

Climate change adaption in Nijmegen

How does the European Green Capital adapt itself to increasing precipitation?

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Summary

Increasing precipitation and its consequences have recently received more attention as they, in one way or another, influence our health, safety, living conditions, and economic matters such as transportation and properties. The present report focuses on the extent to which adaptation measures to precipitation change have been mainstreamed in physical developments in Nijmegen. To conduct this research, information was gathered through interviewing experts involved in climate change adaptation in Nijmegen or in the Netherlands in general, and through scientific literature. Our research shows that precipitation adaptation measures are not yet widely mainstreamed by major actors. These major actors are the municipality of Nijmegen, local citizens and house owners (including both private and social). Since climate change is a complex subject, other actors are involved, such as insurance companies, water boards and actors at a provincial level. Although the municipality devotes a great deal of attention to motivating citizens, involvement in the private sector still needs to be improved. They should be more aware of precipitation risks, their possible solutions, and their benefits in order to be motivated to bring adaptation measures into effect on their own property. In general, the responsibilities among different parties are unclear; hence need more focus. This could improve successful cooperation between different fields, the more active participation of citizens and the application of measures in physical developments. Although areas of improvement have been pointed out, Nijmegen is on its track to develop more mainstreaming of precipitation change measures.

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Chapter 1: Introduction

Even though climate change is a global process, the consequences take place on different scales. Anthropogenic climate change is caused by the global increase of greenhouse gases emissions. Attention is often focused on the mitigation of climate change. However, the earth has already warmed up by 0.8 °C since the industrial revolution and this number will increase independent of the emissions we are yet to produce. It is therefore crucial to anticipate the changes, not only prevent them. Adaptation towards climate change is generally more effective when implemented on a local scale. Even though national programs exist, most measures are taken by the municipality or other parties on local scale. In this report, we will focus on the generally less highlighted part of climate change action, being adaptation. This will be analyzed for the city Nijmegen.

The city Nijmegen is a Dutch city with around 175000 inhabitants, located in the province Gelderland. The city is located around the river The Waal, which is both a meltwater and a rainwater river (Image 1). Nijmegen is located in the East of the Netherlands and since its average altitude is around 31 meters above the N.A.P. (Alles op een rij, 2011).

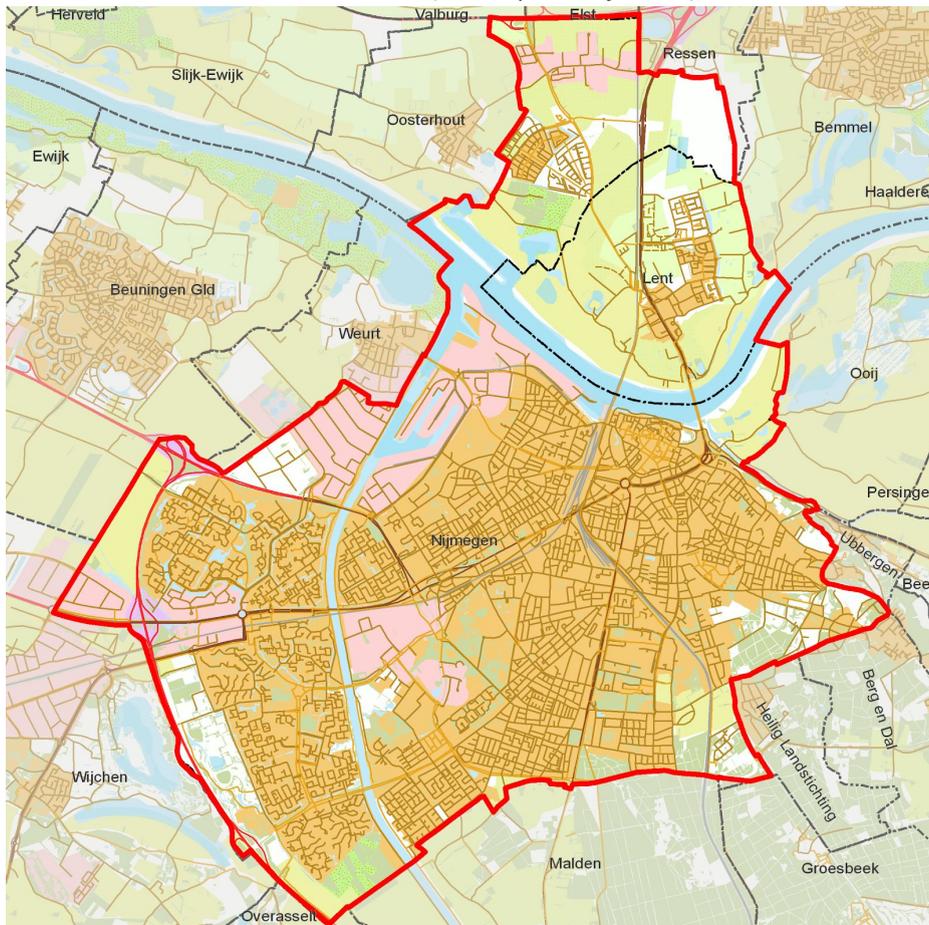


Image 1: the city of Nijmegen. Image retrieved from https://upload.wikimedia.org/wikipedia/commons/0/0c/BAG_woonplaatsen_-_Gemeente_Nijmegen.png

Climate change causes multiple problems, the most significant of which for the city of Nijmegen are: heat stress, flooding and precipitation increase. The average temperature in Nijmegen will increase, as well as the amount of extremely warm days (Klimaat-effectatlas, n.d.). This is especially dangerous to elderly people. Flooding is mostly due to increased water levels, which are caused by increasing intensity of precipitation and meltwater. Since Nijmegen is vastly above sea level, the risk lies mainly

with the river the Waal. It is generally accepted that these problems are well solvable upstream of the river. As opposed to heat stress, increasing precipitation is expected to cause economic damages rather than health risks. Both the amount and intensity of precipitation will continue to increase, which can, when unable to remove the water at a sufficient rate, cause the flooding of streets and basements.

In this report, we will focus on the effects of the increase of precipitation. This includes all kinds of precipitation in Nijmegen and will therefore include both rain and hail, but not flooding risk due to precipitation upstream of Nijmegen. There are three reasons for this decision. Firstly, the problems caused by precipitation are approached differently from other climate adaptation processes, as the damages are more materialistic (S. Meijerink, personal communication, April 26, 2018). This requires a different problem solving approach and makes analysis particularly interesting. Secondly, most climate adaptation measures in the Netherlands relate to flood risk management. While the increase in precipitation and its intensity will bring significant risks, it currently receives less attention. By placing focus on this, the analysis and recommendations will be most impactful. Lastly, precipitation problems are particularly effectively solvable within the scale of Nijmegen. Flooding requires a larger scale with upstream collaboration, whereas heat problems require a smaller scale: neighbourhoods with a high percentage of elderly people. Precipitation, however, causes problems throughout the entire city and the problems are connected to the route the water takes.

The increase in precipitation is an issue that is best addressed in combination with ongoing developments. We define mainstreaming as the International Institute of Environment and Development (IIED) does: mainstreaming is *“the informed inclusion of relevant environmental concerns into the decisions of institutions that drive national, local and sectoral development policy, rules, plans, investments and actions”* (IIED, 2007). To acquire a full picture, both the public and private sectors in Nijmegen are evaluated. These sectors are evaluated based mostly on in-depth interviews, as this approach is the best available to us and as it gives us a chance to get the viewpoint of all actors in the matter. The main actors we were able to contact are the municipality, the citizens and the house owners (institutions and personal), but the province, waterschappen and insurance companies also play a role. We define the main actors as the actors directly involved in the problem solving of the precipitation risks on a locals scale, such as citizens, and the smaller actors as the actors indirectly involved, such as the waterschappen. Waterschappen is also a key actor, but compared to local changes in the city, their responsibilities lie especially in rural areas. We also chose to exclude the actors we could not contact, such as real estate companies; financiers of houses or project developers, as we did not have sufficient information about them. The evaluation of and giving recommendations on mainstreaming for these actors focuses on ongoing physical developments. This includes both large and small developments, ranging from the maintenance of the sewage by the municipality to the creation of green roofs and gardens by citizens. We will mostly focus on houses and partly on public areas owned by the municipality. We will not go into private properties that are not houses, such as offices, schools or shops, as we have less in-depth knowledge about the decision making process on the development of these areas.

To conclude, our research question is formulated as follows: *To what extent do the public and private sectors take the increase in precipitation into account in ongoing physical developments in Nijmegen?* To answer this question, we will first delve further into the different problems caused by climate change in chapter 2. Chapter 3 contains an overview of the involved actors, and their respective actions and interactions. In chapter 4, these actions and interactions will be evaluated based on the Delta programme framework of knowing, willing, working. Recommendations will be made as well. The concluding remarks give an overview of the answer to our research question. A list

of the people interviewed to answer this question can be found in appendix 1. A summary in Dutch is provided as well (appendix 3).

Chapter 2: The effects and risks associated with increased precipitation

There are various consequences and risks connected to increased precipitation. According to De Urbanisten & Management team of Rotterdam Climate Proof (2013), with every degree rise in temperature, rainfall will increase by 14%. Particularly in summer, extreme rainfalls will become an issue. This will be similar for hail: by 2050, hailstorms will become more extreme. In the warmest scenario of the KNMI, the hailstorms were predicted to be twice as common. Problems associated with an increase in precipitation will also worsen due to an increased hardening of the surface area. In the following chapter, the previously mentioned problems will be discussed.

The situation in Nijmegen

According to the Klimaateffectatlas (n.d.), the total precipitation will increase by 75 mm by 2050. It is predicted that in the winter season, precipitation will rise from 208 mm to 275 mm. More precisely, in winter, by 2050 the winter will be averagely wetter, with precipitation that will increase from 127 mm per ten days to up to 141 mm per ten days. In summer, especially extreme rainfall events increase, from 46 mm to 53 mm (Naar een RAS Rijk van Maas en Waal, n.d.). Additionally to the increase in amount of rainwater, heavy rainfalls will be more frequent. Even so, Nijmegen is still relatively safe in comparison to the West of the Netherlands because it is located on higher ground (T. Verhoeven, personal communication, April 6, 2018).

For the older parts of the city, adaptation measures are more difficult to implement than in newer parts (S. Meijerink, personal communication, April 26, 2018). Therefore, one can define particularly vulnerable areas (see Infobox 1). 19th century urban districts such as Nijmegen's city centre are at risk due to being densely built-up and paved over with little vegetation (De Urbanisten & Management team of Rotterdam Climate Proof, 2013). Furthermore, the southern and eastern areas of Nijmegen will be the most affected by rising groundwater level (Klimaateffectatlas, n.d.).

Finally, an increase in precipitation will also lead to higher costs, as damage caused by heavy rainfall will be increasing. That damage is assumed to increase by 5% in the best, and 139% in the worst case scenario in the next decennia. The same holds true for hail – damage due to hail may double in cost (Klimaatkwetsbaarheden- en kansentitatie Rijk van Nijmegen en Land van Maas & Waal, 2016).

Infobox 1: Old urban areas

In old urban areas, the infrastructure was built without much attention to climate change, as this was not a very important phenomenon at the time. It is often difficult to make these old buildings climate proof now, as it is very time and money consuming. Owners usually wait until the building is written off, because else it would be unlivable for months (P. Leroy, personal communication, April 18, 2018). These matters cause the old city of Nijmegen to be relatively precipitation problems-prone. The area intended can also be seen in the figure below, as there is a great concentration of older buildings (red, orange) on the left side area.



Figure from R.j. de Witte (2014). Legend: Red: until second world war (<1945), Orange: after second world war (<1970), Pink: city renovation (1970-1985), Green: new (>1990), Blue: original linear building, Red with dots: owner-occupied properties.

Consequences of increasing precipitation

To assess the consequences of an increase in precipitation, Boogaard, Bruins, and Wentink (2006) describe four risks of increased precipitation: a water shortage in summer, high groundwater levels in winter, low water quality in general and an increase in intensity mostly in summer.

The groundwater levels get affected by rain that seeps into the groundwater, causing it to rise. This may result in health issues for residents and issues in buildings, such as mould (Hoogvliet, van Vliet, Schasfoort, & van de Ven, 2014). Other affected areas may include agriculture or nature.

Additionally, the water quality decreases because the sewage water mixes with surface water and groundwater which then also causes the quality of the soil to decrease. This becomes clearer when looking at the 'thinwater' problem: Increased precipitation dilutes the water. However, to function properly, the water purification system of the Waterschap needs the water quality to be as highly concentrated as possible, as the water is purified through bacteria. Therefore, rainwater diluting the water in the pipes becomes a problem (K. Oosters, personal communication, May 17, 2018).

Furthermore, the sewage system will be stressed due to an overload of rainwater. Here, water nuisance is caused by an increase in erosions of lateral moraines or rainfall collecting into runoff which ends up in the sewer system (Klimaatkwetsbaarheden- en kansennotitie Rijk van Nijmegen en

Land van Maas & Waal, 2016). In addition to that, the quality of the surface water declines as well, causing dirty water to end up in ponds and lakes (S. Meijerink, personal communication, April 26, 2018). This occurs due to unpurified water flowing into the urban surface water when the sewer systems are overwhelmed during heavy rainfalls (“Climate change/ urban groundwater management”, n.d.).

Consequences of flooding due to precipitation

With an increase in frequency and intensity of rainfall, flooding within the city becomes a problem in various areas. Especially low-lying areas within cities are prone to be affected due to the height differences influencing the flow of the water (S. Meijerink, personal communication, April 26, 2018). Flooding in cities can affect i.a. basements, shops, streets or intersections. It can cause further damage to vehicles because of standing water on streets. Another big problem are health risks, as there are higher chances for pests within the water. In relation to that, health problems arise due to an increase in cyanobacteria. Cyanobacteria form due to a combination of high temperatures and still water. Usually, water comes from city areas used as pastures. Thus, there are a lot of nutrients in the water for the next 200-300 years after the pastures were turned into urban areas, like for instance in Lent. This increase in water leads to plants dying which then deteriorate in the water of the lakes, causing a abundance on nutrients. However, this also proposes health issues, since lake water with toxic cyanobacteria can be deadly. This can be seen in dead animals, e.g. birds, but also in human deaths: in the Netherlands, 150 people per year die due to cyanobacteria. This number is expected to increase as cyanobacteria are present earlier in the year; from April onwards (J. Roelofs, personal communication, April 25, 2018).

Chapter 3: An overview of the involved actors in the public and private sectors in recent physical developments and their actions/ interactions

On a national level, all European countries have to make climate change adaptation plans. Those adaptation plans mainly sum up what needs to be done and describe planned actions on a rather non-specific level: 'something has to happen'. The issue is directed to the municipalities and final actions are often taken at a local level (P. Leroy, personal communication, April 18, 2018). Therefore, the following chapter aims to explain the responsibilities, actions and interactions of the most important local actors in the climate change adaptation process in Nijmegen.

The following sections will focus on three key players in implementing climate change adaptation in ongoing physical developments in Nijmegen being the municipality, the citizens, and the house owners. Additionally, we will give a short overview of some minor actors in climate change adaptation in Nijmegen (Figure 1).

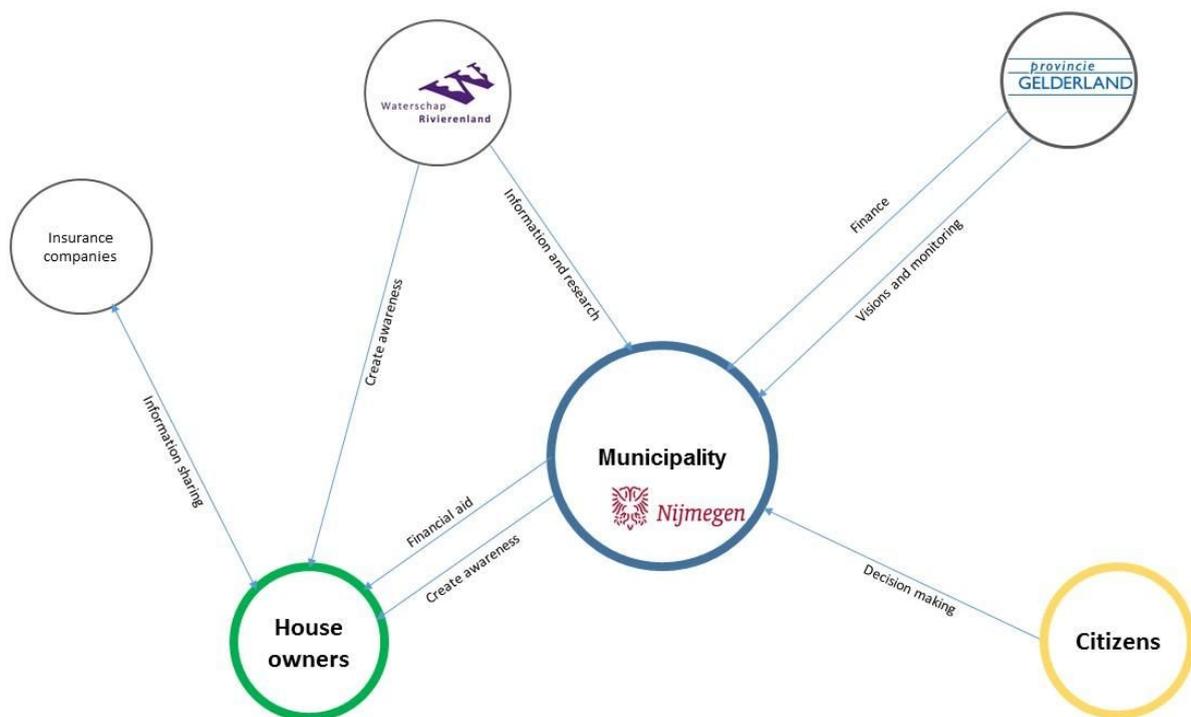


Figure 1: Schematic representation of the major actors involved in recent physical developments and their interactions

The municipality

In general, the system for climate change adaptation is better developed in Nijmegen compared to smaller municipalities. The municipality has individual policies, as it is relatively large and has the knowledge and power, also through advisors, to implement these on this local scale. Important departments in the municipality concerning adaptation to increasing precipitation are the department for water and environment, the department for spatial planning and the sewage department.

Responsibilities

The municipality's responsibility lies solely in public areas and making them adapted to climate change. However, the municipality does attempt to raise awareness in the private sector by speaking to citizens about the risks that come with climate change and increasing precipitation. They do not, however, see themselves as being accountable for making the privately owned houses adaptive to precipitation changes. They focus on making the owners of these properties aware of the potential problems and hope that this will result in adaptation measures (T. Verhoeven, personal communication, April 6, 2018). The consciousness and potential cooperation between the municipality and the private house owners is deemed to be of utmost importance for the efficiency of combating precipitation problems (K. te Velde, personal communication, April 25, 2018). Another important responsibility of the municipality with regards to precipitation is the sewage system. The sewage system plays a great role in the transportation and drainage of water and therefore is essential for precipitation problems. However, the sewage system has limited capacity to drain water, which can lead to problems in the summer when there are heavy rainstorm peaks.

Actions

Consciousness & involvement

In the last couple of years there has been great attention to make people conscious about climate change and the required adaptation that comes along (T. Verhoeven, personal communication, April 6, 2018). Conversations with citizens informing them on the risks of precipitation has been a key part of climate change adaptation strategy for municipality. There are multiple other ways of informing, one of those ways being by making a website. The municipality is currently working on this, as they will create one comparable to the website 'Climate Proof Arnhem'. The website will function as an information platform with the aim to give private residents more insight into climate change risks and possible adaptation measures they can take. The website of Arnhem advises residents on what they can do themselves, and makes contact with for example hardware stores, garden centers or people who disconnect sewers to facilitate the process (S. Meijerink, personal communication, April 26, 2018).

Another very important action of the municipality is to involve citizens more in the process of making Nijmegen climate-proof. One example of this involvement is 'Operatie Steenbreek', in which citizens are encouraged to replace the bricks and pavement of their property and gardens by plants to make their neighbourhood greener. In order to make more people participate, some of those operations can be set up in a social way, combined with an ensuing barbecue for example (Koen te Velde, personal communication, April 25, 2018). Another measure to take more citizens into account are the so-called 'Afkoppeling Teams' of the municipality, where they actively convince people to disconnect their rainwater from the sewage system. The municipality also replaces concrete paths and surfaces with pavement bricks. This allows more rainwater to seep away compared to a fully sealed surface.

Sewage & decoupling

In order to prevent flooding and to ensure the water quality, policies are created with intentions to apply the order of (1) holding the water, (2) maintaining the held water and (3) draining the water away (S. Meijerink, personal communication, April 26, 2018). The first measure is to hold the rainwater on the spot where it falls. If the capacity of that area is maxed out, the second step is to maintain the water in ponds for instance. The third measure is to drain the water. This can be done through for example infiltration facilities, which ensure that the water goes into the ground, such as a done in Enschede with a Wadi system (also see infobox 2). The last step is only done if the river or the sewer would be flooded otherwise.

Another measure to prevent rainwater flooding the streets is to renew and to enlarge the pipes of the sewer as more water can then be stored and drained. The budget for climate change adaptation in Nijmegen was approximately 15 to 16 million euros last year. Of that amount, 3 to 4

million euros were used to renew a few kilometers of pipes out of approximately 700 kilometers in total (T. Verhoeven, personal communication, April 6, 2018).

In the new areas of Nijmegen, the approach is to set up separate sewer systems in new construction projects. An example would be to set infiltration crates under newly build houses ; the rainwater can go into those infiltration crates and then back into the groundwater. An advantage of this system is that it diminishes the amount of water on the streets and in the river (S. Meijerink, personal communication, April 26, 2018). An alternative to the infiltration crates, which is especially suited for low-lying areas are the Wadi's. The accumulated rainwater goes into the Wadi's and through them back into the groundwater. On the other hand, there are the old areas in Nijmegen. In these areas, the strategy is to decouple the pipes of rain water and wastewater. The aim is to prevent flooding of the pipes by disconnecting the rainwater from the sewer (S. Meijerink, personal communication, April 26, 2018).

The municipality of Nijmegen still has several plans for the future, as for example to develop a strategy for climate adaptation for every city part. Additionally, it plans the application of a concrete strategy for diminishing or preventing damage from heavy rainfall on the basis of modellative preventive research about size, causes and measures (Gemeentelijk rioleringsplan Nijmegen, 2017).

Infobox 2: The Wadi system in Enschede

The neighbourhood Ruwenbos in the Dutch city of Enschede has its only Wadi system. Water is captured and transported and stored on the surface, such that the sewer is not used for precipitation water. Advantages of this system include that the risk of flooding is significantly lower than with a tradition sewage system, while the costs are only a bit higher, mainly due to maintenance costs. Citizens are generally very content with the system. In Nijmegen, this system is also, in lesser extent, implemented in new neighborhoods. A disadvantage of this system is the fact that it is very difficult to implement in already existing neighborhoods. For the neighborhoods with the biggest risks in Nijmegen, like the old city center, a Wadi system is not a suitable solution. However, green parking spaces could be implemented based on this system.



source: <http://www.urbangreenbluegrids.com/projects/ruwenbos-enschede-the-netherlands/>

Interactions

The Municipality offers subsidies for the private sector if a private house owner is willing to make their garden greener (T. Verhoeven, personal communication, April 6, 2018). There are also subsidies for green roofs, facades and for rain barrels. Additionally, the municipality gives subsidies for decoupling the rainwater from wastewater; a citizen can apply for 5 euros per square meter for underground infiltration of the rainwater or 10 euros per square meter for above-ground infiltration of rainwater (Subsidie afkoppelen regenpijpen, n.d.). The latter option is the preferred one of the municipality because of the purification of the water. Finally, regarding finances, the municipality is also creating a fund for loans regarding the implementation of adaptation matters by citizens (Gemeente Nijmegen, 2018).

The municipality tries to involve citizens by involving them in plans and decisions they plan to make them on neighbourhood-scale. This includes plans with regards to precipitation. Besides this, the Municipality works together with Waterschappen for information gathering.

Lastly, the Municipality checks for climate resilience of new buildings through the 'watertoets' (Hoogvliet et al., 2014) and has the authority to force major housing associations to implement climate adaptation measures as a part of the 'prestatieafspraken'. Newly built buildings will have climate change adaptation taken into account this way, as for example also can be seen in the Vossenpels (Infobox 3).

Infobox 3: the Vossenpels

The neighbourhood the Vossenpels, located in between the towns of Lent and Bemmelen, will serve as an example neighbourhood for new sustainability implementations, as stated in Nijmegen's coalition agreement of 2018. Adaptation measures such as a lower parking norm and an increased amount of greenery will be tested here first. In this neighbourhood, adaptation measures go hand in hand with mitigation measures.



The citizens

Responsibilities

The society and the citizens within society have great responsibility of the surroundings they live in. Specifically citizens do have important information concerning the local situation regarding precipitation on a neighbourhood-level, and are particularly interested in making sure their living environment is attractive. However, problems from precipitation such as flooding of their basements are also their own responsibility.

Actions

People can, on their own initiative, delink their rainwater from the sewers. There are grants for green gardens and green roofs. This also applies to renters, but they are less willing to do this as they will have additional costs for something that is not necessarily fully theirs (L. Bouwmans, personal communication, April 25, 2018). Additionally, citizens can participate in projects as for example 'Operatie Steenbreek' or they can make their garden greener to reduce the amount of rainwater on the streets and to prevent an overload of the sewage system. Citizens are very willing

to cooperate on creating a liveable environment, but not as interested in the concept of 'climate change adaptation' per se (T. Verhoeven, personal communication, April 6, 2018).

Interactions

As mentioned earlier, the connection between citizens and municipality is essential. Apart from the interactions that have already been mentioned, it should be mentioned that citizen initiatives are very much focused on their own desires. Therefore, they are more driven to accomplish individual or neighbourhood-scale goals, and will take use of current specific situations in local environment. However, municipalities develop a vision and policy, then create plans mostly focused on uniformity, certainty and equality between citizens. These two conflicting goals can cause the municipality's attempts to involve citizens in their policy to not be adaptive enough for the citizen initiatives (van Hunen, 2015). Citizens also need to be 'persuaded' by municipality in some way. As discussed at a symposium for climate change adaptation (16-05-2018) in Molenhoek, actors from different backgrounds came to the conclusion that the municipality should take an initiative, but requires full cooperation from the citizens and other parties (e.g. insurance companies) to fully accomplish effective climate change adaptation measures. The role of citizen is a key element.

House owners (institutions and private)

There are seven Social Housings Associations in Nijmegen: De Gemeenschap, Mooiland, Portaal, Talis, SSH&, Standvast Wonen and WoonGenoot. Besides these social housing associations, people can own their own homes. Both of these categories will be discussed in this part.

Responsibilities

House owners are responsible for rain and groundwater problems. People used to have a lot of their basements flooded, as climate change adaptation measures have not been that popular until more recent years. Flooding in Nijmegen is partly covered by insurance companies, but only inside the dikes.

Actions

House owners can take similar actions as the ones taken by citizen. They decouple their rain water, get more green gardens and think about removing grey areas. Social housing associations do this as well, even though they have a responsibility to keep the costs for climate change adaptation low as they cannot just raise the rent of their renters.

Interactions

House owners get informed by the municipality and they get pushed to mention their problems to the municipality. However, they have privacy rights with regards to the insurance companies, and might not be willing to share information with the municipality because it costs effort and can include personal details. Therefore, the municipality cannot gain house-specific data on this through insurance companies. (T. Verhoeven, personal communication, April 6, 2018)

The social housing associations usually have conversations with the municipality about recent developments and their plans for adaptation (M. Infantes, personal communication, April 16, 2018). Adaptation measures, as for example green zones, are very expensive and social housing companies are unable to simply raise rent without further consequences. They have to work together with each other and with the municipality to meet their development goals. (M. Infantes, personal communication, April 16, 2018) Therefore, social housing associations have meetings with the municipality where they explain their adaptation plans and the municipality helps the social housing associations to develop sustainably as far as possible (M. Infantes, personal communication, April 16, 2018).

Smaller actors

Insurance companies

Insurance companies have the responsibility to spread awareness about climate adaptation amongst private home owners. They do this, for instance, via the website BlueLabel, which is an information site focused on precipitation. However, they are not able to reward their customers financially for adapting, as the costs for insurance are already very low in Nijmegen according to them. Insurance companies have information about damages specific to postal codes and house numbers. However, they are not allowed to share the information specific to house numbers due to several reasons, the most important one being the law of Algemene Verordening Gegevensbescherming (AVG), which is a law on privacy and protection of personal data. Insurance companies would like to work with policy makers in the future (M. Scheers, personal communication, April 23, 2018 and Ohra environmental statement). Fortunately they can, however, share information on the spatial level of streets and neighborhoods if this information is not linkable to a specific household. This information could be used by the municipality to have a more detailed map of the vulnerable areas.

Waterschappen

Waterschappen are responsible for the purification of wastewater and the risks that come with the rise of surface water. The waterschappen have models of the surface water systems and they regularly simulate different situations by varying the strength and frequencies of rain showers. Such information is processed in water plans. This information as well as information about where the endangered areas are is being reported to the municipality. Furthermore, the Waterschappen maintain insulation and surface systems within urban areas.

Not only does the Waterschappen provide the municipality with information, but they also receive information from the municipality, especially on an advice level. The Waterschappen used to work only with their regular partners as the municipality, but now they focus more on communication with others, such as involved insurance companies, businesses, schools, housing, energy, architects, as more disciplines need to be involved.

Waterschappen also try to involve citizens in the process of climate adaptation. For instance, they try to make people aware of the importance of a green garden through commercial broadcasts (Garden programs on RTL 4/5) (S. Meijerink, personal communication, April 26, 2018). Waterschappen are mainly joining initiatives that are taken by the municipality, as they feel that municipality should take the initiatives, while they themselves still have a proactive role in pursuing these goals (Symposium climate change adaptation, 2018). One example would be the initiative to make schoolyards greener and to involve parents in the process (K. Oosters, personal communication, May 17, 2018).

Province

The final actor which is closely related to all previously mentioned actor is the province. For Nijmegen, this is the province of Gelderland. the province is acts as an advisor solely. It looks through already created plans by municipalities or the Waterschappen and gives advice on potential improvements (K. te Velde, personal communication, April 25, 2018) . The province does not carry any full responsibility or decision power in that sense, but can guide the other actors with its knowledge.

Chapter 4: Evaluation of the climate adaptation

Throughout the entire story of adaptation measures of increased precipitation as a consequence of climatic changes in the city of Nijmegen in the Netherlands, both actions and considerations by key stakeholders of the city should be evaluated. From such evaluations, strengths and drawbacks of different actors could be pointed out to make room for further improvements in the future. To evaluate, criteria have been developed through experts' knowledge from literature and in-depth interviews with people who take different roles in climate change adaptation in Nijmegen. To be more specific, environmental concerns, cost effectiveness, hydraulic effectiveness, co-benefits and opinions of local residents should be taken into account. Within the scope of this chapter, recommendations would also be given to each group of actors.

The evaluating criteria will be based on those of the Delta Programme, as on the one hand, a majority of projects of the city are within the framework of the programme; and on the other hand, such guidelines are in general quite clear and could be adaptable to the current situations of Nijmegen. The Delta Programme evaluates progresses using three steps, being *Knowing*, *Willing* and *Working*. First of all, each actor is evaluated based on their knowledge and consciousness of increasing precipitation risks and current situation. Further and even more importantly, it should be assessed whether the actors are aware of their personal and specific responsibilities within planning, designing and implementing adaptation measures. Secondly, for the *Willing* stage, goals and ambitions of every actor will be evaluated. This means questions about whether the plan is designed and created holistically, which then consider different aspects of the problem; whether the time frame is realistic; and whether working ambitions of other stakeholders are incorporated in the plan should be considered. Last but definitely not least, the actions (or potentially, considerations) of each stakeholder should be assessed. It is vital to take into account the environment concerns (or in other words, the protection of local biodiversity) of Nijmegen, the cost-effectiveness, co-benefits of actions or considerations and opinions and cooperations of local residents among other things. In appendix 2 an infographic is shown which gives an overview of the most important recommendations in that will follow in this chapter.

Municipality

As previous chapters mention, the municipality of Nijmegen is currently working on water projects like upgrading sewage systems and retention basins, decoupling rainwater and wastewater as well as developing green areas throughout the city and on top of roves.

Knowing

The municipality is working to adapt to increased precipitation based on the guidelines from the Delta Programme. Even though the Netherlands is a relatively small country in size, it is undeniable that the Delta Programme is more of national level. Therefore, the municipality should be aware of this to adapt more resiliently to the situation of Nijmegen. Furthermore, in the Delta Programme, flood risk management is more focused on than rainwater, although increased precipitation in general received more attention recently. The municipality of Nijmegen is also conscious of the risks of increased precipitation (including those of increased hails) and of the endangered parts of the city. This could be the catalyst for a timely and effective plan and implementation.

Willing

It is observed that the municipality has concrete goals and ambitions to adapt to increasing precipitation in the city. To illustrate, adaptation plans also incorporate traffic (including public transport), housing, waste management and the attempt to improve residents' involvement in decision making phase. Hence, it could be concluded that co-benefits have been taken into great consideration. The municipality of Nijmegen is aiming at a sustainable city.

Working

According to P. Leroy (personal communication, April 18, 2018), Nijmegen already did a lot of changes in regard to climate change related risks. This is owing to largely the work of the people within the municipality. However, speed and effectiveness of water projects could be improved (P. Leroy, personal communication, April 18, 2018). On the other hand, it is understandable that adaptation to increasing precipitation is a long run process, and that short-term measures are not always desirable. Furthermore, communication within the network of parties responsible for adaptation solutions to increasing precipitation is until now ineffective. Therefore, measures have been taken to improve involvement in the decision-making stage. Within the municipality itself, there are unclear tasks and responsibilities of specific personnel, said M. Reijnierse (personal communication, April 24, 2018).

To elaborate, Nijmegen is still in the phase of building networks and human resources are trying to figure out the roles each actor play. When it is combined with the fact that climate change adaptation is a relatively new issue, it might pose a challenge to evaluate the progress holistically. Also within collaborative work, P. Leroy (personal communication, April 18, 2018) mentioned that the coordination between the Province of Gelderland and the Municipality of Nijmegen is not sufficiently satisfactory or independent. The professor also claimed that legal instruments are more focused on climate change mitigation.

Recommendations

The work of the municipality to adapt to increasing precipitation possibly sometimes contradicts with other stakeholders' interests (P. Leroy, personal communication, April 18, 2018). Therefore, the new environmental act '*Omgevingswet*', which is planned to be implemented in January 2021, might be a solution to incorporate individual interests into collective interests. The goals of the act are as follow (P. Leroy, personal communication, April 18, 2018): Firstly, the living environment of Dutch citizens is an essential element to consider in physical developments. Therefore, attempts are supposed to be made to further improve the environment so residents could have higher quality living conditions. Secondly, decentralization is mentioned in the regulations, meaning that citizens have the right to participate in decision making in their neighbourhoods and they should be encouraged by the local authority to do so. As a result, more transparent information about local situations is needed. Thirdly, within the evaluation process, two distinctive criteria would be necessary. On the one hand, it should be checked if in-charge personnel accomplish their assigned tasks. On the other hand, the extent to which other involved parties' ambitions have been integrated should be evaluated. Lastly, stakeholders have the right to check and control each other to ensure their interests are integrated. In short, this new environmental law should be an opportunity to monitor and evaluate climate change adaptation measures.

Another recommendation is more transparent information provided to residents. Firstly, information about subsidies for green gardens and water decoupling should be widespread because financial incentives are highly likely to increase people's motivation to take adaptation measures. Secondly, as far as we understand, each household receives different bills every month, namely consumed water, sewage tax, purification and water safety tax. Therefore, it could be useful to issue only one bill so the entire 'water chain' is demonstrated. As a consequence, citizens would understand what the taxes are being used for. This could pose a challenge since different institutions have to work together.

Dutch citizens have to pay a fixed amount to get their households connected to the sewage system. A suggestion is that the price should be calculated based on how hard each household's surface is. This might act as a precursor to greener gardens, as green and soft surfaces cost less, and thus act as a financial incentive (S. Meijerink, personal communication, April 26, 2018).

It is also recommended that the municipality and local residents should work together for several reasons (S. van Hunen, 2015; K. Oosters, personal communication, May 17, 2018). Firstly, it is evident that the municipality has knowledge of large areas of the city, while local residents are

aware of their neighbourhoods. Effective cooperation means measures are consistent in the central level, but also timely and in accordance with specific situations of specific neighbourhoods (Also see infobox 3: a case study on an efficient Wadi system in Enschede)- Furthermore, the municipality could even assist with those who could not take care of their garden, such as the elderly, in order to reduce the amount of hard surfaces. Effective collaboration also means the communication effort is successful and important information from the authority could get across. This is important since citizens should be aware of the subsidies available for rain- and wastewater separation and growing green areas, as incentives motivate them to adapt to increasing precipitation in the city.

Lastly, the municipality should contact insurance companies since they possess a significant amount of information about precipitation damages and about the vulnerable areas. The insurance companies would be willing to work with them as less damages mean less expenses for insurance companies. However, the municipality should understand that insurance companies would not like to lose competitive advantages to other companies (Achmea, 23-04-2018).

Citizens

Citizens are a vital group of actors, since they are responsible for implementing adaptation measures in their own households and neighbourhoods. Furthermore, they are getting encouraged to contribute to decision making phase with the local authority.

Knowing

Citizens are likely to know the benefits of growing plants in their gardens, having green roofs or decoupling rainwater and wastewater. However, they potentially do not know much about the subsidies they could get from the municipality to take adaptation measures.

Willing

Currently the motivation for the citizens to adapt to increasing precipitation using the measures suggested by the municipality is low. This could be because communication between citizens and the municipality is unsatisfactory. As a result, citizens might not be conscious of their specific role regarding increasing precipitation adaptation and become dependent on the work by the municipality.

Working

The citizens generally have a low motivation to take adaptation measures. This can also be observed in the low amount of involvement of the citizens when it comes to decision making processes within the municipality.

Recommendation

Current state of low motivation to take measures could be improved given that citizens' individual interests could be incorporated into collective interests. In this way, citizens are more aware of the risks of damages to their own neighborhoods if inappropriate measures are taken, which in turn motivate them to get information from and coordinate with the municipality.

House owners

Knowing

Social housing associations play a larger role than private house owners (P. Leroy, personal communication, April 18, 2018). Social housing is in general the accommodation of lower-income people. Usually these people are not concerned about the risks of changes in precipitation as they have more to worry about in their lives. Private house owners; on the other hand, should be more aware of precipitation increase risks and appropriate solutions to the problem since a number of basements have been flooded.

Willing

Consciousness about adaptation measures of increased precipitation and motivation to take actions of house owners is still low, although effort has been made by the municipality to increase citizens' involvement. In general, citizens are especially not concerned about precipitation increase, given that its consequences do not affect their property and neighbourhood.

Working

Mitigation is often more focused than adaptation. Besides this, creating green areas is expensive and social housing associations like the SSH& (student housing organization in Nijmegen) cannot simply increase the rent. Moreover, social housing associations form an association and in general they have more contact with the municipality (M. Infantes, personal communication, April 16, 2018).

Recommendation

It is suggested that house owners, both private and social, become more aware of their roles within precipitation change adaptation. To be more specific, the municipality could motivate tenants of social housing in Nijmegen using economic arguments. Tenants ought to know that rents and other costs could decline if proper measures such as decoupling rain- and wastewater are taken. Furthermore, smaller actions like protecting the environment by protecting the greeneries or use water economically are also encouraged. In general, interests in complying with the policy of the municipality regarding adapting to precipitation changes could be improved if they are more related to people's concerns, which are their own living environment and properties.

Smaller actors

Insurance companies

Insurance companies have a significant amount of information about damages associated with increased precipitation, as citizens and house owners share these with them. However, they are not yet actively involved in solving the problems.

Waterschappen

The Waterschappen act as an expert organization which provides information to other parties. In the past, their regular contact was the municipality, but now, besides the municipality, they also work together with education institutions, businesses, house owners and architects. The expansion of network means information is reached further; hence, there are likely to be more concerns about changes in precipitation and possible solutions. Furthermore, Waterschappen regard climate change adaptation as a relatively new issue. At the moment it is not clear, even to themselves, who is exactly doing what. As a consequence, it might be challenging to evaluate the entire process as well as individual accomplishments. Waterschappen base the evaluation on the guidelines in accordance with the Delta Programme at the moment.

Provincial level

The province's involvement in climate change adaptation is at the phase of planning, researching and monitoring. To illustrate, the Delta programme checks whether the municipality are sufficiently engaged in climate change adaptation, including increasing precipitation adaptation. However, it is evident that the program is not enough specific to the local level. Koen te Velde (personal communication, April 25, 2018). regards these as 'ambition levels'. What the province is trying to do is foreseeing the visions of climate change adaptation in current and future developments of Nijmegen. P. Leroy (personal communication, April 18, 2018) also suggests that more cooperation among Dutch cities and among EU countries are needed.

Recommendations

There should be an interdisciplinary approach that consists of other aspects such as living standards, safety etc. besides targeting precipitation increase. This means communication among different sectors and involvement of private and public sectors should be improved. The solutions should also be considered within the whole story, along with other risks such as heat and drought. Furthermore, the insurance companies have a lot of information and some of them are willing to work with the municipality to share information. However, at the moment, there is very little contact. This means the insurance companies could strive to share more information out of their own by contacting the municipality.

Conclusions

In our research, we communicated with a great multitude of involved people from various parties. Through interviews and literature studies we gathered information on the different involved actors, which combined to create a coherent overview of the roles of the different actors in the Nijmegen regarding precipitation change adaptation.

Two major recurring themes in the interviews and the literature are the themes of the division of responsibility and that of citizen involvement. One thing that became clear over the course of our research is that the division of responsibility between different actors is very unclear. For instance, for the municipality it is unclear how much responsibility they have to take for the property of house owners. There exists no overarching document of any kind which binds each actor to exactly their responsibilities.

The problem of citizen involvement seems paradoxical: Most damage occurs on the property of citizens, yet the citizens are not motivated to take precipitation adaptation measures. The municipalities' influence is mostly limited to the public sector; in which they are mainstreaming climate change adaptation in physical developments in multiple ways, such as adding more public greenery, upgrading the sewage system and replacing concrete roads with paved roads. The municipality also seems to take certain responsibility for the private sector, although their influence here is much more limited. Through spreading awareness and providing subsidies and loans, the municipality also tries to motivate actors in the private sector to take adaptation measures. However, the success of the municipality herein is limited. Most citizens do not seem to be interested in taking climate change adaptation measures; and when they are, it is almost exclusively from a liveability perspective.

We consider future research on adaptation mainstreaming in physical developments on two matters especially important: The first is research on how the municipality could effectively convince citizens to implement adaptation measures. We consider this to be the foremost problem in climate change adaptation concerning precipitation in Nijmegen at this moment. The second valuable topic of research is that of precipitation adaptation in major physical developments. In the process of our research, our focus fell on small-scale adaptation measures such as adding greenery and decoupling rainwater. Precipitation adaptation measures in major physical developments, as implemented (and possibly mainstreamed) by project developers, urban designers and architects were largely undiscussed. This shows a good opportunity for future research.

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Appendix 1: Overview of interviewed people

Table containing the name, function and form of contact for all mentioned interviewed people.

Name	Function	Contact
Ton Verhoeven	policy advisor on water and climate adaptation from the municipality of Nijmegen	Interview in person (6th of April)
Marjolijn Infantes	real estate consultant for the SSH& (social housing)	Interview over the phone (16th of April)
Prof. Dr. Pieter Leroy	Professor of Environment and Policy at the section Geography, Planning and Environment at Radboud University.	Interview in person (18th of April)
Prof. dr. em. Jan Roelofs	Former head of the Department of Aquatic Ecology and Environmental Biology, Institute for Water and Wetland Research, Radboud University Nijmegen	Interview in person (25th of April)
Achmea (Marc Scheers)	Spokesperson of Achmea (insurance)	Contact through mail (23rd of April)
Hans W. André de la Porte	Press and publicity department of Vereniging Eigen Huis (association for private home owners)	Contact through mail (23rd of April)
dr. Sander Meijerink	Associate professor of Water Governance	Interview in person (26th of April)
Koen te Velde	Project leader on climate adaptation for the province of Gelderland	Interview in person (25th of April)
Marjolein Reijnierse	Waterschap rivierenland	Interview in person (24th of April)
Karin Oosters	Waterschap Rivierenland, Responsible for Nijmegen	Interview in person (17th of May)
Lusanne Bouwmans	Vice chair and spokeswoman climate adaptation for D66 Nijmegen	Interview in person (25th of April)

Appendix 2: Infographic

HOW TO DEAL WITH PRECIPITATION CHANGE IN NIJMEGEN

REPLACE
Citizens should replace the hard surface areas in their gardens with greenery to have less precipitation nuisance and less heat stress.

DECOUPLE
House owners should decouple their rainwater from the sewage system.

SHARE
The municipality should contact insurance companies to map out the vulnerable areas in the city more clearly.

MAP
Responsibilities for precipitation change adaptation should be mapped per actor on a regional and national scale.

PROMOTE
The municipality should promote (information about) the subsidies for adaptation more extensively.

TOGETHER
Together we can make Nijmegen a future proof city to avoid damages and improve the living quality. Start now.

Appendix 3: Dutch summary

Samenvatting

Verhoogde neerslag en de gevolgen daarvan hebben onlangs de aandacht getrokken, omdat ze van invloed kunnen zijn op onze gezondheid, veiligheid, leefomstandigheden en vooral op onze economie; de eigendommen van mensen. Het huidige rapport richt zich op de mate waarin adaptatiemaatregelen voor veranderingen in neerslag geïntegreerd zijn in de fysieke ontwikkelingen in Nijmegen. Om dit onderzoek uit te voeren, werd informatie verzameld uit wetenschappelijke literatuur en zijn experts geïnterviewd die betrokken zijn op het gebied van klimaatadaptatie in Nijmegen en Nederland in het algemeen. De belangrijkste actoren zijn de gemeente Nijmegen, lokale burgers en huiseigenaren (zowel privé als sociale huisvestingen). Aangezien klimaatverandering een complex onderwerp is, zijn er nog andere actoren betrokken zoals verzekeringsbedrijven, Waterschappen en actoren op een provinciaal niveau. Kijkend naar alle actoren, blijkt uit ons onderzoek dat adaptatie op verhoogde neerslag niet voldoende worden geïntegreerd. Hoewel de gemeente veel aandacht besteedt aan het motiveren van burgers, moet de betrokkenheid vooral in de private sector nog steeds worden verbeterd. Naast dat burgers zich bewuster moeten worden over de bestaande risico's van neerslag, moeten ze ook actiever worden gestimuleerd om de voordelen te realiseren van het toepassen van adaptatiemaatregelen op hun eigen bezit. Om klimaatadaptatiemaatregelen in de toekomst nog succesvoller in ruimtelijke ontwikkelingen te integreren, moeten de verantwoordelijkheden tussen verschillende partijen duidelijker worden gemaakt. Hierdoor zou een succesvolle samenwerking van verschillende velden, de actievere participatie van burgers en ook het toepassen van maatregelen in fysieke ontwikkelingen verbeterd kunnen worden. Hiernaar is dan ook vervolgonderzoek nodig. Hoewel ons rapport verbeterpunten voorstelt, moet worden benadrukt dat Nijmegen al op weg is om maatregelen voor neerslagveranderingen op alle gebieden te integreren.

Conclusies

In ons onderzoek hebben we met veel mensen van verschillende partijen gecommuniceerd. Via interviews en literatuurstudies verzamelden we informatie over de verschillende betrokken actoren, die samen een overzicht gaven over de rollen die verschillende partijen in Nijmegen innemen.

Twee belangrijke terugkerende thema's in de interviews en de literatuur zijn de verdeling van verantwoordelijkheden tussen verschillende actoren en de betrokkenheid van burgers. In de loop van ons onderzoek werd duidelijk dat de verdeling van verantwoordelijkheden tussen de verschillende partijen erg onduidelijk is. Voor de gemeente is het bijvoorbeeld niet altijd even helder hoeveel verantwoordelijkheid zij moeten dragen voor het eigendom van burgers. Tot nu toe bestaat er geen overkoepelend document dat elke actor bindt aan zijn of haar taken en verantwoordelijkheden.

Het probleem van burgerbetrokkenheid lijkt paradoxaal; de meeste schade ontstaat op het eigendom van de burgers, maar toch zijn zij niet voldoende gemotiveerd om maatregelen voor verhoogde neerslag te nemen. In de gevallen dat dit toch gebeurt, is het bijna uitsluitend vanuit een leefbare omgeving perspectief. De gemeente lijkt hiermee een zekere verantwoordelijkheid over te nemen voor de private sector. Door het verspreiden van bewustzijn en het verstrekken van subsidies en leningen, probeert zij actoren in de private sector te motiveren om aanpassingsmaatregelen te nemen. Het succes van de gemeente hierin is echter beperkt. Hoewel de gemeente probeert burgers actief met maatregelen te stimuleren, blijft hun invloed uiteindelijk vaak beperkt tot de publieke

sector. In de publieke sector integreert de gemeente klimaatadaptatie maatregelen vooral in fysieke ontwikkelingen. Voorbeelden hiervan zijn: het rioleringsstelsel aanpassen en loskoppelen, meer openbaar groen toevoegen, Wadi's opzetten of het vervangen van betonnen wegen.

We beschouwen toekomstig onderzoek naar het integreren (mainstreaming) van adaptatiemaatregelen in fysieke ontwikkelingen op twee punten uitzonderlijk belangrijk. Het eerste punt heeft te maken met dat onderzoek nodig is naar hoe de gemeente burgers effectiever kan overtuigen om aanpassingsmaatregelen te nemen. We beschouwen dit op dit moment als het grootste probleem in de aanpassing aan klimaatverandering met betrekking tot verhoogde neerslag in Nijmegen. Door de participatie van burgers te verhogen, zal het probleem collectief aangepakt kunnen worden. Ten tweede zal onderzoek naar adaptatiemaatregelen voor aanpassingen aan verhoogde neerslag in grotere fysieke ontwikkelingen waardevol zijn. In het kader van ons onderzoek hebben wij ons op kleinschalige aanpassingsmaatregelen zoals het toevoegen van groen en het ontkoppelen van regenwater gefocust. Adaptatiemaatregelen binnen grotere fysieke ontwikkelingen, zoals geïmplementeerd (en mogelijk geïntegreerd) door projectontwikkelaars, stadsontwikkelaars en architecten, waren grotendeels onbesproken. Dit toont een goede gelegenheid voor toekomstig onderzoek. Klimaatadaptatie in Nijmegen kan op verschillende punten nog verbeterd worden, maar het is belangrijk om te melden dat Nijmegen al goed op weg is om een goede adaptatie aan toenemende neerslag te realiseren.