

Policy Coherence in Urban Heat Island mitigation and Nature Policies in Dutch Municipalities

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Summary

Due to climate change, Urban Heat Islands (UHI) are becoming an increasingly more frequent phenomenon. Vegetation is one of the mitigation strategies of heat stress and could simultaneously improve urban nature quality. In the Netherlands, municipalities are to an extent responsible for climate adaptation of cities, and also show interest to tackle urban biodiversity problems. This research aims to find out what is documented in literature about synergies between nature and minimising UHI, and to what extent municipalities respond to those synergies. This results in two main research questions: 1) what are the synergies and trade-offs between minimising UHI effect and nature quality and cultural services as reported in scientific literature, and 2) what are municipalities planning to do to minimise UHI and to what extent are those municipalities utilising synergies and avoiding trade-offs? To do this, this research uses the Policy Coherence Framework, a scientific literature study, and three case studies.

The scientific literature study provided five different nature goals that might be of interest for municipalities to implement to ensure better general nature quality, of which two were linked to minimising heat stress. Those goals are *access for everyone to green space* and *connectivity of urban nature areas*. Additionally, four different instruments were found to be synergetic for nature quality and heat stress reduction, namely increasing number of urban green spaces, tree management, green roofs, and water systems. The three case studies (municipality of Eindhoven, 's-Hertogenbosch, and Deventer) provided insights in how municipalities are utilising synergies by applying the Policy Coherence Framework. All three municipalities showed different strengths and weaknesses when it came to policy coherence. Of the three municipalities, 's-Hertogenbosch showed highest overall policy coherence. Although there are clear differences between the municipalities, further research is needed to determine what the cause is of the differences and how the municipalities will implement the goals and instruments found.

This research showed that the Policy Coherency Framework is useful as a theoretical base to determine the coherency of climate policy and nature policy on a local governmental level. However, since there is not a single methodology for conducting a policy coherency assessment, further research can create a more standardised methodology for the Policy Coherence Framework.

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1. Introduction

Over the last few decades human-induced emissions resulted in increased greenhouse gas emissions, sea level rise, and increased average temperature worldwide (IPCC, 2014). The KNMI has made a scenario-based assessment of future climate development in the Netherlands. According to this assessment, it is likely that summer temperatures will increase between 1.1°C and 2.4°C (Huynen & Martens, 2015). These changes in climate are mainly because of changing air circulations in Western Europe and rising global temperatures (Huynen & Martens, 2015).

Heat will be more intense in urban areas because of the Urban Heat Island (UHI) effect. We speak of an Urban Heat Island when densely urbanised areas have a higher recorded temperature than neighbouring (rural) areas (O'Malley et al., 2015). Temperatures tend to be higher in cities because of, for example, densely built buildings with heat retaining properties, the use of low-albedo materials, and reduced wind speed (O'Malley et al., 2015). Higher temperatures have a profound influence on the city. Firstly, the heat stress can have a negative effect on human health, resulting in cardiovascular stress, thermal exhaustion, and heat strokes (O'Malley et al., 2015). Because of the increased temperature, it is predicted that at first cold-related mortality will decrease in the Netherlands, but over the years the heat-related mortality will increase more than the cold-related mortality decreased (Botzen et al., 2020). Secondly, microclimates in cities will change because of the increased temperature, due to the formation of ground-level ozone, alteration of wind patterns, and changes in local ecosystems (O'Malley et al., 2015). There is also evidence that UHI has influence on the precipitation in the city, as precipitation was higher in urban areas than in rural areas during summer and autumn, and was lower in spring and winter (Golroudbary et al., 2018).

Vegetation is seen as one of the possible mitigation strategies for UHI. Trees and other forms of vegetation are also known to reduce the surrounding temperature. The cooling effect of vegetation is dependent on the foliage density, leaf area index, and leaf area density (Tan et al., 2016). One study shows that increasing vegetation, especially curb-side planting, has a greater positive effect than increasing the albedo (Rosenzweig et al., 2006).

Vegetation is not only useful for minimising UHI, but it also helps increasing biodiversity in cities and serve as recreation areas for citizens. The impact of vegetation on biodiversity depends on the type of nature and the kind of nature management (Aronson et al., 2017), whereas the frequency of people going to nature areas and doing physical activities depends on the amount of nature area in people's living environment (Gerstenberg, 2017). Being outside can increase social integration and interaction between neighbours (Chiesura, 2004). Having nature for recreational use is important in cities, not only for citizen's physical health, but also for mental health (Chiesura, 2004).

It is known that there are certain trade-offs and synergies when it comes to nature and climate adaptive (and in particular UHI) policymaking. Green roofs, for example, have high management intensity and economic input (Aronson et al., 2017) and they can enhance storm-water management, improve air quality, and increase urban biodiversity (Susca et al., 2011), but they have a low native species diversity (Aronson et al., 2017). Depending on what the goals are, certain nature-based solutions might be a better fit than others because of the trade-offs and synergies.

In short, nature can play a key role on different topics regarding the city life, but there are some trade-offs and synergies between different goals of nature and climate policy. In the Netherlands, implementing infrastructures to become climate neutral is the job of the municipalities. These tasks include making buildings more sustainable, increasing the area of nature, and creating a plan on how they can be zero-emission in 2030 (Ehrismann et al., 2020). Cities in Southern Europe are more adapted to UHI than cities in Northern Europe (Kovats & Hajat, 2008). Nevertheless, a quick Google scan showed that municipalities in the Netherlands regard UHI as important, and that it is often mentioned in their climate adaptation plans.

In total there are 32 municipalities in the Netherlands with more than 100 000 inhabitants. A quick Google search was done to find the most recent climate adaptation and nature plans of the municipalities. Dutch municipalities started writing climate adaptation plans in the last few years. For a large portion of the municipalities with more than 100 000 inhabitants, these are already published and can be found on the municipal websites. The most important climate adaptation topics for municipalities are heat, drought, and flooding.

Dutch municipalities all have the same organisation of tasks. At the top of the organisation of the municipality there are the mayors. They are the head of the local council, head of the college of mayor and aldermen (*college van burgemeester en wethouders*), and they are responsible for the public order and safety (Rijksoverheid, n.d.-a). The mayor and the aldermen govern the municipality. The number of aldermen depends on the number of councillors, which again depends on the number of citizens in the municipality. All aldermen have their own area of tasks, like education or finances. To handle those tasks they work together with citizens, organisations, and businesses, but they also talk with officials from the provinces and national government (Rijksoverheid, n.d.-c). Lastly, there are the councillors, who determine the most important points of policy for the college, and check if the college is executing the policies well. They also have contact with citizens and deal with more practical issues of the municipality (Rijksoverheid, n.d.-b).

To summarise; the Urban Heat Island effect is recognised as a future problem by Dutch municipalities, since many of the municipalities mention the effect in their policy documents. Moreover, nature has great potential to mitigate the heat, whilst also having other positive effects on the environment and society (e.g., increase of biodiversity, and increasing mental health and physical health). However, it is not yet known how municipalities are utilising the synergies and avoiding the trade-offs when it comes to solving problems across sectors, and more specifically between nature and UHI adaptation policies. This also shows to what extent various parts of the organisation of the municipality work together to solve problems efficiently.

In order to examine the trade-offs and synergies between policies around UHI mitigation and nature, this research will use the Policy Coherence Framework. Policy coherence is “*an attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objectives*” as stated by Nilsson et al. (2012, p.396). This research will look at the policy coherence of the goals, instruments and decisions, and actors.

The aim of this research is to find out what is documented in literature about synergies between nature and minimising UHI, and to what extent municipalities respond to those synergies. There are two objectives that will facilitate the achievement of this aim; 1) gathering a clear overview of synergies and trade-offs regarding the goals, policy instruments, and actors in those two fields, and 2) presenting three cases to determine to which extent these cases are utilising the synergies between the two policy fields, and where the policy coherence can be improved.

The next chapter will break down the conceptual framework for this research. The conceptual framework is the base for the research questions and methodology and will therefore be presented prior to the research questions and methodology.

2. Conceptual framework

This chapter will discuss the key concepts for this research. Firstly, the definition of nature for this research will be explained. This will be done by using the different images of nature by Buijs (2009). Secondly, important information on the Urban Heat Island will be explained, which will both provide background information and more specific information important for this research. Then, I will dive into the policy formation cycle framework. Lastly, I will talk about the policy coherence framework. This will be the main framework for this research.

2.1. How to define nature?

People have different interpretations when it comes to what nature encompasses. The most basic definition of nature comes from the dictionary, being; everything on Earth not made by humans: plants, animals, mountains, etc. (Van Dale, n.d.). Since this definition lacks detail, grey areas exist in people's personal definitions. For example, water might be considered 'nature' in essence, especially when water is linked to rivers, lakes, and oceans. However, when talking about fountains, some people might suddenly not consider the water in the fountain as nature anymore (whilst others might still see it as nature). It is therefore important to dive deeper into the different perceptions and which perceptions are important in cities. To do this, Buijs (2009) provides different images of nature in his paper.

Buijs (2009) mentions that the images of nature show how people view nature. He did research on the views of nature in the Netherlands. There are several ideal types of images of nature, including wilderness image, autonomy image, inclusive image, aesthetic image, and inclusive image. The *wilderness image* is based on a strict nature-culture divide. The absence of humans, and holistic, ecocentric values are important (Buijs, 2009). The *autonomy image* is also based on the separation of nature and culture but places the emphasis on the natural autonomy of natural processes, where nature does not need human interference. Individualistic and biocentric values are important (Buijs, 2009). The *inclusive image* is based on the idea that nature and culture can be combined, and that nature and culture are interrelated and mutually dependent on each other. All living things, including humans, are defined as nature (Buijs, 2009). The *functional image* is based on a strong hands-on view, where nature should be managed intensively. Well-managed nature areas improve utilitarian values and increases aesthetic (Buijs, 2009).

When looking at the different images of nature, *wilderness image* is the least relevant for cities, since within cities it is hard to divide nature and culture, and the absence of humans is not feasible. The separation of nature and culture is also the reason that *autonomy image* is hard to express within cities. This means that

nature in cities is often viewed in the *functional image*, where nature should have a utilitarian value, or in the *inclusive image*, focussing more on the interrelation between humans and nature.

This research will view nature as the plants and non-domestic animals, as well as the natural processes between those groups. This research will look first and foremost at vegetation and waterbodies, since those have the biggest impact on UHIs. When increasing the amount of vegetation and waterbodies, it is evident that the amount of fauna will increase too, resulting in an increased biodiversity. When looking deep into this, complex ecological structures can be revealed. This is not the main objective of this research; therefore, this research will include fauna (both on land and in water) on a shallower level.

Below-ground organisms and processes will not be taken into account. The main reason for this is the time limitation for this research. This means that processes like drainage will not be included, though there might be synergies and trade-offs between UHI and drainage-improving strategies.

2.2. Urban Heat Islands and health impacts

The Urban Heat Island (UHI) effect is caused by the build environment. We speak of a UHI when the built environment (e.g., city centres) has a higher average temperature than the neighbouring areas. There are several causes for the UHI, as listed in Kleerekoper et al. (2012):

- Low albedo materials absorb short-wave radiation from the sun, and radiation is trapped by multiple reflections between buildings and the street surface.
- Long-wave radiation is absorbed and re-emitted by air pollution in urban atmospheres.
- Obstructions of the sky by building results in less long-wave radiation heat loss from street canyons.
- Combustion processes increase the anthropogenic heat in cities.
- Building materials with larger thermal admittance increase heat storage.
- Cities have a bigger surface area compared to rural area, increasing heat storage.
- Urban areas have a decreased evaporation because of less vegetation and less permeable materials.
- The turbulent heat transport from within streets is decreased by a reduction of wind speed.

Increased temperature has several impacts on human health, and thus on society. Extreme heat can lead to different physical complaints in humans and animals, called heat stress (Klimaatadaptatie Provincie Noord-Brabant, 2019). Heat stress can result in different illnesses like heat syncope, cardiovascular stress, thermal exhaustion, and even heat strokes (Kleerekoper et al., 2012). Heat strokes can lead to kidney and liver failures, respiratory distress syndrome, and disseminated intravascular coagulation (Kleerekoper et al., 2012).

Moreover, heat strokes have a significant case-mortality ratio, and can result in death rapidly (Kovats & Hajat, 2008). In case of survival, organs will be permanent damaged, which can increase the risk of early mortality and can cause severe functional impairment (Kovats & Hajat, 2008). Severe heat strokes will occur when the body's core temperature is over the 103°F, or 39.4°C (Kovats & Hajat, 2008). Studies show that mortality due to temperature is higher in cities because of the UHI, one of the reasons being that the temperatures stay higher during the nights (Kovats & Hajat, 2008).

Nature-based solutions are one way to contain the UHI. Nature-based solutions allow for sustainable solutions by focussing on benefits for both the environment and for people (Eggermont et al., 2015). As this description shows, when implementing nature-based solutions, not only environmental problems can be minimised but also problems of citizens, like decreased health because of heat stress. Spending time in nature has some remarkable benefits for humans.

Nature experiences are associated with psychological well-being. Moreover, some types of nature may even decrease the risk factors and burden of some types of mental illness (Bratman et al., 2019). Nature experiences are associated with improving both sleep and stress levels. Sleep problems and stress are major risk factors for mental illness, especially for depression (Bratman et al., 2019).

Climate policy and nature policy both provide options to deal with the environment in such a way that it benefits humans and flora and fauna. The synergies between the two fields can be noticed in the field of UHI mitigation, where nature-based solutions both have influence on biodiversity and on climate mitigation and adaptation.

All benefits that nature can provide can be divided into ecosystem services; provisioning services, regulating services, supporting services, and cultural services. This research will mainly focus on three of the four services, namely the regulating, supporting, and cultural services. Regulating services are often invisible and often taken granted for (FAO, n.d.-c). The regulating services that this research will look at are the moderation of extreme events (in particular heat stress) and local climate and air quality.

Then you have the supporting service. Supporting services are the basis of all ecosystems and their services (FAO, n.d.-d). This research will view the increase in nature in the city and biodiversity as a supporting service.

Lastly, this research will look at cultural services. These are non-material benefits for humans, like mental and physical health benefits and aesthetic inspiration (FAO, n.d.-a). This research will mainly look at mental and physical health aspects of the cultural values.

This study does not consider provisioning services. Provisioning services are material benefits that people obtain from ecosystems, like water, food, and wood (FAO, n.d.-b). Although these are important benefits for society, it does not fit within the scope of this research.

2.3. Policy Cycle Approach

The Policy Cycle is a process model of policy making, based on three features of policy making; 1) policy making happens in presence of multiple constraints, 2) policy making involves the existence of various policy processes, and lastly 3) policy processes form an infinite cycle of decisions and policies (Knill & Tosun, 2008). There are five stages in the Policy Cycle framework, 1) agenda setting, 2) policy formulation, 3) policy adoption, 4) implementation, and 5) evaluation (Jann & Wegrich, 2007; Knill & Tosun, 2008). This research only investigates the second stage of the policy cycle, the policy formulation.

This research looks at the policy formulation stage of nature and climate policies. The policy formulation stage of the Policy Cycle framework includes the problem definition, discussion, and acceptance or rejection of feasible actions. Policy formulation deals with the elaboration of alternatives of actions (Knill & Tosun, 2008). Where the agenda setting phase shows where we want to go, the formulation stage is about how to get there (Turnpenny et al., 2015). It should answer the “what” questions, like: What is the plan for dealing with the problem? What are the alternatives? What externalities (both positive and negative) are associated with all the alternatives? (Sidney, 2007).

2.4. Policy Coherence Framework

Policy coherence is a concept that is easy to grasp, but hard to measure (May et al., 2006). In daily speech, it often has the meaning of various policies having the same set of ideas or objectives (May et al., 2006). However, this is quite a limited view on the concept. Scholars have different, and more extended, definitions for policy coherence. Wiedemann & Ingold (2021, p.4) state that policy coherence measures the extent to which different objectives and policy instruments in a given sector complement each other without introducing conflicting incentives or compromising effectiveness and efficiency in producing one outcome rather than another. The objectives are again a factor in the definition of policy coherence, but Wiedemann & Ingold (2021) also emphasise that those objectives and instruments *complement* each other, and without having clear *trade-offs* in effectiveness and efficiency. This research uses the definition of policy coherence of Nilsson et al. (2012, p.396): “an attribute of policy that systematically reduces conflicts and promotes

synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objectives”.

Policy coherence is important since different policies can operate at the operational level, which can influence their effectiveness (Ranabhat et al., 2018). Research also shows that supportive policy in one sector can be undermined by unsupportive policies in another sector (Ranabhat et al., 2018). It is therefore important to understand if different, but related, policies have common goals, and if there are contradictories (Ranabhat et al., 2018). There are different kinds of policy coherencies, it can be internal (within a policy sector) or external (between different policy sectors) (Nilsson et al., 2012). Moreover, the coherency can be on a horizontal or vertical level (Nilsson et al., 2012). There are many other scholars that came to similar conclusions. Whilst most of them formulate the different dimensions slightly different, horizontal and vertical components are always of importance (Duraiappah & Bhardwaj, 2007). This research will look at external and horizontal coherency.

There is not one specific way to assess if there is a high policy coherence. Duraiappah & Bhardwaj (2007) looked at different literature studies to see if there were common features in the definition of policy coherence. They found the following three features: 1) goal integration without compromising the integrity of each goal, 2) integration of institutions, administrations, and organisations through, for example, legal arrangements, procedures or instruments, infrastructure, or decision-making between sectors, and 3) integration at the level of actors responsible for policy implementation of integration among actors (Duraiappah & Bhardwaj, 2007). When synthesising these three features, we find that you can therefore assess policy coherence in terms of goals (overall themes), instruments and decisions (ways to achieve the goals), and actors (institutions responsible) (Duraiappah & Bhardwaj, 2007). Wiedeman & Ingold (2021) found just two criteria for policy coherence in literature, being cross-sectoral formulation of objectives, and cross-sectoral instrumental types. These are similar to the ‘goals’ and ‘instruments and decisions’ features of Duraiappah & Bhardwaj (2007).

From these two different viewpoints we can synthesise three main assessment areas for coherence, being goals, instruments and decisions, and actors. This study will therefore use these three areas as well. Coherence between goals shows how overall themes overlap and are integrated. Instruments and decisions show the way a goal is achieved. Though the goals of nature policies and climate policies can differ, the way to reach these goals can have similarities, creating synergies. The coherence of actors shows how responsible actors are integrated and working together.

There are some complications when assessing policy coherence. The first complication is identifying the policies that should cohere. This has partly to do with the scope of policies, which can be very broad or very specific (May et al., 2006). Secondly, you cannot measure the consistency of policies directly. This is because how policies are framed can be very broad or very narrow, be opaque, or can be symbolic or hortatory (May et al., 2006).

Nilsson et al. (2012) showed one way to conduct a Policy Coherence Assessment, with two main steps. The first one is making an inventory of policy objectives, and the second one is making a screening matrix (Nilsson et al., 2012). Making an inventory of policy objectives is needed to get a comprehensive overview of the policy objectives (Nilsson et al., 2012). The Screening Matrix has as purpose to do a quick map of the overall interactions (Nilsson et al., 2012). Duraiappah & Bhardwaj (2007) use a content analysis to see how often specific words are mentioned in documents. Then they use quantitative techniques to translate the qualitative information into a numerical measure. Mallory (2016) looks into the policy coherence between China's subsidies policies and China's stated goals in fishery management. The methods of the paper show the overall approach of the author. It is done by elaborating on China's stated goals in fishery governance and by analysing the subsidies for fisheries. Then the author categorises the subsidies for fisheries by their sustainability, to lastly discuss subsidies in the context of overall fisheries policy coherence (Mallory, 2016). In this research, Mallory (2016) makes a clear distinction between internal, transnational, vertical, and horizontal policy coherence.

The examples provided show that there is not a single way to do a Policy Coherence Assessment. Since none of the examples provides a methodology that fits this research completely, this research will take elements from the examples to create the methodology. Nevertheless, the examples do provide a solid base and information as to what the important parts of a Policy Coherence Assessment are.

To see the policy coherence between nature policy in cities and climate policies of municipalities, the following steps have been taken. First of all, goals for both nature policy in municipalities and climate policy for municipalities have been extracted. After that, following Nilsson et al. (2012) a matrix was made with colour coding to express the relation between two different goals. Nilsson et al. (2012) did this step with actors in the field. This will not be done in this research for creating the matrix, due to limited time.

3. Research questions

The Urban Heat Island effect is recognised as a future problem by Dutch municipalities, as many of them mention the phenomenon in their policy documents. Moreover, nature has great potential to mitigate the heat, whilst also having other positive effects on the environment and society (e.g., increase of biodiversity, and increasing mental and physical health). However, to what extent municipalities utilise the synergies between nature policies for increasing nature quality and cultural services and policy regarding UHI remains unknown. Therefore, the aim of this research is to find out what is documented in literature about synergies between nature and minimising UHI, and to what extent municipalities respond to those synergies. Following this, the main and sub-research questions are:

1. *What are the synergies and trade-offs between minimising Urban Heat Island effect and nature quality and cultural services, as reported in literature?*
 - *What are the relations between the goals of the mitigation methods and the goals for biodiversity and cultural services?*
 - *Which instruments and decisions are important for implementing the mitigation method?*
 - *Which actors play a role with implementing this mitigation method?*
2. *What are municipalities planning to do to minimise UHI (by using nature) and to what extent are those municipalities utilising synergies and avoiding trade-offs?*

3.1. Scope and Limitations

Nuruzzaman (2015) has made a clear overview of the major strategies to mitigate the UHI effect. These are: high albedo roofing materials, high albedo pavements, green vegetation, shade trees, pervious pavements, water bodies, urban planning, and green roofs. This research focusses on the nature-based solutions and will therefore not investigate the high albedo and pervious materials. Moreover, Nuruzzaman (2015) mentions in his literature review about green vegetation only trees. Therefore, this research will combine the 'green vegetation' and 'shade trees' to one topic, namely street trees. This means that the topic discussed in this part will be green roofs, street trees, and water bodies.

Case studies will be used in this research to answer the second research question. Three case studies will be done. Although more cases would give a better representation for municipalities in the Netherlands, time limitations did not allow for more case studies. The three cases have been selected to be as much of a representation for Netherlands as possible, whilst keeping practical aspect in mind. Chapter 3. *Methodology* will dive deeper into the selection process of the case studies.

4. Methodology

The first part of the research will be a literature study, where existing literature will be analysed to answer the first research question and its sub-research questions. Background information on the UHI and the known mitigation methods using nature will be considered.

First, an analysis of those UHI mitigation methods and their relation to nature quality and cultural services was conducted. In order to do this, search engines like Google Scholar and the online WUR library were used. Whilst conducting the literature research, words such as “green roofs”, “UHI mitigation strategies”, “biodiversity”, and “recreation” were used. These words resulted in more general papers that provided information on the topic, and from which more specific topics would follow. For example, in the case of green roofs I came to the words “extensive roofs” and “intensive roofs. Words like: “temperate climate”, “Europe”, and “the Netherlands” were used to get more regional-specific results, although in some cases examples from other regions of the world were interesting to compare European/Dutch practices with.

For some topics it was desirable to get more up to date references. To do this, the range of publications dates was set from 2015 till now (2021/2022). For topics where this was less important (more general information or information on the theoretical framework) this was not done. Moreover, it is good to remember that the last Dutch municipal elections were in 2018. Therefore, most municipal documents are from after that period, to ensure to have the latest policy implementations and ideas. To get more specific information about the Netherlands, the key search words were translated to Dutch, this way also Dutch research articles could be found.

Another method to gather relevant literature is by using related articles or sited articles. Some online scientific journals give you an overview of related articles, and the reference lists shows used articles. This is mainly used to get more in-depth information on a topic that might be discussed in research.

For the second question, “which instruments and decisions are important for implementing this mitigation method?”, a similar method was used. However, instead of only using scientific papers, for this part also websites of the government (both national and local) and other relevant organisations were to determine what the status is of policies and options regarding e.g., funding, tax, and initiatives. Lastly for the actors, the general structure and responsibilities of municipalities is described. Additionally, some other general actors were listed.

The second part of the research investigated to which extend the municipalities make use of the synergies and trade-offs between the two policy areas: climate adaptation (in particular, UHI) and nature protection.

The matrix made in the first part of the research will provide the basis. This is an ex-nunc assessment, since the selected municipalities already have plans, and are in, or moving into, the implementation phase. The policy cycle approach and the theory on policy coherency were used in this part to understand the relation between policies mitigating UHI and nature policies. This was done by looking through policy documents and interviewing different people from the municipalities that are involved in the policymaking or implementation of the plans, to follow the two steps from the Policy Coherence assessment. For all cases, different municipal documents were found in relation to nature and climate policy. The goals found in scientific literature are searched for in these documents. When found, the documents were assessed to see if the municipality related the goal to heat stress reduction. For the instruments, the documents and website of the municipalities are scanned to determine to what extent the instruments are used by the municipality. When the municipality mentions the reason or benefits of instrument use, this will be noted as well. Lastly, for the actors the different tasks of the aldermen are determined, specifically to see if the policy areas nature and climate are under the same alderman. Moreover, when the municipality is working together with other organisations to work on nature and climate adaptation, especially when it relates to nature-based solutions and heat stress mitigation. Three different people from the municipalities were to be interviewed to gain knowledge on the interaction between the different policy-making departments of the municipality. Because of busy schedules only one interview has been done. This interview was semi-structured and covered the information that is not (yet) published in policy documentations. After the interview, a condensed report was made, to synthesise the information. This is a time-efficient, yet effective, way of reporting the interviews

The second part of the research was done by using case studies. In total there were three different cases. These cases were selected by using several criteria. First of all, the municipality needed to be Dutch and needed more than 100.000 inhabitants. However, Amsterdam, Rotterdam, Den Haag, and Utrecht are not taken into account because they are so much bigger than the rest of the municipalities (359.400 - 873.300 inhabitants) and are therefore not representative for the majority of the larger Dutch municipalities. Secondly, the municipalities needed climate and nature policy documents. How the municipality made and structured those documents is not considered whilst making the selection, to ensure no bias towards more well-developed policy documents that would not be representative for municipality in the Netherlands. And lastly, the municipalities needed to be relatively easily accessible, and needed to be fairly known to the researcher, so less time needed to be spent to get familiar with the different neighbourhoods and natural areas.

The selected municipalities were Eindhoven, 's-Hertogenbosch, and Deventer. These three municipalities were chosen because they all have different characteristics. First of all, they all are a different size city, with

Eindhoven being the largest with 235 691 citizens in 2021, then 's-Hertogenbosch with 155 490 citizens in 2021, and the smallest being Deventer with 101 236 citizens in 2021 (CBS, n.d.). The three municipalities have both nature and climate documents but have different ways of documenting their plans and policies regarding nature and climate. The municipality of Eindhoven and Deventer have two different documents for the topics, whereas 's-Hertogenbosch has combined the two topics into one document. Moreover, the municipalities 's-Hertogenbosch and Deventer have the benefit that the author or the thesis supervisor has lived in the municipality. Because of these personal ties, research can be done more efficiently because the area is well-known. Due to the time restraints for this research, efficiency is an important factor. Lastly, Eindhoven mentioned that it is the greenest city of the five largest cities in the Netherlands (Gemeente Eindhoven, 2017). Although this is a self-proclaimed title, it could be an interesting factor in this research.

There are several limitations that come with creating the scope for this research. As mentioned before, only three municipalities will be used as cases. This makes it hard to make statements about Dutch municipalities in general. The main reason is that all three municipalities have more than 100 000 citizens. There are only 32 municipalities in the Netherlands with more than 100 000 citizens. Smaller municipalities may have a different problem when it comes to nature policy and heat stress reduction, because they typically have a smaller urban area. It is difficult to say whether the three municipalities are representative for the 32 larger municipalities in the Netherlands. During a quick internet scan, it became evident that most larger municipalities have already published their climate adaptation plans, and these also include the problems of UHI and heat stress. Moreover, the three cities do represent different sizes of cities which could give some interesting insights, since the city of the municipality might influence how they deal with challenges.

5. Synergies and Trade-offs between UHI adaptation and nature

This chapter will analyse the impact of nature-based solutions on UHI mitigation, biodiversity, and cultural services. As described in the theoretical framework, the Policy Coherence Framework uses three features: goals, instruments, and actors. The next part of the research will use these features to determine the policy coherence of nature policy and heat stress reduction as written in scientific literature. Often policy documents will speak of ‘heat stress’ instead of UHI. Therefore, this research will from now on use them interchangeably. Chapter 5 will follow the same structure but will look at the policy coherence of the three case studies.

5.1. Goals

In this part, examples of nature and climate goals for municipalities will be listed and explained. Since there are no international review studies of municipal goals for nature policy and heat stress, and most Dutch municipalities do not systematically list such goals, this analysis is based on two main sources; one from the Vereniging Nederlandse Gemeenten (VNG, *Association of Dutch Municipalities*) (VNG International, 2020) and another from a group of stakeholders and professionals from New York City (Sanderson et al., 2018). Heat stress is viewed as separate from nature goals and is also the only goal related to climate change adaptation.

Goals of nature policy in cities

There are three points to keep in mind when reading the goals in this part of the research. First, only relevant goals for this research will be listed. The relevance is high when the goal is a direct nature goal, and when the goal is clear, both in wording and in meaning. Second, the goals actually need to be goals. This sounds obvious, but in reality many things are mentioned as goals that are actually instruments. Lastly, sometimes different goals say practically the same thing. In this case, the goals will be combined to one goal.

The Vereniging Nederlandse Gemeenten (VNG, *Association of Dutch Municipalities*) has set up a campaign called Gemeenten 4 Global Goals (*Municipalities 4 Global Goals*). At the time of writing, 117 Dutch municipalities are part of this campaign (VNG, n.d.). The goals are based on the Sustainable Development Goals (SDGs) from the United Nations. They took the most applicable goals and targets for municipalities, and made a list of practical activities municipalities can do to help achieve that goal/target (VNG International, 2020).

The relevant SDGs, as listed by VNG International (2020), are Goal 11 (sustainable cities and communities) and Goal 15 (life on land). The last set of goals that talk about nature and biodiversity is Goal 14 (Life below water). However, Goal 14 talks about marine ecosystems, and is therefore not relevant for this study. The targets from goal 11 and 15 that are relevant for nature policy in cities are:

- 11.3. Inclusive and sustainable urban development, and building capacity for participative, integrative, and sustainable planning and management of human settlement in all countries.
- 11.6. Reduce the negative impact on the environment by cities per capita, also with special attention to air quality and waste management.
- 11.7. Accessibility for everyone to safe and inclusive green and public spaces, especially for women, children, elderly, and people with disabilities.
- 11.a. Support positive economic, social, and ecological connections between urban and rural areas, by strengthen national and regional development planning.
- 15.1. Ensure conservation, recovery, and sustainably usage of freshwater ecosystems, such as forests, ground water, lakes, etc.
- 15.5. Urgent action to stop the decline of natural habitats and the loss of biodiversity to protect species that are threatened with extinction.
- 15.8. Limit invasive exotic species and their impact in both land and water ecosystems.
- 15.9. Integrate ecosystems and biodiversity values in national and local planning.
- 15.a. Mobilise money to protect biodiversity and ecosystems (VNG International, 2020).

When looking at those different (sub)goals we can conclude several things. First, goal 11.3 is very broad and unspecific. When looking at goal 11.3 inclusiveness in relation to nature, it can be argued that accessibility to green is overlapping (11.7). Goal 11.a is not applicable to this study, since it relates also to both economic and social connections, by strengthen national and regional development planning. Moreover, goals 15.9 and 15.a are more similar to instruments than they are to goals (as defined by this research).

A group of stakeholders and professionals also has set up nature goals for New York City for 2050. They have split the goals in two different types: functional goals, and compositions (Sanderson et al., 2018).

Their functional goals include:

1. Biodiversity and habitat – providing living environments for a diversity of species
2. Connectivity - better enabling the movements of plants and animals through the city
3. Inspiration - further encouraging human creativity and appreciation of beauty through nature
4. Health and refuge – promoting physical and mental wellbeing
5. Open space – lies within reach of all New Yorkers

6. Shade – cools the city

The list for composition goals includes (Sanderson et al., 2018):

1. Native ecosystems
2. Native species
3. Access to nature to all New York residents
4. Integration of nature into the built environment
5. Engagement of people through participation

Both VGN International (2020) and Sanderson et al. (2018) provided nature goals for municipalities.

When combining the two sets of goals, the following list of nature goals can be created:

- N1. Stop decline in biodiversity and natural habitats
- N2. Limit invasive exotic species
- N3. Access for everyone to green space
- N4. Connectivity of urban nature areas
- N5. Participation of citizens

N1. Stop decline in biodiversity and natural habitats

Urbanisation is one of the greatest threats to biodiversity. Nevertheless, cities can be very important for native biodiversity conservation. This is because cities have a range of habitat types, such as gardens, yards, remnant patches of native vegetation, urban wastelands, and green roofs (Aronson et al., 2017). In Australian cities, thirty percent of the threatened plant and animal species were found in cities (Ives et al., 2015). It is therefore important that cities are aware of the threatened species and put effort in the conservation of them.

N2. Limit invasive/exotic species

Not all exotic species are invasive. A species is considered invasive when they have a tremendous negative influence in native ecosystems, cultivated ecosystems, and managed landscapes (Tobin, 2018). However, Tobin (2018) states that the majority of non-native species are relatively benign, pose only negligible impacts, or are even beneficial. It is very hard to establish whether species are actually invasive, since the impacts are hard to quantify. This is also because it is linked to human expectations, which can differ among people (Tobin, 2018).

Invasive non-native species are often more prolific in urban areas than in rural areas. This is because the opportunity for introduction, establishment, and spread of these invasive species is often improved by human activities, habitat modification, and other disturbances (Gaertner et al., 2017). There are two competing theories that is supported by empirical evidence; 1) a species-poor community is more susceptible to invasive species, and 2) a diverse native community can more easily accommodate invasive species (Pitt, 2008). Warmer conditions may impact the spread of invasive species in temperate regions. This is because many invasive species have range limits set by extreme cold and ice cover (Hellmann et al., 2008).

However, scholars are debating what the role of exotic species should be in cities. Liu & Slik (2022) found two different point regarding trees in a biodiversity friendly city. Their first point regarded the number of trees. Their second point, however, stated that biodiverse friendly cities should have a higher proportion of native trees because they are known foraging-resources for native animals. Study shows that it is possible to carefully select exotic tree species that will have a positive effect on native animal species, though this is often less effective than using native tree species (Liu & Slik, 2022). Moreover, exotic species can become invasive (Liu & Slik, 2022). However, Sjöman et al. (2016) do not fully agree with this point made by Liu & Slik (2022). They argue that native species may indeed be better adapted for (semi-) natural conditions, but in cities the conditions are often harsher, because of heat stress, droughts, and human pressures. These different pressures may even increase due to climate change (Sjöman et al., 2016). Exotic species perform better under these hard urban conditions (Sjöman et al., 2016), and may therefore be a better option.

Municipalities need to consider the species they use carefully. Exotic species might be better adapted for urban conditions and might be better in the long-term considering climate change, but there is the threat that the exotic species become invasive. Native species are considered to have a higher biodiversity value.

N3. Access for everyone to green space

A green space can provide both mental and physical health benefits for people. There is evidence that the benefits include reduction of stress, psychological restoration, promotion of social cohesion, provision of space for physical activity, increased birth weight, and reductions of in cardiovascular disease and all-cause mortality (Mears & Brindley, 2019). Moreover, research shows that greenspace has the potential to reduce health inequalities associated with socioeconomic deprivation (Mears & Brindley, 2019). It is considered an environmental inequity when there is not adequate greenspace provided for more deprived groups. Therefore, access to greenspace has become an environmental justice issue (Mears & Brindley, 2019).

Most research regarding accessibility of green spaces focus on two aspects: the distance to a green space, and the area available at that green space (de Sousa Silva et al., 2018). The European Environment Agency has made the recommendation that there should be a green space within 15 minutes walking distance from where they live (de Sousa Silva et al., 2018). However, following the research by de Sousa Silva et al. (2018), different researchers haven concluded different distances (from 5 to 15min) and different sizes of green space (1-10 ha).

N4. Connectivity of urban nature areas

Landscape connectivity has become a global conservation priority (LaPoint et al., 2015). However, generalising and comparing the state of landscape connectivity is hard because there are different types of connectivity, definitions are inconsistently applied, and there are varying methods for quantifying each type of connectivity (LaPoint et al., 2015). In ecology, structural connectivity and functional connectivity are often used. Structural connectivity is the physical attribute to the landscape, and functional connectivity is more organism-oriented, where behavioural responses are interpreted to see whether landscape patches function as connected (LaPoint et al., 2015).

N5. Participation of citizens

Participation of citizens in local government has often been seen as a way to enhance communication between citizens and government, for building public support for local government goals, and for developing public trust in the government (Berner et al., 2011). When more actors are involved in the decision-making-progress, governance outcomes, including social and environmental benefits, will be improved (Buijs et al., 2016).

Goals of climate adaptation policy in cities

Climate policies can serve different goals, such as reducing stormwater runoff, reducing droughts, and mitigating extreme weather events. This research, however, focusses on one specific goal: reducing heat stress in cities.

This goal comes back in different documents. For example, in Handreiking Global Goals in het Gemeentelijk beleid 2020 (VNG International, 2020) the following examples of how municipalities can add to Goal 13 (Climate Action) are mentioned:

- Conducting a stress test for flooding, drought, and heat.
- Create awareness by citizens and companies; together try to prevent heat stress by implementing appealing green areas, like; parks, city- and façade gardens, green roofs, tiny forests. Also, in socially vulnerable neighbourhoods.

When looking at the policy documents from municipalities, the conclusion can be made that most large municipalities do mention heat stress as a potential threat that needs to be mitigated, like for example the municipalities of Groningen (Gemeente Groningen, n.d.), Tilburg (Gemeente Tilburg, 2020), Zaanstad (Gemeente Zaanstad, 2020), 's-Hertogenbosch (Gemeente 's-Hertogenbosch, 2021a), Zwolle (Gemeente Zwolle, 2019), Eindhoven (Gemeente Eindhoven, 2017), Delft (Gemeente Delft, 2019), and Deventer (Gemeente Deventer, 2019a) have mentioned heat stress as an important topic in their climate/nature documents.

The coherence between the goals

In sum, the following goals for the coherence analysis are identified:

- H1. Heat stress reduction
- N1. Stop decline in biodiversity and natural habitats
- N2. Limit invasive/exotic species
- N3. Access for everyone to green space
- N4. Connectivity of urban nature areas
- N5. Participation of citizens

In Table 1, the coherence between goals is described. Notably, there were no trade-offs found in the scientific papers read for this research.

Goals	Influences	Explanation
H1	N2	When temperatures increase, more invasive species can find habitat.
N1	-	From scientific literature it does not seem like there is a clear synergy or trade-off with the other goals.
N2	N1	When you limit invasive species in a habitat, other species have more space and opportunity to grow. This can increase the biodiversity in a city.
N3	H1, N1, N5	H1. To make sure that everyone has access to it, most cities need to increase their green space area. More greenery in the city will also help to reduce heat stress. N1. When ensuring access for everyone to green space, the amount of green area needs to be expanded. When done right, this can increase biodiversity and habitat areas. N4. When you increase the amount of nature so everyone has access to it, it can also increase the connectivity between nature patches. To achieve this, careful planning is needed.

		N5. When people are more surrounded by nature, they may feel more bonded and responsible for it. This can increase the willingness to participate in the
N4	H1, N1, N3	H1. To increase connectivity, there needs to be more nature and greenery. This will also help achieving the goal of reducing heat stress. N1. When you want to stop declination of biodiversity and natural habitats, connecting urban areas is a good start. It creates extra habitat possibilities, and green corridors can be used by species to move from one nature patch to another. N3. When you want to increase the connectivity between nature patches, you need to create more greenery between those two patches. This leads to more nature are in total. This could contribute to getting access to nature for everyone.
N5	N2, N3	N2. When citizens are actively participating in nature conservation in the city, they will also get more involved and educated. This could lead to more mindful gardening, with the use of more native species instead of invasive/exotic species.

Table 1: Goal coherence found in scientific literature.

5.2. Instruments

Policy instruments are the ways to achieve the goals. Nuruzzaman (2015) has made a clear overview of the major strategies to mitigate the UHI effect. These are: high albedo roofing materials, high albedo pavements, green vegetation, shade trees, pervious pavements, water bodies, urban planning, and green roofs. This research focusses on the nature-based solutions, and will therefore not look into the high albedo and pervious materials. Moreover, Nuruzzaman (2015) mentions only trees in his literature review about green vegetation. Therefore, this research will combine the ‘green vegetation’ and ‘shade trees’ to one topic, namely street trees. This means that the topic discussed in this part will be; green roofs, street trees, and water bodies.

Increase number of green spaces in cities

Green spaces are seen as a way to mitigate UHI in cities. There is not yet a universally accepted definition of urban green space. Definitions range from place with natural surfaces or settings to specific types of urban greenery (WHO Regional Office for Europe, 2016). The WHO Regional Office for Europe (2016) describes that most studies follow the definition that urban green space usually includes public parks and gardens. However, the most common definition used in studies for urban green spaces in Europe is defined as public green areas used mainly for recreation (WHO Regional Office for Europe, 2016). This

research will follow these definitions and will view urban green spaces as natural spaces that are designed for recreation. Although urban green spaces are preferably open for public, it is not viewed as a prerequisite for this research, since increase in natural surface in highly paved over areas is beneficial for heat stress reduction. This research does not include street trees, green roofs, or waterbodies in the definition of urban green spaces since those will be discussed separately in this study.

One example of urban green spaces is urban parks. Large urban parks (larger than 20ha) in city centres often have a significant impact on the temperature of urban spaces because of their location and large area (Aram et al., 2019). Studies performed on medium-sized urban parks (0.1-12ha) showed that when parks are larger, the temperature decrease is larger and reaches further away (Aram et al., 2019). Moreover, parks with dense vegetation cover have the greatest cooling effect and thermal comfort (Aram et al., 2019).

Tree management

Street trees are important for both mitigating heat stress and for biodiversity purposes. Trees affect urban areas in three ways, by blocking the wind, blocking the solar radiation, and by transpiration from the leaves (Wang & Akbari, 2016). The three crown could increase all of these effects (Wang & Akbari, 2016). One way to measure the crown is by using the Sky View Factor (SVF), which is the fraction of sky area someone sees when looking up. An SVF of 1 is a completely open sky, and an SVF of 0 is a completely close indoor environment (Wang & Akbari, 2016). The tree crown diameter has a bigger impact on the SVF than the height (Wang & Akbari, 2016). It is therefore that trees with a larger diameter of crown that are planted closely together leaving no space between them have a bigger impact on mitigating the air temperature and UHI (Wang & Akbari, 2016).

When air temperatures exceed 20degrees Celsius, people tend to move out of direct sunlight and move into the shade (Wang & Akbari, 2016). However, the Mean Radiant Temperature (MRT) is a more accurate indicator for human thermal comfort since it shows the sum of all short-wave and long-wave fluxes absorbed by the human body (Wang & Akbari, 2016). Also for minimising the MRT, trees with a larger diameter crown and no open spaces between them are more effective (Wang & Akbari, 2016).

However, it takes some time before trees are large enough to provide shade (Nuruzzaman, 2015). This means that the trees planted now provide limited benefits for UHI mitigation in the first few years. Moreover, street trees that have large canopies also pose a threat during storms since they are more vulnerable (Nuruzzaman, 2015). In case of a huge storm, larger trees can damage buildings and can be dangerous for pedestrians.

Trees can also add to the biodiversity. Ikin et al. (2015) did research to key lessons for achieving biodiversity sensitive cities and towns in Australia. One of their key lessons was that large old trees need to be managed for long-term sustainability. Maintaining old trees are important for the persistence of wildlife, which cannot be replaced by young trees (Ikin et al., 2015). Moreover, Liu & Slik (2022) found that there was an association between the increase of trees in the city and tree diversity and their associated wildlife, like bats, bees, birds, and beetles. Liu & Slik (2022) found two different points regarding trees that a biodiversity-friendly city should incorporate. The first one is that biodiversity-friendly cities should have a large number of different tree species supporting multiple ecosystem functions (Liu & Slik, 2022, p.2). If there is a higher diversity of tree species in a city, there is also a higher diversity in wildlife species. Cities that have a tree monoculture, tend to have lower wildlife species diversity and there will be more species' specific pests and deceases (Liu & Slik, 2022).

The second point by Liu & Slik (2022, p.2) is that biodiversity-friendly cities should have a higher proportion of native trees because they are known foraging resources for native animals. Although not all scholars agree with this statement (e.g., Sjöman et al., 2016), it does provide an interesting point of view that municipalities can incorporate.

It is also important to consider if the neighbourhoods where the trees are planted already have substantial nature features. Kardan et al. (2015) did research on the positive effect of trees on mental and physical health in Toronto, Canada. Their study results were that if, on average, a neighbourhood had 10 trees or more, then the people who live there have a significantly higher health perception and significantly less cardio-metabolic conditions (Kardan et al., 2015). A study done by Soga et al. (2021) on the importance of nearby nature for mental health during the COVID-19 pandemic showed that people with homes with a view on nature reported a better mental status (Soga et al., 2021). Since the COVID-19 pandemic more people work from home. Thus, it is important to ensure green views not only from workplaces, but also more from citizen's houses. Street trees can provide such a view.

Lastly, street trees can also function as natural corridors, therefore planting trees strategically between nature patches can increase the connectivity between nature patches.

The increase of street trees also can have some negative impacts on citizens and the city. First of all, the presence of deciduous trees is one of the factors that increases habitat suitability for rats (Löhmus & Balbus, 2015). Rats are hosts for many zoonotic diseases. They also can cause gnawing damage and spread rat allergens (Löhmus & Balbus, 2015). Connectivity between green areas in cities also may increase the opportunity for rat dispersal (Löhmus & Balbus, 2015). Secondly, allergic respiratory response to pollen

is very common public health problem, and is increasing throughout the world both in prevalence and severity. A wide range of tree species are producers of the aeroallergens that causes symptoms. Examples of tree species are birch, alder, hazel, oak, olive, and cypress (Löhmus & Balbus, 2015).

To conclude, when municipalities decide to increase the number of trees of cities, they should bear in mind the following things:

1. Make a long-term plan that allow trees to grow big and old, to increase the amount wildlife and for shade.
2. Plant multiple species of trees, to increase diversity of wildlife.
3. Plant trees close to each other, to have larger shade area.
4. Look for native species if possible, but assess if the native species will have the ability to endure climate change in cities.
5. Place more trees in neighbourhoods which little nature.
6. See if street trees can be strategically places to create natural corridors.
7. If possible, try to choose for species that produce less aeroallergens that cause symptoms.

Green roofs

Between 20-25% of urban surface consists of roofs (Susca et al., 2011). Green roofs are helpful for mitigation UHI because the soil and vegetation convert energy to latent heat through evapotranspiration. This reduces the amount of sensible heat that is transmitted to the air or within buildings (Razzaghmanesh et al., 2016).

Oberndorfer et al. (2007) mentions two different types of green roofs, intensive and extensive roofs. Intensive roofs are best described as a ground-level garden on your roof. They are functional and aesthetically pleasing, and they increase living space. However, they do need a substrate depth of more than 20cm, and because of the design and this substrate depth, often the weight is so high that structural improvements are necessary to support the weight (Oberndorfer et al., 2007). Extensive roofs are a modern version of the concept. It is lightweight and you only need a substrate depth of 2-20cm. Typically, most roofs should be able to bear the weight without further structural improvements (Oberndorfer et al., 2007). Aesthetical value is less prominent than the functional value (Oberndorfer et al., 2007). As established in the conceptual framework, nature viewed in cities can be autonomous, inclusive, or functional, but the wilderness frame is not prominent in cities. This fits well with the ideas of green roofs.

Not all plant species can live on a green roof. Roofs have challenging conditions for plant survival and growth. Often the kind of plants that can live on a roof are plants that are very stress-tolerant (Oberndorfer

et al., 2007). Extensive green roofs typically have low organic content in the substrate, which is not only more fire-proof, but also reduces maintenance because the plants that can grow there are often hardy, low growing, and drought-tolerant taxa (Thuring & Grant, 2015)

Although green roofs have a greater conservation value than conventional (black) roofs, it does not mean that the conservation value is necessarily high. Williams et al. (2014) says that it is hard to understand the conservational value because reports do not identify whether species are native or exotic. Moreover, there is a difference between ground-level biodiversity and the biodiversity on rooftops. What the exact difference is differs per taxa and per study (Williams et al., 2014). However, Williams et al. (2014) have done a literature review, and the different green roof projects descriptions cited benefits for the following taxa the most often: native plants, birds, butterflies and moths, and bees. However, because of the low organic component in the substrate, and the lack of deeper horizons in the soil, the soil-dwelling organisms found on green roofs are mainly generalist, cosmopolitan species associated with dry, exposed, disturbance-prone areas (Thuring & Grant, 2015).

Although no trade-offs are found in scientific literature for green roofs regarding nature protection and heat stress reduction, one is found between green roofs and water quality. When intensive green roofs need often fertilization, the runoff can contain more nutrients. This will decrease the stormwater quality (Choi et al., 2021).

To summarise, green roofs cannot only mitigate heat stress, but might also be able to enhance biodiversity and the connectivity of nature patches, although it is not known if this is a very effective method. The last implementation reason for green roofs is that when they are built on public buildings they can function as parks, and be used in the same way as ground level parks (Kotzen, 2018). This can increase the accessibility of nature for residents. To do that, the construction of the buildings need to be strong enough to carry the weight of the park. This may not always be possible for existing buildings, but when constructing new buildings, this could be taken into mind.

Water systems

The Netherlands is a country with many water structures (e.g., rivers, lakes, and canals). Water has several cooling properties. It can cool by evaporation, by absorbing heat when there is a large water mass, or by moving the heat out of the area when the water is moving (Kleerekoper et al., 2012). The average cooling effect is 1-3degrees to an area of approximately 30-35m (Kleerekoper et al., 2012). The water application is more effective when the water is flowing or dispersed, or when the water body has a large surface (Kleerekoper et al., 2012). The water system with most cooling effect is the dispersed water from a

fountain, then the flowing water, and the least cooling effect comes from stagnated water (Kleerekoper et al., 2012).

Moreover, water is needed to ensure that green structures can continue evapotranspiration that is cooling the environment (Kleerekoper et al., 2012). This makes blue structures even more important for mitigating UHI.

Species composition of macroinvertebrates and biodiversity in urban water systems is mostly influenced by the nutrients and vegetation. It is very likely that the amount of nutrients will be higher due to climate change, because of increased precipitation. The increased precipitation will lead to higher water levels in rivers and canals, and therefore an increase of local seepage of groundwater. More nutrients in urban surface water will lead to less native macroinvertebrates and to more exotic species (Vermonden et al., 2012).

Urban waterbodies provide several ecosystem services, like stormwater retention, erosion and flood control, plant and animal community maintenance, and carbon sequestration. Waterbodies and wetlands also are aesthetically pleasing and strengthen the ecological food chain (Löhmus & Balbus, 2015). However, there are also potential nuance and health threats that water structures can create, such as providing habitat for mosquitos and exposing humans, pets, and wildlife to toxic algal bloom (Löhmus & Balbus, 2015). Stagnant, shallow water is the primary factor that is related to high mosquito counts. Toxic algal bloom is mostly related to low water circulation and overabundant nutrient input (Löhmus & Balbus, 2015). Therefore, to counter those downsides, it can be a solution to create flowing water structures instead of stagnant ones.

5.3. Actors

The municipalities

All municipalities in the Netherlands have a council (*gemeenteraad*), a mayor, and the B&W (*college van Burgemeester en wethouders, college of mayor and aldermen*). The council is elected every four years by the citizens of the municipalities. The more citizens there are in the municipalities, the bigger the council is. The council comes together every month and is public. The council has three important jobs; 1) making the broad outlines of municipal policies, 2) checking if the B&W is doing their jobs well, and 3) representing the citizens (ProDemos, n.d.).

The aldermen are chosen by the council. Every alderman has a specific policy area that they are responsible for (ProDemos, n.d.). These areas include nature and climate adaptation. These two fields can be given to

the same alderman, but also to different aldermen. On the sites of municipalities you can find who is responsible for which policy areas.

Other actors

In the Netherlands, the provinces are primarily responsible for the nature in their province. However, municipalities now often also try to increase nature area and biodiversity in their borders for different reasons. Municipalities are increasingly often also planting additional trees in the city.

There are also other actors that own land. This can be for example private owners, companies, and organisations. On their owned land, they can (to an extent) choose how much nature is present. For some projects they can ask for subsidies from municipalities, like for green roofs. When implementing green roofs, there are often requirements about the minimal amount of area, minimum water retention, and minimum period the owner needs to preserve and maintain the green roof (Liberalesso et al., 2020). However, in other countries different ways of promoting green roofs are used, for example tax reduction are common in South America and obligations by law are more common in Asia (Liberalesso et al., 2020)

6. Case studies – insights from three municipalities

This part of the research will conduct three case studies, the municipalities Eindhoven, 's-Hertogenbosch, and Deventer. Per case the important documents will be listed. After that, the policy coherence between the goals, instruments, and actors will be determined, by using the insights from chapter 6. Goals that fall under the same bigger goal found in the scientific literature will be grouped together. The same approach will be used for the instruments.

6.1. Eindhoven

The municipality of Eindhoven

The municipality of Eindhoven is a municipality in the south of the Netherlands, in the province Noord-Brabant. It has 235 691 citizens and is thus the 5th largest municipality of the Netherlands (CBS, n.d.). Besides its high number of citizens, the municipality of Eindhoven also has a high population density. In 2021 the municipality counted 2689 citizens per km² (CBS, n.d.). The municipality of Eindhoven only includes the city of Eindhoven, without other villages.

Figure 1 shows a map of the temperatures on a summer day in Eindhoven. The three blue/green areas on the map immediately stand out. These are the three 'groene wiggén' of Eindhoven, the three nature areas of the municipality. The Groenbeleidsplan of Eindhoven states that the groene wiggén are the main reason why Eindhoven is the greenest city of the five biggest cities of the Netherlands.

Though those green areas lower the temperature in the area, the rest of the municipality clearly has higher temperatures during a hot summer day, in some places exceeding 40degrees Celsius.

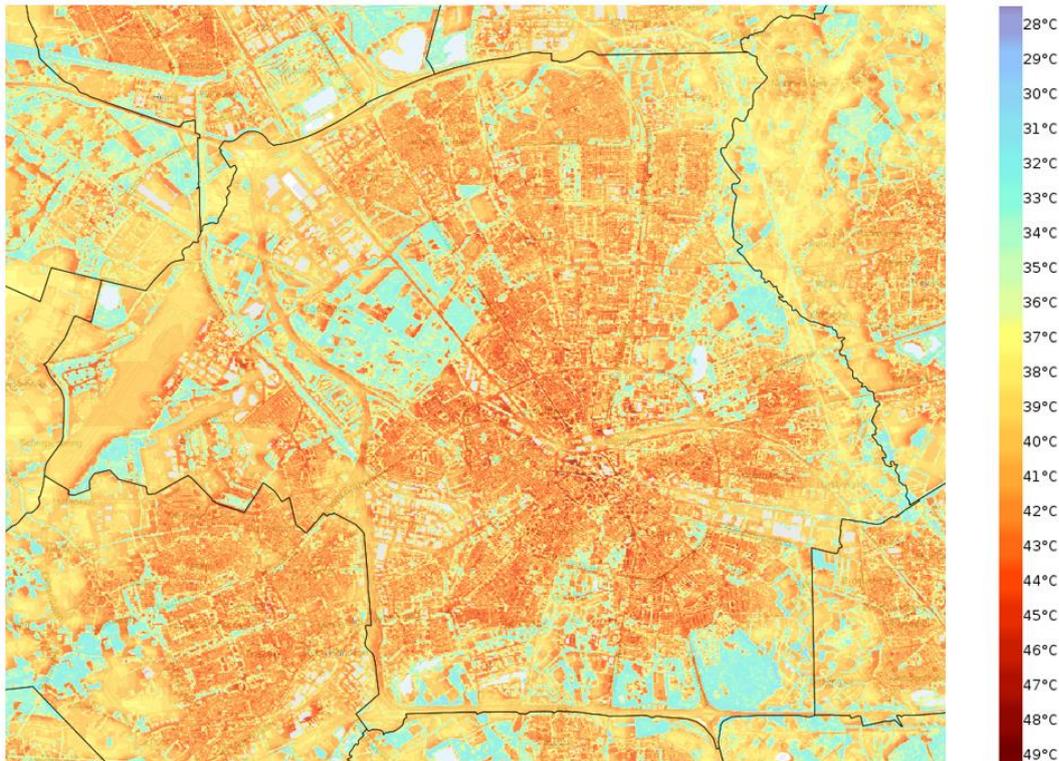


Figure 1: Heat stress map of the municipality of Eindhoven (Atlas Natuurlijk Kapitaal, n.d.)

The documents

For this case, between 10 and 15 documents were read. Only a handful proved to be useful for this research. The reason not more of the documents were useful is because numerous documents had a different general topic than the research, the specific information in the document did not fit the scope of the research, or the document was made in a time period that made it irrelevant for this research.

The municipality of Eindhoven has several documents regarding nature and climate policy. The first document is the Groenbeleidsplan (Gemeente Eindhoven, 2017). This document discusses the history of Eindhoven, the green and built structures, the functions of green in the city (including being climate adaptive), ambitions and policy. This document describes heat stress as a threat and how nature can cool the city.

The Handboek Openbare Ruimte (*Public space manual*) is the operational manual of the visions for the public spaces in Eindhoven from 2006, including for nature. To all neighbourhoods in Eindhoven different levels of quality are assigned (standard, plus, special, and exclusive), and can be found on a map on page 24. These qualities tell something about different kind of spatial design elements can be used for that neighbourhood (Gemeente Eindhoven, 2021a).

The document Erfgoeddoelen (*Heritage goals*) talks about what they want to achieve with historical sites in the city. In this document, there is also a small section related to nature goals (Gemeente Eindhoven, n.d.-d).

The municipality also has published other documents regarding climate change. One of them is a climate document (*Klimaatplan*) called “Naar een klimaatneutraal Eindhoven”. This document is mainly about reducing CO₂ emissions in the city (Gemeente Eindhoven, 2020).

Heat stress

Heat stress is a topic that is highlighted in both nature and climate policy documents of the municipality of Eindhoven. For nature policy, the Groenbeleidsplan (Gemeente Eindhoven, 2017) mentions heat stress multiple times, often in the context of cooling the area with green structures. For example, under ‘energy: less use of non-sustainable sources’ it says that nature can be used as natural cooler (p.68) and that the municipality wants to use nature for decreasing the heat stress (p.72).

For climate policy, the Klimaatplan (Gemeente Eindhoven, 2020) does mention that green and blue structures are important for recreation, relaxation, heat stress and flood risk reduction, biodiversity, and clean air, water, and ground (p.8). However, it is not a goal in this specific document since the document mainly focusses on CO₂ reduction.

The coherency of the goals and heat stress reduction

Stop decline in biodiversity and natural habitats

The municipality of Eindhoven has set the goal to implement specific ecological nature design and conservation methods to protect vulnerable habitats and locations with extraordinary flora and fauna to ensure their existence (Gemeente Eindhoven, 2017, p.70). The municipality expresses that the quality of the habitats is very important, but in no way is this goal linked to heat stress reduction in the Groenbeleidsplan (Gemeente Eindhoven, 2017).

Limit invasive/exotic species

The Groenbeleidsplan (Gemeente Eindhoven, 2017) describes that the municipality wants to focus on sustainable green design with attention to different topics, including local plant species and native plant materials, but also climate change, climate adaptation, and the prevention of plagues and illnesses (p.68). Here the municipality shows that they are thinking about the coherency between climate adaptation and nature policy. Heat stress is not specifically specified, although climate adaptation does include heat stress

reduction, especially since the municipality has mentioned heat stress as one of the main problems in the future for the municipality when it comes to climate problems.

Access for everyone to green space

In none of the documents it was specifically mentioned that the municipality wanted to create green space in such a way that all citizens have green spaces nearby. However, multiple times the documents mentioned the desire for an increase in nature area. Specifically, the Groenbeleidsplan (Gemeente Eindhoven, 2017) mentions that 1) that there should be the possibility to recreate and play in the vicinity, and 2) that they want to increase the nature area in the areas with a low natural value. This, however, was not linked to heat stress reduction in the document.

Connectivity of urban nature areas

The Map of Ambitions for nature policy, found in the Groenbeleidsplan (Gemeente Eindhoven, 2017, p.66-67), show the different green and blue structures the municipality wants to create. The ambitions for these kinds of structures are mainly found in the northern part of the municipality. The Groenbeleidsplan (Gemeente Eindhoven, 2017) also mentions that that ecological green should be added to the 'missing links' in the green infrastructure of the municipality (p.70). Another ambition is to protect spatial structures. One of these structures is the Dommel river in the city centre. This river is seen as an ecological corridor (p.70). Although the municipality has goals related to the connectivity of urban nature areas, none of these goals are directly related to the reduction of heat stress in the document.

Participation of citizens

The Groenbeleidsplan (Gemeente Eindhoven, 2017) states that the municipality wants to make landowners and other citizens aware of the possibilities to contribute to nature on their own grounds (p.70). Another goal is that the municipality wants to increase greenery in cooperation with owners, users, and partners in the city (p.69). This goal is mentioned under the second central theme, called Climate Adaptation. The introduction after this header mentions the intention to reduce heat stress by increasing the area of nature. Therefore, this goal directly related to the decrease of heat stress.

This kind of citizens participation was also a topic during the interview. Since a substantial part of the buildings in the municipality is not owned by the municipality but is privately owned, there are different initiatives by citizens participation for which the municipality hands out subsidies. Also, it is possible to adopt (part of) the street as occupant of the street, and (re)organise and maintain the street (Interview Municipal Official Eindhoven 1, 31 March 2022). The municipality undertakes different actions to reach

more citizens to increase the participation of different initiatives (Interview Municipal Official Eindhoven 1, 31 March 2022).

Other goals from the document that are related to this topic are 1) the municipality wants to search for locations to play, recreate, and sports together with citizens, and together they will choose an appropriate solution for the target audience (Gemeente Eindhoven, 2017, p.72), 2) the municipality a wants to integrate green structures that will involve citizens actively and learn the citizens about nature (Gemeente Eindhoven, 2017, p.75), and 3) when there are green residents' initiatives the municipality wants to stimulate education about nature (Gemeente Eindhoven, 2017, p.75). None of these goals are directly related to heat stress reduction.

Other goals

There are also goals in the Groenbeleidsplan (Gemeente Eindhoven, 2017) that do not fit the above mentioned themes, but are related directly to heat stress reduction by the municipality. Most of these other goals are under the second central theme, climate adaptation. These are:

- Decrease the amount of paved over area, and fill it with greenery
- Increase the amount of nature, for a better living environment, stimulate green roofs and façade vegetation, and be an example as municipality.
- More space for water structures, for better water storage. Stimulate water storage on roofs and on the façade of buildings, be an example as municipality, clean rainwater not in the sewer systems but into the vegetation and create new water systems or make the old water systems visible again above ground.

Conclusion

The municipality of Eindhoven has many nature goals. Some of these goals are related to heat stress by the municipality, either directly or indirectly. The following table sums up the coherency of the goals with heat stress reduction as described by the municipality.

Goals	Explanation
Stop decline in biodiversity and natural habitats	This goal is clearly mentioned in the Groenbeleidsplan but is not linked to heat stress reduction.
Limit invasive/exotic species	The use of local species will be used for climate adaptation. Though this is not directly linked to heat stress reduction since the municipality sees heat stress as a future problem, this suggests that the municipality does indirectly links the two goals together.

Access for everyone to green space	This goal is clearly worked out in the Groenbeleidsplan, but is not further linked to heat stress reduction.
Connectivity of urban nature areas	The municipality made a map that shows where they want to add green structures to connect urban nature areas. This was not linked to heat stress reduction in the document.
Participation of citizens	The municipality has several ideas to increase participation of citizens. Specifically, the municipality wants to collaborate with owners, users, and partners to increase nature area. The introduction text showed that the municipality relates increased nature area to heat stress reduction.

	Clear coherency
	No coherency

Table 2: the coherence between the nature goals and reducing heat stress as mentioned in the documents of the municipality of Eindhoven.

As Table 2 shows, heat stress reduction is in some instances related to other goals of the municipality. This, however, is often done in a more indirect way, because heat stress is mentioned in introductions and because climate adaptation is used as a term without stating what specific concepts of climate adaptation are meant or viewed as important.

Since the link between the goals and heat stress reduction is often mentioned in an indirect way, assessing the goal coherency is hard. Although I do believe that the municipality does see the link, the municipality could be clearer in their documents to increase the coherency.

The coherency of the instruments

For the instruments I will look at different documents published by the municipality of Eindhoven, like the Groenbeleidsplan (Gemeente Eindhoven, 2017), Uitvoeringsprogramma binnenstadsvisie DOEN – Bijlage 1 (Gemeente Eindhoven, n.d.-g), and the Ontwikkelperspectief 2040 Centrum Eindhoven (2020). Also, there are different pages on the municipality site that show different projects in the city related to adding more green and blue structures.

As described, the Groenbeleidsplan (Gemeente Eindhoven, 2017) has a section about the ambitions of the municipality on nature policy. After the ambitions, there is a section with guidelines and process agreements, and lastly there is a section with strategies. These strategies are similar to what is described in The Handboek Openbare Ruimte (Gemeente Eindhoven, 2021a).

Destination plans for the municipality are still only made for smaller areas, not for the whole city (Interview Municipal Official Eindhoven 1, 31 March 2022). The municipality of Eindhoven wants to improve the whole city, but the focus is more on some neighbourhoods than others, depending on what the neighbourhoods need (Interview Municipal Official Eindhoven 1, 31 March 2022).

Increase amount of green spaces

The Ontwikkelperspectief 2040 Centrum Eindhoven (2020) states that for every new housing, there will be at least 8m² greenery within 300m of the building. The green area needs to fulfil at least two of the mentioned functions, of which *green for relaxation and recreation* should always be pursued. The full list of functions is (Ontwikkelperspectief 2040 Centrum Eindhoven, 2020):

- Recreation
- Identity
- Climate adaptation (cooling, water storage)
- Nature (biodiversity)
- Production
- Water (storage) + surface water

In the guidelines part of the Groenbeleidsplan (Gemeente Eindhoven, 2017) the municipality expresses the desire to realise a completely city-covering nature infrastructure.

There are many projects on the municipal website, one of them being project Nieuw Bergen. This project redevelops the area by the Deken van Somerenstraat, and adds more housing and around 3.200m² green area in the city centre (Gemeente Eindhoven, n.d.-e).

Tree management

Trees are often mentioned in the Groenbeleidsplan (Gemeente Eindhoven, 2017), but there is no management plan in this document. However, there are regulations for tree management, that state when a permit is needed regarding chopping down trees, or having a inventory and/or transporting timber with a plant decease (Gemeente Eindhoven, 2021b).

Raadsinformatiebrief – Onderwerp vaststellen van richtinggevende uitgangspunten voor vaststellen van voorlopig ontwerp (Gemeente Eindhoven, 2022) the municipality shares some of the instruments they want to focus on while renovating the southern train station square. The municipality wants to have a collection of trees and plants, which will create an ‘optimal biodiversity value’. Because of the high crown

of the trees, the station (which is also a national monument) will still be good visible (Gemeente Eindhoven, 2022).

Green roofs

Green roofs are mentioned multiple times in the Groenbeleidsplan (Gemeente Eindhoven, 2017). This is in the ambitions part of the document; there the municipality mentions that they want to stimulate green roofs to increase the green area in the municipality. They want to inform citizens and entrepreneurs on the (subsidy) possibilities. The webpage discussing different subsidies lists the requirements before citizens can apply for green roof subsidies. Citizens can also apply for the subsidy together with their neighbours (Gemeente Eindhoven, n.d.-f).

The municipality also has their own projects where forms of green roofs are used to create more greenery in the city centre. There is a green pavilion on the 5th floor of the old V&D building in the city centre (Gemeente Eindhoven, n.d.-c).

Water systems

In the documents not much was found about water systems. However, during the interview water systems was a well discussed topic, also in relation with public support. When having stagnant above ground water some risks are involved, such as bad water quality which can result in health risks. Therefore, the municipality tries to minimize the risks when looking for solutions to increase the water storage (Interview Municipal Official Eindhoven 1, 31 March 2022).

The project; the Internationale Knoop XL project, that stretches from the PSV stadium to the Dommel (*KnoopXL - Eindhoven Internationale Knoop XL*, n.d.) is an example where water systems are implemented again. For the Stationsweg the focus is on increasing the amount of green and to bring the Gender above ground again (Gemeente Eindhoven, n.d.-g).

Conclusion

When looking at the instruments of the municipality of Eindhoven, it is notable that the instruments are not very elaborated. The documents do not specify how they want to achieve their goals, and what they are going to do specifically. Though the municipality does explain different projects on the municipal website, the explanation is mostly superficial and lacks some in-depth information. This kind of information might be enough for the average citizen, but it does not provide a clear overview of the instruments used.

Though most instruments are found back in different projects, the coherency of the instruments is not high. This is mainly because there is no clear municipal plan that describes which instruments will be used where, and if there are more elaborated plans it is not available for/easily found by people that do not work for the municipality.

The coherency of actors

Multiple actors are responsible for and influencing the policy making and implementing of green structures. First, there is the college of mayor and aldermen is responsible for the daily governance of the municipality. In Eindhoven the following sectors are divided under the aldermen (Gemeente Eindhoven, n.d.-b):

- Alderman of finance and business operations
- Alderman of housing, neighbourhoods, work, and spatial development
- Alderman of youth, care and welfare, poverty, and integration
- Alderman of mobility, culture and design, city centre, and city marketing
- Alderman of economics, Brainport, innovation, education, and sports
- Alderman of climate and energy, public space and nature

There is one person responsible for both climate and nature, though spatial development, mobility, and 'city centre' are also topics that are related to the design of the city. Mobility is one of the topics that has still many opportunities to increase the amount of green and blue structures in the city. This is because a lot of people are still using their cars in the city. There are now electric scooters that you can rent with an app, but this is often not used instead of cars, but it is something extra in the city (Interview Municipal Official Eindhoven 1, 31 March 2022). When transport in the city changes, and less public space is spent to facilitate the cars of people, more space can be used for nature (Interview Municipal Official Eindhoven 1, 31 March 2022).

When plans are made different actors are part of the process, as illustrated by the creation process of destination plans. Destination plans of neighbourhoods are documents that are legally binding. They describe the usage and construction options for specific locations in a neighbourhood. In the municipality of Eindhoven, a few steps are taken before such a destination plan is finished. The first step is that the mayor and aldermen will give the option to other (governmental-)organisations to collaborate on the plans. The second phase is that the college of mayor and aldermen agree on the design. When they have agreed on the design of the destination plan, the design will be available for the public digitally and at the Inwonersplein for 6 weeks. During these 6 weeks, everyone can send their reaction on the plans to the local council. After the 6 weeks the third phase starts. Here the local council accepts the destination plan, and the final destination plan will be written. The final plan is also available for 6 weeks. Stakeholders

can appeal at the Raad van State (*Council of State*). When the plan is accepted, it is final and legally binding (Gemeente Eindhoven, n.d.-a). When looking at this process, multiple actors can be identified: the college of mayor and aldermen, the public/citizens, local council, other stakeholders, and when they appeal even the Council of State is involved in making these plans.

There are also different partnerships between the municipality and other organisations and businesses. The municipality of Eindhoven is part of UNaLab, a European project that helps cities to prepare for a changing climate, like heat stress and flooding. The solutions that UNaLab uses are all nature-based. In total there are 28 partners, like research institutes, engineering firms, and advice firms. Eindhoven is considered to be a front-runner, together with Genova and Tampere (Gemeente Eindhoven, n.d.-h). One of the projects that UNaLab is involved with is the development of Vestdijk (Gemeente Eindhoven, n.d.-h).

Overall conclusion on the policy coherency of the municipality of Eindhoven

The municipality of Eindhoven has several documents that were used for this study. The main used document was the Groenbeleidsplan (Gemeente Eindhoven, 2017). There was not specifically a document or section in a document for climate adaptation and heat stress reduction, though at some points it was mentioned in the Groenbeleidsplan (Gemeente Eindhoven, 2017). The Groenbeleidsplan (Gemeente Eindhoven, 2017) does have many nature goals that are structured clearly. Although this does not improve the coherency for the goals, it does provide a good steppingstone to incorporate climate adaptivity.

For the instruments it was difficult to gather the information. In some documents different instruments were described, but overall that information was lacking. The municipal website does have their different projects listed. From this some information can be retrieved, although it lacked in-depth information.

There is one alderman responsible for both nature and climate. This is positive, since it makes coherency in policy making for goals and instruments easier. The interview revealed that there are some ideas that could increase the nature area in Eindhoven that need to be discussed with aldermen from other disciplines, such as mobility. Moreover, the municipality is trying to work together on both a local/citizen and an international level. The municipality has some procedures in place to ensure that citizens of the municipality can react to plans made for the municipality. Surely this is not done for every decision that is made, but for the destination plans quite an elaborate procedure is in place. Lastly, the municipality works together with different organisations and businesses that are specialised in greening cities and making them more climate adaptive.

Table 3 shows the overall coherency for the municipality of Eindhoven.

Coherency	Explanation
Goals	Though heat stress is mentioned a few times, the links between nature goals and heat stress reduction is often indirect and unclear.
Instruments	Little information is provided on the instruments used to achieve the goals. Although most instruments can be found in one of the projects, overall, there is not a clear overview or plan.
Actors	The list of different actors involved in nature policy and heat stress reduction is promising. The two policy fields are under the same alderman and some interesting partnerships are in place to help with both increasing nature values and making the city more climate adaptive.

	Clear coherency
	Unclear/indirect coherency
	No coherency

Table 3: overall coherency for the municipality of Eindhoven

6.2. 's-Hertogenbosch

The municipality of 's-Hertogenbosch

The municipality of 's-Hertogenbosch is like Eindhoven in the province of Noord-Brabant on the border with Gelderland. In 2021 the population of 's-Hertogenbosch was 155 490, with a population density of 1414 citizens per km² (CBS, n.d.). The municipality of 's-Hertogenbosch consists of the city 's-Hertogenbosch and a few villages, with the largest being Rosmalen on the east side of the city.

Figure 3 shows the map of temperatures for the municipality of 's-Hertogenbosch on a summer day. Notable is that outside urban areas the temperatures often is considerably high, except for a few spots that light up blue. Nevertheless, the city and surrounding villages are very notable on the map because of their higher temperatures. The municipality of 's-Hertogenbosch has some important nature areas, including the Moerputten and the Bossche Broek, which are both part of Natura2000 (Natura2000, n.d.-b).

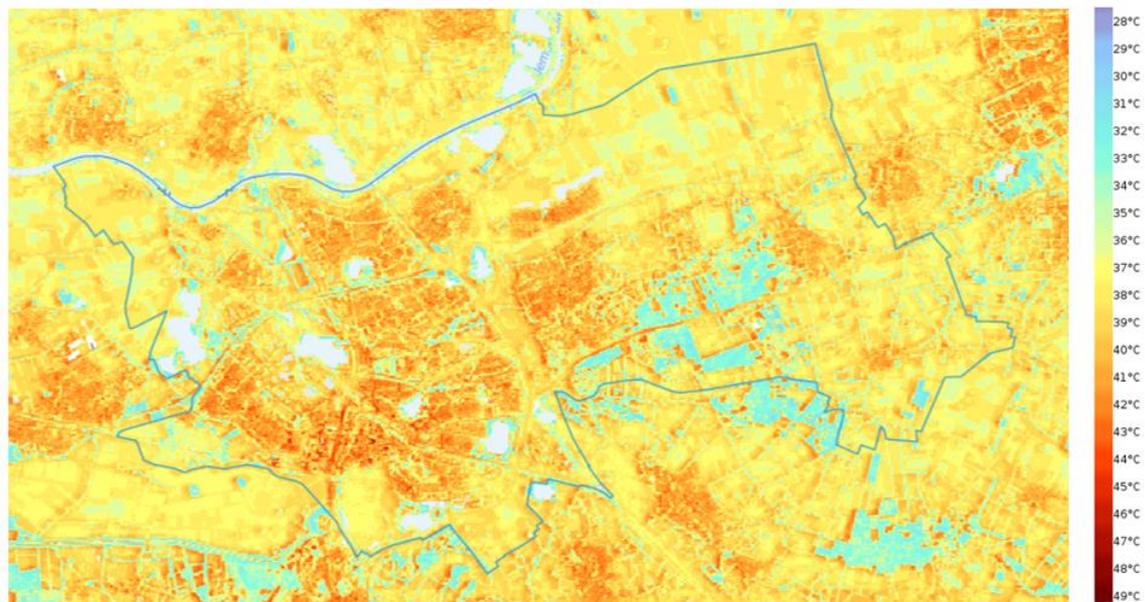


Figure 2: Heat stress map of the municipality of 's-Hertogenbosch (Atlas Natuurlijk Kapitaal, n.d.).

Documents

The municipality of 's-Hertogenbosch combined their nature and climate vision into one document, called 's-Hertogenbosch Groen en Klimaatbestendig' ('s-Hertogenbosch Green and Climate Proof) (Gemeente 's-Hertogenbosch, 2021a). In this document they show the threats regarding nature/biodiversity and climate change. Both heat stress and nature in cities are topics in this document. This document shows the ambition of the municipality, and how the municipality wants to realise their ambitions.

The municipality of 's-Hertogenbosch also publishes Progress Messages every quarter of the year. Here the municipality describes what happened regarding sustainability and greening. This research will use those publications to see what kind of instruments are used in the last few years, and to find some examples of implementation. The ones used in this study are from October 2020, October 2021, and January 2022

There are also other documents that touch upon sustainability, climate adaptation, and climate mitigation. An example is the Duurzaamheidsakkoord – Duurzaam wonen, 's-Hertogenbosch 2018-2025 (*Sustainability agreement – Sustainable living, 's-Hertogenbosch 2018-2025*) (Gemeente 's-Hertogenbosch, n.d.-c). This is an agreement between the municipality and the cooperations BrabantWonen, Kleine Meierij, Mooiland, and Stedelijk Huurdersplatform. This agreement addresses both climate mitigation and climate adaptation challenges.

Heat stress reduction

The municipality of 's-Hertogenbosch has taken both climate and nature policy into one document. The document 's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a) mentions heat stress reduction as one of the main ambitions (p. 17). This is taken together with water management in the municipality. The focus in the description of the ambitions is more focussed on water management and less on heat management. This document also describes that there is not yet a unifying approach to decrease heat stress, but that the municipality wants to increase the green area to create shadow, decrease the heating of buildings and paved over areas, and to maintain comfortability in the city even on hotter days (p.18).

In the document Duurzaamheidsakkoord – Duurzaam wonen, 's-Hertogenbosch 2018-2025 (Gemeente 's-Hertogenbosch, n.d.-c) it is written that the different actors that participate in the agreement have a goal to decrease heat stress, by increasing the nature area in private gardens and in public spaces.

The coherency of the goals and heat stress reduction

's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a) is the main document that describes the goals, visions, and main actions of both nature and climate policy. The goals are called ambitions in this document. The three main ambitions are:

- The city can deal with flooding and heat stress
- Green nearby
- The relation between urban natural areas and rural areas.

These three main ambitions are worked out with a description containing both sub-goals and some instruments. The next part of the research will describe the sub-goals found in this document and if the municipality relates them to heat stress reduction.

Stop decline in biodiversity and natural habitats

The document 's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a) portrays the ambition to increase nature in highly paved-over areas, especially near shopping malls and business areas. The document states that this is mainly needed to decrease the temperature on hot days (p.18). Although the goal is not specifically describing the stop of the decline in biodiversity and natural habitats, adding nature in locations where there is not yet nature present is inherently increasing habitats. It is important that the municipality pays attention to the kind of nature they implement. Another goal in the document shows that the municipality of 's-Hertogenbosch wants to pay attention to this by stating that the municipality strives to be a municipality where populations of flora and fauna that naturally occur in the area have enough habitat to exist (p19).

Limit invasive/exotic species

The choice of plants and materials is discussed multiple times in the document 's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a). As described above at *stop decline in biodiversity and natural habitats*, the municipality wants to be attractive for local flora and fauna. Moreover, the municipality mentions that when they need to choose for what species of trees and plants they want to plant, the ecological value of the species is important. As a rule, the municipality tries to incorporate as many native species as possible. However, the municipality does acknowledge that in some cases it is more desirable to have exotic species, since those species might be a better fit for the specific location (p.19). These goals are not linked to heat stress reduction in the documents.

Access for everyone to green space

The document 's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a) states that the municipality wants to create accessible green spaces close to its citizens (p.19). The municipality wants to increase green structures in the city centre, since that is the area with the least amount of nature (p.18). Although it is not specified in the document, this could be linked to the earlier statement that the municipality wants to increase green spaces to minimise heat stress.

Connectivity of urban nature areas

The document 's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a) describes that the waterways in the city are very important for the connectivity of urban nature areas. Also,

they connect urban nature areas with nature areas outside of the city (p.19). Waterways are mentioned to be important for connecting urban nature areas but is not mentioned as an important way of minimising heat stress. Therefore, it is assumed that the municipality does not see those two goals as linked together.

Participation of citizens

The document 's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a) states that the municipality wants to invite citizens to help brainstorm where in their neighbourhoods trees can be planted and where the citizens want to have more green areas. The municipality mentions that trees are important during hot days, for shadow and cooling. This shows that the municipality links those two goals together and wants citizens to participate in their endeavours to reduce heat stress. Additionally, the municipality also claims to stimulate and support citizens' initiatives for more green spaces (p.20), which is also linked to heat stress reduction by the municipality.

Conclusion

In sum, the municipality of 's-Hertogenbosch has made multiple connections between heat stress reduction and the nature goals. The goals that are related to heat stress by the municipality are N1, N3, and N5, though some more clearly than others.

Goals	Explanation
Stop decline in biodiversity and natural habitats	Municipality wants to increase nature in highly paved-over areas, to decrease heat stress on hot days. When adding nature to highly paved-over areas, this does create more habitat for biodiversity.
Limit invasive/exotic species	Though this goal is not directly related to heat stress reduction, the municipality does mention that they try to pick species with climate change in mind.
Access for everyone to green space	The municipality wants to create accessible green space for everyone and wants to add greenery to space where it is most needed. The municipality has mentioned that they want to increase amount of green to reduce heat stress, but the link is indirect.
Connectivity of urban green areas	Waterways are mentioned as important structures for connecting nature areas, but it is not mentioned as helpful for heat stress reduction.
Participation of citizens	Municipality involves citizens when making plans for implementing instruments that are beneficial for nature and heat stress reduction.

	Clear coherency
	Unclear/indirect coherency
	No coherency

Table 4: the coherence between the nature goals and reducing heat stress as mentioned in the documents of the municipality 's-Hertogenbosch.

When looking at table 3, it is evident that the municipality of 's-Hertogenbosch does mention heat stress reduction as one of the incentives to work on some of the nature goals. This means that the coherency of the goals of 's-Hertogenbosch is put in the nature and climate policy.

The coherency of instruments

Different documents are used to determine the policy coherency of the instruments. As basis the document 's-Hertogenbosch Groen en Klimaatbestendig is used again, but it is complemented with examples and information given in the different Process Messages, that are published every quarter of the year. Although many Progress Messages are read, the three that provided most information on the instruments are the ones from October 2020, October 2021, and January 2022.

Increase number of green spaces in cities

In the document 's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a) the municipality expresses the intention to increase the green space in the municipality. On page 18, the municipality describes that they want to increase the number of green structures in highly paved over areas, such as business areas and shopping malls.

In the urban area, there are different campaigns to engage citizens while greening the area. The campaigns include the construction of tree gardens and the substitution of street tiles with green patches (Gemeente 's-Hertogenbosch, 2021b). The substitution of street tiles for green patches is part of the Dutch Championship Tegelwippen, where the municipalities in the Netherlands are battling to see who can substitute the most tiles (Gemeente 's-Hertogenbosch, 2021b). Also school playgrounds are renovated to become more green, which is not only beneficial for heat mitigation and biodiversity, but also for the children who play there (Gemeente 's-Hertogenbosch, 2021b).

Overall, the municipality shows that they want to invest in greening areas that are lacking nature currently, and places that are often visited by citizens, such as their own gardens and school playgrounds.

Tree management

Trees are important for the municipality of 's-Hertogenbosch. Important tree structures will be protected and further developed as a green framework of the municipality. A balanced age distribution and a variation of species is strived after by the municipality (Gemeente 's-Hertogenbosch, 2021a, p.21). Trees and shrubs will be used to provide shelter and food for birds and small mammals (Gemeente 's-Hertogenbosch, 2021a, p.19). Moreover, as mentioned before, the municipality did mention that trees are important during hot days, for shadow and cooling properties (Gemeente 's-Hertogenbosch, 2021a).

The Voortgangsbericht duurzaam 's-Hertogenbosch januari 2022 (*Progress Message Sustainable 's-Hertogenbosch*) describes what the municipality did for tree management. The intention is to plant 20-25 hectares of forests before 2023 with the help of the province Noord-Brabant and the Groen Ontwikkelfonds Brabant. In order to do this, the municipality has different initiatives to involve citizens. First of all, the municipality wants to include the education system to increase the involvement of citizens. Moreover, the citizens of the neighbourhood Zuid were allowed to decide where 97 new trees in the neighbourhood are going to be placed (Gemeente 's-Hertogenbosch, 2022).

Another interesting project in the city centre of 's-Hertogenbosch was the replacement of the trees at the Parade, a town square next to the Sint-Jan's Cathedral. The chestnut trees that were originally on the square were replaced by linden and elms. This was decisions was made after consultation with experts (Gemeente 's-Hertogenbosch, 2022).

The municipality of 's-Hertogenbosch is increasing the number of trees in the municipality and tries to involve citizens in the process. Besides mentioning the importance of trees for heat stress reduction, the municipality also seem to consider the species of trees to ensure the compatibility with the harsher conditions for trees in the city.

Green roofs

The Voortgangsbericht Duurzaam 's-Hertogenbosch oktober 2020 mentions that there was a subsidy for green roofs from the municipality in 2020 and 2021. In the spring of 2020, a letter was sent to all the households that have a flat roof in the municipality to inform households about green roofs. This, together with social media campaigns and neighbourhood newsletters, was done to actively promote green roofs. After the municipality actively promoted the green roofs they saw an increase in applications (Gemeente 's-Hertogenbosch, 2020). However, at the time of writing this research (2022) the municipal website still shows the availability of subsidies for green roofs. The subsidy will be available until the maximum amount of money available is met (Gemeente 's-Hertogenbosch, n.d.-d).

There is also a data-platform from the municipality that shows where there are green roofs already, which roofs in the municipality are suitable, and how many m² of green roofs have been added per year (Duurzaam 's-Hertogenbosch, n.d.). Several benefits of green roofs are mentioned as well, including heat stress reduction. Remarkably, increase of nature area and biodiversity goals are not mentioned here. Lastly, this site also gives answers to often asked questions, which is mainly about practical issues like subsidy and which roofs are suitable for a green roof (Duurzaam 's-Hertogenbosch, n.d.). Figure 3 shows that in 2020,

when the municipality was promoting green roofs, the area of green roofs in the municipality indeed did increase more than in other years.

Overall, the municipality did actively promote green roofs in the past and with success. This effort has been decreasing over the last two years, though there is still funding left. Since green roofs have multiple benefits, both for the nature values as for heat stress reduction, the municipality should reconsider their effort and maybe start a new campaign.

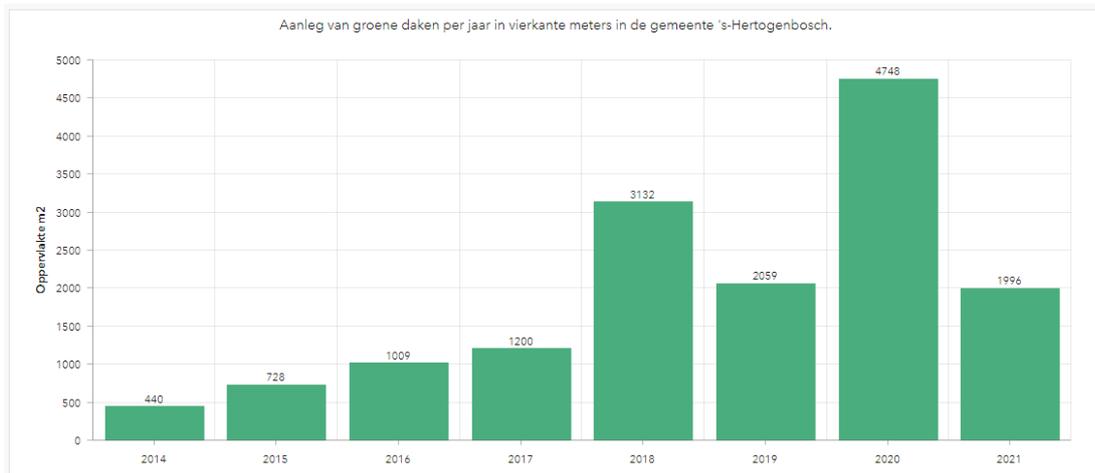


Figure 3: The increase of green roof area per year in the municipality of 's-Hertogenbosch, retrieved from Duurzaam 's-Hertogenbosch (n.d.)

Water systems

The municipality expresses that there is not yet a clear plan for water usage, although the waterways in the city are used increasingly more often. Waterways in the city are used for waterborne transport, tourism, recreation, and is important for nature (Gemeente 's-Hertogenbosch, 2021a, p.11). The document 's-Hertogenbosch Groen en Klimaatbestendig (Gemeente 's-Hertogenbosch, 2021a) speaks of blue structures and water management only in the context of ensuring that floodings will not happen in the future. Water systems are not mentioned as a potential instrument to mitigate heat stress. This is a missed opportunity, especially when you realise that the city centre of 's-Hertogenbosch has the Binnendieze, a network of small canals.

Conclusion

All the instruments found in the scientific literature are found in the documents of the municipality of 's-Hertogenbosch. Often, they apply an instrument for multiple reasons at once, not just for one specific goal. For most of these instruments the municipality does seem to acknowledge the importance for both nature improvement and for heat stress reduction. The usage of all these instruments show that the

municipality is actively using instruments that, when implemented strategically, can have major benefits for both nature goals and heat stress reduction.

However, the municipality does not mention heat stress reduction specifically when describing all the instruments. This is mainly the case with the water systems, for which many uses are described, but not heat stress reduction. Also, for green roofs it is specified that the municipality wants to promote them as a climate adaptation tool, but not for nature benefits. For the other instruments, the intention for implementing them seems related to both nature goals and heat stress reduction. Like for example the project to increase greenery on children's playgrounds and tree management.

Although the municipality shows interest in implementing all the instruments, it can still increase the coherency by being more mindful of all the different benefits that come with the different instruments. Tree management and increase the amount of nature areas seem to be the two most used instruments from this list. This is because the municipality is very mindful of how to choose locations and how to proceed when they have found a location. Therefore, it is positive that they do recognise for both instruments the added benefits for both nature and heat stress reduction.

The coherency of actors

The municipality of 's-Hertogenbosch has five different aldermen. All of them have their own responsibilities for governing the city. The following division of tasks is made in this municipality (Gemeente 's-Hertogenbosch, n.d.-a):

- Alderman of finance, economics, and ICT
- Alderman of sustainability, environment, and culture
- Alderman of sustainable mobility, talent development, and wellbeing
- Alderman of work and income, healthcare, heritage, and sport
- Alderman of housing, spatial planning, and participation

The alderman of sustainability, environment, and culture is, among other things, responsible for climate and energy, and for water and greenery (Gemeente 's-Hertogenbosch, n.d.-b). That both climate and greenery is under the same alderman is positive for the policy coherence.

The municipality of 's-Hertogenbosch works together with different organisations that are offering living space for citizens in the municipality. Together they have made agreements as to what they want to achieve in the coming years. One of the topics is climate adaptation & biodiversity (Gemeente 's-Hertogenbosch, n.d.-c).

Overall conclusion on the policy coherency of the municipality of 's-Hertogenbosch

The municipality of 's-Hertogenbosch has one document that covers both climate and nature ambitions. This has resulted in some nature goals being directly linked to heat stress reduction. Although not all goals are related as clearly, the municipality shows that they link climate adaptation and nature both by taking those two policy areas together and linking aspects from both areas in their document.

As described, every quarter of the year the municipality releases a document describing what is done on nature and sustainability. These documents for the last few years contained most of the instruments that are central in this research, except for the implementation of water systems. Although the municipality is using the instruments that this research has found, there are no (public) documents that describe clearly what the municipality is planning for the future when it comes to implementing instruments. This is something that the municipality could improve.

Nature and climate fall under the same alderman. This means that there is great potential to have a high coherency between nature and heat stress reduction. The municipality also works together with some housing organisation on biodiversity improvement and climate adaptation.

Coherency	Explanation
Goals	The municipality of 's-Hertogenbosch clearly relates two of the goals to heat stress reduction. Additionally, the municipality relates one goal in a more indirectly to heat stress reduction.
Instruments	The municipality is implementing most of the instruments related to increase in nature area/biodiversity and decrease of heat stress, except for water systems. For some of the instruments the municipality clearly describes the benefits for heat stress reduction.
Actors	The municipality does have greenery and climate placed under the same alderman. Moreover, the municipality works together with housing organisations on biodiversity improvement and climate adaptation.

	Clear coherency
	Unclear/indirect coherency
	No coherency

Table 5: overall coherency for the municipality of 's-Hertogenbosch

6.3. Deventer

The municipality of Deventer

The municipality of Deventer is located in the province Overijssel and has 101 446 citizens. The population density of the municipality of Deventer is 775 citizens per km² (CBS, n.d.).

The municipality of Deventer consists of Deventer city, and multiple smaller villages. The larger part of the municipality is quite cool during summer days, but the larger urban areas (specifically Deventer city and the village Schalkhaar) show darker red colours. The Ijssel floodplains are part of Natura2000 (Natura2000, n.d.-a).

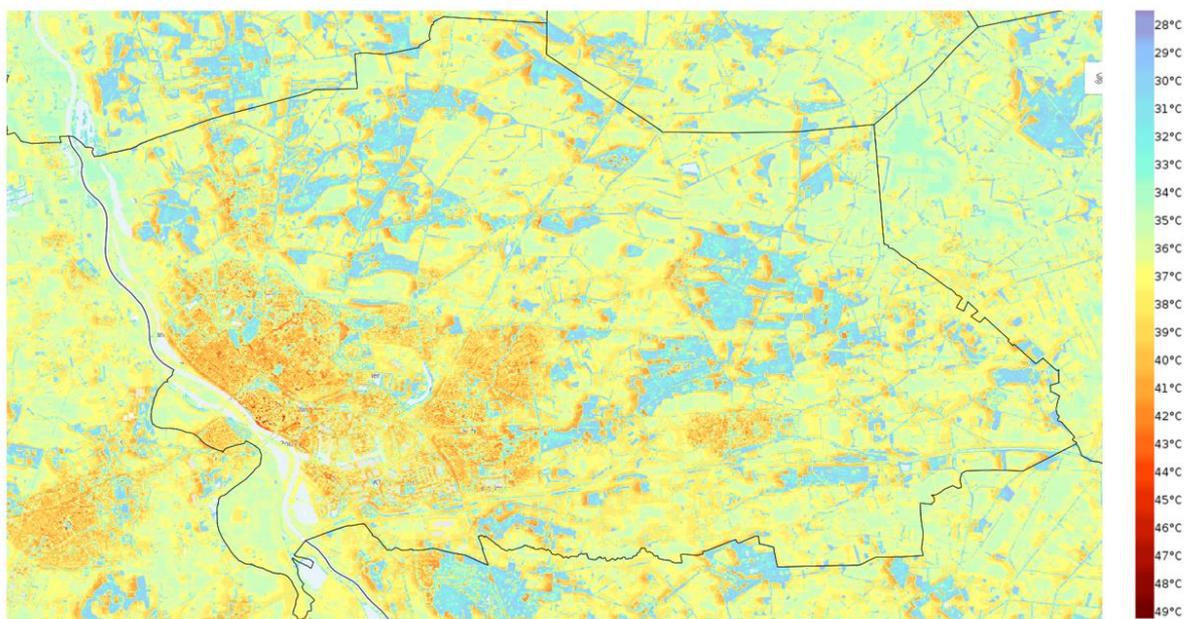


Figure 4: Heat stress map of the municipality of Deventer (Atlas Natuurlijk Kapitaal, n.d.).

The documents

The municipality of Deventer published three main documents relevant for nature protection and heat stress reduction. The first document was made for nature policy for the years 2007 to 2017, called *Groenbeleidsplan 2007-2017; Deventer groen van betekenis* (Gemeente Deventer, 2007). A renewed document has not been made for nature policy ever since. Therefore, this study will investigate this document to see what the plans were in this time area.

The second document the municipality has published is the *Werkwijze voor beleid en uitvoering van de Ecologie in Deventer (Procedure for policy and realisation of the ecology of Deventer)* (Gemeente Deventer, 2013) which describes the ambitions that are discussed during an outdoor workshop of the municipality, in

cocreation with different active sustainable groups in Deventer. Although the document is presented as a document with procedures around nature policy, it is in reality more a summary of the workshop that has yet to be transformed into strategic policy.

Lastly, the municipality of Deventer has published a climate adaptation program in 2021 called Deventer Klimaatadaptatieprogramma (Gemeente Deventer, 2021). The main topics in this document are water management, drought, heat stress, and water safety. For these topics the document contains the problems, goals and approach, and the executive program.

Heat stress

The document Deventer Klimaatadaptatieprogramma (Gemeente Deventer, 2021) describes the current heat problems in Deventer. The last few years have become hotter and hotter, and together with heavy rainfall and droughts, the municipality wants to become more climate adaptive. The municipality has as ambition to lower the average air temperature, both during the day and night (Gemeente Deventer, 2021). Moreover, the Klimaatadaptatieprogramma (Gemeente Deventer, 2021) mentions that the municipality wants to take measures to minimise the effects of increasing urban temperatures and to fully take climate adaptation into consideration during the maintenance of nature (p.24).

The coherency of the goals with heat stress reduction

Stop decline in biodiversity and natural habitats

The document Deventer Klimaatadaptatieprogramma (Gemeente Deventer, 2021) mentions that the municipality was announced one of the winners for the yearly Global Goals Municipal Elections by the Vereniging Nederlandse Gemeenten. In the Klimaatadaptatieprogramma the municipality describes how climate adaptation can help for different SDGs. For SDG 15 the municipality writes that the most effective way to reduce heat stress is by implementing more trees and greenery, because of the evapotranspiration and shadow (p.16). The Groenbeleidsplan of Deventer (Gemeente Deventer, 2007) contains different goals that fall under *Stop decline in biodiversity and natural habitats*. These are goals; 3a. when strengthening the green structures, the priority is on the optimalisation of the quality of the existing parks in the city and neighbourhoods (p.34), and all goals under point 5: preserve and strengthen of the diversity of flora and fauna (p.41). The municipality is also focussing on preserving the ecological qualities of surface water and banks (p.37). Because the Klimaatadaptatieprogramma (Gemeente Deventer, 2021) does mention the increase in nature area as being positive for heat stress reduction, the municipality does link those two aspects.

The municipality is also focussing on specific species, called ambassador species. The idea is that the ambassador species are part of an ecosystem, which means that if the ambassador species are doing well in the municipality, other species should be thriving as well. The ambassador species for the urban area are the house sparrow, the common swift, and specific plants on walls. For the rural areas in the municipality the badger is the ambassador species (Gemeente Deventer, 2013). The focus of the municipality on these species is not related to heat stress mitigation.

Limit invasive/exotic species

The municipality of Deventer is focussing on an exotic species that is currently growing in the municipality, the Japanese knotweed (*Reynoutria japonica*). The municipality has some procedures in place to prevent further dispersion of the species, and the website states that if citizens find the Japanese knotweed in their garden, they best remove it (Gemeente Deventer, n.d.-b).

The Bomenbeleidsplan (Gemeente Deventer & Team PRO/IBL, 2021) mentions that the use of local tree species do have the preference, but because of the changing climate the municipality needs to add exotic species as well to ensure enough greenery in the municipality (p.9). The document Deventer Klimaatadaptatieprogramma (Gemeente Deventer, 2021) states that trees and greenery are one of the most effective mitigation strategies available, and that local plant species have the preference when increasing the amount of greenery and trees, since that should contribute to a climate adaptive environment (p.16). Although heat stress reduction is not mentioned directly, this goal is indirectly related to heat stress reduction.

Access for everyone to green space

The Groenbeleidsplan of Deventer (Gemeente Deventer, 2007) shows that the municipality has put some effort in researching to see how much green there is per household, and how far people have to walk before they reach nature areas of good recreative quality. One of the studies is done by Alterra. This research shows that most citizens of Deventer live within 500meter of nature areas.

That the municipality takes the amount of green close to citizens seriously is also notable in the goals the municipality has set. Subgoal 3c states: robust green close to houses, that is why expanding green areas is needed (Gemeente Deventer, 2007, p.34). This is reinforced by most of the subgoals of goal 6. The subgoals include again robust green for citizens to use close to home. But also; green in neighbourhoods need to be put together as much as possible, and making semi-public green space as open for public as possible (Gemeente Deventer, 2007, p.45).

Although the municipality seems to be working on the accessibility of green spaces, it is not linked to heat stress reduction.

Connectivity of urban nature areas

The Groenbeleidsplan of Deventer (Gemeente Deventer, 2007) has two very distinct subgoals that are related to the connectivity of urban nature areas. The first one is subgoal 3d, which states that the missing links in the green infrastructure need to be realised (p.34). The second one is subgoal 5b; that green in neighbourhoods need to be connected as much as possible, to create larger green areas that provides opportunities for a larger biodiversity (p.41). Both goals are not related to heat stress in the document.

Participation of citizens

The Groenbeleidsplan of Deventer (Gemeente Deventer, 2007) does not say anything about citizen participation in their goal section. However, in their instruments chapter the municipality does describe the importance of the participation of citizens. The municipality expresses the importance of including citizens in the making of the nature plans, mainly because it creates public support and wishes of citizens can be incorporated. Citizen's participation in nature management is less supported by the municipality. The municipality of Deventer gives as main reason that management by citizens depends on a few enthusiastic people, but when those people move somewhere else, the management tasks falls upon the municipality again (Gemeente Deventer, 2007).

The tree management plan of the municipality (Gemeente Deventer & Team PRO/IBL, 2021) does mention that the municipality wants to involve citizens. The municipality wants to actively ask citizens to think of places in their neighbourhood where trees could be planted. Although as stated before, trees are mentioned to be an important factor for heat stress mitigation in the Klimaatadaptatieprogramma of the municipality (Gemeente Deventer, 2021), and therefore those two goals can be seen as linked together in those documents.

Conclusion

For the coherency between the goals and heat stress reduction the following table can be constructed:

Goal	Explanation
Stop decline in biodiversity and natural habitats	The municipality is focussing on strengthen the green infrastructures in the city, and their climate adaptation program does acknowledge the importance of green structures for heat stress reduction.

Limit invasive/exotic species	Indirectly linked, since the municipality does state that local plant species helps to make the municipality more climate adaptive. Heat stress reduction itself is not mentioned.
Access for everyone to green space	The municipality takes great measures to meet this goal, by for example researching how much green there is per household and the distance to the green area. The goals created for accessibility confirm that the municipality takes this goal seriously.
Connectivity of urban nature areas	The municipality does have some goals related to connectivity of urban nature areas. The main reason given is to provide opportunities for biodiversity.
Participation of citizens	Although the Groenbeleidsplan did mention that citizen's participation is not always as useful, the Klimaatadaptatieprogramma does mention that they want to involve citizens more in the decision of where to plant more trees. The Klimaatadaptatieprogramma very clearly states that trees can make the municipality more heat stress resilient.

	Clear coherency
	Unclear/indirect coherency
	No coherency

Table 6: overview of coherency of goals for municipality of Deventer

Table 6 shows that, overall, there are some goals linked to heat stress reduction. However, there are some things that are important to keep in mind when analysing the goal coherency. This has mainly to do with the documents used for this assessment. The municipality has made a climate adaptation plan recently, but their nature policy document is outdated. Since their nature plan is from some years ago, the link with heat stress reduction is not very apparent in that document. The climate adaptation plan does mention the use of greenery for reduction of heat stress, but there is no further elaboration on that. To increase the coherence between the nature goals and heat stress reduction, the municipality of Deventer should invest in a new version of their nature strategy and focus on their nature strategy more on climate adaptation.

The coherency of instruments

The Groenbeleidsplan of Deventer (Gemeente Deventer, 2007) has a chapter called instruments, where the municipality works out how they wanted to achieve their goals. However, there are also other sources that describe the instruments separately, like a tree management plan (Gemeente Deventer & Team PRO/IBL, 2021) and a website that provides information on green roofs (Deventer Stroomt, 2020).

Increase amount of green area

The municipality of Deventer has multiple documents that touch upon nature policy and nature conservation, such as the Groenbeleidsplan (Gemeente Deventer, 2007), Werkwijze voor beleid en uitvoering van de ecologie in Deventer (Gemeente Deventer, 2013), Omgevingsvisie Deventer (Gemeente Deventer, 2019b), and the Bomenbeleidsplan (Gemeente Deventer & Team PRO/IBL, 2021). Moreover, the municipality also has several webpages that discuss different topics regarding nature in the municipality.

The municipality of Deventer seems to focus more on enhancing and strengthening the current existing nature areas instead of increasing the number of nature areas. Although enhancing and strengthening of existing nature areas is beneficial for the biodiversity and sustainability of the existing nature, it does not fully account for this instrument.

Tree management

The municipality of Deventer has a policy document for trees for the time period of 2021-2030. This new policy document is based on the evaluation of the tree management document from 2007-2017. The themes that are in this new document that were not yet present in the old document are: climate neutrality, climate adaptation and drought/heat stress, plagues and tree illnesses, and public opinion (Gemeente Deventer & Team PRO/IBL, 2021). The new tree management plan mainly consists of information on how trees will be managed strategically. Interestingly, the document does mention that the municipality wants to use more different tree species (Gemeente Deventer & Team PRO/IBL, 2021). The municipality also wants to create a roadside management plan, where they not only look at trees but also other kinds of vegetation to increase biodiversity. Increase in biodiversity is mentioned as an instrument to decrease pests and illnesses (Gemeente Deventer & Team PRO/IBL, 2021). Lastly, the municipality wants to work together with students from the University of Applied Sciences Larenstein on a plan for the blue-green structures in the municipality. This is to see where there are still opportunities for becoming more climate adaptive (Gemeente Deventer & Team PRO/IBL, 2021).

The Groenbeleidsplan of Deventer also makes some statements involving trees (Gemeente Deventer, 2007). First of all, the Groenbeleidsplan describes how the municipality decides where to plant trees and where not. This topic is also important in the Tree management plan (Gemeente Deventer & Team PRO/IBL, 2021). Also, the municipality does mention that there is an option to put important trees that need protection in the spatial development plan of the municipality (Gemeente Deventer, 2007).

Green roofs

Deventer Stroomt is an initiative of the municipality, Enexis, and housing corporations eder1, Rentree, De Marken, and Eigen Bouw. They have created a website that describes different measures that citizens can implement to become more climate adaptive (Deventer Stroomt, 2020). They have made a webpage with information regarding green roofs. This webpage has several features. First of all, it has a link to the 'Groene dakenkaart' (*green roof map*), where people who live in Deventer can see if their roof is suitable for a green roof, how large the green roof can be, and the costs. The Groene dakenkaart also provides information on different kind of green roofs (intensive/extensive), the benefits of green roofs (both biodiversity and heat stress reduction are mentioned), and there is an often-asked-questions section (Gemeente Deventer, n.d.-a). The municipality does not give out subsidies, but Water authority Drents Overijsselse Delta does give out subsidies when multiple households apply (Deventer Stroomt, 2022).

Water systems

Surface water is important for the green structures in the municipality. The municipality of Deventer is next to the IJssel river, and the municipality sees surface water as important for the green structures in the municipality. The Groenbeleidsplan of Deventer specifically mentions water quality as an important factor that they want to focus on (Gemeente Deventer, 2007).

The Klimaatadaptatieprogramma (Gemeente Deventer, 2021) does mention that both greenery and water have a cooling effect on the area (p.23). When the document discusses how the municipality wants to approach heat stress reduction, it mentions that the municipality wants to take heat stress and the cooling effects of greenery and water structures into account when making spatial plannings of areas (p.23). However, water systems are not mentioned again in any other points in the approach of heat stress reduction.

Conclusion

The municipality of Deventer does not focus on all the instruments. The increase of nature area is not apparent from the documents, and also water systems are not worked out in detail. The municipality seems to put more effort in enhancing and strengthening nature structures instead of increasing the number of them. Although the IJssel river is an important part of the identity of Deventer, there is not much attention to the river and other water structures in the city. However, the municipality does mention water structures as a way to decrease heat stress in their Klimaatadaptatieprogramma (Gemeente Deventer, 2021).

The municipality of Deventer has a document for tree management that has been released recently (2021). This document mainly describes the strategical management of the trees, though it does mention some benefits for climate adaptation and for climate neutrality. Although the municipality does not have a subsidy system for green roofs, they do show initiative to increase the number of green roofs through Deventer Stroomt, where they provide information on green roofs.

To conclude, the municipality of Deventer does have some instruments in place to increase nature values and work on heat stress reduction. However, the instruments are scattered over different documents and there is room for more coherency when it comes to how to use the instruments to truly achieve heat stress reduction. For example, the municipality does have an elaborate policy on tree management, which does describe the importance of trees for heat stress reduction and biodiversity, but the document does not focus much on increasing the number of trees.

Coherency of actors

The municipality of Deventer has five different Aldermen. The division of tasks is the following:

- Alderman of finance, spatial development and 'Omgevingswet' (eng. environmental law), 'Wet Maatschappelijke Ondersteuning' (WMO), and rural policy.
- Alderman of welfare, health, and integration, sports, income, housing, restructuring, and estates.
- Alderman of culture and events, care for heritage and monuments, sustainability and environment, staff and organisation, and protected living.
- Alderman of economics, recreation and tourism, international policy, labour, and connecting with the community.
- Alderman of the living environment, youth, education, regional cooperation, and business areas.

Besides those responsibilities, all the aldermen and mayor are also a so-called wijkwethouder (eng. neighbourhoodalderman). The aldermen in Deventer are responsible for different neighbourhoods. All these neighbourhoods have their own budget that is managed by the citizens in that neighbourhood (*In Gesprek Met Wijkwethouder Carlo Verhaar over de Binnenstad*, 2021).

As mentioned before, the municipality of Deventer has set up an initiative with other housing corporations and Enexis to inform people what they can do to be more climate adaptive. This is done through a website. Because of this, the municipality works together with housing corporations and Enexis, which is an energy company, and is also providing information to citizens about what they can do.

Overall conclusion on the policy coherency of the municipality of Deventer

The municipality of Deventer has a new climate plan, but an outdated nature plan. Because the goal coherency is mainly based on the nature plan, a few conclusions can be made. At first glance, the municipality does have some coherency between heat stress reduction and nature policy. This is mainly found in the *participation of citizens* goal and the *stop decline in biodiversity and natural habitats*. The relation between heat stress and nature is not found in the Groenbeleidsplan (Gemeente Deventer, 2007), but is in the newer documents. Although the coherency is not found in the Groenbeleidsplan, the newer document does not only present current problems and solutions, but also current visions on the problems. Therefore, when the relation was mentioned in one of the newer documents, this research regards that as coherence. Since the Groenbeleidsplan (Gemeente Deventer, 2007) is outdated, it is hard to determine what is currently done on nature management and policy. Therefore, the coherency in reality might differ from what is assessed in this research.

For the instruments, the municipality has mentioned different instruments in different documents, though not always thorough and clearly. Although many of the instruments are used by the municipality, the coherence could be enhanced by creating a coherent document including both nature-climate goals and instruments.

The municipality of Deventer has five different aldermen. The division of tasks is quite specified. There are different aldermen that could be involved in the creation of climate and nature policy. One of the aldermen is responsible for the *Omgevingswet*, which is a new law since 2022 concerning everything related to the physical living environment. Besides this alderman, there is also an alderman responsible for sustainability and environment, and lastly another for the living environment. Notably, for none of the aldermen 'nature' is specifically mentioned to be their responsibility. This might be one of the reasons why there is not yet a new nature plan published. The municipality of Deventer does have wijkwethouders and the initiative Deventer Stroomt that does try to include citizens and some corporations. Although this is positive, the aldermen are responsible for policy making in a municipality. Because of the unclarity regarding responsibilities, the coherency of the actors is considered to be low.

Coherency	Explanation
Goals	The municipality clearly links two goals with heat stress and links one goal indirectly with heat stress. The other two goals are not linked.
Instruments	The municipality does not focus on all the instruments. Trees and green roofs are the instruments from the list that get the most attention by the municipality.
Actors	The division of responsibilities regarding nature and climate adaptation is unclear.

	Clear coherency
	Unclear/indirect coherency
	No/low coherency

Table 7: overall coherency for the municipality of Deventer.

7. Discussion

This research was conducted to find out two things, 1) the synergies and trade-offs between minimising Urban Heat Island and nature quality, and 2) how municipalities are utilising these synergies. To find answers to the first research question, a scientific literature study was conducted. This, together with the Policy Coherence Framework, formed the foundation of the case studies. To gather the results of the case studies two different methods of collecting information was used. First of all, published information of municipalities was used as main sources. Municipalities publish a considerable amount of information on their websites and in documents. Even though many documents are easily found, in-depth information is often lacking. In some cases, the documents that were found referred to other documents which were not available on the website. Therefore, a second information-collecting method was added to this research, namely interviews. Interviews with experts from the municipality are an effective way to get more insight in the perception of the municipality regarding nature and heat stress reduction. Moreover, by conducting interviews this research includes between-method triangulation, where different methods (reactive such as interviews and non-reactive like analysing available materials) are used, to capture different aspects of the research issue (Flick, 2004). Interviews with an alderman or other important municipal official were planned for all three cases. However, the busy schedules of these aldermen and officials due to the elections and other important activities made it hard to contact them and to plan interviews within the time frame of this research. Therefore, only the interview for the municipality of Eindhoven has been conducted. The consequences of only conducting an interview for the municipality of Eindhoven are 1) between-method triangularity was not reached for 's-Hertogenbosch and Deventer and 2) knowledge gaps that were still present after thoroughly reading policy documents could not be filled with information from interviews, meaning that on some parts the policy coherency is higher though not recorded in the documents.

An interview was conducted with an official from the municipality of Eindhoven. The interview focussed on the information that was not yet found in municipal documents, and to gain a better overview of the perspective of the municipality on nature and heat stress reduction. As a consequence, little attention was paid to the realisation of the goals and instruments. This research as a whole determined the level of coherency between nature policy and heat stress reduction as is written down by the three case studies. This research has not looked into the future realisation of the goals and the instruments municipalities mention to incorporate.

The results of the case studies show that there are quite a few different ways municipalities can record their nature and climate policy, and to what extent the municipalities incorporate synergies in their policy documents. This research looked at three different municipalities. For more information on how these

municipalities are selected and which ones they represent see chapter 3. *Methodology*. Although these municipalities represent the different sizes of municipalities, generalising the findings for all municipalities above 100 000 inhabitants is almost impossible. This is because this research determined how the municipalities scored on policy coherency, but did not investigate the reasons why the scores of coherency features differed between municipalities. The explanation why municipalities score high or low for policy coherency could be explained by both internal and external factors. When more case studies have been performed, trends regarding what influences the level of coherency might become visible. Although further research might provide better insight in the factors influencing policy coherency in municipalities, when research is done after several years findings might differ from this study. Climate mitigation is becoming a more prominent topic for governmental bodies every year, and as temperatures are rising heat stress will become more apparent in cities. This means that it is highly likely that over the next few years heat stress mitigation will become increasingly important in municipalities, which might result in more attention from municipalities to heat stress mitigation methods. This means that when this research will be done again after 5 or more years, municipalities might have a better view on how to tackle this problem, and consequently the policy coherence between nature policy and heat stress mitigation might reflect this.

Generalisation of the results of the case studies of this research is hard, and it is arguably not of that much interest. This is mainly because this research did not strive to give an overview of the policy coherence of municipalities in general. This research focussed on applying the Policy Coherency Framework on a new research scope and gathering knowledge on the extent of utilising synergies during climate and nature policy making. Although case studies do not have a high internal and external validity, they are extremely useful for addressing complex processes in a specific context, as is the case in this research. Rather than trying to generalise the findings, focussing on the differences found between the cases is what gives interesting insights.

The research shows that the Policy Coherence Framework can be used to determine the coherency of nature and climate policy on a local governmental level. It provides a theoretical base for identifying policy coherency, and to determine in which areas or coherency features the municipalities can increase their efficiency. Additionally, it provides a clear way of structuring the vast amount of information that can be found in policy documents and on municipal websites. During this research it became evident that municipal policy documents tend to mix goals and instruments, even when the documents had separate sections for goals and instruments. The Policy Coherence Framework, specifically as used in this research, provides a way to determine the coherence in an organised way. Although scientific literature did not provide a single approach for assessing policy coherence, the overall framework provides a scientific focus

that enables to see relations between different policy areas. For this framework to be used to its full potential in these kinds of policy areas some standardised procedures would be beneficial, although may be impossible to create. This research based the methodology on Duraiappah & Bhardwaj (2007), Wiedeman & Ingold (2021), and Nilsson et al. (2012), but there are many other experts that use this framework in a different way, depending on the kind of coherency, the implications of the research, and scope.

The Policy Coherence Framework is globally used in different sectors, and on different policy levels. Different adaptations of the framework are used in other sectors, with other dimensions (horizontal/vertical, external/internal). However, to my knowledge, no research has been done on the policy coherency between nature policy and heat stress reduction in municipalities in the Netherlands, or elsewhere. Since there are no similar studies done, some weaknesses in the approach used in this research should be acknowledged. First of all, this research assumes that the acknowledgement of the positive relation between nature and reduction of heat stress results in policy coherence. This, however, may not necessarily be the case. The main reason for this is that the municipal documents sometimes relate heat stress reduction and nature benefits in general sense but are not actively mentioning heat stress reduction whilst describing their (nature) goals. Although the acknowledgement shows that the municipality is aware of the possible synergies, they may not actually act on it. Secondly, this research only investigates instruments that scientific literature mentions to be beneficial for both nature quality and heat stress reduction. This means that other instruments that might result in trade-offs are not looked into. Duraiappah & Bhardwaj (2007) mention a similar weakness in their research and propose a relational analysis for both positive and negative impacts of instruments. This would be recommended for further research. Another weakness of this research is that it mainly focussed on the synergies between nature and heat stress reduction. At the start of the research, both synergies and trade-offs were looked into. Since trade-offs between heat stress reduction and nature policy were not found in the earlier stages of this research, I decided to focus primarily on the synergies. Since clear trade-offs between nature goals and heat stress reduction were not apparent, the importance for municipalities to focus on synergies and increasing policy coherence of those two fields in policy making is underlined again. Lastly, as mentioned before, this research did mainly focus on the ambitions of the municipalities, but that does not inherently mean that those plans will be realised. Interviews could have provided more insights in the intension of realising the ambitions. It would be interesting to see if the municipality that scores higher on coherency also implements more measures to actually realise their plans.

There are still some knowledge gaps surrounding this research topic that would benefit from future research. Further research is useful for determining the reason why some municipalities have a higher

policy coherence than others. This research only determined if there is policy coherence, not why there is coherency. As mentioned before, as of now, it is hard to determine if there is a specific reason that results in some municipalities having a greater policy coherency, and if so, what this cause is and how other municipalities can learn from it. Secondly, more work is needed to create a methodology for this framework that could be used in multiple situations across multiple horizontal and vertical dimensions. Additionally, future research could investigate how policy coherence is related to the implementation stage of the nature and heat stress reduction goals and instruments. Finally, there are more topics that are currently becoming increasingly important for municipalities, such as reducing CO₂ emissions and water management. The policy coherency of nature, heat stress reduction, reducing CO₂ emissions and water management would be an interesting research, though complex to carry out when using the current Policy Coherence Framework.

8. Conclusion

For this research, the following research questions were constructed:

1. *What are the synergies and trade-offs between minimising Urban Heat Island effect and nature quality and cultural services, as reported in literature?*
 - *What are the relations between the goals of the mitigation methods and the goals for biodiversity and cultural services?*
 - *Which instruments and decisions are important for implementing the mitigation method?*
 - *Which actors play a role with implementing this mitigation method?*
2. *What are municipalities planning to do to minimise UHI (by using nature) and to what extent are those municipalities utilising synergies and avoiding trade-offs?*

In the literature study goals, instruments, and actors were found that could lead to policy coherency. A list of nature goals was created based on several scientific papers, with the following goals:

- Stop decline in biodiversity and natural habitats
- Limit invasive/exotic species
- Access for everyone to green space
- Connectivity of urban nature areas
- Participation of citizens

A scientific literature study was conducted to examine to what extent these goals were related to heat stress mitigation. Heat stress reduction had a positive effect on *limiting invasive/exotic species*, and only *access for everyone to green space* and *connectivity of urban areas* were found to have a positive effect on heat stress

reduction. Although, when citizens are educated and actively involved in the decision-making progress, their personal actions might further improve the environment as well.

There were also four instruments found that are beneficial for both nature conservation and heat mitigation. These are increasing the urban nature area, increasing number of trees, green roofs, and water systems. For the actors, different municipalities can have different aldermen configurations, meaning that climate and nature are topics that can be assigned to the same or different aldermen, depending on the municipality. Moreover, there are also other actors that can play a role in the coherency, such as private landowners, companies, and organisations.

The case studies provided information on the policy coherency in Dutch municipalities. The following table summarises the key findings:

	Eindhoven	's-Hertogenbosch	Deventer
Goals	Links in documents are often indirect and unclear	Two goals are linked clearly to heat stress reduction and one indirectly	Two goals are linked clearly to heat stress reduction and one indirectly
Instruments	Little information available, no clear overview of instruments they want to use	Most instruments are implemented by municipality, benefits to heat stress reduction are sometimes mentioned	The municipality does not focus on all instruments, but mainly focusses on green roofs and trees.
Actors	Two fields under same aldermen, actors involved looks promising	Two fields under same alderman, works together with housing corporations, not many actors involved.	The division of responsibilities regarding nature and climate adaptation is unclear.

- Clear coherency
- Unclear/indirect coherency
- No/low coherency

Table 8: The policy coherence for the three different cases; the municipalities Eindhoven, 's-Hertogenbosch, and Deventer.

From this analysis we can conclude that the municipality of 's-Hertogenbosch shows the highest policy coherence. It is interesting to notice that all three municipalities have different strengths and weaknesses when it comes to the policy coherence in the different coherency features.

As mentioned before, the goals that were found to be synergetic with heat stress reduction were *access for everyone to green space* and *connectivity of urban nature areas*. However, when assessing which nature goals,

the municipalities often linked to a reduction of heat stress another pattern is found. Table 9 shows that the municipalities link *participation of citizens, decline in biodiversity and natural habitats*, and to some extent *the limitation of invasive and exotic species* to heat stress reduction, whilst *access for everyone to green space* and *connectivity of urban areas* is less mentioned. Both *participation of citizens* and *stop decline in biodiversity and natural habitats* are goals that most, if not all, municipalities linked to heat stress reduction. This is an interesting finding, since this means that the municipalities have a different view on what is important when dealing with such issues. One of explanation for this difference could be that municipalities put a lot of importance on public support, since they govern on a local level.

Goal	Eindhoven	's-Hertogenbosch	Deventer
Stop decline in biodiversity and natural habitats			
Limit invasive/exotic species			
Access for everyone to green space			
Connectivity of urban nature areas			
Participation of citizens			

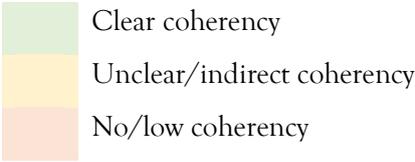


Table 9: summary of the policy coherence between the goals and heat stress reduction as mentioned by the three different municipalities.

The instruments found in scientific literature that are synergetic for heat stress reduction and biodiversity and cultural services are 1) increase number of green spaces in cities, 2) tree management, 3) green roofs, and 4) water systems. It differs between municipalities to what extent the instruments are used and worked out in their municipal documents and websites. Trees and green roofs are instruments that are used by all three municipalities. Notably, water systems are rarely mentioned by the municipalities as instruments to reduce heat stress. The municipality of Deventer and 's-Hertogenbosch are located next to rivers, but those rivers are not running through the cities. The municipality of Eindhoven wants to bring the Gender on ground level again. None of the municipalities is mentioning these waterways to transport heat out of the city. Additionally, none of the municipalities mentioned fountains and similar water systems as an instrument to reduce heat stress.

Lastly, this research assessed the policy coherence for the actors that are responsible for nature and climate (adaption) policy. The literature review gave an overview of the important governmental layers in

municipalities. Different policy areas are divided amongst the aldermen of the municipality. Both the municipality of Eindhoven and the municipality of 's-Hertogenbosch very clearly have put climate and nature together under the same alderman. The municipality of Deventer chose to divide the tasks of the aldermen a bit differently than the other two municipalities. This made it hard to say for certain which alderman was responsible for nature and climate adaptation, especially since nature is not mentioned as one of the task areas.

Overall, the municipalities are utilising the synergies between nature and heat stress reduction. The three case studies scored high for coherency on various parts of the assessment, as visualised by table 8. None of the municipalities scored high coherency on all three features of the Policy Coherence Framework (goals, instruments, and actors).

There are several recommendations for municipalities that want to utilise the synergies between nature and heat stress reduction.

- It is important that municipalities actively search for coherency in their nature and heat stress reduction goals. Although the way from setting goals to implementation is long, creating coherency in the goals stimulates thinking through the coherency lens and provides a backbone for implementation. The municipality of 's-Hertogenbosch had one single document where both nature and climate adaptation was described. This can be one of the reasons why 's-Hertogenbosch has a high overall policy coherency.
- If the municipality wants to implement instruments of which the success is dependent of citizens, the municipality should actively promote the implementation of the instrument and ensure that the information is send to the citizens. Although the municipalities have on their websites information regarding projects that might include citizens (like increasing the number of green roofs), more actively promoting such projects results in an increase of applications. This was shown by the municipality of 's-Hertogenbosch. When they actively promoted green roofs, they saw an increase in applications.
- In general, none of the three municipalities had a clear long-term plan or strategy available on how they actually want to tackle challenges regarding nature and heat stress. In order to overcome those problems, translating goals into strategies is important. Having concrete strategies makes sure that different projects are coordinated. This is important to ensure that the goals can be achieved in a coherent manner, and so visions are carried out in effectively.
- Although not much was found in scientific literature about the importance of citizens' initiatives for nature policy and heat stress reduction, the importance of public support cannot be denied. The municipality impacts the living environment of people directly, since it is a local

governmental organ. Therefore, incorporating the needs and wants of citizens is something that should not be overlooked. This can be done by stimulating more citizens' initiatives or by organising workshops where citizens can voice their opinion and help creating a plan for the neighbourhood.

The contribution of this study to the field of research is twofold. First of all, there is no other research known that attempts to map the policy coherence of nature policy and heat stress reduction in (Dutch) municipalities. Heat stress will be something that society has to deal increasingly with in the future. Additionally, biodiversity is globally declining and increasingly more species are threatened due to habitat change, overexploitation, invasives, climate change, and pollution (Pereira et al., 2012). Municipalities have limited resources, meaning that the municipalities need to spend their resources wisely and effectively. Utilising synergies in different policy areas can lead to multiple benefits when only investing once. Climate change will influence the challenges societies face in the future, increasing the importance of making urban areas climate adaptive. Additionally, this research might be interesting for municipalities, both the ones that are used as case study and the ones that are not, since it shows how municipalities can increase the effectiveness of their policy making by increasing policy coherence. Municipalities should be able to do a self-assessment by using this framework and see which synergies they utilise and where they miss out.

Secondly, this research adds to the existing literature on the usage of the Policy Coherence Framework. This framework has showed to be useful for defining synergies on between two policy areas on a local governmental level. However, examples for policy coherence between nature and climate adaptation policies on a municipal level are lacking in scientific literature, resulting in an absence of a fitting methodology for this kind of research. This research shows how the framework can be transformed in a methodology for such studies. Further development of this framework so it becomes a clear framework to use for research on different policy levels will increase the usage of this framework. Policy coherence is a tool that could be used by academics, but also by governments and organisations that want to increase their policy making effectiveness.

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Interview

Interview Municipal Official Eindhoven 1, 31 March 2022

Name: anonymous

Function: Adviser urban water and climate adaptation

Date: 31 March 2022

Appendix A

Interview topics and questions for the interview with the municipal official of Eindhoven. Because of the semi-structured nature of the interview, general topics were written down to aid the conversation.

1 - inzicht krijgen over persoon en functie

U bent senior projectleider, adviseur en beleidsmedewerker water en klimaat. Hoelang doet u dat en wat zijn uw belangrijkste taken?

2 – rol groen/blauwe structuren voor klimaatadaptatie, hittestress

Wat is uw visie op de rol van natuur op klimaatadaptatie binnen de stad? (en u bent de beleidsmedewerker water en klimaat, heeft u dezelfde visie als het gaat om blauwe structuren in de stad en klimaat adaptatie?)

3 – stand van zaken en de uitdagingen

Hoever is gemeente Eindhoven met de implementatie van stedelijk groen en klimaat adaptatie?

Zijn er grote uitdagingen waar Eindhoven voor staat als het gaat om vergroenen en klimaatadaptatie?

4 – hoe is het beleid georganiseerd?

Is er een grote overkoepelend natuur en klimaat plan dat in detail al uitwerkt waar bijvoorbeeld natuur moet komen en voor welke doelstellingen? Of wat dat meer op project-schaal bekeken?

Ik heb op de site van gemeente Eindhoven verschillende projecten gevonden in de binnen stad en andere wijken die meer natuur willen terughalen in de stad.

Ziet u ook veel initiatieven vanuit de inwoners zelf?

5 – welke mensen binnen de gemeente spelen een grote rol?

Binnen een gemeente zijn er natuurlijk verschillende wethouders, beleidsmedewerkers, enzovoorts die zich bezighouden met dit soort vraagstukken. Welke samenwerkingsverbanden zijn volgens u essentieel bij het realiseren van een groenproject dat aanhaakt op hitte stress adaptatie?

Zijn er nog andere stakeholders/belangen die van belang zijn, en hoe wordt daar verder op ingespeeld?