limitations

Mostly due to lack of time, there are some limitations connected to this research. These limitations contain the following:

- It focuses on only one out of nine sectors described by the National Adaptation Strategy (2016), namely the agricultural sector. So it is not a complete inventory of data-needs linked to climate adaptation in the Netherlands. Therefore, it is recommended that Statistics Netherlands will conduct comparable research with students in the future, to find out what other data-needs are connected to the other sectors.
- Due to lack of time, not all factors within the agricultural sector were taken into account. With the focus group discussions and the online survey, in total 33 factors that were connected with the agricultural sector, were narrowed down to five factors.
- The amount of respondents on the online survey was disappointing. However, due to the focus group discussion that we held, which were a considerable success, a clear to 5 could still be created.
- The focus of this research was initially on the regional level. Because it was sometimes hard to put into regional perspective, not all recommendations are fully regionally based.
- As the regional and national scale could in this context differ greatly with the international or global scale, it could be difficult to relate some of the outcomes to other countries or regions. But as climate change is a global phenomenon, the outcomes of the research can be used by other countries or regions.
- Due to time restrictions, I was not able to answer the third sub-question of this research. Looking back, it was a bit over-ambitious to add this question in such a short timeframe.
- We desired to also involve a policy-maker in this research, but due to time restrictions this was not realistic.

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List of Abbreviations

CBS - Centraal Bureau voor de Statistiek; outside the Netherlands known as 'Statistics Netherlands'. Their task is to publish reliable and coherent information that responds to society.

CLO - Compendium voor de Leefomgeving; outside the Netherlands known as 'Environmental Data Compendium'. They publish facts and numbers about spatial developments, environment, and nature.

KNMI - Koninklijk Nederlands Meteorologisch Instituut; outside the Netherlands known as 'Royal Netherlands Meteorological Institute'. Their tasks are weather forecasting and monitoring of weather, climate, air quality and seismic activity.

NAS - National Adaptation Strategy. A report about climate change adaptation in the Netherlands.

PBL - Planbureau voor de Leefomgeving; outside the Netherlands known as 'Netherlands Environmental Assessment Agency'. They are the national institute for strategic policy analysis in the field of the environment.

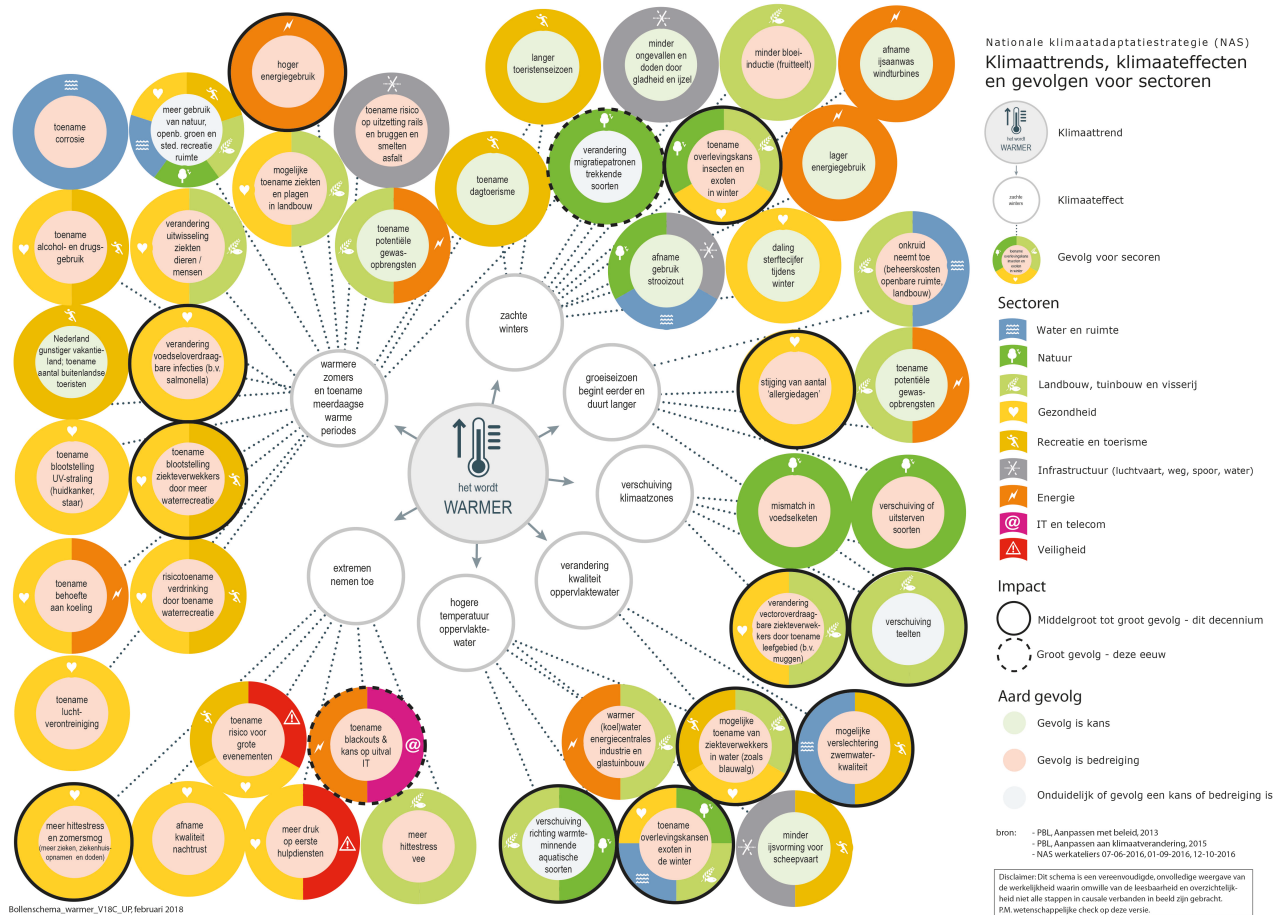
RAP - Regional Adaptation Plan. A report about climate change adaptation in the province of Overijssel.

RHDHV - Royal HaskoningDHV. An international advice- and engineering firm, a fusion of engineering firms Royal Haskoning and DHV.

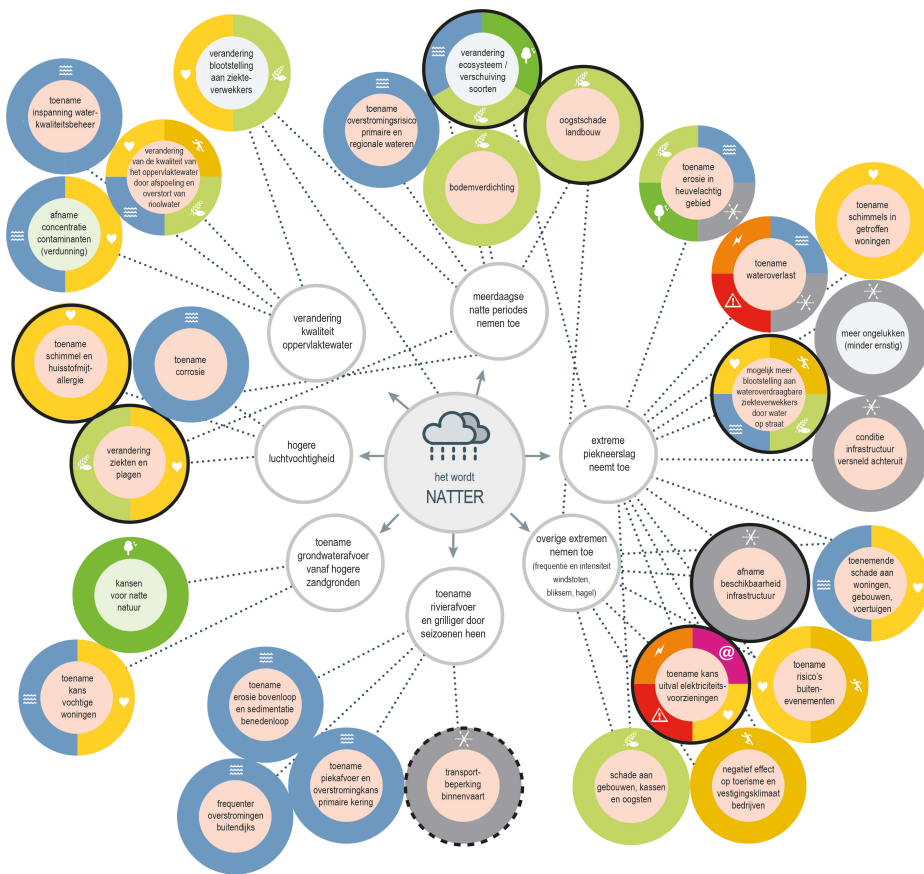
UNPD - United Nations Procurement Division. Their task is to provide expert procurement services and business advice to the United Nations Headquarters.

Appendix I: National Adaptation schemes - Agricultural Sector (Meijs, et al., 2016)

Climate change effect 1. It is getting warmer.



Climate change effect 2. It is getting wetter.



Nationale klimaatadaptatiestrategie (NAS) Klimaatrends, klimaateffecten en gevolgen voor sectoren

Klimaatrend
 Klimaatrend

Klimaateffect
 Klimaateffect

Gevolg voor sectoren
 Gevolg voor sectoren

Sectoren

- Water en ruimte
- Natuur
- Landbouw, tuinbouw en visserij
- Gezondheid
- Recreatie en toerisme
- Infrastructuur (luchtvaart, weg, spoor, water)
- Energie
- IT en telecom
- Veiligheid

Impact

- Middelgroot tot groot gevolg - dit decennium
- Groot gevolg - deze eeuw

Aard gevolg

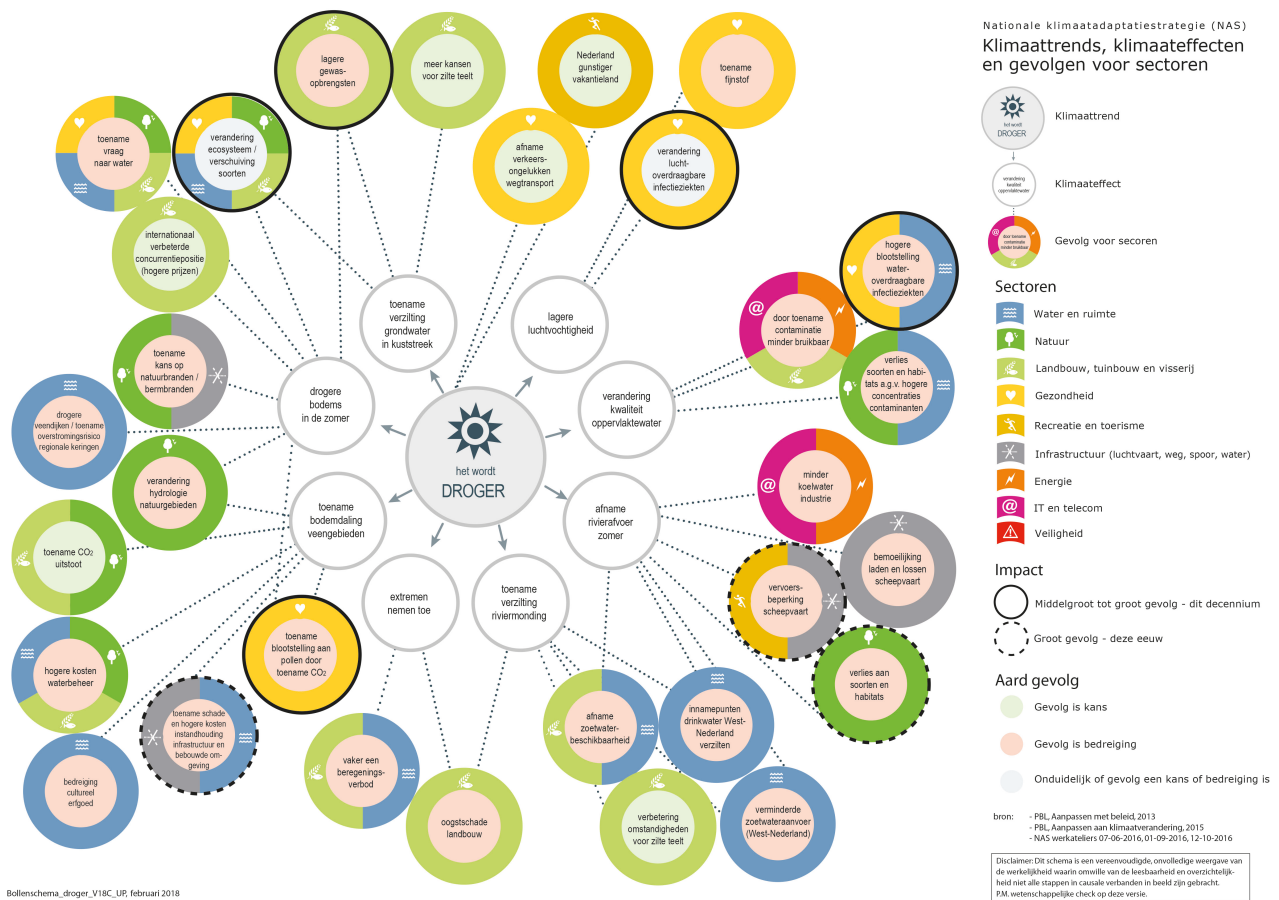
- Gevolg is kans
- Gevolg is bedreiging
- Onduidelijk of gevolg een kans of bedreiging is

bron: - PBL, Aanpassen met beleid, 2013
 - PBL, Aanpassen aan Klimaatverandering, 2015
 - NAS, Werkplan 2015, 01-09-2016, 12-10-2016

Disclaimer: Dit schema is een vereenvoudigde, onvolledige weergave van de werkelijkheid waarin omwille van de leesbaarheid en overzichtelijkheid niet alle stappen in causale verbanden in beeld zijn gebracht. P.M. wetenschappelijke check op deze versie.

Bollenschema_natter_v18c_UR/februari 2018

Climate change effect 3. It is getting dryer.



Climate change effect 4. Sea level is rising.



Nationale klimaatadaptatiestrategie (NAS) Klimaatrends, klimaateffecten en gevolgen voor sectoren



bron: - PBL, Aanpassen met beleid, 2013
- PBL, Aanpassen aan klimaatverandering, 2015
- NS, Werkdoel 07-06-2016, 01-09-2016, 12-10-2016

Disclaimer: Dit schema is een vereenvoudigde, onvolledige weergave van de werkelijkheid waarin omwille van de leesbaarheid en overzichtelijkheid niet alle stappen in causale verbanden in beeld zijn gebracht. P.M. wetenschappelijke check op deze versie.

Bolleschema_zeespiegel_V18C_UR, februari 2018

Appendix II: Online Survey Protocol

Appendix II: Online survey protocol

Allereerst wil ik u hartelijk bedanken voor uw deelname aan dit onderzoek.

Hieronder zullen vier bollen schema's worden gepresenteerd. Ik wil graag van u weten welke vijf effecten het meest urgent zijn, aan de hand van vier bollen schema's. Hierbij kijkt u alleen naar de effecten die gevolgen hebben op sector Landbouw (lichtgroene bollen). Hierbij is de bedoeling de klimateffecten te prioriteren van 1. (meest urgent) naar 5. (minst urgent van de vijf). Geef bij elk effect een toelichting over waarom u het urgent vindt, welke data behoeften bij dit effect wel, en welke (nog) niet vervuld worden.

Houd er tijdens het invullen van de vragen rekening mee dat er vier bollenschema's zijn, waarvan ik van u verwacht in totaal vijf te prioriteren. Mocht u vinden dat een aantal effecten op elkaar lijken, dan mogen deze worden samengevoegd.

Nogmaals hartelijk dank voor uw deelname aan dit onderzoek.

Met vriendelijke groet,

Harm Jan Haasjes

Bollen schema's worden gepresenteerd (zie Appendix I voor de volledige afbeeldingen):

- Klimaattrend 1. Het wordt droger.
- Klimaattrend 2. Het wordt natter.
- Klimaattrend 3. Het wordt warmer.
- Klimaattrend 4. De zeespiegel stijgt.

Questions online survey:

Klimaattrend 1.

Klimaateffect 1. Toelichting. Waarom urgent? Welke databehoeften zijn er al wel, en welke moeten nog vervuld worden?

Klimaattrend 2.

Klimaateffect 2. Toelichting. Waarom urgent? Welke databehoeften zijn er al wel, en welke moeten nog vervuld worden?

Klimaattrend 3.

Klimaateffect 3. Toelichting. Waarom urgent? Welke databehoeften zijn er al wel, en welke moeten nog vervuld worden?

Klimaattrend 4.

Klimaateffect 4. Toelichting. Waarom urgent? Welke databehoeften zijn er al wel, en welke moeten nog vervuld worden?

Klimaattrend 5.

Klimaateffect 5. Toelichting. Waarom urgent? Welke databehoeften zijn er al wel, en welke moeten nog vervuld worden?

Appendix III: Results of the Survey

- Klimaattrend 1. Het wordt droger.
- Klimaattrend 2. Het wordt natter.
- Klimaattrend 3. Het wordt warmer.
- Klimaattrend 4. De zeespiegel stijgt.

The numbers up top in the table mean the following:

- 1: The amount of times the climate effect is considered most urgent in the survey and focus group discussions.
- 2: The amount of times the climate effect is considered second most urgent in the survey and focus group discussions.
- 3: The amount of times the climate effect is considered third most urgent in the survey and focus group discussions.
- 4: The amount of times the climate effect is considered fourth most urgent in the survey and focus group discussions.
- 5: The amount of times the climate effect is considered fifth most urgent in the survey and focus group discussions.

Klimaat effecten	1	2	3	4	5	Tot aal
Hoger waterverbruik en piekverbruik	1	2	-	2	1	6
Toename ziekten en plagen in landbouw (cluster)	3	3	4	2	2	14
Toename potentiële gewasopbrengsten	-	-	-	-	-	-
Andere teelten	1	1	-	1	1	4
Meer insecten die ziekteverwekkers kunnen overdragen (bijvoorbeeld muggen)	-	-	1	-	-	1
Kwaliteit (zwem)water verslechtert (onder andere meer ziekteverwekkers in water) (cluster)	1	1	3	2	-	7
Toename (overlevingskans) insecten en exoten in winter (kan dit geclusterd worden?)	-	-	1	-	-	1
Minder bloei-inductie (fruitteelt)	-	-	-	-	1	1
Verandering migratiepatronen trekkende soorten	-	-	-	-	-	-
Meer hittestress vee	-	-	-	2	-	2
Toename (blootstelling aan) infectieziekten en plagen (cluster)	3	3	4	2	2	14

Bodemverdichting	-	-	-	1	2	3
Verandering ecosysteem/verschuiving soorten (2x)	2	3	1	1	1	8
Toename wateroverlast	4	-	2	-	-	6
Slechtere waterkwaliteit door afspoeling, erosie en overstort van rioolwater (cluster)	1	1	3	2	-	7
Toename erosie (in glooiend gebied)	-	-	-	-	-	-
Meer blootstelling aan water-overdraagbare ziekteverwekkers door water op straat	-	-	-	-	-	-
Lagere gewasopbrengsten (2x)	3	5	2	3	-	13
Toename (letsel)schade personen, groen, (agrarische gebouwen, voertuigen)	-	-	-	-	1	1
Uitval vitale en kwetsbare infrastructuur	-	-	-	-	-	-
Frequenter overstromingen buitendijks	-	-	-	-	1	1
Toename vraag naar water	2	2	-	1	1	6
Verandering ecosysteem/verschuiving soorten (2x)	2	3	1	1	1	8
Vaker een beregeningsverbod	1	1	1	-	-	3
Internationaal verbeterde concurrentiepositie (hogere prijzen)	-	-	-	-	-	-
Lagere gewasopbrengsten (2x)	3	5	2	3	-	13
Afname zoetwater-beschikbaarheid (2x)	6	3	2	5	1	17
Water minder bruikbaar of meer voorzieningen voor nodig	-	-	-	-	-	-
Toename biomassa door toename CO2 uitstoot	-	-	2	-	1	3
Afname waterkwaliteit door minder doorspoelen (cluster)	1	1	3	2	-	7
Stijging grondwaterpeil rondom IJssel en Vecht	-	2	2	1	1	6
Toename problemen waterafvoer vanuit regionale wateren	-	-	1	-	-	1
Afname zoetwater-beschikbaarheid (2x)	6	3	2	5	1	17

Appendix IV: Interview Protocol

Naam:

Naam organisatie:

Datum en plaats:

Tijdstip:

Ik ben een vierdejaars Global Project & Change Management student van Windesheim Honours College in Zwolle. Voor het CBS en gemeente Zwolle doe ik onderzoek naar de databehoeftes met betrekking tot klimaatadaptatie in de landbouw sector. Klimaatadaptatie initiatieven en projecten zijn vaak grootschalig en duur. Daarom is het belangrijk dat ze gebaseerd zijn op goede en complete data.

Gezien de beperkte tijd die ik heb om mijn onderzoek uit te voeren, heb ik besloten me te richten op een aantal factoren binnen de sector. Deze klimaateffecten zijn beschreven in het Regionaal Adaptatie Plan, opgesteld in opdracht van de Provincie Overijssel in 2017. In dit adaptatie-plan staan ongeveer 30 klimaateffecten met betrekking tot de landbouwsector beschreven. Door middel van een online survey en focus groep discussies heb ik de vijf meest urgente effecten bepaald. Dit interview zal gaan over deze vijf klimaateffecten en de bijbehorende data behoeften. Allereerst wil ik u vragen of dit interview opgenomen mag worden? Met uw gegevens zal vertrouwelijk omgegaan worden.

Effect 1. Afname zoetwater-beschikbaarheid

-Denkt u dat het effect "afname zoetwater-beschikbaarheid" terecht in de top 5 meest urgente klimaateffecten zit?

-Waarom wel/niet?

-Wat zijn de belangrijkste componenten van het effect "afname zoetwater-beschikbaarheid"?

-Welke data is er noodzakelijk met betrekking tot klimaatadaptatie bij het effect "afname zoetwater-beschikbaarheid"?

-Is deze data momenteel al beschikbaar?

-Zo ja, waar is dit te vinden?

-Zo nee, waar kan dit vandaan gehaald worden?

Effect 2. Toename ziekten en plagen in de landbouw

-Denkt u dat het effect "toename ziekten en plagen in de landbouw" terecht in de top 5 meest urgente klimaateffecten zit?

-Waarom wel/niet?

-Wat zijn de belangrijkste componenten van het effect "toename ziekten en plagen in de landbouw"?

-Welke data is er noodzakelijk met betrekking tot klimaatadaptatie bij het effect "toename ziekten en plagen in de landbouw"?

-Is deze data momenteel al beschikbaar?

-Zo ja, waar is dit te vinden?

-Zo nee, waar kan dit vandaan gehaald worden?

Effect 3. Lagere gewasopbrengst

- Denkt u dat het effect "lagere gewasopbrengst" terecht in de top 5 meest urgente klimaateffecten zit?
 - Waarom wel/niet?
 - Wat zijn de belangrijkste componenten van het effect "lagere gewasopbrengst"?
- Welke data is er noodzakelijk met betrekking tot klimaatadaptatie bij het effect "lagere gewasopbrengst"?
- Is deze data momenteel al beschikbaar?
 - Zo ja, waar is dit te vinden?
 - Zo nee, waar kan dit vandaan gehaald worden?

Effect 4. Verandering ecosysteem/verschuiving soorten

- Denkt u dat het effect "verandering ecosysteem/verschuiving soorten" terecht in de top 5 meest urgente klimaateffecten zit?
 - Waarom wel/niet?
 - Wat zijn de belangrijkste componenten van het effect "verandering ecosysteem/verschuiving soorten"?
- Welke data is er noodzakelijk met betrekking tot klimaatadaptatie bij het effect "verandering ecosysteem/verschuiving soorten"?
- Is deze data momenteel al beschikbaar?
 - Zo ja, waar is dit te vinden?
 - Zo nee, waar kan dit vandaan gehaald worden?
 - Welke acties komen hierbij kijken?
 - Wie gaan dit financieren?

Effect 5. Slechtere waterkwaliteit

- Denkt u dat het effect "slechtere waterkwaliteit" terecht in de top 5 meest urgente klimaateffecten zit?
 - Waarom wel/niet?
 - Wat zijn de belangrijkste componenten van het effect "slechtere waterkwaliteit"?
- Welke data is er noodzakelijk met betrekking tot klimaatadaptatie bij het effect "slechtere waterkwaliteit"?
- Is deze data momenteel al beschikbaar?
 - Zo ja, waar is dit te vinden?
 - Zo nee, waar kan dit vandaan gehaald worden?

Overig

- Zijn er nog andere, niet genoemde, factoren die van belang zijn met betrekking tot klimaatadaptatie?
 - Zo ja, welke?