

The Urban 'Regreenation' of Groningen.

A bachelor thesis on how to reduce urban heat in Groningen via sustainable innovations.



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Abstract

This research is to analyse ways to reduce urban heat in the city of Groningen via implementing sustainable innovations. To research this, the following research question has been addressed: *“How can the municipality of Groningen adapt to the issue of urban heat via the usage of sustainable innovations?”*. Three in-depth interviews were conducted to determine the different perspectives of the municipality of Groningen, a housing corporation in Groningen and the green mayor of Groningen. A heat map of Groningen and policy reports on urban heat and/or climate adaptation have been analysed as well. According to the map, the industrial sites and the city centre are the main hot areas. The policy reports showed the possibilities of reducing urban heat and implementations to provide more greenery into the city between 2020 and 2024. The interviews showed that cooperation between included actors should improve. Implementing sustainable innovations are hindered by financial issues, policy acts and lack of cooperation.

Keywords: climate adaptation, urban heat, green roofs, vertical green systems, sustainable innovation, cooperation.

Table of contents

Abstract	1
Table of contents	2
1. Introduction	3
1.1 Background	3
1.2 Problem statement	4
1.3 Scientific and social relevance	4
1.4 Research question	5
1.5 Hypothesis	5
1.6 Structure of the research	5
2. Theoretical framework	6
2.1 Definition of keywords	6
2.2 Types of sustainable innovations	6
2.3 Social innovation	7
2.4 Conceptual model	8
3. Methodology	9
3.1 Multi-method approach	9
3.2 Primary data	10
3.2.1 Ethical concerns	10
3.3 Secondary data	11
4. Results	13
4.1 Spatial variety in heat stress	13
4.2 Current and future policies	14
4.3 Opportunities and restrictions on reducing urban heat	17
4.3.1 School buildings	17
4.3.2 Housing corporations	18
4.3.3 Financial improvement	19
4.3.4 Reflective materials	20
5. Discussion	21
6. Conclusion	22
References	23
Appendix I - Consent form for the interview	26
Appendix II - Interview with a climate adaptation policy officer of Gemeente Groningen	27
Appendix III - Interview with the real estate director of housing corporation Nijestee	29
Appendix IV - Interview with the green mayor of Groningen	31
Appendix V - Information given before the interviews	33
Appendix VI - Inferential coding	34

1. Introduction

1.1 Background

In the last few decades, the world has been warming up (Allen et al., 2018). The greenhouse gasses form a ‘blanket’ between the earth’s surface and the ozone layer causing radiation of the sun to stay underneath the greenhouse gasses (Mann, 2020). This results in for example temperature rises which causes ice caps to melt and extreme droughts. This lowers the albedo effect; the reflection of the sun on white surfaces, which results in even more absorption of heat (Davidson, 2020; Santamouris, 2014). In Europe, the last 6 summers have been the warmest 6 summers ever measured (NOAA, 2020). For many urban areas that resulted in high temperatures inside homes and cities. A common response, especially combined with the housebound policies due to COVID-19, was to invest in cooling systems for the houses. People bought fans or air-conditioning, took long cold showers, filled (small) pools with water, etc. which means more use of resources. The urban areas already use more resources than the rural areas and this will not be sustainable if it continues to be used in this manner (Davidson, 2020).

Another effect on the urban temperature is the world’s population growth and the desire to live in an urban region. There has been a rapid population growth with an increase of 4.8 billion people in the last 80 years and more than 55% of the world population lived in urban areas by the year 2017 (Ritchie, 2018). To maintain space for cities, vegetation had to make way for buildings and concrete. Figure 1 shows that in the Netherlands the urban population consists of 15.6 million people which is more than 90% of the total Dutch population (Ritchie, 2018).

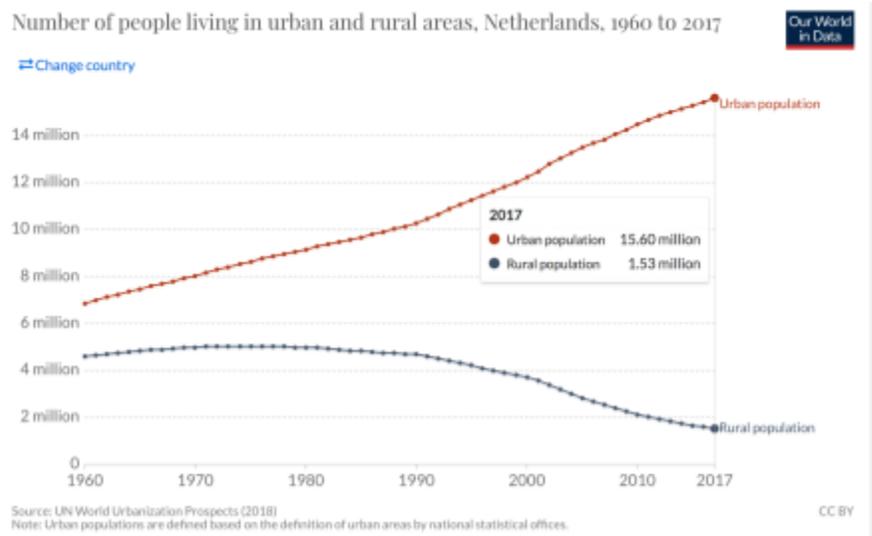


Figure 1: urbanised areas versus rural in the Netherlands (Ritchie, 2018)

1.2 Problem statement

The two effects mentioned in section 1.1 result in urban heat islands (Santamouris, 2014). The buildings and its material together with the lack of vegetation cause urban regions to be warmer than rural areas (Erell et al., 2011). In the Netherlands, urban temperatures can

differ up to 5 degrees from rural temperatures (Gemeente Groningen, 2016). Each individual, in an attempt to deal with the heat, makes extreme use of resources which result in higher numbers of electricity usage, water usage, etc. as well as 12% higher risk of death in the Netherlands due to heat, drought, etc. (Gemeente Groningen, 2020). To decrease the impact of urban heat and combat climate change, research has to be conducted on how neighbourhoods in cities can reduce the impact of rising temperatures in urban areas. When sustainable solutions are created, cities can be resilient to futuristic problems and by doing so also reduce costs and use of resources in the long term. Therefore, it is important to look at the root of the problem, start from the bottom up and find sustainable solutions.

Singapore has embraced this need for sustainability to make the 'Gardens by the Bay' and create sustainable cycles of energy and water (Gardens by the bay, N.D.). The park contains 1.5 million plants and has become a well-known tourist attraction, making it an economic advantage as well. In Rotterdam, a square was designed to have two purposes: a playground for kids and a water reservoir (De Urbanisten, 2013). When heavy rain showers occur the square acts as a water reservoir with the possibility to play around and over the water. When the square is dry, it is a playground to play e.g. basketball. These are two examples of using climate adaptation as an economic, environmental and social advantage.

1.3 Scientific and social relevance

It is important to discover how the rising temperatures can be reduced and balance is restored to keep the earth habitable for humans. Greenery can help by absorbing carbon dioxide and releasing oxygen and evapotranspiration causing the air to contain more water which makes it cooler. A positive effect of greenery is that people are healthier when surrounded by greenery. Research has shown that only seeing greenery will make people more active and mentally healthier (Gemeente Groningen, 2020; Gemeente Groningen, 2016). People who live in cities suffer more from depression and partake in less daily activities than those living in rural areas. Humans are also 2% less productive per degree Celsius above 25 degrees (Gemeente Groningen, 2016). This article is focused only on the city of Groningen, the Netherlands due to the availability of data and the pragmatics. There has been a lot of research on sustainable innovations itself and how implementation can make a difference. Yet there is a lack of research on how this needs to be implemented to create an effective reduction of urban heat together with who is involved and how. The goal of this research is to address this gap.

1.4 Research question

This research aims to find an adaptation possibility for the city of Groningen to deal with the urban heat caused by climate change. The following research question is addressed: *“How can the municipality of Groningen adapt to the issue of urban heat via the usage of sustainable innovations?”*. To answer this research question the following subquestions are addressed:

1. “What are sustainable innovations?”
2. “What types of sustainable innovations are able to reduce urban heat?”
3. “Who is in charge of implementing such innovations in Groningen?”
4. “What are the policies in the city of Groningen on the temperature rise and what measures adapting to urban heat have already been taken?”
5. “Where are the hottest areas in the city of Groningen?”
6. “What additional measures can be taken and by whom?”

1.5 Hypothesis

The expected outcome of this research is that the influence of sustainable innovations will decrease the average temperature and the stress of the urban heat will diminish. The expectation is that the use of greenery in the city with a certain distribution will help to decrease the urban temperature. Depending on the secondary data collection, the specific distribution will be determined during the research. The expectation is that the most influential factor are policies supporting those innovations or policies restricting the possibilities of implementation.

1.6 Structure of the research

The second chapter consists of the theoretical framework where relevant keywords and concepts are explained. Chapter 3 considers the methodology which explains the form of research. The results are in chapter 4 which analyses the primary and secondary data. Chapter 5 contains the discussion which is a (critical) reflection of the research process and next is the conclusion of the research. After the conclusion, the references and appendices can be found.

2. Theoretical framework

2.1 Definition of keywords

Sustainable innovation is a rather wide concept with a variety of definitions. Here, innovation towards sustainability is seen as a transformational process that changes the present to a more comfortable or more desirable world (Baskaran and Mehta, 2016). Innovation can refer to social, economic, environmental, technical and cultural aspects. Baskaran and Mehta (2016) discuss how innovation is based on experiences and ideas of the present and the past and is then formed into a desirable future. The sustainable part is based on three pillars; social development, economic development and environmental protection (Mason, 2020). Where innovation provides a transformation, sustainability offers the desirable part and keeps humans from wasting resources and being able to provide the next generation with resources based on the 17 Sustainable Development Goals (UN, 2012).

An important factor in this transformation is the people involved (James, 2015). They determine the success of the innovation by being intrigued and giving the innovation life or by neglecting it. According to Chen (2011), urban design is most reliant on the interaction between a city and its inhabitant. He explains that this interaction also increases social, economic and environmental suspects when being considered during the design phase. This influences the three pillars of sustainability (Chenn 2011; James, 2015; Mason, 2020).

Therefore, sustainable innovation is seen as ‘the innovation or solution for the problem is on environmental, social and economic aspects more beneficial (or less damaging) than the present situation’, where the resources that are used can be restored, will not run out or that the next generation does not have to live with the consequences of past generations (James, 2015; Davidson, 2020; Thornton et al., 2020; Kareem et al., 2020; Lind et al., 2020).

2.2 Types of sustainable innovations

Sustainable innovations are used to adapt or reduce the temperature in urban areas. Urban Heat Islands (UHI) are a result of rising temperature due to climate change and urbanisation. The buildings and materials that are used absorb heat, making the urban region a heat island compared to the rural areas nearby. This phenomenon causes electricity and other cooling resources to be used twice as much in urban regions than rural together with higher mortality and morbidity rates (Pigliautile et al., 2020).

Plants could reduce the temperature by lowering the concentration of carbon dioxide, therefore thinning the atmospheric smog above urban regions whilst increasing the concentration of oxygen and evapotranspiration which results in cooler areas (Davidson, 2020). This was researched in Québec where 40 projects on the reduction of urban heat via greenery like plants and green roofs were funded and supported by non-governmental organisations and

municipalities (Beaudoin and Gosselin, 2016). In Balmaseda and Amurio a project was started called the 'regreenation' (Senosiain, 2020). The spatial plan was to increase the amount of greenery in the cities to reduce urban heat. Green roofs, green walls and sustainable urban drainage were implemented improving the quality of living and reducing urban heat.

Vertical greenery systems (VGS) is a great example of this. VGS “[consists] of climbing plants and shrubs growing along building facades or along supports such as trellises can reduce surface temperatures due to shading, cooling the ambient air through evapotranspiration, and reducing infiltration through wind speed attenuation” (Afshari, 2017, p.205). A benefit of VGS is that it needs vertical surfaces which are abundantly present in densely built urban regions (Afshari, 2017). The main influential factors to use VGS are the area between the ground level and the root of the plants, the wind speed and the access to water the plants.

Another sustainable innovation is green roofs. Green roofs are vegetation on the rooftop of buildings that completely or partially fill the rooftop and can be divided into two types: extensive and intensive (Santamouris, 2014). According to Santamouris (2014), extensive green roofs (EGF) are “light and are covered by a thin layer of vegetation” and the intensive roofs as “heavier and can support small trees and shrubs” (p.684). The green roof can reduce the heat by absorbing the heat of the sun and transforming it to O₂, increasing the albedo of the city and evapotranspiration which also causes the temperature to decrease (Afshari, 2017; Santamouris, 2014).

Furthermore, reflective materials on rooftops help reduce urban heat, e.g. Roofclix which create a white layer above the roof reflecting heat in the summer (Roofclix, 2014). Another possibility is white paint combined with elastomeric, acrylic coatings and/or polyurethane to create a higher albedo (Santamouris, 2014). By increasing the reflection of the rooftops the radiation of the sun will be reflected back into the atmosphere directly instead of getting absorbed by dark roofs.

Other sustainable innovations (e.g. water reservoirs) are not mentioned in this research. That is because this research is only looking at solutions that are used on already existing materials (e.g. rooftops) to deal with the densely built areas that are causing urban heat.

2.3 Social innovation

Spijker and Parra (2018) mention that “social innovations acts towards the fulfilment of needs which are fundamental to, and a prerequisite of, the sustainable development of a city” (p.1017). Social innovations can help different sectors and involved groups cooperate, resulting in a more desired and sustainable outcome (Moulaert et al., 2010). Social innovation can create a ‘consciousness’ for the involved people resulting in a better understanding of the problem and the need for a solution and thereby creating more desirable cooperation (Spijker and Parra,

2018). To implement sustainable innovations to reduce urban heat there might be a need for social innovation as well.

2.4 Conceptual model

To make sustainable innovation work, the people have to be intrigued into the projects to use it (James, 2015). They need to understand the possible benefits and the effects it has on them and the urban area. Climate change and urbanisation already have effects on the urban heat, so to decrease it, sustainable innovations and social innovation need to be implemented to decrease urban heat and change the effect on the citizen. To do so, citizens need to be aware of their participation. In figure 2 the effects, theories and important factors are visualised.

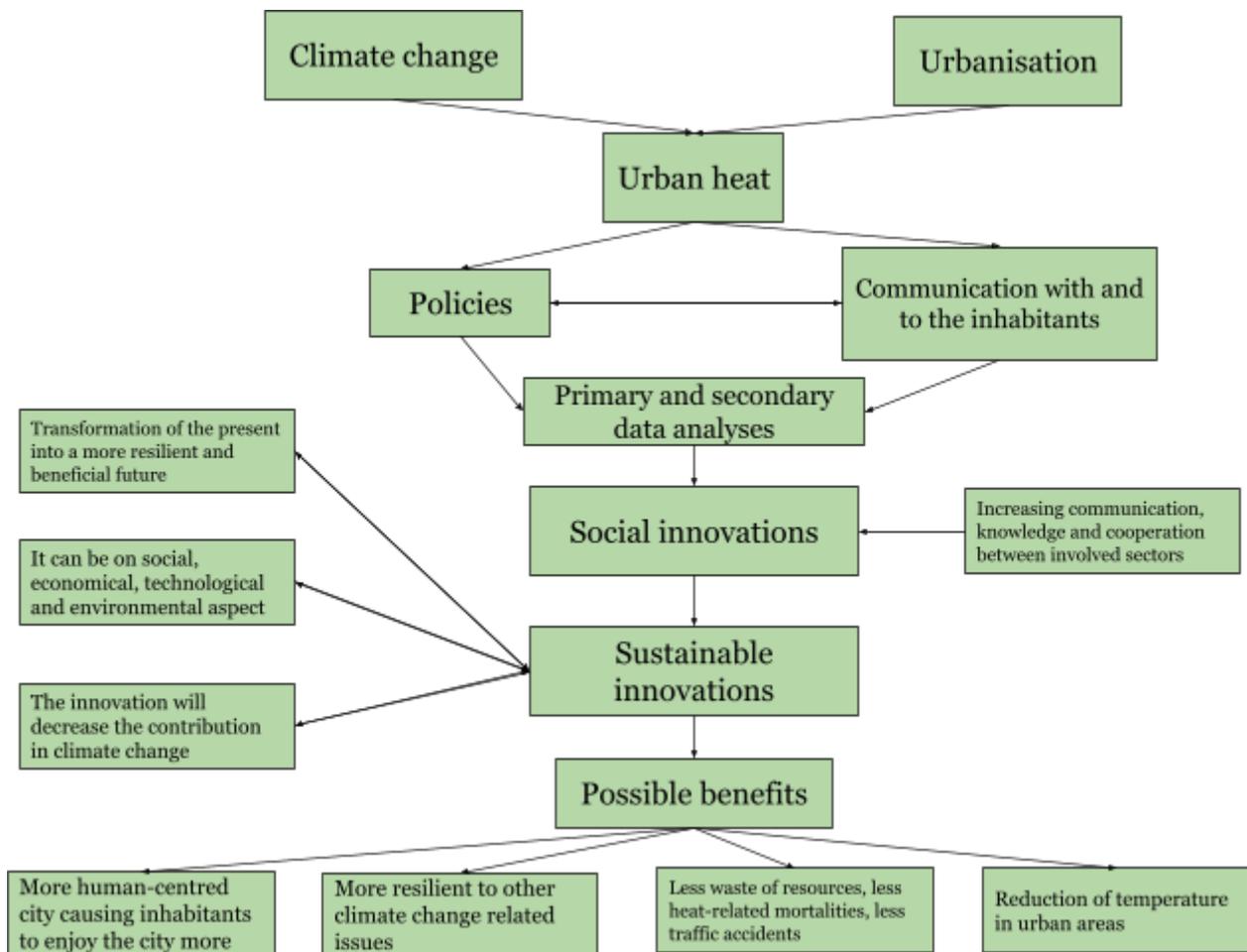


Figure 2: a conceptual model (author, 2020).

3. Methodology

3.1 Multi-method approach

In this research, a multi-method approach was conducted to determine how the city of Groningen can reduce urban heat via sustainable innovations by using the different perspectives of involved organisations. Qualitative primary data and literary secondary data were used to answer the research question.

Table 1 shows each method of data collection that was conducted to answer each subquestion. For the primary data collection, three in-depth interviews were held to get a different understanding of the organisations as well as the problems the organisations face in this subject. The in-depth methods of interviewing offer personal aspects from the respondents on how they look at the organisation and the process. Furthermore, they offer the possibility to find out different problems and restrictions the organisations have to deal with or opportunities that arise (Clifford et al., 2016). The goal of the interviews is to obtain information on the possibilities to reduce urban heat, the restrictions, the regulations involved organisations have to obey, as well as a deeper understanding of the organisations itself. Since both secondary and primary data is analysed, three respondents of the interviews in this research is considered

Table 1: methods of data collection per sub research question

Sub Research question	Method of data collection	Extra information
What are sustainable innovations?	Literature review.	Based on literature the definition for this research will be determined.
What types of sustainable innovations are able to reduce urban heat?	Literature review, policy analysis & interview with the green mayor of Groningen, Gemeente Groningen & Nijestee.	The interviewees will be asked what their perspective is on this subject.
Who is in charge of implementing such innovations in Groningen?	Literature review & interview with Gemeente Groningen.	Gemeente Groningen has information on implementing policies.
What are the policies in the city Groningen on the temperature rise and what measures adapting to urban heat have already been taken?	Policy analysis, literature review & interview with Gemeente Groningen, the green mayor of Groningen, Nijestee.	The policies will be analysed before the interviews, however, the interviewee will still be asked about the policies because they have (inside) information.
Where are the hottest areas in the city of Groningen?	Data analysis from the <i>hittestresskaart</i> by Gemeente Groningen.	This secondary data shows a map of the heat distribution which will be analysed.
What additional measures can be taken and by whom?	Interview with Gemeente Groningen, Nijestee & the green mayor of Groningen.	Each interviewee will be asked what they think is needed to be added to reduce urban heat in Groningen.

enough. The important sectors; the municipality, housing corporations and a policy officer of climate adaptation are interviewed.

The collected secondary data was divided into three sectors: existing scientific literature; policies on the subjects of climate adaptation, Groningen and heat islands; and a heatmap made by Gemeente Groningen. The heatmap was used to visualise and analyse the heat distribution within Groningen. The literature review is to be well informed before the interviews, to define certain phenomena and keywords to conclude the same definition and to analyse past findings in the topic of climate adaptation. The policy analysis is a value to the information needed for the in-depth interviews and to answer the fourth and sixth sub-question as well as finding possible short-comings that could be solved as well.

3.2 Primary data

The interviewees who were contacted are the green mayor of Groningen, director of housing corporation Nijestee, and an alderwoman and -man of Gemeente Groningen. The interviewees were contacted through email. After 2 weeks the interviewees who had not responded were contacted by telephone or WhatsApp. The alderwoman and -man were contacted via their spokesperson who stated that they were not available, however, the spokesperson sent the research questions around to other people within Gemeente Groningen, resulting in an interview with a policy officer on climate adaptation.

The next step was to ask the interviewees to talk over the logistics and send the prior information, consent form and the interview questions which can be found in Appendix I to V. The interview with the green mayor took longer than 60 minutes and the other two interviews were within 50 minutes. The interviews were done on online platforms due to COVID-19 restrictions.

This resulted in interviews with a policy officer of Gemeente Groningen, director of housing corporation Nijestee and the green mayor of Groningen. The interviews are used to determine the current policies on urban heat, what has been done so far on urban heat reduction, the possibilities on urban heat reduction by using existing policies to benefit the sustainable innovation and to what extent there are restrictions or policies blocking possibilities of using sustainable innovations. In figure 3 the coding tree is visualised which was used to analyse the data. Further information on the coding process can be found in appendix VI.

3.2.1 Ethical concerns

Clifford et al. (2016) state the importance of ethical consideration during research. Clifford et al. (2016) explain that the following concepts need to be included to have ethical research: justice, beneficence/non-harming, respect/cultural awareness, consent and confidentiality. Table 2 shows how these concepts are included in this research.

Table 2: Ethical concerns of this research.

1. Justice	The research is just with a positive distribution between benefits and burdens.
2. Beneficence/ non-harming	This research will not be harming in any way to the people included and is meant to be beneficial to all included.
3. Respect	The researcher was respectful to the interviewees and was aware of the possible cultural differences.
4. Consent	The participants had to give consent to certain criteria, e.g. recording the interview before the researcher was allowed to interview them. The interviewees were allowed to stop the recording at any given time if requested and were informed beforehand, which can be found in appendices I to V.
5. Confidentiality	The participants allowed the interviewer to use their names, however, they are still not referred to by name but as “respondent”. The recordings and interviews are stored on a laptop that is password-protected to keep the data private and safe.

3.3 Secondary data

The secondary data was divided into three sectors: heatmap, (scientific) literature and policies. The ArcGIS map of Gemeente Groningen was used to analyse their *hittestresskaart 2018* which is a representative of urban heat in Groningen in the year 2018 (Gemeente Groningen, 2019a). This map visualises the stress level of the heat based on colours (red is hot and blue is cold). Gemeente Groningen has a document that contains how they calculated the *hittestresskaart 2018* which was analysed to understand the influence of variables on the dataset and possible discussion points on the data collection.

The *NAS* and the *Uitvoeringsagenda Klimaatbestendig Groningen 2020-2024* have public access and were analysed to determine existing policies, the possibilities on sustainable innovations, how the policies influence the implementation of sustainable innovations and what Gemeente Groningen is already doing to reduce urban heat (programmamateam NAS, 2020; Gemeente Groningen, 2020). Based on the information given in the interviews, *Groenplan: Vitamine G, Groningen Duurzaam warm* and the *press release* in English of the new coalition agreement were analysed (Gemeente Groningen & Strootman Landschapsarchitecten, 2020; Gemeente Groningen, 2012; Gemeente Groningen, 2019b). In figure 3 the coding tree is visualised which was used to analyse the data. Further information on the coding process can be found in appendix VI.

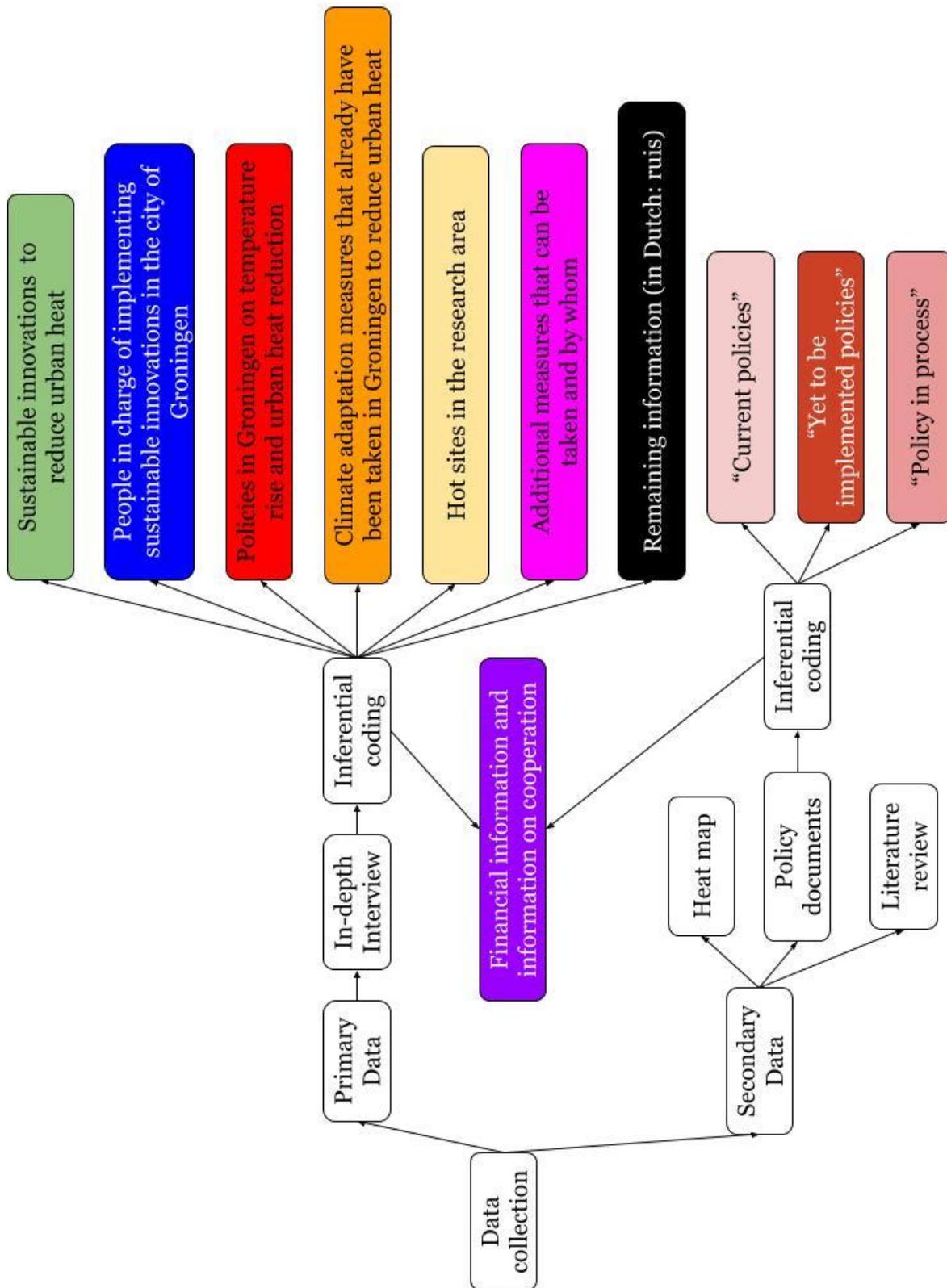


Figure 3: Coding tree (author, 2020).

4. Results

4.1 Spatial variety in heat stress

Gemeente Groningen made a map of heat stress in Groningen (Gemeente Groningen, 2019a). They used their resources to collect data such as temperature, greenery, land use, weather and water distribution (de Nijs et al., 2019). After the data collection, they used the programme ArcGIS to transfer the data into a map. This map was found on the website of Gemeente Groningen with open access and represents the year 2018. The map is shown in figure 4 with the legend on the right side. Gemeente Groningen has labelled red as warm, yellow as average and blue as cold. It was not found what temperatures are connected to these labels resulting in an abstract use of the data. The factors that were included in the calculations of this heat map are air temperature, radiation and humidity (De Nijs et al., 2019; Gemeente Groningen, 2020).

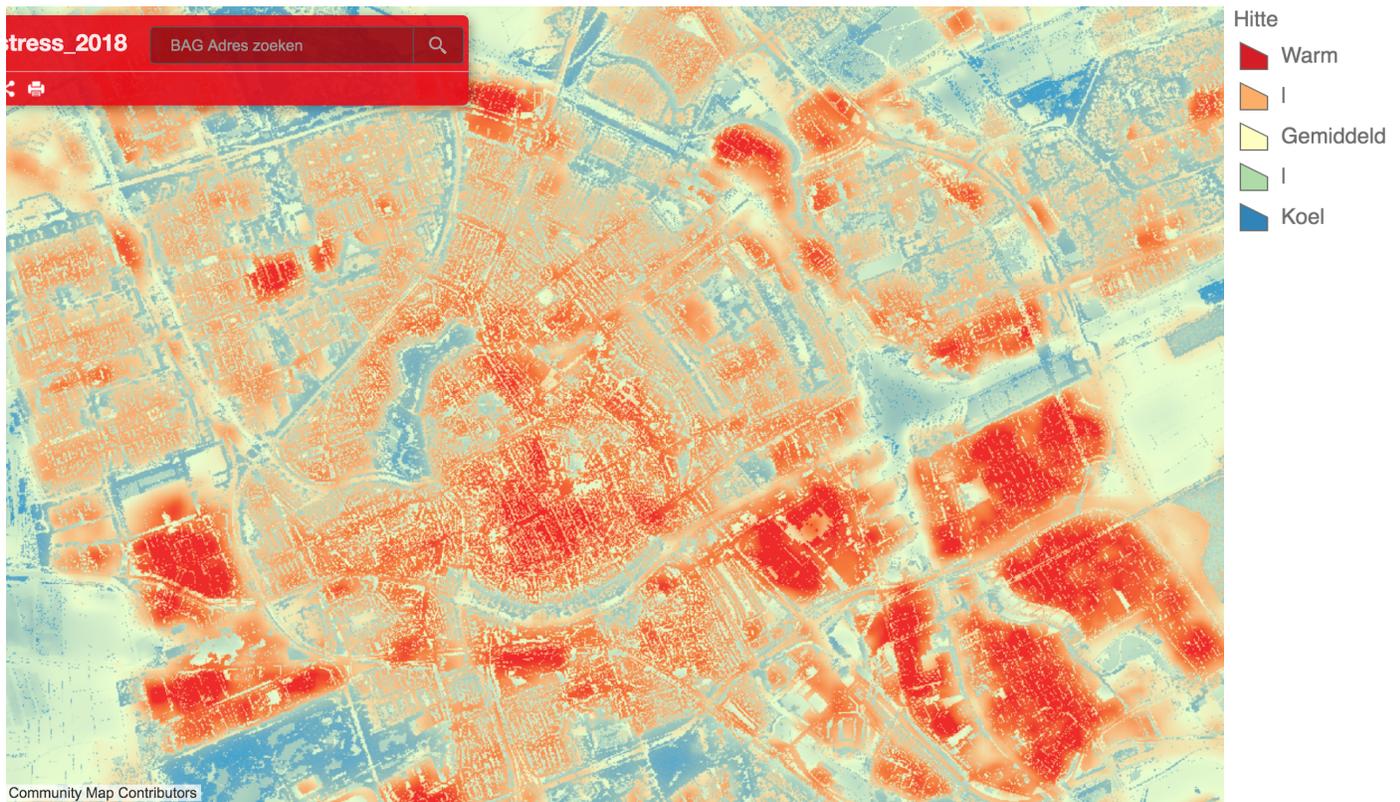


Figure 4: map of heat stress in Groningen (Gemeente Groningen, 2019).

When looking at the map more areas are coloured red(dish) than blue(ish). The southeast, southwest and the city centre show the most red spots. Areas like Noorderplantsoen and water areas are coloured blue with the directly surrounding areas also blue, green or yellow meaning that the area is cooler than the city centre or the southwest or -east. This map is a

visualisation to the extent of the problem and an explanation of the problem. The problematic areas seem to be in the city centre and the industrial sites with a lot of concrete and buildings.

These temperatures are a result of densely filled areas with many buildings, (brick)streets, concrete, impermeable materials and few greenery such as industrial sites, schools, nursing homes, hospitals; or in other words buildings with much roof surface.

Figure 4 visualises that the distribution of the hotter areas are rather equal in the city centre where every neighbourhood is in the orange or red zone. The map also shows that where there is water or green the site is cool(er), being in the blue or green zone showing that greenery can help reduce urban heat.

4.2 Current and future policies

The policies were analysed with the purpose to find the goals related to climate adaptation in Groningen and heat stress, the ambitions, when and how they should be reached, the regulations, actors involved and critical issues in the matter.

Figure 5 shows in what order the restrictions, regulations and laws on climate adaptation are decided on. The Intergovernmental Panel of Climate Change (IPCC) has stated in the fifth report that the goals should be reached by 2050 (IPCC, 2014). According to their goals and terms, the following governmental institutions determine their strategy. Furthermore, figure 5 shows how each governmental institution is influenced by the decisions of the previous institutions.

The New Coalition Agreement and *Uitvoeringsagenda Klimaatbestendig Groningen 2020-2024* state the goals and terms of the municipality of Groningen and how they are going to achieve a more climate-adaptive city (Gemeente Groningen, 2019b; Gemeente Groningen, 2020). These goals and key elements are shown in table 3. The NAS was written to give perspective to the situation and the needs to reach the goals of the IPCC.

The key elements and goals are to reclaim the public areas, implement more greenery and make greenery more accessible (Gemeente Groningen, 2019b; Gemeente Groningen, 2020).

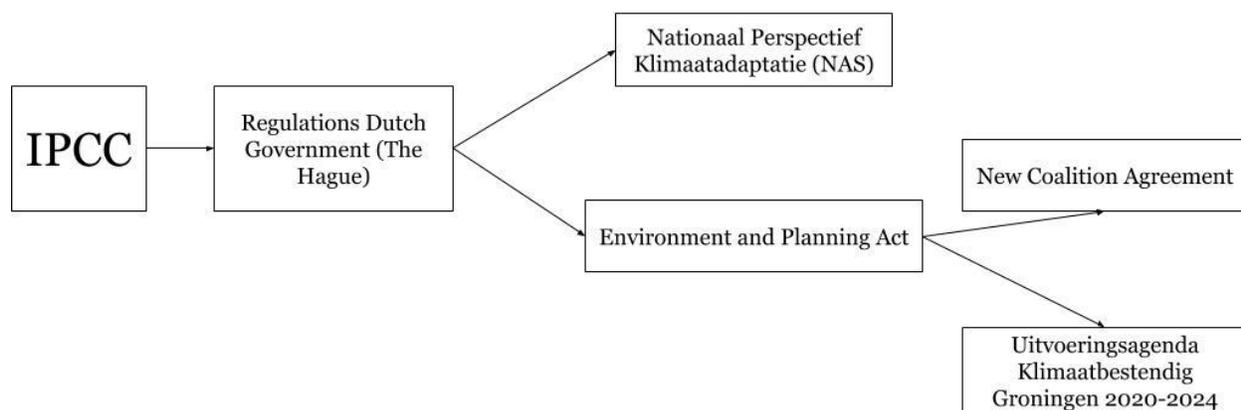


Figure 5: the order of decision-making (author, 2020)

The intention is to make the streets more pedestrian-focused instead of car-focused. By doing so the larger area of the street can be used for walking, cycling, playing and recreational purposes whilst allowing more greenery in those areas. Examples that are used in the coalition's statement are placing benches on the grass as an invitation as it is now in front of greenery appearing as a blockade. This has a significant contribution to reducing urban heat as the greenery can absorb the heat, CO₂-emissions and releasing evapotranspiration which contributes to cooling (Davidson, 2020).

In the NAS report, it is stated multiple times that heat has not got the attention yet that it should have from governmental institutions. This was also mentioned by the respondent of Gemeente Groningen in the interview where he stated that (urban) heat did not make the priority list up until recently (Interview: Gemeente Groningen, 2020). NAS explains the importance of further researching the spatial developments and the financial sector (programmteam NAS, 2020). Furthermore, the report mentioned the negative effects on health, economy, facilities, etc. that can be caused by urban heat. The NAS report also discussed that the communication needs to be better. This is shown in the *Uitvoeringsagenda Klimaat-bestendig Groningen 2020-2024* as the research showed people often do not know that they are eligible to receive subsidies for green roofs. Therefore, the stimulating role of gemeente Groningen is not as effective as it could be (Gemeente Groningen, 2020). The municipality does support green roofs via subsidies and to replace tiles in front of homes with plants (Gemeente Groningen, 2020).

To increase the knowledge of citizens and to offer them easier access to scientific information, the green mayor is working on an IPCC based in Groningen; the Groningse Panel on Climate Change (Interview: Green mayor, 2020). The respondent stated to be working together with scientists to construct a panel where citizens can ask climate-related questions. The respondent mentioned:

“My suggestion to a professor in Groningen was to start a Groningen Panel on Climate Change with all the scientists in Groningen that are related to the topic. [...]. The result would be a scientific panel which is in direct contact with the IPCC and can interpret the content of the rapports of the IPCC relevant to Groningen.” (Interview: Green Mayor, 2020).

By creating this Groningen Panel on Climate Change this respondent would offer the citizens the knowledge they need to adapt to climate change.

Table 3: the different policy document with their key elements and goals.

Policy document	National or Local	Key elements	Measures on reducing urban heat
Uitvoeringsagenda Klimaatbestending Groningen 2020-2024	Local	Research on who is seen as responsible for climate adaptation and climate change. Reclaim public spaces. The ambitions of Gemeente Groningen are supposed to be reached before 2030.	Instate more greenery and make it more accessible. Making streets more pedestrian- focused instead of car-focused. Stimulate citizens and organisations to use sustainable innovations via e.g. subsidies.
Nationaal perspectief klimaatadaptatie (NAS)	National	To give perspective to the problem statement. To divide the problem into sectors that should have attention. Statements on why certain sectors need more attention.	Addressing the serious need for a separate sector for heat. Addressing the serious need for financial support in the sector for heat. Addressing the serious need for cooperation and communication in the sector for heat.
Groenplan: vitamine G	Local	Easier access to greenery through a green network that will be created. Five different themes; people first, reclaiming public areas, Groningen active, energy transition as a drive for district and village renewal, and Groningen develops	Using other cities as examples to conduct in Groningen. Implementing more greenery. Themes 'reclaiming public areas' and 'Groningen develops' <i>can</i> be used to take measures to reduce urban heat, but has not been fully applied in the themes.
New Coalition Agreement	Local	Reclaim public spaces. Stimulation by Gemeente Groningen through e.g. subsidies. Regulation by Gemeente Groningen to make other involved actors take measures. The ambitions of Gemeente Groningen are supposed to be reached before 2030.	Implementing more green into public areas and adjusting the dominant subject of a street.
Environmental and Planning act	Local but obligations established nationally	Restrictions each municipality has to implement → in what way is to determine by the municipality itself	A number of x meters of greenery in the municipality (x to be still decided since the 50% that it was supposed to be was seen as unachievable in urban areas. There should be a 'shade-area' every 5 minutes walking distance.

4.3 Opportunities and restrictions on reducing urban heat

Gemeente Groningen has three different roles. The respondent of the municipality described these roles as:

“stimulating, regulating and directing. The municipality can direct in the public areas. They will be the people deciding what will be implemented and what will not since that is their working area. Although Gemeente Groningen decides what will be implemented within Groningen, they do communicate and discuss with the people living in the relevant neighbourhood. The regulating role is in the form of permits and laws. Gemeente Groningen can decide who will get certain permits regulating the construction and other actions. The law also decides certain actions taken by Gemeente Groningen as well as citizens of Groningen to fulfil the law” (Interview: Gemeente Groningen, 2020).

With these roles, the municipality tries to fulfil its coalition agreement by 2030. But with those roles come complications between sectors as well. Opportunities that could help their coalition agreement succeed are not being seen or not being used due to lack of communication and cooperation (programmamateam NAS, 2020). Several sectors such as housing corporations and school boards could be included as completion to reach the goals. By combining the sectors to fulfil the needs to create a sustainable city, social innovations need to be included as well (Spijker and Parra, 2018). The development of sustainable cities needs to include cooperation between the involved sectors and the government which can be reached via social innovations.

4.3.1 School buildings

In the report, *Uitvoeringsagenda Klimaatbestendig Groningen 2020-2024* is explained that children and elderly are seen as the most vulnerable group to heat. Children spent (at least) 6 hours a day in a school building. These school buildings are often big, concrete and surrounded by a tile-laid playground. The green mayor stated in the interview that he was also a member of a school board (Interview: Green mayor, 2020). The heat map (Gemeente Groningen, 2019a) showed that these tile and concrete areas are most hot. The municipality and initiatives such as Operatie Steenbreek try to stimulate people to replace the tiles by greenery and plants as the tiles are often excess and not necessary (Stichting Steenbreek, 2019; Interview: Gemeente Groningen, 2020). Green roofs could be implemented on the school buildings where possible and the playground pavement could be replaced by greenery. By doing so, different spots in the city centre help decrease urban heat whilst increasing health of the vulnerable groups and reducing the use of resources to cool the buildings in summer (Pigliautile et al., 2020). A restriction to this idea is stated in the interview with the green mayor that

“Most schools do not know their different possibilities in sustainable innovations they could use.” (Interview: Green mayor, 2020).

The respondent of Gemeente Groningen stated that a restriction to them is that school areas are not public but belong to the school board meaning that they cannot implement these changes (Interview: Gemeente Groningen, 2020). However, the green mayor stated to know that the schools are open for ideas and changes which means that there is an opportunity for implementing more greenery if the cooperation is done correctly, which currently is not the case (Interview: Green mayor, 2020). A form of restriction, in this case, is (the lack of) cooperation and communication between Gemeente Groningen and school boards.

4.3.2 Housing corporations

Another important group of actors in this matter are housing corporations. The city centre is filled with housing that belongs to housing corporations. The respondent of the municipality explained that the property act is a restriction for them since the housing in Groningen is not public property. Therefore, the municipality uses their regulating role in these cases, the respondent explained (Interview: Gemeente Groningen, 2020). In public areas, Gemeente Groningen can implement sustainable innovations to reduce urban heat. However, many roofs and facades are not the property of Gemeente Groningen but of the property owner, e.g. a housing corporation or a landlord or a citizen of Groningen. However, the respondent of Nijestee stated to have to obey so many regulations they do not have much resources (e.g. financial) left to also implement sustainable innovations even though this is a goal of Nijestee (Interview: Nijestee, 2020). This was not only stated by the respondent of Nijestee but also the green mayor mentioned:

“Housing corporations have been extremely limited in terms of money and laws. They are tied with both hands and feet” (Interview: Green mayor, 2020).

And even though a main goal of the municipality is to increase greenery in the city, there is yet to be cooperation between these sectors. Housing corporations own many roofs and walls in the city meaning they could implement sustainable innovations like green roofs. The respondent of Nijestee stated to be keen to do so, however, due to regulations demanding certain investments to be made they are not always able to. This is a complication that *could* be resolved via regulation changes, which would result in more greenery on buildings spread through the city of Groningen reducing urban heat whilst helping Gemeente Groningen fulfil their policy. The respondent of Nijestee also stated that:

“You see that often the boundaries of an organisation is blocking the possibility to make an integrated plan with the needed actors” (Interview: Nijestee, 2020).

The lack of cooperation is interfering with implementing sustainable innovations that could benefit all involved organisations. A difficult matter in this subject is the financial sector. Green roofs are relatively new and most times cost too much for the organisation to invest with no direct financial profit or not at all.

4.3.3 Financial improvement

Sustainable innovations and the theme “urban heat” is rather new on the priority list (Interview: Gemeente Groningen, 2020). The innovations are quite expensive and are not profitable (enough) for organisations to rely on them as an income. Therefore, organisations and initiatives such as housing corporations and schools can not invest (fully) in sustainable innovations, e.g. green roofs. A result of the interviews was that each respondent stated their sector to be interested to join forces but that they can not make all the investments themselves (Interview: Green mayor, 2020; Interview: Nijestee, 2020). A solution that is offered by Gemeente Groningen is subsidies to procure green roofs as part of their stimulating role (Gemeente Groningen, 2020). However, Nijestee stated that they can not rely solely on subsidies for all the housing they built (Interview: Nijestee, 2020). Since the housing corporations possess many houses in the municipality it will definitely be worth it for Gemeente Groningen to include the housing sector within the financial plans.

Another financial hiccup is that many sectors for climate adaptation have their own financial sector and a calculated budget. The sector ‘heat’ does not (programmteam NAS, 2020). With sustainable innovations not being financially beneficial, there is no financial reason for market-reliant initiatives and organisations to make this investment (Interview: Nijestee, 2020; respondent Gemeente Groningen, 2020). But also Gemeente Groningen could reduce costs in different sectors when investing in the heat sector. An example is the sewage system. It is very expensive to renew or expand but with more heavy rainfall it is needed. Unless forces are joined. The respondent of Nijestee explained the possibility of a crates system on roofs which stores rain when there are heavy rain showers. This decreases the pressure on the sewage system. When the sewage system is ready, the crates slowly release the water they contain so the sewage system will not flood (Interview: Nijestee, 2020). The housing corporations can not make these investments by themselves. It would save the municipality money if they make this investment from (a part of) the calculated cost for the renewal of the sewage systems. This offers opportunities for both sectors if handled with the right communication and cooperation (programmteam NAS, 2020; Gemeente Groningen, 2019b; Interview: Nijestee, 2020; Interview: Green Mayor, 2020).

4.3.4 Reflective materials

It was explained by respondents that reflective materials do not reduce the urban heat as much as would be preferable. However, for rooftops where greenery is not possible due to ballast or the gradient, reflective materials are a better alternative than dark roofs. When using reflective materials on flat roofs it can also improve solar energy. When placing double-sided solar panels on the reflective roofs both the direct sunlight and the reflected sunlight will create energy to use (Interview: Green mayor, 2020).

5. Discussion

Due to the densely built area, the sustainable innovations that use already existing surfaces are exclusively researched. Sustainable innovation in this research was defined as ‘the innovation or solution for the problem is on environmental, social and economic aspects more beneficial (or less damaging) than the present situation’, where the resources that are used can be restored, will not run out or that the next generation does not have to live with the consequences of past generations (James, 2015; Davidson, 2020; Thornton et al., 2020; Kareem et al., 2020; Lind et al., 2020). Implementing green roofs, replacing pavement with greenery and vertical green systems are main examples that suffice to this definition.

The heat map showed that paved areas, mainly the city centre, and industrial sites are hot areas that can increase heat stress on people, materials and the economy. The implementation of greenery decreases the urban heat, increases peoples health, improves the economy through e.g. tourism and decreases excessive usage of resources (Davidson, 2020; Gemeente Groningen, 2020). However, the greenery is not always green. The flora that is most efficient in reducing urban heat in summertime, is bare and brown in wintertime but it will still have the desired effect.

The main findings of this research are the need for better and more specific cooperation between involved sectors and organisations, the several opportunities that can arise from properties spread throughout the city, and the financial obstacle. The cities hottest areas are paved areas and while initiatives already urge people to replace their tiles with plants, whole school areas and elderly homes could be replacing pavement for greenery. This way the most vulnerable groups to urban heat are directly influenced as well as the total reduction of urban heat in the municipality. The primary data showed that currently both involved sectors to change this are operating through regulations and not communicating directly. The people in charge of implementing sustainable innovations in Groningen is Gemeente Groningen. They decide on what regulations, policies and laws are active in Groningen and to whom they are relevant. In the interviews, both organisations seemed eager to cooperate, yet it is not happening up until now. To reach this valuable cooperation social innovation needs to be included when implementing sustainable innovations. There may be other obstacles blocking the implementation of sustainable innovations that are unknown in this research.

To increase cooperation, social innovation is important as well. Citizens need to know what they can do and the different sectors that can help need to be heard as well. During this research, the different interviewed respondents seemed interested in working with other sectors and making changes, yet there seemed no communication between the sectors directly.

6. Conclusion

To conclude, the most important measure to reduce urban heat in Groningen via sustainable innovations is to increase the cooperation between the involved sectors via social innovation; Gemeente Groningen, housing corporations, schools, property owners, tenants and simply the citizens of Groningen and using the policies implemented between 2020 and 2024 to reduce urban heat in Groningen via green roofs, vertical green systems, transforming pavement into greenery, increasing public greenery and reflective materials. The future spatial plans should then be to create a sector for urban heat in combination with the climate adaptation process which has its own reserved costs and different involved institutions in the decision-making board to reach the desirable cooperation. This sector should include plans such as depaving school playgrounds, implementing green roofs in cooperation with the housing corporations and the municipality, depaving public areas and connecting homes through green corridors supporting house owners to do the same.

Further research is needed to avoid gentrification. The greenery improves the quality of living and it should be prevented that this advantage will be exploited. To prevent the upper-income class from dominating neighbourhoods and creating neglected neighbourhoods, research on preventing this gentrification needs to be conducted.

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Appendix I - Consent form for the interview

Agreement to participate

in (bachelor) research project: Bachelor thesis

Title: The reduction of urban heat in Groningen.

This research studies how sustainable innovations can reduce urban heat in Groningen.

- I have read and I understand the information sheet of this present research project.
- I have had the opportunity to discuss this study. I am satisfied with the answers I have been given.
- I understand that taking part in this study is voluntary and that I have the right to withdraw from the study up to three weeks after the interview and to decline to answer any individual questions in the study.
- I understand that my participation in this study is confidential. Without my prior consent, no material, which could identify me, will be used in any reports generated from this study.
- I understand that this data may also be used in articles, book chapters, published and unpublished work and presentations.
- I understand that all information I provide will be kept confidentially either in a locked facility or as a password protected encrypted file on a password-protected computer.

Please circle YES or NO to each of the following:

I consent to my interview being audio-recorded YES / NO

I wish to remain anonymous for this research YES / NO

If YES

My first name can be used for this research YES / NO

OR

A pseudonym of my own choosing can be used in this research YES / NO

“I agree to participate in this individual interview and acknowledge receipt of a copy of this consent form and the research project information sheet.”

Signature of participant: _____ Date: _____

“I agree to abide by the conditions set out in the information sheet and I ensure no harm will be done to any participant during this research.”

Signature of researcher: _____ Date: _____

Appendix II - Interview with a climate adaptation policy officer of Gemeente Groningen

Thank you for taking the time to meet with me. Your answers will help me with my research for my bachelor thesis which tries to understand how urban heat in Groningen city can be reduced via sustainable innovations. To begin this interview you have given your consent that you agree to this interview and that you are aware that the interview is being recorded for i.a. transcription of the interview.

This interview will last approximately one hour.

Please note that you are welcome either to answer questions in this interview from your own individual perspective, or as a spokesperson for the Gemeente Groningen, but it will be helpful if you indicate for each answer which perspective you are speaking from.

Introduction (5 min) as well as thanking them for their time / ask about recording/explaining the structure of the interview / introducing myself and my research.

1. Can you tell a bit about yourself and your organization?
 - a. What is your function within your organization?
 - b. How is your organization structured in terms of sustainability? E.g. who are involved, what do they do and how are they connected to one another
2. To what extent is the reduction of urban heat an issue and what is its priority (to your organisation)?
 - a. What type of innovations have been used to reduce the process
 - b. In what way are you familiar with the problem?
 - c. In what way are you familiar with possible solutions?
3. What are the implementations and policy goals concerning sustainable innovations in Groningen that you are responsible for/that are important for your function?
4. How does the process of implementing climate adaptation, as far as you are involved, work?
 - a. Who determines what will be implemented and what will not?
 - b. Where do you search for best practices? Why there?
 - c. To what degree can you transfer policy and in what way would or have you done this?
 - d. What type of research do you, or other people do for you, in order to identify the effects of the implementation of such an innovation?
 - e. What does the evaluation of a sustainable policy look like?
 - f. What actors are involved in the policy process?
5. How is Gemeente Groningen trying to reduce urban heat in its city?

- a. What kind of policies are included for or in this problem?
- b. What kind of other organisations already help or want to help to address the issue?
- c. How could Gemeente Groningen increase their help? What kind of tools or forms of resources does Gemeente Groningen need?
6. How do policies influence sustainable innovation to reduce heat, in your experience?
 - a. How do policies benefit sustainable innovation to reduce urban heat?
 - b. How do policies restrict sustainable innovations to reduce urban heat?
 - c. What has been done so far to reduce urban heat?
 - d. To what extent do sustainable innovations influence the city and its citizens in e.g. social or cultural aspects?
 - e. What do you experience as restrictions on or of sustainable innovations and why?
7. To what extent can the process of implementing such policies and/or sustainable innovations to reduce urban heat be (negatively) influenced and by whom/what?
8. Do you want to add something concerning the interview?
9. Is there something else that you would like to mention (possibly off the record)?

Thanking the interviewee/asking if he/she would like to receive the final version of the thesis.

Note to self: After turning off the recorder ensure to also pause/ make a sentence of reflection to give them a chance, if they wish, to comment further. Although you may not be able to quote it in your research often people say very interesting things once the tape is turned off which can help with contributing to your wider understanding!

Appendix III - Interview with the real estate director of housing corporation Nijestee

Thank you for taking the time to meet with me. Your answers will help me with my research for my bachelor thesis which tries to understand how urban heat in Groningen city can be reduced via sustainable innovations. To begin this interview you have given your consent that you agree to this interview and that you are aware that the interview is being recorded for i.a. transcription of the interview.

This interview will last approximately one hour.

Please note that you are welcome either to answer questions in this interview from your own individual perspective, or as a spokesperson for the Gemeente Groningen, but it will be helpful if you indicate for each answer which perspective you are speaking from.

Introduction (5 min) as well as thanking them for their time / ask about recording/explaining the structure of the interview / introducing myself and my research.

1. Can you tell a bit about yourself and your organization?
 - a. What is your function within your organization?
 - b. How is your organization structured?
2. Can you tell a bit about the projects you are working on?
3. What are in your opinion the most important developments concerning housing in Groningen?
 - a. How does it relate to other developments in the city?
 - b. To what extent do renters get a say in the decision-making?
 - c. Does Nijestee feel connected socially and culturally to Groningen and if so, in what way?
4. What kind of measures is Nijestee taking in terms of sustainability?
 - a. What role does Nijestee play in sustainability?
 - b. What kind of goals does Nijestee have?
 - c. In what way has Nijestee been sustainable until now? Can you tell me about the 'restwarmte' project in 2010 with Gemeente Groningen
 - d. What would Nijestee need and from whom to become more sustainable?
 - e. What role does your organization play in the development of sustainable policies and in what way have or could Nijestee influence this?
 - f. What is the plan (with current policies and regulations) to include sustainability in the organisation?
5. How do you think urban heat can be reduced?

- a. In what way does Nijestee have experiences with urban heat? E.g. through complaints, own experience, damage to buildings, etc.
 - b. How are the responsibilities divided on this topic within the organisation?
 - c. In what way does Nijestee try to reduce urban heat?
6. What are, according to you, important factors to be able to focus on the subject of urban heat aside from the core of the organisation?
 - a. What other actors are, in your opinion, involved in this?
 - b. What are the important or difficult factors that have an influence on the organisation to take measures to reduce urban heat?
 7. Do you want to add something concerning the interview?
 8. Is there something else that you would like to mention (possibly off the record)?

Thanking the interviewee / asking if he/she would like to receive the final version of the thesis / contact me for further questions

Note to self: After turning off the recorder ensure to also pause/ make a sentence of reflection to give them a chance, if they wish, to comment further. Although you may not be able to quote it in your research often people say very interesting things once the tape is turned off which can help with contributing to your wider understanding!

Appendix IV - Interview with the green mayor of Groningen

Thank you for taking the time to meet with me. Your answers will help me with my research for my bachelor thesis which tries to understand how urban heat in Groningen city can be reduced via sustainable innovations. To begin this interview you have given your consent that you agree to this interview and that you are aware that the interview is being recorded for i.a. transcription of the interview.

This interview will last approximately one hour.

Please note that you are welcome either to answer questions in this interview from your own individual perspective, or as a spokesperson for the Gemeente Groningen, but it will be helpful if you indicate for each answer which perspective you are speaking from.

Introduction (5 min) as well as thanking them for their time / ask about recording/explaining the structure of the interview / introducing myself and my research.

1. Can you tell a bit about yourself?
 - a. You have just become the first 'Groene Burgemeester' of Groningen and the Netherlands, what does that entail?
 - b. I understand that you want to include citizens and use their knowledge as well, can you explain a little on how you want to do this?
 - c. To what extent do you think urban heat has become an issue to the city of Groningen?
 - d. How is your function/organization structured in terms of sustainability? E.g. who is involved, what do they do and how are they connected to one another
2. In what way are you involved in the development or implementation of sustainable innovations to reduce urban heat in the city of Groningen?
 - a. How are you connected to the organisation in terms of authority and implementation?
 - b. To what extent do you research or discuss sustainable innovations (on the reduction of urban heat)?
3. To what extent is the reduction of urban heat an issue and what is it's priority (to you)?
 - a. What type of innovations have been used to reduce the process of urban heat
 - b. In what way are you familiar with the problem?
 - c. In what way are you familiar with possible solutions?
4. What are the implementations and policy goals concerning sustainable innovations in Groningen that you are responsible for/that are important for your function?
5. What are the goals concerning sustainable innovations in Groningen that you are responsible for/that are important for your function?

6. What strategies do you plan on using to reach the goals based on urban heat that you have chosen to take on?
 - a. What kind of policies are included for or in this problem?
 - b. In what way do you feel responsible for a solution to reduce urban heat?
 - c. How could you increase your help? What kind of tools or forms of resources does Gemeente Groningen need?
7. To what extent do you analyse or use the best practices in other cities? Could you give an example(s)?
8. How do policies influence sustainable innovation, in your experience?
 - a. How do policies benefit sustainable innovation to reduce urban heat?
 - b. How do policies restrict sustainable innovations to reduce urban heat?
 - c. To what extent do sustainable innovations influence the city and its citizens in e.g. social or cultural aspects?
 - d. What do you experience as restrictions on or of sustainable innovations and why?
9. To what extent can the process of implementing such policies and/or sustainable innovations to reduce urban heat be (negatively) influenced and by whom/what?
10. Do you want to add something concerning the interview?
11. Is there something else that you would like to mention (possibly off the record)?

Thanking the interviewee/asking if he/she would like to receive the final version of the thesis.

Note to self: After turning off the recorder ensure to also pause/ make a sentence of reflection to give them a chance, if they wish, to comment further. Although you may not be able to quote it in your research often people say very interesting things once the tape is turned off which can help with contributing to your wider understanding!

Appendix V - Information given before the interviews

Hartelijk dank dat u meewerkt aan een interview voor mijn scriptie van de studie Spatial Planning and Design. In deze brief treft u alle informatie aan die nodig is voor het interview. Zoals het thema, de onderzoeksvraag, het doel van het interview en wat mijn bevindingen tot nu toe zijn. Ook treft u aan het einde een toestemmingsformulier aan dat ik graag ondertekend terug ontvang. Met dit formulier stemt u toe dat het interview mag worden opgenomen om een transcriptie te maken, u beaamt dat u zich ervan bewust bent dat u het interview op elk gewenst moment mag stoppen en dat ik alleen met uw toestemming directe quotes gebruik. Het transcript is alleen voor mijzelf en wordt niet toegevoegd in het document en wordt bewaard op een laptop vergrendeld met een wachtwoord.

In mijn scriptie onderzoek ik hoe de stedelijke hittestress kan worden verminderd door gebruik te maken van duurzame (groene) innovaties die op kleine en grote schaal gebruikt kunnen worden. Mijn onderzoeksvraag is: “hoe kan de stad Groningen zich aanpassen aan het probleem stedelijke hitte door gebruik te maken van duurzame innovaties?”. Belangrijke begrippen in mijn onderzoek zijn duurzaamheid, stedelijke hittestress en duurzame innovatie. In steden is een meestal een gebrek aan oppervlaktes omdat de stad voor een groot gedeelte al vol gebouwd is (verdichting). Daarom kijk ik vooral naar oplossingen die in de hoogte gaan en gebruik maken van al bestaande gebouwen. Voorbeelden daarvan zijn ‘vertical green systems’ waarbij planten worden gebruikt om de hitte te absorberen en koelte af te geven. Dit kunnen planten zijn zoals klimop. Een ander voorbeeld zijn groene daken. Het voordeel van deze innovaties is dat er gebruik wordt gemaakt van bestaande gebouwen en dat de planten ook de donkere, hitte-absorberende materialen afschermen van de zon wat zorgt voor een vermindering van hittestress. Als oplossing voor daken waar groen niet op kan groeien wegens bijvoorbeeld een te grote helling was het idee om reflecterende (witte) verf te gebruiken om zo te zorgen dat de daken niet de hitte opnemen maar terug reflecteren in de lucht waardoor er minder stedelijke hittestress is. Mijn onderzoek gaat nu vooral door op wat er nodig is om dit te kunnen implementeren en wat (bekende) voordelen maar ook nadelen zijn van wetgeving en beleid dat hierop van toepassing is. Mijn idee is om te kijken wat er nodig is, voor wie, hoe een eigenaar en/of bewoner (huurder) hulp kan krijgen en zelf meehelpen. Daarbij kijk ik naar Gemeente Groningen, Peter Bootsma de eerste en enige groene burgemeester van Nederland en woningcorporatie Nijestee om te onderzoeken wat er nodig is, maar ook wat er (mogelijk in samenwerking) gecreëerd zou kunnen worden om te zorgen dat deze duurzame oplossingen daadwerkelijk geïmplementeerd kunnen worden. Daarover ga ik u interviewen. Ik heb de vragen al uitgewerkt en deze als bijlage toegevoegd zodat u weet welke vragen ik ga stellen. Alvast heel veel dank voor uw hulp bij mijn onderzoek en tot 2 november.

Appendix VI - Inferential coding

For both the primary data and the secondary data the same classification was used. The subjects within the data were divided into 8 groups. The groups were based on the subquestions of the research in order to make a clear overview of the data to analyse it. Each group then got their own colour and all the text in the data was colour coded. After the data was colour coded, all the text with the same colour was analysed and compared. The 8 groups of subjects were as followed:

1. The meaning of sustainable innovations;
2. Sustainable innovations that can reduce urban heat;
3. People in charge of implementing sustainable innovations in the city of Groningen;
4. Policies in Groningen on temperature rise and urban heat reduction;
5. Climate adaptation measures that already have been taken in Groningen to reduce urban heat;
6. Hot sites in the research areas;
7. Additional measures that can be taken and by whom;
8. Remaining information (in Dutch: ruis).

During the colour coding, the first two groups were coded in the same colour because the data for both groups were entangled together. The first two groups were colour coded green. The third group was colour coded blue. The fourth group was colour coded red and the fifth group orange. For the fourth and fifth group, these colours were used because the subjects were closely aligned but for the data analysis, it was important to make a distinction between the two groups. The sixth group was colour coded yellow. The seventh was colour coded pink. The last group was colour coded black. This was to make the remaining information less striking.

The fourth group was divided into subgroups for primary and secondary data analysis. The subjects of the subgroups were divided into current policies, yet to be implemented policies or in the process of implementation (including the plans that will be implemented in 2020-2024 connected to climate adaptation and urban heat). The subgroups were labelled by names instead of colour coded. The names were 'current', 'yet to be' and 'in process'. For the secondary, there were two more groups; financial information and information about the cooperation. These groups were called 'financial' and 'cooperation'.