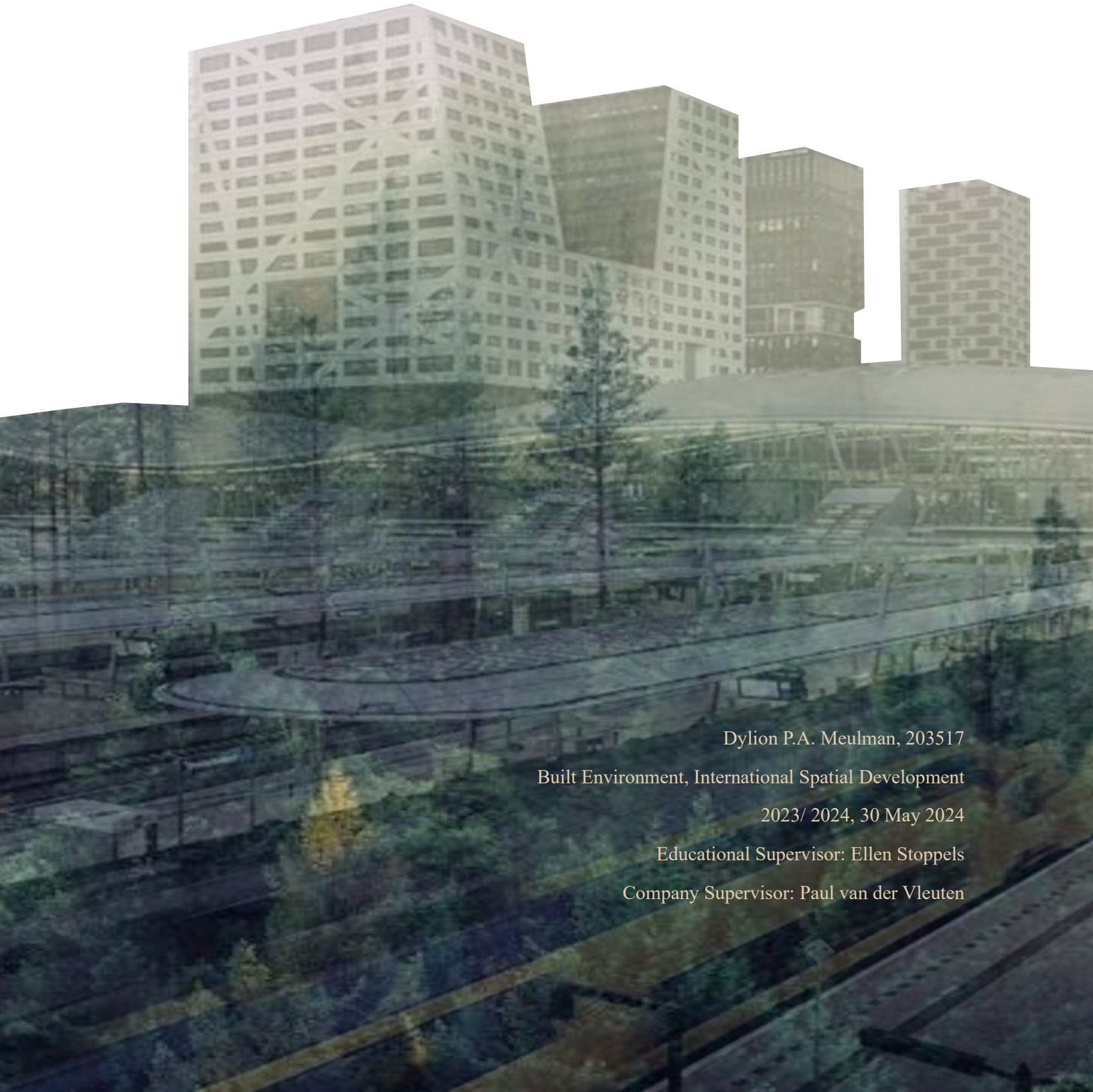
CLIMATE ADAPTATION AT THE STATION DISTRICT OF UTRECHT

AN INTEGRATED ANALYSIS OF CLIMATE ADAPTATION STRATEGIES WITHIN HIGHLY URBANIZED AREAS



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PREFACE

During my bachelor's in Built Environment, International Spatial Development, I learned to research various concepts within the urban environment. As a student with a keen interest in sustainable development, I became intrigued by the subject and curious about its future transformations. This curiosity led me to write my thesis on climate adaptation at LBP|Sight. Through different application methods, I joined the department of planning and permits. Together with Paul van der Vleuten, I decided to research the future of climate adaptation in urban developments.

I would like to thank my supervisors, Paul van der Vleuten and Ellen Stoppels, for their invaluable help and expertise during my research. Additionally, I extend my gratitude to the planning and permits team for their collaboration and support, with special thanks to Hans Geleijns for providing access to his network.

Nieuwegein, 30 May 2024

ABSTRACT & KEYWORDS

Climate change is getting worse, making climate adaptation more prevalent in urban developments. However, this underdeveloped concept is not yet fully integrated into urban development practices. This is an extended problem in densely urban areas where space is scarce. This literature and qualitative research deemed to find answers for the development of climate adaptation through the investigation of stakeholders, and the implementation of measures. It found that the municipality currently has qualitative legislation, by clarifying this legislation and facilitating climate adaptive measures on their own territory. Vegetation would be posed to have the highest impact, especially when considering the combination of functions, it poses. An environmental program could enhance this process of implementation by giving an exact plan of implementation.

Key words:

Climate Adaptation, Environmental Act, highly urbanized developments

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LIST OF ABREVIATIONS

AI	Artificial Intelligence
Bbl	Bestluit bouwwerken leefomgeving [Constructions Work Decree]
Bkl	Besluit kwaliteit leefomgeving [Decree on Environmental Quality]
CUHI	Canopy Urban Heat Island
DPRA	Deltaprogramma Ruimtelijke Adaptatie [Delta Plan Spatial Adaptation]
HDSR	Hoogheemraadschap Stichtse Rijnlanden [Water Board of Stichtse Rijnlanden]
HvA	Hogeschool van Amsterdam [Amsterdam University of Applied Sciences]
MER	Milieu Effect Reportage [environmental Impact Report
NAS	Nationale Adaptatie Strategie [National Climate Adaptation Strategy].
Ow	Omgevingswet [Environmental Act]
PET	Physiological Equivalent temperature
RSU2040	Ruimtelijke Strategie Utrecht 2040 [spatial strategy Utrecht 2040]
SECAP	Sustainable Energy and Climate Action Plan
SUHI	Surface Urban Heat Island
TKS	Toolbox Klimaatbestendige Stad [Toolbox Climate-proof City]
UHI	Urban Heat Island

1 INTRODUCTION

1.1 ORIENTATION & CONTEXT

Climate Change is one of the most impactful challenges of current times (Balaban, 2012). The definition of climate change is the shift of average climate conditions on earth to increased average temperatures within the atmosphere (Deri & Alam, 2008; IPCC, 2007; Bulkeley & Betsill, 2013). This results in extremer weather conditions, particularly when comparing summer with winter (Dorenbosch et al., 2022). Natural phenomena such as solar radiation and volcanic activity are causing changes in climate. Still, human activity is primarily linked to the current acceleration of climate change (IPPC, 2007; Deri & Alam, 2008; Dankers & Feyen, 2009; Bulkeley & Betsill, 2013). The industrial revolution was a watershed moment in the history of human-caused climate change. Following that there was a significant increase in fossil fuel usage and ecological damage (Costello et al., 2009). In recent times, temperature records have been consistently surpassed. The year 2023 was claimed to be the warmest ever measured, and February 2024 witnessed the warmest temperatures ever recorded for that month. (RTL Nieuws, 2024; Schuttenhelm, 2024). Furthermore, extreme weather-related damages reached a record peak in 2022, with total insurance inquiries surpassing 886 million euros (Ekker, 2023; Albers et al., 2015). Climate change not only affects materials, yet it may also have a negative impact on people their health and well-being, such as heat waves (Albers et al., 2015). Thus, dealing with climate change has grown to be an issue that has impacts on multiple fields on society and environment.

Whether or not comprehensive mitigation strategies are implemented, human activity will always contribute to climate change (Adger et al., 2003; IPPC, 2007; Klein et al., 2007). As a result, it is crucial to recognise adaptation strategies as well. Climate adaptation in this case refers to the modifications made to the environment in reaction to anticipated changes in the climate and its consequences, whereas mitigation measures involve lowering the number of emissions emitted into the atmosphere (Oppenheimer & Anttila-Hughes, 2016; Pasimeni et al., 2019).

Urban Environments are particularly vulnerable to climate change, suffering from increased heat, droughts, Heavy rainfalls, and floodings (Revi et al, 2014; Rosenzweig et al., 2011; Bulkeley & Betsill, 2013; Municipality of Amsterdam, 2020). Metropolises are especially vulnerable because of the high concentration of people residing in the same region, combined with the prevalence of unnatural materials, which exacerbate the effects of climate change. (Berdahl & Bretz, 1997). The problem of climate change within the city is expected to rise since urbanization is occurring. It is prognosed that 70% of the national population growth in the Netherlands is focused in its largest municipalities. This level of urbanization is no different in Utrecht with an expected growth of over 26% in 2035 from 2021 (CBS, 2022). The renovation of the Utrecht Station area reflects these trends, altering a densely populated location with minimal vital city space (De Wijs et al., 2016). Consequently, implementing climate adaptation strategies in crowded, constrained neighbourhoods—which are already more vulnerable to climate change—may be challenging.

1.1.1 Station District

Within the centre of the city, Bertolini & Spit (2005) indicated a high degree of priority for redevelopment of the central station according to European policy. This is owing to the station being the largest and most busy within the Netherlands. Once renovations were finished in 2016, multiple means of travel were brought together under a single roof (Benthem Crouwel Architects, 2020). On an average workday in 2022, more than 144,000 people entered and exited the station, with numbers likely to increase in the coming years (NS, n.d; Benthem Crouwel Architects, 2020). These figures indicate that the station district is seen as the city's gateway point,

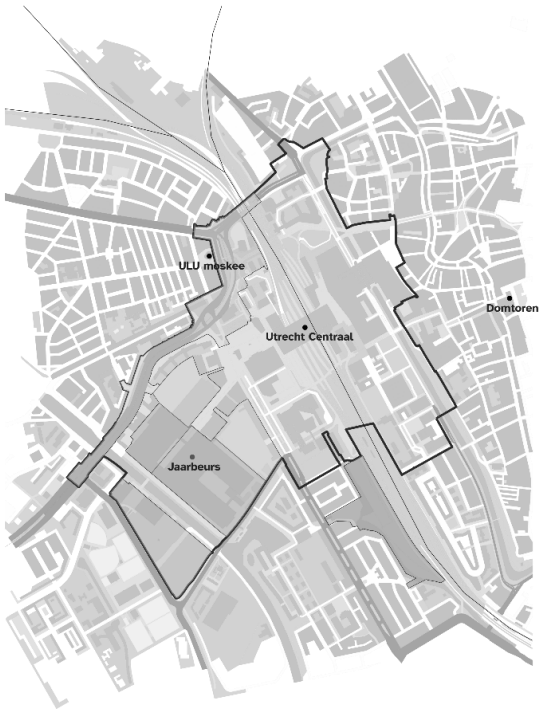

Figure 1: Study area of the research opposed, being the station district of Utrecht (CU2030, n.d.a.)

concentrating many visitors to Utrecht. For this reason, it was crucial that the station its rehabilitation took its surroundings into factor (Zemp et al., 2011; NS, n.d.). The district's redevelopment was expected to be mostly finished in 2020 under the title "CU2030" shown in *figure 1* (Zwiers, 2015). The station district nowadays encounters a broad range of 27 completed and ongoing projects, including the new city hall and mixed-use complexes (Buijze, 2013; Conceição, 2015). Adjacent to this, the Hoog Catharijne mall underwent renovations, and the neighbourhood saw the addition of several cultural hubs, including a music hall and a library (Conceição, 2015).

1.1.2 Environmental Act

The "Environmental Act" [Omgevingswet, Ow] was adopted on January 1, 2024, marking a substantial change in the Dutch environmental planning regulations (Schultz van Haegen-Maas Geesteranus, 2011; Aan de slag met de omgevingswet, n.d). The aim of the act is to allow more flexibility within spatial planning and to better align plans with each other. It is intended to give municipalities more flexibility in decision-making to have more alignment with their own objectives. Standards are therefore more abstract on the national level to create room for decentralized governmental bodies (Dembski et al, 2014). Nonetheless, there are concerns regarding the new environmental act its ambiguity and lack of guarantees. The "Federation of Spatial Quality" [Federatie Ruimtelijke Kwaliteit] expressed reservations about the probable effectiveness of the proposed procedures. The current framework acknowledges positive aspects such as integrated approaches, citizen participation, and municipal leadership. However, the federation argues that it lacks specificity and does not provide concrete guarantees to support the law's goals (Ten Cate, 2018). This would mean that it could exacerbate precarious conditions for relevant parties.

1.2 RESEARCH GAP

As previously stated, the repercussions of climate change, which include heatwaves, droughts, excessive precipitation, and flooding, are becoming more visible while causing difficulties in metropolitan areas. Adaptation measures may assist in reducing consequences of climate change and create more livable settings. However, because climate adaptation techniques are still being developed in the Netherlands, it is unclear how they will be proposed. This, together with the changes and disparities in the recently passed environmental act, makes climate adaptation prospects difficult to anticipate.

The objective of this study is therefore to evaluate how climate adaptation measures are created and implemented in urban settings, with a focus on the station district of Utrecht. This involves looking into the influence of legislative instruments such as the Environmental Act, as well as the involvement of numerous stakeholders in urging effective adaptation strategies. Furthermore, the study will assess which existing and proposed solutions contribute to the area's climate. The study's findings will help to improve urban climate adaptation

management. Flooding adaptation procedures are not included in this study since this is not a major issue in the station district and are usually addressed on a regional basis.

The objective will be investigated based on the following research model [figure 2] and questions mentioned below:

Main Research Question:

"How do policy instruments and stakeholder involvement play a role in developing and implementing climate adaptation strategies in the Utrecht station district?"

Research Questions:

1. What are present and anticipated climatic conditions within the Station District?
2. How do policy instruments and stakeholders impact climate adaptation?
3. How could various physical climate adaptation approaches be evaluated and monitored to improve the circumstances in the station district?
4. What potential significance could the study have for the global south?

1.3 READING GUIDE

This report is divided into nine chapters. Chapter 2 contains the Theoretical Framework containing the concepts of climate change and its effects, adaptation strategies, and the theories behind the environmental act. Chapter 3 will discuss the methods, elaborating on the research strategy and data collection. Chapter 4 investigates the climatic conditions of the station district, finding the major issues within the district. Chapter 5 discusses the environmental act and which implications it has on climate adaptation. Furthermore, will it analyse the different stakeholders based on power and interest. Chapter 6 regards the different measures that could be opposed and how stakeholders evaluate and monitor such measures, also discussing

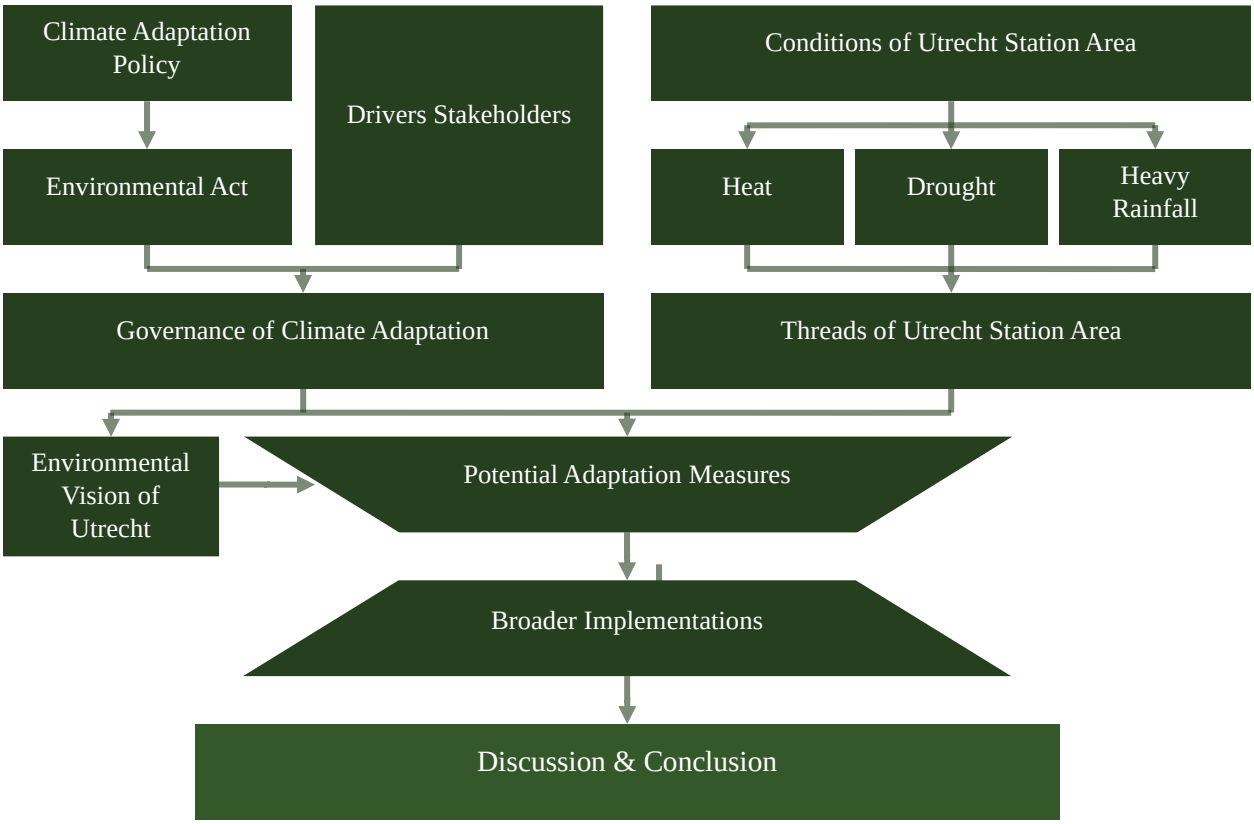

Figure 2: The research model of the study

toolboxes that could help with climate adaptation governance. Chapter 7 discusses the main findings and looks at how this could be adapted to the global south. Chapter 8 combines the theoretical framework and the other chapters, showing how the theory is connected to practice. Chapter 9 is the last chapter that would answer the main research question through the conclusion, while giving recommendations for future research.

2 THEORATICAL FRAMEWORK

The theoretical framework will dive into notions about climate change and adaptation in urban environments. In contrast, the principles underpinning the environmental act would be investigated, highlighting the different implications that the Ow as framework legislation has on urban development and environmentally conscious practices.

2.1 CLIMATE EFFECTS AND ADAPTATION

As pointed out in the introduction, cities are particularly vulnerable to climate change impacts being heat, droughts, and waterlogging. This section will investigate the fundamental causes and implications of these phenomena.

2.1.1 Climate Effects in Urban Environments

Heat

Extreme heat events are becoming more common in metropolitan areas, posing significant concerns. Climate change exacerbates this trend (Santamouris, 2014b). This phenomenon could also be referred to as the Urban Heat Island [UHI], referring to the temperature disparity in comparison to its rural counterparts (Oke, 1982; Oke, 1997; Van Hove et al., 2011; Santamouris, 2018; Sultana & Satyanarayana, 2020). The UHI could be separated into two distinct types being surface and atmospheric UHI (Akbari et al., 2008; Van Hove et al., 2011).

Surface Urban Heat islands [SUHI] exist within materials heating up structures in urban environments. SUHI exist at ground level heating up structures within urban environments (Yuan & Bauer, 2007; Van Hove et al., 2011). Urban surfaces like pavements and roofs are causing SUHI due to radiation of the sun raising the temperature up to 50°C in comparison to ambient air temperature (Berdahl & Bretz, 1997). Dark objects, including asphalt and concrete, absorb more heat than light-coloured objects. This is caused by the degree of reflection, known as the albedo effect; a lower albedo indicates higher temperatures (Solecki et al, 2005; Icaza et al., 2016). Materials that increase heat in street canyons usually have low albedos and high heat radiation, like glass, concrete, and bricks. Natural or light materials with high albedos and low heat radiation, such as wood and light high-pressure laminate, are better for urban temperatures (Stache et al., 2022).

Atmospheric Urban heat islands on the other hand, refers to the air temperature. The most common term used for this is the canopy urban heat islands [CUHI], which are found between trees, structures, and ground level (Yuan & Bauer, 2007; Van Hove et al., 2011). CUHI is weaker in the mornings, while it starts radiating after sunset due to the gradual release of thermal energy from urban infrastructure (Akbari et al., 2008). CUHI is indirectly impacted by SUHI, however, do ambient temperatures having less fluctuations than surface temperatures (Akbari et al., 2008). *Figure 3* illustrates the relationship between CUHI and SUHI and shows that the highest surface temperatures are found in heavily urbanised areas, increasing the temperatures at night.

The typical exclusion of plants could be a problem within the urban environment. Plants can reduce the heat radiation since plants, although opposing a lower albedo, still do not increase in heat as much as other materials. This is because vegetation uses part of solar radiation for photosynthesis [related to SUHI]. In addition, is evapotranspiration another principle that could decrease temperatures (Qui et al., 2013). Evapotranspiration is the process by which water is transferred from the surface to the atmosphere, transforming from liquid to vapour (Wang & Dickinson, 2012; Brolsma, 2022a). This evapotranspiration process consumes more energy in the air, which is then not available for heating [related to CUHI] (Kluck et al., 2020a). Greener and bluer environments lead to increased

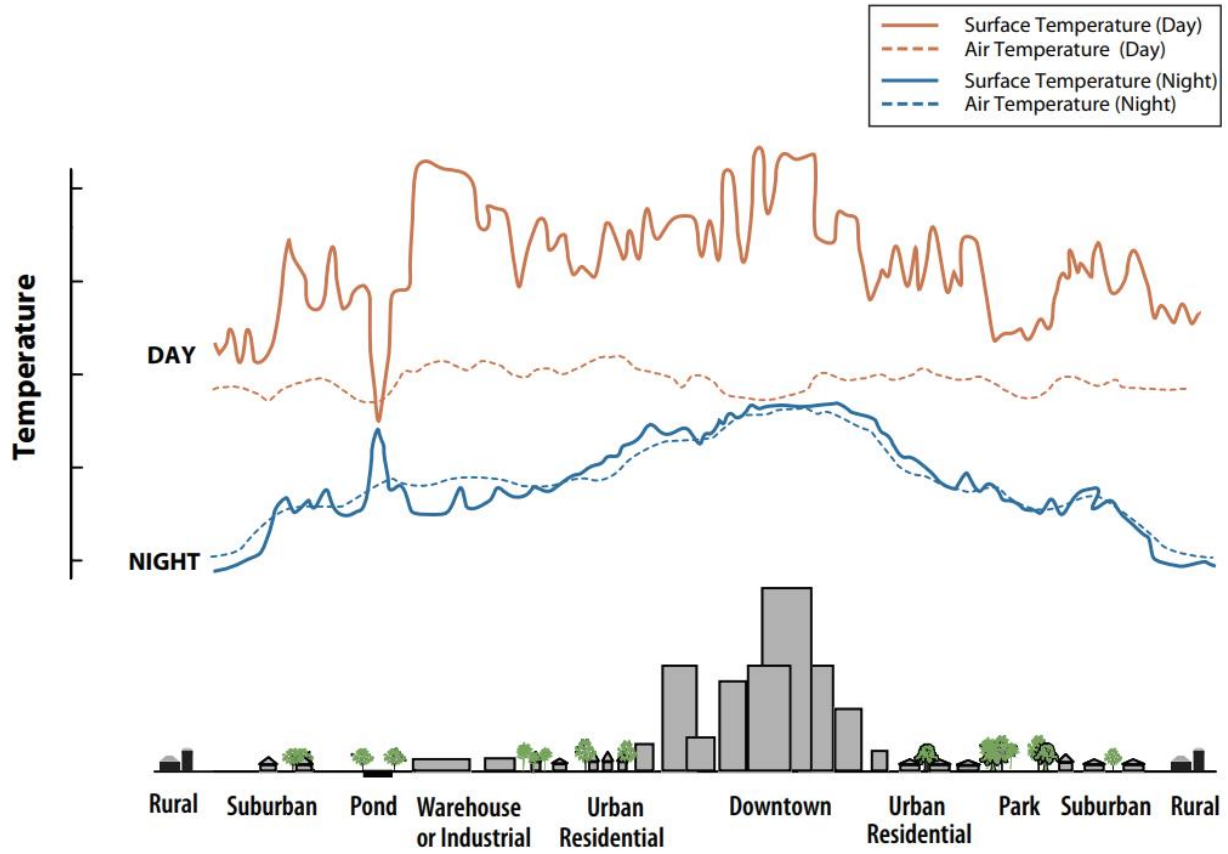

Figure 3: Difference between Atmospheric and Surface UHI adjusted from Voogt (2000) (Akbari et al., 2008).

evaporation and cooling (Brolsma, 2022a). Vegetation, therefore, could reduce both types of UHI.

There is also another method of measuring heat stress, being the Physiological Equivalent temperature [PET]. This indicates the human experience of temperature, that is not only dependent on-air temperatures. It includes factors that could increase heat release of human bodies, such as wind, speed and air humidity, and heat radiation (Höppe, 1999). In the Netherlands the PET is one of the main forms of heat stress according to Koopman et al. (2020). The CUHI has direct impact on the PET while SUHI has indirect effects on the PET, only having effect when heat radiates into the air.

Waterlogging due to Precipitation

Extreme rainfall episodes are becoming more prevalent, rising by up to 50%; this might lead to increased waterlogging events due to the large quantities in a short period. (Le Page, 2023). Factors of waterlogging the factors that contribute to the occurrence of water overflow are numerous. According to Hoes (2007), the following factors have an impact on overstaying: precipitation; Land use and landscape characteristics; and geology. There are various sub-factors under the heading "land use and soil characteristics". Central is the soil's infiltration capability. Land usage is related to petrification and consequently runoff. Given the extent of petrification in the urban region, this might have a big impact. However, the soil type also has an impact; for example, clay-based soil is less permeable than sandier soil. Landscape design can thus have an impact on a local level (Smits et al., 2004) therefore, the primary distinction between rural and urban settings is that metropolitan areas are far more densely built and

have less surface water. Infiltration capacity is predicted to have a much larger impact in urban than rural settings (Hunt & Watkiss, 2007; Satterthwaite et al., 2007; Wilby, 2007). According to Smits et al. (2004), extreme precipitation occurs primarily during the summer months, making the measures most important in that season.

Drought

There are four different categories of drought: hydrological, agricultural, socioeconomic, and meteorological. In terms of precipitation, groundwater, crops, and urban life, each one denotes a brief scarcity of water (Wilhite & Clantz, 1985; Wilhite, 2000). Urban drought is closely related to socio-economic both indicating a sudden decrease in water supply while the demand is increased (Zhang et al., 2019). Economic losses could be mainly found underground when also having reduced groundwater levels. Soil settlement, peat oxidation, and clay contraction could occur when soil is dry. These occurrences have the potential to cause subsidence, heightened flood threat, groundwater complications, as well as structural and damage to infrastructure (STOWA, 2022). In addition, could the pile foundations be exposed to arid conditions. Even if the exposure is brief, it reduces the circulation of oxygen and eventually leads to bacterial infestation. After ten to twenty years of accumulated dryness, degradation may proceed quickly, putting the foundation's integrity at risk (Kok, 2021). Dryness mainly has economic downsides to it.

2.1.2 Adaptation Strategies

As previously stated, climate change increases vulnerability to adverse weather conditions (Revi et al, 2014; Rosenzweig et al., 2011; Bulkeley & Betsill, 2013; Municipality of Amsterdam, 2020; Brinkmann et al., 2010). This is not possible to only tackle when using “mitigation strategies” (Adger et al., 2003; IPPC, 2007; Klein et al., 2007; Stocker et al., 2013; UNEP 2021). The Definition of mitigations strategies is the reduction in the number of emissions released into the atmosphere, In CO2 gasses and the enhancement of green areas is seen as crucial in the fight against climate change (Oppenheimer & Anttila-Hughes, 2016; Zhang & Ayubb, 2021; UN, 2021). Adaptation strategies are complementary to the mitigation strategies, addressing current and future impacts of climate change (Pasimeni et al., 2019; Adger et al., 2003; IPPC, 2007; Klein et al., 2007; Stocker et al., 2013). The Intergovernmental on Climate Change [IPCC] (Pasimeni et al.,2019) specifies methods for adaptation as:

> *Adjustments in natural or human systems in response to actual or expected climate and its effects.*

Thus, climate adaptation tries to reduce the effects of climate change while adaptation tries to adjust to the changing climate conditions. Despite the disparities amongst the two methods, it is difficult to show an obvious division between both, in some cases adaptation also poses mitigation and vice versa (Pasimeni et al.,2019).

Climate Adaptation is deemed to be a difficult topic. First there is the high unpredictability of climate chance, making it difficult to attach significance to it (Foster et al., 2011). This would imply that measures could be unnecessary. On the other hand, strategies have proven challenging to execute in metropolitan locations for governments due to its scarce space and high level of vulnerability (pasimeni et al., 2019). That is why a three-step plan has been introduced to maximize the approach against climate change. three crucial measures to take when improving sustainability within cities. The first step is to undertake a baseline inventory, which examines the current state of the environment and identifies areas for improvement. In addition, governments would develop a Sustainable Energy and Climate Action Plan [SECAP] outlining short-, medium-, and long-term solutions to climate obstacles. Finally, governing bodies are expected to monitor the SECAP using the "learning by doing" strategy, which allows cities to learn from previous experiences

regarding the effects of climate change (Pasimeni et al., 2019; Andreanidou et al., 2018).

2.1.3 Socio-Technological Transitions

New concepts have barriers to popularity due to existing regulations, infrastructure, user practices, and maintenance networks. This can commonly encounter a mismatch with the current socio-institutional framework (Freeman and Perez, 1988). Similar may also be true for climate adaptation, which has historically been difficult to forecast. However, as the effects of climate change become more widely recognised, things are altering. Such development could be categorised as socio-technological transformations. This process has three steps, with an extinct hierarchy depicted on the left of *figure 4* (Geels, 2002).

Niches are the lowest level; they are shielded from bigger market influences and serve as growth areas for radical and unpredictable advances (Schot, 1998). Niches must be established independently of the market since the performance level is relatively low while the cost can be quite substantial. Such characteristics emerge as part of the process itself. When the arrows in *figure 4* get thicker, the process of innovation decreases, eventually reaching regime level. This level encompasses additional minor improvements to design. Furthermore, complimentary elements appear, such as policy. When these components become more and more integrated into the system, a technology may reach the landscape level. A socio-technical landscape can be defined by its profound structural patterns, which are incorporated into society. The causes are subsequently linked to configurations of space (Geels, 2002). This process, then, is the transition from small-scale ideas to notions implemented into cities as well as politics.

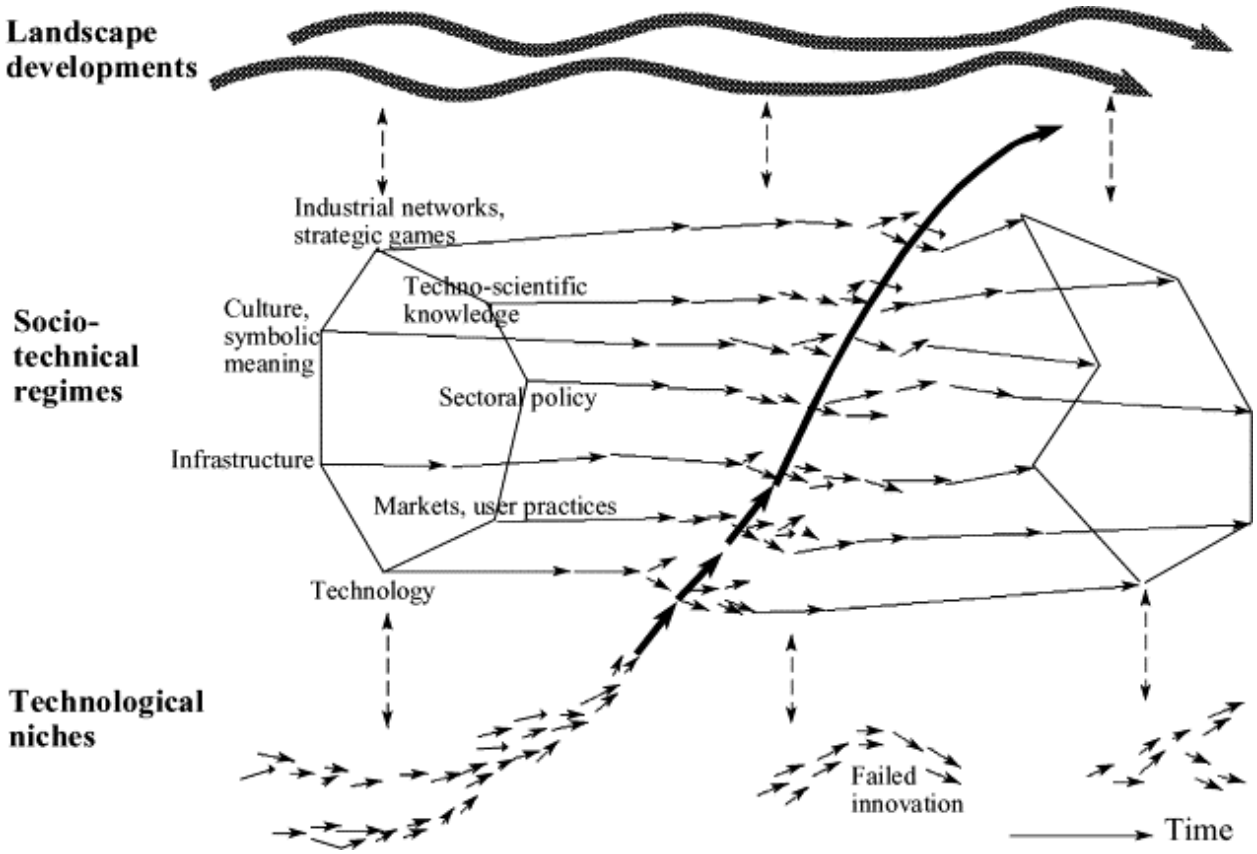

Figure 4: Socio-technological transitions and its imposed hierarchy, through a multi-level perspective (Geels, 2002).

2.2 FRAMEWORK LEGISLATION

The Environmental Act could be referred to as "kaderwet" [Framework Legislation]. This principle is based on broad initiatives from national and regional authorities, while it is primarily created at the local level (Wensink, 2018; Van Gestel & Vleugel, 2013). According to Hoekema & van Manen (1994), the broader policies consist of few substantive standards. Furthermore, the aim to combine present regulations and rules appears to be considered an essential element of the framework (Van Gestel & Vleugel, 2013).

2.2.1 Decentralization

Decentralization is one of the main concepts of framework legislation, enhancing local authority through the shift from national to locally elected bodies of authority. The process which takes place to achieve decentralisation is called deconcentration (Burki et al., 1999; Hennekens et al., 1995; De Roo, 2004). Still, is expected that the deconcentrated authorities are still components of a "unitary state" (hennekens et al., 1995). Decentralisation may also result in greater responsibilities for the private sector, leading to privatisation alongside deconcentration (Black, 1997).

Decentralisation motivations may be divided into two categories: democratic and functional. Decentralisation attempts to solve or minimize inefficiencies, enabling for more reflective reactions per case (Oosting, 1984a; Fleurke et al., 1997). The capacity of working would be optimized while it tries to ensure effective task completion (Oosting, 1984a). Decentralisation, from a democratic standpoint, may allow for more social effect while lowering the scope of power, allowing for greater public engagement in decision-making (Oosting, 1984b; Fleurke et al., 1997). In settings as in the Netherlands, this approach may tackle local and regional issues in such a way that it is more straightforward, potentially lowering inequalities within the population (De Roo, 2004; Oosting, 1984a). therefore, decentralization may look at more human concentrated and suitable for its situation solutions.

Nevertheless, decentralised systems may provide obstacles, notably in terms of decision-making efficiency, which may limit productivity (Marlet & Poort, 2003; Burki et al., 1999). National governments typically have more resources and a higher degree of expertise than local counterparts. Additionally, do national governments have more significant financial assets and lower levels of dept (Marlet & Poort, 2003). This may lead to difficulties reaching a desired outcome.

2.2.2 Complexity Theory

Dealing with complexity is an important component of urban planning decision-making, and deciding on an appropriate choice is equivalent to determining the right path to follow (Faludi, 1998). Expertise is important in decision-making due to the amount of available data, as well as its trustworthiness and objectivity (Martens & Van Weelden, 2013). Next to this should According to Zuidema (2016) and De Roo (2004) indicate that the level of decentralization during planning varies, according to the complexity of the matter. As more stakeholders are involved, the level of complexity increases. Decentralised governance is a superior approach for handling complex issues since it uses a reasonable inclusive approach of communication (De Roo, 2004). This opens the door to a bottom-up policy approach, which allows for the consideration of various interests and may result in a better, while being time-consuming, resolution (Irvin & Stansbury, 2004). Using a plausible method, less complex issues could be resolved centrally and more universally (De Roo, 1999; De Roo, 2004). De Roo (2004) translated the required level on decentralisation through a decision-making model shown in *figure 5*. The following questions should be asked per axis:

1. What should be accomplished? [vertical]
2. Who is at stake? [horizontal]

3. How will this be accomplished?
   [diagonal]

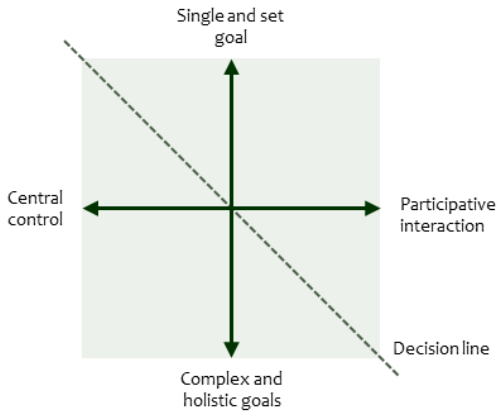

Figure 5: De Roo (2004) decision-making model for the degree of decentralisation.

Decision-making is meant to be related to technical and interactive reasoning. The decision-making model includes an authoritarian justification in the left column and an interactive justification in the right column (De Roo, 2004).

Disregarding its level, complexity can be separated into technical and social complexity. Baccarini (1996) defines technical complexity as a combination of two components: differentiation and dependency. Differentiation implies variability in the number of actions that must be taken, and the level of competence needed at each stage. Interdependence refers to the connectivity and mutual reliance of multiple project parts, such as process phases, expert teams, and the technology used (Baccarini, 1996). In essence, differentiation underlines the level of complexity inherent in a project's numerous tasks and components, whereas interdependence emphasizes the deep relationships and interactions between these activities and components. Next to this, social complexity significantly influences decision-making processes. This complexity arises from the variety of stakeholders, each bringing a wide range of expectations and opinions. Long-term planning could particularly benefit from considering the dynamics of stakeholders' experiences and personalities. Furthermore, the desires of those involved may evolve during the process, adding a layer of complexity to reaching a consensus (Conklin, 2006).

2.2.3 Governance

In the last century, governance was viewed simply as a process executed by the government or government-related enterprises. However, in the late twentieth century, this viewpoint began to shift substantially (Rydin, 2010). According to Rhodes (1997), the new governance model considers a broader range of participants and employs a network-based policy framework. Because the creation and implementation are not limited to governmental agencies. Furthermore, the change is characterised by citizens and civil society groups actively influencing policy rather than simply participating in elections.

The term 'governance' nowadays refers to systems that produce, deliver, and legitimise public policy via networks of many stakeholders. These networks offer new forms of legitimacy, access to resources, and novel dispute resolution techniques. Stone (1989) contended that the development of governance models was a direct response to traditional government institutions' incapacity to handle policy issues. While governance has increased the state's power to interfere, it does so indirectly, allowing for action on public problems outside of traditional state institutions. This increased involvement is critical for achieving public policy goals, and it represents a fundamental shift away from the hierarchical, government-dominated systems of the past and towards more inclusive and flexible systems of governance of today (Rydin 2010).

According to Bulkeley and Kern (2006), there are numerous forms of governance in the field of sustainability, reflecting the "ways of steering". They identified the following four distinct frameworks of governance [by public entities]:

Self-Governance	Setting an example by themselves through the exploitation of sustainable initiatives within its own activities [such as buildings].

By provision	Implementing numerous infrastructural and service-related activities themselves to promote sustainability in the environment.
By Regulating	Enforce sustainable ideals in the environment through regulations.
By Enabling	Champagning and guiding the sustainable principles. This is for example through a subsidy.

3 METHODS

To generate answers to the research gap presented in the introduction, a shift from theory to practice is necessary. This chapter will cover over the factors employed in the practical component of the research questions in this study. The research strategy is described in Section 3.1. This section will cover the study's key considerations. Section 3.2 outlines how the data was acquired and how it helped to answer the study questions.

Within the study, ai has been conducted to orientate on topics as virtual assistance and the improvement of text by adjusting the written sentences. The policy of the Buas could not be found thus will it use the policy of Wageningen University of Applied sciences stating the following (WUR Student Support, 2024):

you may use AI only to support essential academic skills like critical reflection, literature research, and scientific writing, not to replace those skills.

3.1 RESEARCH STRATEGY

The research strategy will outline the primary considerations of the case study, including case selection, legislative approach, and interviewing methods.

3.1.1 Case Study

A comprehensive understanding of a topics background and the needed procedures for application could be effectively researched through a case study (Saunders et al., 2012). This is also the case for this research, demonstrating the different implications that climate adaptation may bring, while offering a scope to the number of [external] elements to consider. In addition, could this also give guidance to the interviews, having the opportunity to provide concrete examples.

For the case selection different criteria were considered. With as first criteria, that it would has to be an area where climate adaptation is of high significance. Highly urbanised areas were the result, opposing high rates of vulnerability to the impacts of climate change while providing little opportunities to deploy measures. Furthermore, it was deemed vital that LBP|Sight had developed and would develop in the area, hence improving the study's value to the company and providing connections for potential interviewees. A development also increases its prominence on stakeholders' agendas, making it easier to recall within interviews. From this point forward, old city centres were no longer considered, mostly because the company does not develop in such locations. From this point the choice was between the Zuidas in Amsterdam and the station district in Utrecht. Utrecht was chosen owing to its vulnerability to climate change and the company's involvement with various initiatives there. Furthermore, the district is partially developed, presenting a variety of conditions, allowing for contrasts between existing areas and future development plans. This also presents challenges, having a significantly wider application for the study.

3.1.2 legislation

Legislation of urban development could pose the most concrete changes within the environment, being main drivers for the increase of. With the new Ow in place since the beginning of 2024, the uncertainty over its implications of area development has intensified. Considering other issues such as economic, it would probably resort back to legislative aspects to seek laws that would mandate climate adaption. So, given the significant shift and importance of legislation for climate adaptation, it would be the most plausible study route.

3.1.3 Qualitative Research

The study relies significantly on semi-structured interviews. This qualitative strategy would properly analyse varying viewpoints of stakeholders. The complicated notions of climate adaptation implications and the Ow might be better comprehended in such a format. In addition, would this create a deeper understanding of the relationships between

stakeholders, not particularly being mentioned in literature. Insights could not be reached to this level in quantitative studies, having the tendency to generate more superficial responses.

However, while semi-structured offer deeper insights, it also poses limitations. The minimal audience that was reached would create a biased opinion from the interviewees, while representing its whole organization within the study. This opinion may not always be in line. Additionally, the validity is lowered in comparison to more structured interviewing.

3.1.4 Evaluation

This aspect reaches a deeper understanding of how decision-making is influenced regarding climate adaptation. Just opposing measures would not validate the reasoning behind choices for climate adaptation, while this reasoning could show results regarding future implications of measures.

Toolboxes are the digital methods to enhance decision making. Since Breeam certification is so broad and underdeveloped, it has not been employed as a method while discussed in various interviews and personal conversations. The "Coolkit" was utilised in this study. Despite the study being theoretical, the municipality of Utrecht used its findings to make decisions. As a result, the Coolkit proved also useful in this research. The "Toolbox Climate-proof City" [TKS] is a more specific strategy calculating to specific measurements applied to the map. The TKS will be used for two neighbourhoods in the station district, both using the design this is being imposed. The first district is "Beurskwartier 1", in the middle of the district. This neighbourhood is developing from an open brownfield, to a dense mixed use housing. The other neighbourhood is the "Moreelskwartier" in the south-east of the district, which was proven to have the highest environmental risk in the region. Here will be discovered if the added green suggested in the area would impose significant decreases in temperature. This includes measures for waterlogging, since it was indicated in chapter 4 that waterlogging is significant in that area and the evaporation of such measures could reduce in temperature reductions.

The approach, however, is not merely to look at the data, but also at the potential consequences of employing such toolboxes in contrast to the outcomes of the municipal vision and other studies.

3.1.5 Monitoring

This section looks at the future of climate adaptation, seeking for a deeper understanding on how the stakeholders will learn from the cases that already exist. This is mainly based on their opinions

3.2 DATA COLLECTION

3.2.1 Qualitative Data Collection

Data for the results have mainly considered for the main body of the research. The interviewing of three public and two private organisations are together forming the qualitative data within this study. The three public organisations were all policy developers of climate adaptation, representing the Municipality of Utrecht [Interview 1], the Water Board of Stichtse Rijnlanden also referred to as HDSR [interview 4], and the province of Utrecht [interview 5]. The private organizations consist of a landscape architect for the company Okra, being responsible for multiple designs in the station district [interview 2]; and a project developer at G&S&, responsible for the realisation of the project "Wonderwoods" within the station district.

Data that was collected through these interviews were categorized through the STEEP-analysis, covering social, technical, economic, and political responsibilities as relations of climate Adaptation. These questions were requested to be answered as specifically to the context of the station district as possible. The full questionnaire could be found in *appendix 1*. Data was collected, transcribed, and coded according to the following categories [*appendix 2*]:

- Constraints
- laws
- Role
- Motivation
- Future implications
- Possible Solutions
- Other stakeholders mentioned.

From the coding of the categories, the research could be complemented with the opinion and expertise of the interviewees. The data of the interviews is mostly used in chapter 5 "Legislation and Stakeholders", discussing aspects of legislation and the role of stakeholders regarding climate adaptation. Additionally, Chapter 6 "Potential Measures", discussed the role of stakeholders in the approach of evaluation and monitoring. Finally, other chapters may have used the qualitative data to supplement the evidence discovered.

3.2.2 Conditions of station district

This chapter mainly uses knowledge within the theoretical framework in combination with data from the climate effects atlas. This is a website where different maps show climate effects throughout the Dutch nation. This is the best of dataset found also translating it into maps. These findings have been supported in some instances by interviews or literature research. Resulting in the validation of conclusions already made.

3.2.3 Legislation and Stakeholders

This chapter utilises a combination of qualitative data and literature studies [the qualitative data has been discussed in section 3.2.1]. The literature studies are mainly included in the Ow results, providing insight into what the act comprises. This explains the act itself and its implications. In some circumstances, the literature review clarifies the interviewee's responses by investigating material from the stakeholder under consideration.

3.2.4 Measures and Application

This chapter first bases the vision of the stakeholders on different documentations regarding Utrecht and the station district, complemented with ideas of the interviewees. Major documents leading this section, are the environmental vision and the Vision Climate adaptation, both from the Municipality. The vision of the Nation Province of Utrecht is not mentioned due to its general manner. In addition, would be assumed that national and provincial visions are considered in the municipal visions.

The rest of the chapter discusses measures tackling heat stress. This is due to the conclusions drawn in chapters 4 and 5, which reveal it being the highest thread. This thread relates to both the station district as broader technical and legislative development. Through interview 1, being an employee of the municipality, it was discovered that studies Kluck et al. (2020a,b) at the HvA [Amsterdam University of Applied Sciences] are the leading data source for the municipality of Utrecht to seek for heat stress measures. This is also used for this study, to list the measures and its predicted effects. These measures are further elaborated with a literature review, stating a further explanation of the measures. Blue Measures are not considered, although it may have effects on temperatures. This is due to the limited space the station district has, also not being mentioned for the district in interviews and the visions.

Evaluation includes next to the interviews, the use of two toolboxes, one is the Coolkit, also found within the studies of the HVA; and the other is TKS, found online through the national website of climate adaptation "*Kennisportaal Klimaatadaptatie*" [Climate Adaptation Knowledge Portal]. Both tools use basic guidelines as well as research already been carried out as its basis.

The TKS is a case specific method, showing the effectiveness of different measures in a chosen area. When drawing certain measures on the toolbox, it could be indicated which effects that measure has, such as water retention numbers, heat reduction, and the estimation of costs per measure (Kennisportaal Klimaatadaptatie, 2020).

The TKS will be used to discuss two areas. The first is a yet-to-be-built redevelopment known as "Beurskwartier 1," while the second is “Moreelsepark,” which will be simulated with several measures and their applicability examined. In the second area, different initiatives will be examined that could be implemented in an existing space without redeveloping the buildings.

Beurskwartier 1 was chosen because the high levels of densification in the plan could pose a threat to climate conditions in the area. Moreelsepark, on the other hand, was selected due to its high vulnerability to climate change, primarily seen in waterlogging from precipitation. This case examines whether combining functions, such as reducing waterlogging, could lower temperatures as well according to the Tool. Moreover, applying the same measures in both cases would not add value to the study since the measures for each case will not be compared to each other.

For the areas opposed the following specifications within the TKS will be introduced are listed Below:

- **Neighbourhood type** City centre high-rise structures at a low elevation
- **Climate Adaptation Goal** Heat Stress
- **Relevance multiple-functional land use** Very Significant
- **Scale level** Neighbourhood, street, and building
- **Existing spatial typology** Paved and buildings
- **Subsurface availability** Very low
- **Rooftop type** Flat roofs
- **Soil type** Sand
- **Position in environment** Low-lying flat area

The toolkit generates an estimate of the consequences that a specific measure may have on its surroundings. Using the information provided above, factors such as water retention capacity, evapotranspiration, heat reduction, and expenses are estimated.

To calculate the water retention capacity, the quantity of storage in inches for the measures is multiplied by the area of the project site, and this is displayed in cubic meters (m^3). Heat stress reduction is computed using a Dutch model developed by Steeneveld et al. (2011), which considers the relationship between greenery and temperature. Cool areas are defined as those where an adaptation measure of at least 200 m^2 results in a significant cooling effect. The construction and maintenance costs are estimated at the maximum possible amount, with actual financial impacts likely falling between 60% and 75% of this maximum (Brolsma, 2022b). Additionally, the toolkit includes a green tool and a heat stress tool. The green tool evaluates factors such as health implications and reduced air pollution from adding greenery (Brolsma, 2021). The heat stress tool calculates the PET details of the area (Brolsma, 2022a). However, when using the heat stress tool, the TKS states that it "Could not calculate heat stress layers" The monitoring uses data collected in the interviews showing what action they take in monitoring, in addition to literature seeking for the implications of the replies. The full workings of the Toolboxes could be seen in *appendix 3*.

3.2.5 Global South

Literature of sustainable development in the global south helps to gain a better understanding of the concept. This was afterwards combined with the results found in this thesis.

4 CONDITIONS OF STATION DISTRICT

Chapter 4 will investigate the situation in the station district. This section will assess present and anticipated conditions of heat, drought, and extreme rainfall. The goal is to identify the region's greatest obstacles. The analysis centres on the study question:

What are the present and anticipated climatic conditions within the Station District?

To discover more about the station district, *figure 6* depicts the type of urbanisation that occurred in the station district (hogeschool van Amsterdam, 2023). A large proportion of the area could have the spatial classification of high rise. This will be expanded in the west of the district, shifting from businesses to high rise, according to CU2030 (n.d.b). The railway remains a business category, although there is little room for adaptation within that area.

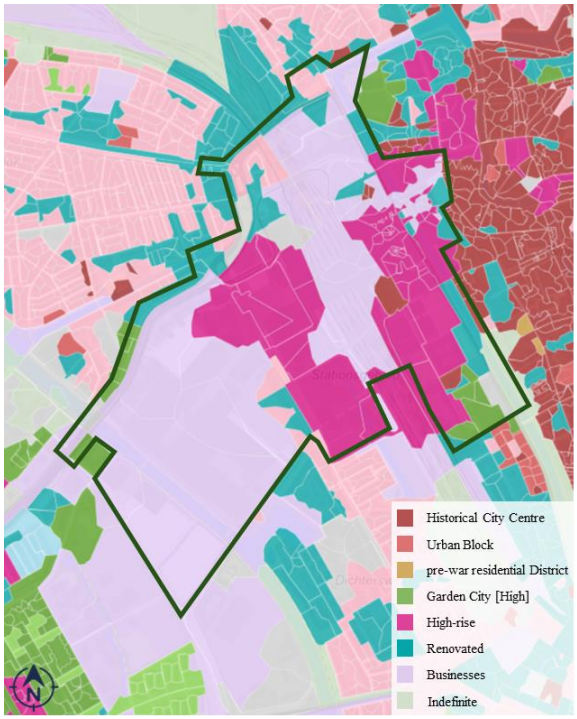

Figure 6: Typology per postal code within station district (Kluck et al., 2023; Hogeschool van Amsterdam, 2023).

As seen in *figure 7*, the RIVM (2020) revealed that the station area has the second highest possible score for climate risk. This map illustrates the risk of excessive heat stress and overflows after severe rainfall. The most vulnerable area is in the south-east of the district. (RIVM, 2020). The areas opposing high risks, typically are heavily paved.

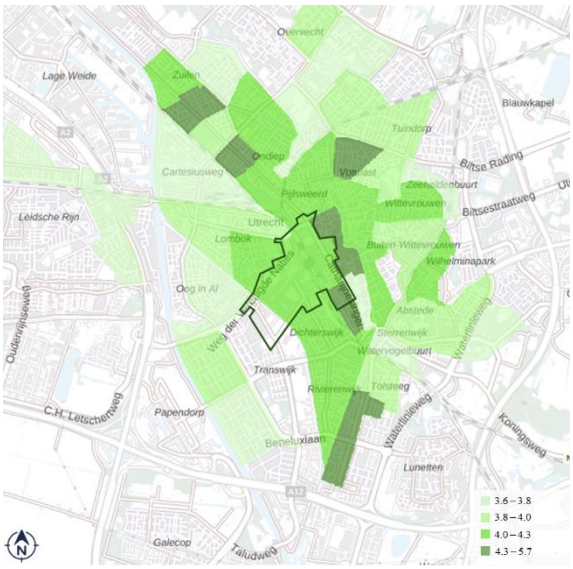

Figure 7: Climate risks within neighbourhoods of Utrecht (RIVM, 2020).

4.1 HEAT STRESS

Figure 8 depicts the perceived temperature between 12:00 and 18:00 [PET] within the station area, already revealing heightened PET in comparison to most of its surrounds. Temperatures in the district are expected to climb considerably between 2016 and 2050. (Wittenveen+Bos, 2021). Public spaces around the station are expected to have the highest PET's during the day reaching temperatures of almost 50 °C. Furthermore, shows figure 8 that the region of the canal, has reduced temperatures in comparison to its surroundings.

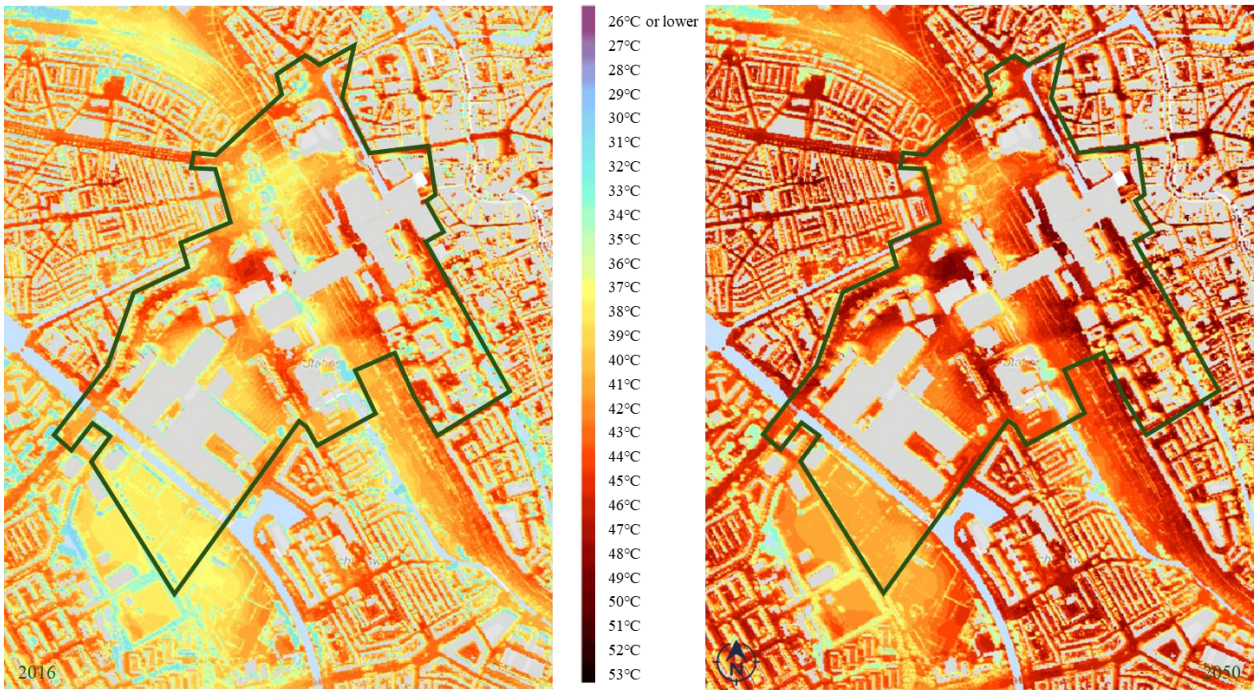

Figure 8: the PET in 2016 [Left] in comparison to the expected PET of 2050 [right] (Wittenveen+Bos, 2021).

To still have a "cool spot" nearby, it is it is critical to have one within reach. This is especially important with the increasing PET the upcoming years. *Figure 9* shows the proximity of cool spots. The criteria for a cool place include having a surface area of at least 200 m2 and not being too narrow. A cool position has a short distance to the road. The greater the speed limit on a road, the farther the cool area must be positioned. Furthermore, the perceived temperature on a hot day should be less than 35 °C (Klimaateffectatlas, n.d.a). In many parts of the area, cool spots are relatively far away, as shown in Figure 9. There appears to be an invisible diagonal line through the area where access to cool spots is limited.

Next to the PET temperatures is the UHI also significant, within the station district, also during the night as shown in *figure 10*. On tropical nights, the temperature does not drop below 20°C, causing significant health risks. in 2016 there were in total one and a half weeks of tropical nights, while this is calculated to be more than one month by 2050. This is shown to be more present within the station area than its surroundings (Klimaateffectatlas, n.d.c.).

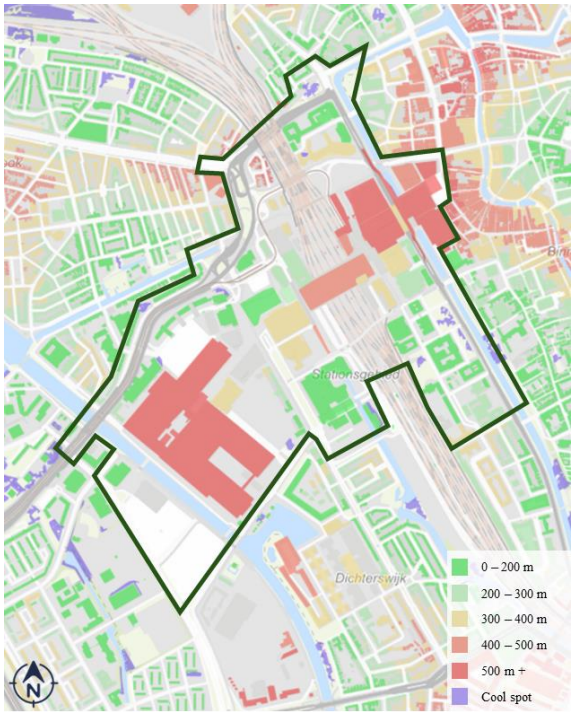

Figure 9: the proximity to cool spots per building in the station district (Klimaateffectatlas, n.d.b.).

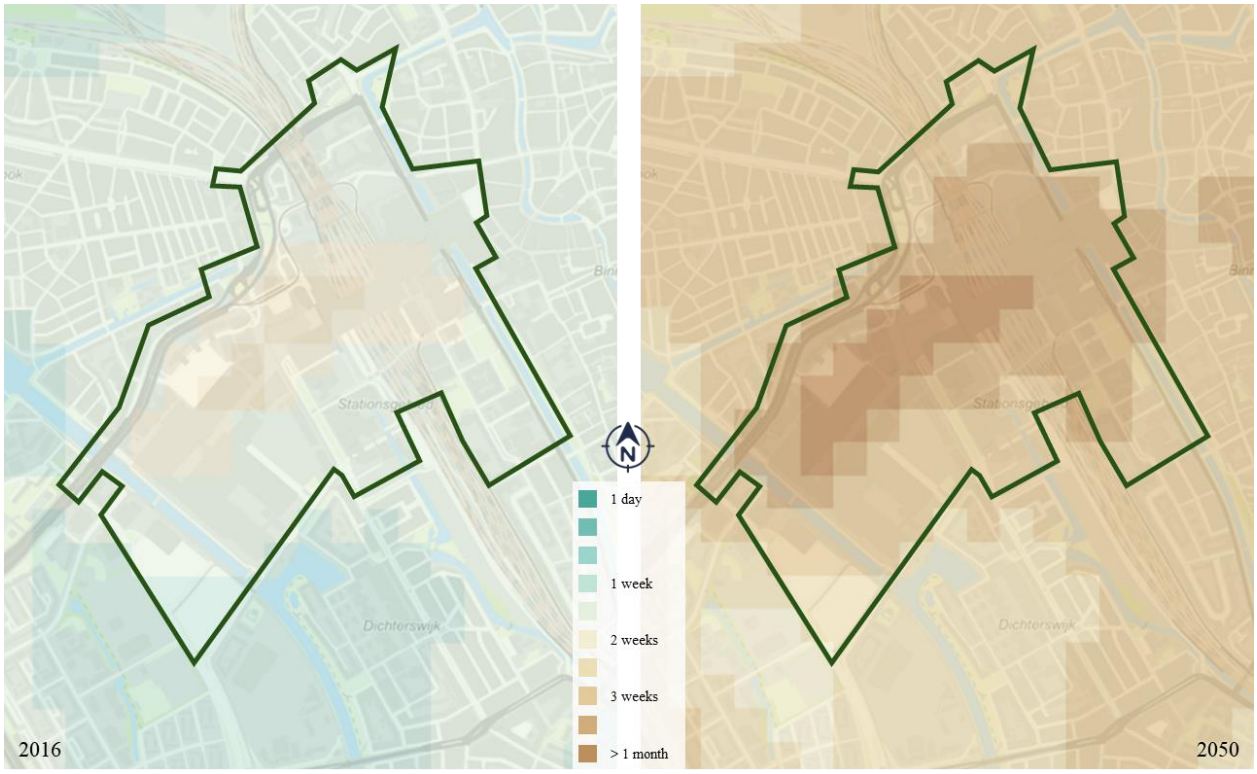

Figure 10: The number of tropical nights per year in 2016 [left] and 2050 [right] (Wageningen environmental Research, 2016).

Wageningen Environmental Research, 2016). A disclaimer of this calculation is that it did not take wind and large bodies of water into account (Klimaateffectatlas, n.d.c.). Still, this could be categorised as one of the major threads to the area.

4.2 DROUGHT

The Netherlands is in an area with declining rainfall during the summer, while evaporation is anticipated to grow. Rising evaporation rates are mostly due to increased temperatures, but they are also worsened by a reduction in cloud cover, resulting in more direct sunlight. Air current changes also influence precipitation and evaporation. Western winds typically bring humid air, resulting in more precipitation, whereas eastern winds often deliver dry air, resulting in elevated evaporation, especially during the summer. The driest KNMI scenario expects a rise in dry easterly winds along with more cloudless days, particularly in the south of the nation and during summertime. As a result, sunlight and evaporation rates are expected to rise (Bessembinder et al., 2023).

However, drought is not a major issue in the station area. Only in extreme cases there would be a water shortage in 2050. A normal situation in 2050 would not include a scarcity of groundwater, just as the current situation (Nationaal Water Model, 2019). Furthermore, as previously indicated in the theoretical framework, pile rot is one of the most critical difficulties associated with drought. Unlike the old city centre is this within the station area, this is not a problem. That is why this issue is included in the proposed legislation, only when combining options, where another issue is more important.

4.3 EXTREME RAINFALL

The Dutch sewerage system can handle 20 to 30 mm/ h. When rainfall has more volume, water accumulates on the streets. When these streets are not able to the precipitation, there is a chance that water will build up, potentially blocking important access routes [Interview 1] (Kennisportaal Klimaatadaptatie, n.d.b). in

addition, is it possible that rainwater could mix with grey water from buildings, providing a health risk if the poisonous water remains at street level (Deltares & Richtlijn Overstromingsrisico's [ROR], n.d.). Waterlogging could also occur within buildings when water enters buildings (Kennisportaal Klimaatadaptatie, n.d.b). This was also mentioned in interview 1 where she also added that installations in buildings could malfunction.

Within the Area, when heavy rainfalls of 70 mm/ two hour occurs, spots in the district already have waterlogging issues, shown in *figure 11*. This could already be viewed as insufficient, even when the HDSR employee mentioned in interview 4 that climate adaptive improvements aim to prevent financial damage when 70 mm/h falls. This is twice as much rain as Figure 11 depicts. This phenomenon occurs once every 100 years. Yet, due to climate change it will be possible that such phenomena will occur two times more often (Deltares & Richtlijn Overstromingsrisico's, 2018).

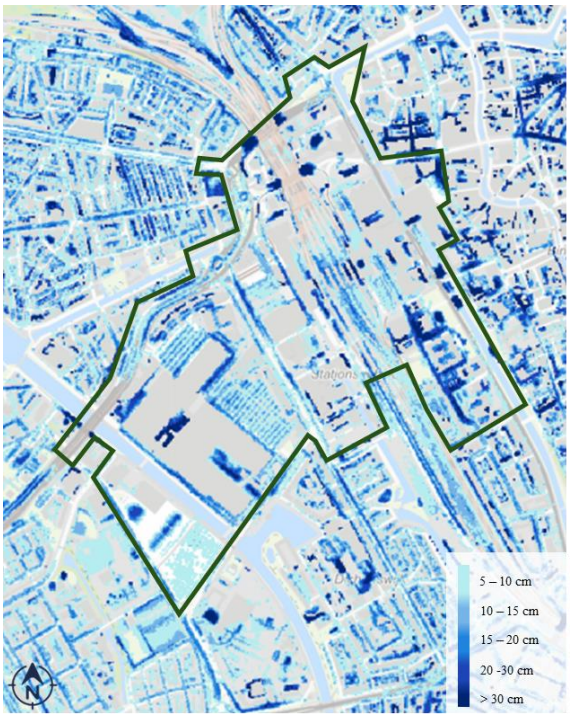

Figure 11: Waterlogging on surface at precipitation rates of 70 mm/ two hours (Deltares & Richtlijn Overstromingsrisico's, 2018).

The infiltration potential is high in the area, primarily consisting of sand terrain (Deltares & Richtlijn Overstromingsrisico's, 2018). Sand has the shortest infiltration time compared to clay, resulting in lower chances of waterlogging during heavy rainfalls (Giab et al., 2021). Moreover, coarser sand has higher infiltration rates due to larger pores that allow water to infiltrate more easily (Rahardjo et al., 2008). However, the total quantity of water infiltration is relatively low in sandy grounds. This is also the case for the station area (Giab et al., 2021; Deltares, 2014).

4.4 GREEN

The Station Area has one of the lowest shares of green within Utrecht, less than 10% of the district is covered with vegetation (Cobra Groenzicht, 2021). However, the grey coverage within the area is over 80% opposing different levels of stress within the area (Cobra Groenzicht, 2021). This opposes serious difficulties when it comes to water infiltration and temperature rises within the area.

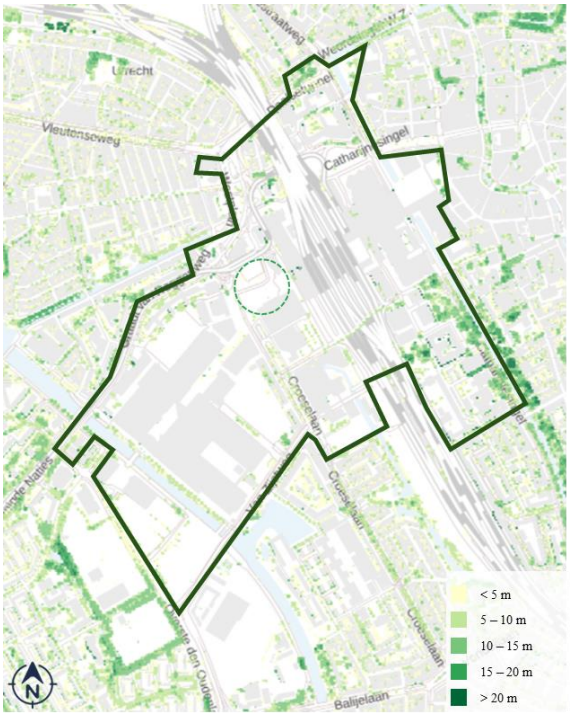

Figure 12: Trees within the station district and its Height (Cobra Groenzicht, 2021).

Figure 12 shows that the placing of towering trees is only available on a larger scale in the south-east of the district. Comparing that location to *figure 8* it could be seen that the perceived temperature and heat stress is significantly less compared to the areas where there are no high trees. Yet, comparing *figure 12* to *figure 11*, shows the relative high waterlogging. This imposes that at that location, trees do not store water.

The Jaarbeursplein located in the dotted circle in *figure 12*, is a location that was deemed to have little space for green by the municipality and landscape architect [Interview 1 and 2]. This also sees a correlation whit heat stress, having a high PET according to *figure 8*.

4.5 CHAPTER SUMMARY

To summarize, heat stress appears to be the most serious issue in the station region, whilst drought appears to be the least serious. Waterlogging could be an issue in some portions of the area. The Station's low share of green and high share of grey surface is the primary source of the area's issues. This high grey content means that there are little options for permeation, whereas the surface heats up fast and quickly. The greatest issue lies in the mix of heavily built-up areas and the insertion of green within its space, heating up and not facilitating infiltration within the Station Area.

5 LEGISLATION AND STAKEHOLDERS

Chapter five will discuss the political aspects for climate adaptation. The first section of the chapter will discuss the environmental act Environmental Act [Ow], while the second section will discuss the motivation of stakeholders. The goal is to identify the obligations and motivations of climate adaptation for the relevant stakeholders. The chapter centres on the study question:

How do policy instruments and stakeholders impact climate adaptation?

5.1 ENVIRONMENTAL ACT

Different laws regarding the environment such as the spatial planning act, are replaced by the Ow [Omgevingswet] The goal of the new law is to simplify and integrate the previous laws of environmental development (Instituut voor Bouwrecht, 2023; Rijksoverheid, n.d.). Now, the value of the Ow could be separated into the physical living environment, and actions that may alter it [Article 1.2, Ow]. The law is defined by its limited Influence of central governmental bodies, giving local governments room to adapt regulations to their situation [Framework Legislation] (Environmental Act 2023 (NET); VNG, 2019). Municipalities will therefore be the main contributor regarding spatial planning according to the Environmental Act 2023 (NET) in Article 2.3 Ow:

> The exercise of the duties and powers under this Act shall be left to the governing bodies of a municipality unless other rules have been made in this regard.

The Ow consist of different tools to organize the act. *Table 1* shows the different policy tools linked to the relevant authority. Below, the tools will be discussed, also implying what it means for climate adaptation.

5.1.1 General National Regulations

The first tool discusses the General National Regulations [Algemene Maatregelen van Bestuur], which comprise four decrees (Official Bulletin of the Kingdom of the Netherlands 2018 (NET)). The "Living Environment Activities Decree" is not included, as it only addresses actions occurring in the environment without discussing the furnishing of the environment (Official Bulletin of the Kingdom of the Netherlands 2018 (NET)). The other decrees are listed below:

Environmental Decree

the relevant authority when issuing permits. In addition, does it regulate the participation and consultation in decision-making. It generally contains procedures (Official Bulletin of the Kingdom of the Netherlands 2018 (NET)).

Table 1: The different policy tools for climate adaptation in the new Ow (Informatiepunt Leefomgeving, n.d.a).

Core Instrument	Municipality	Province	Nation	Waterboard
General National Regulations			Four Decrees	
Environmental vision	Municipal Vision	Provincial Vision	National Vision	
Program	Action Plan [and Others]	Action plans, water program, management plan, [and others]	Action plans, water program, management plan, [and others]	Water management plan
Decentral Regulations	Environmental Plan	Environmental Ordinance		Water board ordinance
Environmental Permits		Environmental Permit		
Project Decree		Project Decree		

Constructions Work Decree [Bbl]

Aspects of construction of buildings regarding safety and –sustainability, amongst others. This decree is relevant for construction practices as the use of the building (Official Bulletin of the Kingdom of the Netherlands 2018 (NET)).

Decree on Environmental Quality [Bkl]

Guidelines and policies for environmental administrative organisations. The use of authority in plans, programmes, and regulations, among other things, is decided here. It also takes environmental quality requirements as cohesiveness and environmental preservation into account (Ministry of the Interior and Kingdom Relations, 2021).

These decrees are the only national regulations that decentral public organizations must follow. Furthermore, is it not possible to have statutes in addition to those mandated by decrees issued by other governments. For example, due of the Bbl, the Municipality of Utrecht is unable to enforce the requirement for green roofs because it exceeds national legal limits. Despite the challenge of legislation, the municipality is still looking for a means to implement this requirement [interview 1].

5.1.2 Environmental Vision

The environmental vision is the second tool that must be used by all decentralized governments. This entails a strategic and integral plan of their goals of the environment. All sectoral planning should be considered [e.g. nature, traffic, environmental policy] (Struiksma, 2012). A vison requires to be made cooperatively, joining multiple public and private entities' strategies to create a system of governance (Kjaer, 2004). The municipality uses this vision to show their goals to all stakeholders. Project developers are thereby asked to respect the aspects within that vision. However, this is more an advice than a demand according to the municipality of Utrecht [Interview 1]. The visions of the relevant entities will be discussed in the Chapter "Potential Measures," since it forms the foundation for interventions that might be implemented throughout the station district.

5.1.3 Environmental Program

The environmental program is an extra tool to put more emphasis on a specific issue specific to a theme, sector, and area. A program consists of two components, the first discussing the creation of regulations for the physical environment's development, use, management, protection, and preservation. The other component, taking measures to achieve objectives in the physical environment to comply with environmental laws and standards. (Niederer, 2021). The Minister in charge and executives of the province, water board, and municipalities are the ones with the authority to design such programs as stated in article 3.4 Ow (environmental Act 2023 (NET); Niederer, 2021). This program could be seen as a concrete execution of what is mentioned in the vision, although there is no link legal link between both (Niederer, 2021).

Regarding climate adaptation the national government already had two programs set before the Ow went into effect. The initial program is the "Delta Plan Spatial Adaptation" [DPRA], which launched in 2017. It states the goal of being a climate adaptive country before 2050. A supplementary plan to the DPRA is the "National Climate Adaptation Strategy" [NAS]. It paves the path towards a climate-proof Netherlands: the approach inspires new climate adaptation efforts while also accelerating as well as extending existing ones. The DPRA and the NAS complement one another (Linckens et al., 2021). The DPRA concentrates on achieving agreements on how to reduce the impact of waterlogging, heat, drought, and flooding; whereas the NAS highlights in which sectors change is most needed, being Safety, living environment, biodiversity, and economy (Synergos Communicatie & Zegge en Schrijve, 2016; Linckens et al., 2021).

5.1.4 Decental Regulations

As mentioned before, the aim of the act is to give more authority to decentralized authorities. This

level of autonomy should be respected. The explanatory statement specifies that the municipality should take care of the physical living environment by setting standards within legislation and activities. When legislation specifically opposes a topic, it is the responsibility of the relevant parties to take measures to prevent negative impacts on the physical living environment (Article 1.7 Ow, Environmental Act 2023). The province and water board use ordinances to implement decentralized regulations. Ordinances work similarly to the four national decrees previously mentioned, covering general legislation that must be followed throughout their jurisdiction. These ordinances elaborate on the vision and work out implications in a legally binding manner (Province of Utrecht, n.d.).

The province's ordinance does not apply to redevelopments occurring within city limits; it is only applicable in circumstances of urban expansion (Interview 5). Currently, the province's ordinance does not contain specific regulations for climate adaptation measures. Flooding is the only aspect of climate resilience considered in the ordinance. While the ordinance mentions climate adaptation, it simply states that it is in the province's interest and that construction projects should be built to be climate adaptive (Environmental Ordinance Province of Utrecht 2024). Interview 5 confirmed that there are few regulations for climate adaptation. This is also true for the municipality, where activities are only discussed within the environmental plan (Environmental Plan Municipality of Utrecht 2024). A municipal employee mentioned that climate adaptation legislation is generally weak and mostly qualitative, especially concerning heat stress (Interview 1).

According to Interview 4, the HDSR (Hoogheemraadschap De Stichtse Rijnlanden) has a Hallmark regulation containing several preconditions regarding water management. When making a project more paved, you must show how you compensate within the project for the reduced infiltration (Interview 4).

Decentralized regulation for the municipality is established through the environmental plan, which should be the central element within the Ow, as stated in Article 2.4. This municipal plan should be developed by its board to enhance the physical living environment through an area-wide plan (Environmental Act 2023). The environmental plan aims to adopt a more holistic approach to an area than the previous "land-use plan." Previously, the land-use plan allocated the function of each plot within the area, while the environmental plan takes a more comprehensive approach (Netherlands, 2014). The idea of the environmental plan is that the proposed plan does not have a binding use but rather a general intent (Van Zundert & Fortgens, 2015). This means that the developer should propose a detailed plan that meets the demands of the environmental plan. This would create a case-by-case approach, optimizing results for each project.

In practice, this means considering which domains are viable within a project and which are less so. For example, if all domains score eight or higher except climate adaptation, which scores a five, you could increase climate adaptation to six. However, this would likely decrease the quality of other domains to a six. Enhancing climate adaptation in this way might reduce the overall quality of the project. These considerations aim to achieve the optimal result for each project and, in the long term, for society (Interview 4).

Once again, the aim of the act is to give more authority to decentralized authorities, respecting their granted autonomy. The explanatory statement emphasizes that municipalities should take care of the physical living environment by setting standards within legislation and activities. When legislation specifically opposes a topic, relevant parties must take measures to prevent negative impacts on the physical living environment (Article 1.7 Ow, Environmental Act 2023). The province and water board implement decentralized regulations through ordinances, similar to the four national decrees previously mentioned. These ordinances elaborate on the

vision and legally binding implications (Province of Utrecht, n.d.).

The province's ordinance applies only to urban expansion, not to redevelopments within city limits (Interview 5). Currently, there are no specific regulations for climate adaptation measures in the province's ordinance, which only considers flooding as part of climate resilience. Although the ordinance mentions climate adaptation, it merely states that it is in the province's interest and that construction projects should be climate adaptive (Environmental Ordinance Province of Utrecht 2024). This lack of specific regulations for climate adaptation is also true for the municipality, which discusses activities only within the environmental plan (Environmental Plan Municipality of Utrecht 2024). A municipal employee noted that climate adaptation legislation is generally weak and mostly qualitative, especially regarding heat stress (Interview 1).

According to Interview 4, the HDSR has a Hallmark regulation with preconditions for water management. Projects that increase paved surfaces must show how they will compensate for reduced infiltration (Interview 4).

The decentralized regulation for the municipality is established through the environmental plan, the central element within the Ow as stated in Article 2.4. This municipal plan should enhance the physical living environment through an area-wide plan (Environmental Act 2023). Unlike the previous land-use plan, which allocated the function of each plot, the environmental plan takes a more holistic approach (Netherlands, 2014). The environmental plan proposes a general intent rather than a binding use (Van Zundert & Fortgens, 2015). Developers must propose detailed plans that meet the demands of the environmental plan, creating a case-by-case approach that optimizes results for each project.

In practical terms, this involves assessing the viability of different domains within a project. For example, if all domains score eight or higher except climate adaptation, which scores a five, increasing climate adaptation to six might decrease the quality of other domains to a six. Enhancing climate adaptation this way could reduce the overall quality of the project. These considerations aim to achieve the best possible result for each project and, ultimately, for society as a whole (Interview 4).

5.1.5 Environmental Permits

The environmental permit is an instrument that must be used while carrying out an activity as well as intending to alter the environment. In such instances, initiators must acquire authorization at a public authority to maintain the quality of the living environment. This permit is valid for the national level within the Bbl, as well as in the province and water board ordinances or local environmental plans (Informatiepunt leefomgeving, n.d.b). An example is a spatial development, when altering the environment pavement in an area could be increased. In such situations the municipality and water board must agree on the changes. When the changes are not meeting requirements or deteriorating from legislations opposed by the governments, a permit must be issued. It could then be stated that the developer must compensate for the reduced quality imposed [Interview 1 and 4].

5.1.6 Project Decree

The project decree is a concrete and formal approval for projects' implementation, operation, and/or maintenance. In appendix 1 Ow of the environmental act 2023 (NET) states that significant construction or installation projects, as well as other activities are all considered within this tool. However, the primary goal of project decisions is to carry out complex projects that serve the public interests. These projects could be utilised by national as well as regional governments (Netherlands, 2016). The railways within the station district are potential infrastructure for such decrees since it bears national significance. Within municipalities, would handle the permits within their territory, accompanied by Prorail (Prorail Communicatie, 2020).

5.2 STAKEHOLDER ANALYSIS

The stakeholder Analysis will first look at ther role of stakeholders and motivation for climate adaptation furhtremore, at the financial implications that were seen per stakeholder. The results are visualised in *figure 13*.

It was already stated in the section decentral regulation that municipalities have the responsibility to ensure that the quality of the living environment is optimised. This is next to their advisory role mentioned before, also an executive role within climate adaptation, in general already being the development of an area according to Muñoz Gielen (2014). This executive role is relevant when the territory is owned by the municipality. This could be in the case of the public space, where the municipality is responsible for its own landscape design and implementation of the public space [Interview 1 and 3]. The second manner is to request implementation through tenders. When a plot of land will be developed and is in ownership of the municipality, non-statutory requirements could give the room for municipalities to demand extra criteria to project developers for climate adaptation, amongst other things. Most developments within the station area are or were tendered, including the redevelopment of Beurskwartier that will be tendered according to the municipality of Utrecht [interview 1]. The tender for the "Jaarbeursgebouw" in the station district stipulated in terms of climate adaptation that water should be retained within the site, ideally by adding vegetation. Additionally, grey and blue water should remain separate. Lastly, will the structure's design reduce the

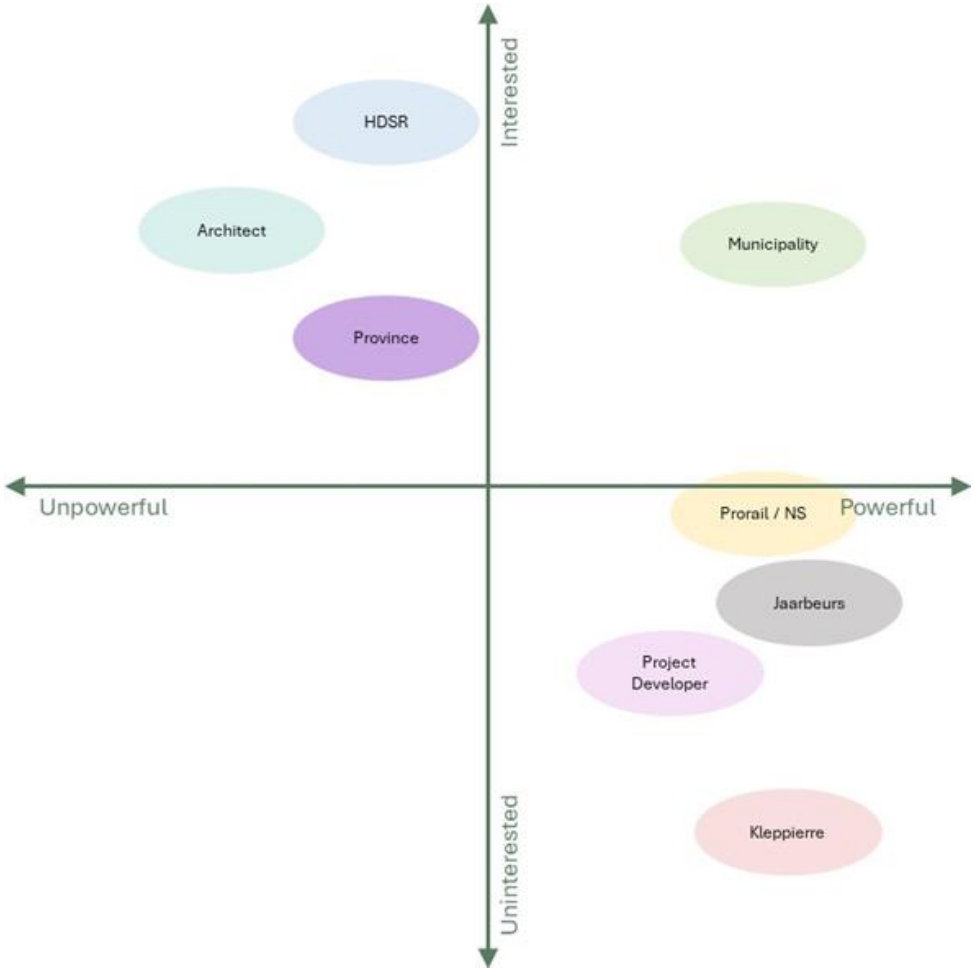

Figure 13: Stakeholder Analysis, placing each stakeholder on the spectrum of power and interest.

Jaarbeursplein's heat island effect and the demand for air conditioning (Bijl et al., 2021).

The Province and Waterboard HDSR do not have an executive role within the topic in metropolitan areas. In addition, is there responsibility rather low within cities, also being the case within the station area. Despite the municipality having the last say on the matter, the province and HDSR are still involved in this issue of climate adaptation within urban areas [interview 4 and 5]. The role of the province is therefore “soft”, stimulating municipalities to take measures within cities. The methods that would be used are the supporting through expertise, guidance, and research according to the province itself [Interview 5]. According to the waterboard, their function is in general the same. However, since the measures within municipalities could have direct impact on the HDSR’s basin, the waterboard has a little more influence within the municipality’s borders. With it is, as the name indicates, the waterboards role merely only focused on water related issues such as waterlogging and drought is also taken into consideration. Heat is an issue that HDSR addresses and assist municipalities with; nevertheless, HDSR is restricted in providing guidelines [interview 4]. This focus from the waterboard could be seen positive since the municipalities have additional other spatial concerns such as mobilities problems and the housing crisis. Making it according to HDSR difficult to make climate adaptation a separate topic. This explains according to HDSR the importance of working with the municipality. At the same time was noted that municipalities are doing a “fantastic job”, especially Utrecht. The HDSR mentions that the proactive approach of Utrecht, resulted in targets that are equivalent to that of the the water board [Interview 4].

According to the municipality, property owners and other organisations oversee the remaining 40% of the city's climate adaptation measures. According to HDSR, this comprises project developers' responsibilities [Interview 1 and 4]. Everyone who wishes to develop something bears responsibility. However, the project developer is not concerned about climate adaptation considering their primary purpose is to generate revenue. They would only consider climate adaptation if individuals were more inclined to settle at the development according to the HDSR [Interview 4]. When discussing climate adaptation with the project developer G&S&, climate adaptation seemed to be only relevant at its own property. In this interview was answered by the project developer that climate adaptation would improve aspects within or at the building. Their impact on the surrounding environment was not mentioned and was seen as the responsibility of municipalities [Interview 3]. This remark is consistent with what was stated in the interview with HDSR about the necessity for settlements for their own growth and then only implementing climate adaptation in such situations.

Urban planners and architects place a great focus on creating a pleasant environment. This indicates that this stakeholder recognises a high degree of ambition in climate adaptation. However, an urban planner must adhere to a particular assignment. The assignment for the station area projects that have already been completed was to establish better link between both sides of the station, without considering climate adaptation within its design. The issue that is the highest on the agenda within the municipality is in most cases the leading factor for what should be incorporated into the developments [interview 2]. Trade-offs are the main contributor to stakeholders such as the municipality to decrease climate adaptation within developments. As mentioned before, there are other concerns that the municipality has responsibility to resolve. It is in most cases about programming, looking at which priorities are the highest at the moment of development according to the landscape architect in interview 2. The assignment for the station area projects that have already been completed was to establish better link between both sides of the station, without considering climate adaptation within its design. The issue that is the highest on the agenda within

the municipality is in most cases the leading factor for what should be incorporated into the developments [interview 2].

These trade-offs could not only be a political manner, but also in a spatial manner, according to the HDSR employee is space scarce within urban settings, in several cases not having physical space for climate adaptation measures. It is a matter of looking collectively what is reachable and works. He stated the following:

> If you want to be completely climate-adaptive in the Netherlands, we all have to move to the East. Then also put up a stilt house or something like that.

For the station district was additionally stated that it is indeed physically not possible to add climate adaptive measures everywhere. For example, adding vegetation was not possible at the Jaarbeursplein due to the underground infrastructure [parking garage] that resulted in to little underground space for vegetation to grow properly. Furthermore, the square serves as a venue for events, thus it must have solid pavement [interview 1 and 2]. Nonetheless, the topic of climate adaptation is gaining momentum within the municipality, with more studies being performed on the consequences of climate change, involving on the social level [interview 1]. Furthermore, it is apparent that climate adaptation measures are becoming increasingly important and more specific within legislation, notable in the environmental vision (Aarts et al., 2021).

There are yet additional parties who could have an impact on landscaping plans. Kleppiere, the business that manages the Hoog Catharijne mall, for example, overruled the municipality by insisting that a portion of a plan to build a jogging route circling Utrecht adjacent to the new canal should be interrupted to make way for a section of the shopping complex. Kleppiere is not the only major private owner of the station district. Three other private stakeholders were mentioned by the landscape architect of interview 2, these are the Jaarbeurs, Prorail and NS. The Jaarbeurs is a major event value that is situated within the Beurskwartier Neighbourhood [Interview 2]. However, the business demonstrated its vision in 2019, transforming its event halls into new urban neighbourhoods. As a landowner, it retains control over the project site, adjusting its plans by delaying certain developments in 2022 (CU2030, n.d.b). Prorail and the NS are responsible for the railway and its travelers however according to the landscape architect in interview 2 they have the following goals:

> The ordinary passenger machine and also just the safety of the passenger machine.

However, the NS stated that it sees from its role as landowners to share the responsibility of sustainable and liveable urban development, together with municipalities (NS Stations, n.d.). Prorail, made a vision regarding *stations of the future*, stating that the station should be a pleasant place to be, with it touching upon increased climate adaptation within its design (Prorail, 2019). The vision of NS and Prorail is claimed to be more than a passenger machine. Furthermore, it may be argued that, while a rail station should be accessible, high temperatures and water caused by heavy precipitation would severely reduce connections to the station. As a result, these stakeholders are increasingly concerned about climate adaptation. This might also be imposed on Kleppiere and the Jaarbeurs, as impacts such as waterlogging may have negative consequences for them should they occur.

5.2.1 Financing per stakeholder

The financial landscape for climate adaptation in urban contexts involves various stakeholders, each with distinct roles and motivations. The province, HDSR, and municipality provide financial support through grants and schemes, although there are challenges related to budget allocation and the motivations of private project developers. Understanding these dynamics is crucial for effectively planning and implementing climate adaptation measures.

Financial resources for climate adaptation are primarily provided through subsidy schemes rather than direct funding. The Province, HDSR, and the municipality each offer these schemes to support climate adaptation interventions [Interview 1, 4, and 5].

The Province of Utrecht has a scheme titled "Green, Healthy, and Climate-Resilient Cities and Towns," aimed at public organizations, offering grants ranging from €2,000 to €50,000 (Province of Utrecht, n.d.). This scheme reconciles three provincial programs: climate adaptation, biodiversity, and a healthy living environment. Applications must comply with at least two of these areas (Province of Utrecht, n.d.).

The HDSR offers two key funds for climate adaptation. The first is the Blue Citizen Initiative, providing funding of up to a few thousand euros for collectives of at least eight citizens who wish to improve water efficiency and sustainability within their watershed [Interview 4] (HDSR, 2018). The second is the Impulse Control Grant, which has a total budget of €1.8 million for 2024. This grant aims to improve water quality and create a climate-adaptive living environment in collaboration with municipalities (HDSR, 2023). Although initially only for governmental bodies, there is ongoing experimentation with involving project developers, though caution is exercised to avoid using tax money for profit-making ventures [Interview 4].

The municipality offers a green roof subsidy to support private initiatives in creating green roofs [Interview 1]. However, there is no specific budget allocated within the municipality for climate adaptation, with financial resources primarily coming from sewerage systems or greening projects. Other municipalities, such as Nieuwegein, may have dedicated funds for climate adaptation [Interview 1].

The roles and motivations of stakeholders are varied. The municipality is responsible for planning, executing, and financing climate adaptation projects within the urban context. Their motivation is to enhance the living environment and ensure sustainability, though the lack of a dedicated budget for climate adaptation poses a challenge (Interview 1). Project developers execute development projects and often seek funding from investors. Their primary motivation is revenue generation rather than environmental improvement (Interview 3; Interview 4). Project developers must cover costs through the sale of premises, aiming to generate profit from their developments.

5.3 CHAPTER SUMMARY

The Environmental Act poses different opportunities for climate adaptation on the municipal level. Other levels of governments do not pose significant influence on the topic. Currently, it might be presented within the vision how climate adaptation will be integrated into the city alongside with additional issues. This vision could be translated into the ordinances and environmental plan, to legalise the goals intended. However, the national decrees could pose limitations to the plan and ordinances The Environmental plan of the municipality of Utrecht has not yet been published regarding climate adaptation. When the plan is published, this could be used by Municipalities [together with the HDSR] to agree on a development with a permit.

The HDSR and province do not play a large legitimate role in climate adaptation in the urban environment. Their role is to facilitate municipalities through the support of knowledge and aiding subsidies. The municipality does have all the authority for the ensuring of environmental quality. Climate adaptation is, however, not the only consideration that has to be made by the entity. Instances of these considerations might be observed through other issues prevalent in cities, as well as a lack of financial resources for adaptive measures. Heat is seen as the most ambiguous measure, with the least concrete legislation.

The stakeholder developing has the responsibility to ensure that the environmental quality is incorporated. This is also the case for climate adaptation. Typically, there are two stakeholders who develop. First, are the project developers. However, developers are less engaged in climate adaptation measures, since primarily being driven by profit motives. The other developer is the Municipality, having two different tactics. The first tactic is the redevelopment of the public space, bearing responsibility to ensure climate adaptation there. The other tactic occurs when redeveloping a neighbourhood. The municipality would in such cases tender its plots for project developers. In such cases, non-statuary demands could be made. The project developers could then hand in a proposal of a design. However, compromises also possess an importance in tenders limiting climate adaptation, utilising a point system at tenders.

6 MEASURES AND APPLICATION

Chapter 6 will discuss the different options that could enhance climate adaptation. First, the vision of stakeholders will be studied. This vision will be used as inspiration for potential measures. Afterwards, would be discussed how measures could be evaluated and monitored by stakeholders. The chapter centres on the study question:

How could various physical climate adaptation approaches be evaluated and monitored to improve the circumstances in the station district?

6.1 VISION

As described in section 5.1.2, the environmental vision is one of the obligated law instruments according to the Environmental Act. The technique should provide an integrated view regarding the spatial/areal aspects of the goals of decentralised public institutions. This part will study the climate adaptation goals indicated in these documents, as highlighted by the interviews. For Utrecht this is the the "spatial strategy Utrecht 2040" [RSU2040] by Aarts et al. (2021).

The Municipality has a distinct vision for climate adaptation in addition to the RSU2040. Adding more green space is considered in both visions as the primary strategy for coping with climate change. The climate adaptation vision takes national plans into account, wanting to be climate adaptive in 2050. Linckens et al. (2021) stated within this vision that the following goals should be reached by then:

- → **Limiting the UHI to a maximum of 5 °C**
  - On hot days, all roadways for cyclists and pedestrians should be shaded. The method should ideally consist of vegetation. Popular routes should have the base of 30% shade [40% during the warmest time of the day].
  - Anyone should be in a 200 m radius to a cool green space of 200 m^2.
  - 40% of the neighbourhood should be covered with vegetation. This also will store water, reducing waterlogging effects and drought
- → **Precipitation of up to 80 mm/h does not cause decay in buildings or render roads inaccessible.**
- → **The surface serves as a sponge, retaining at least 90% water from precipitation. This supply of water should be available during drought.**

Removing paving and adding green is one of the main solutions for the beforementioned aims. This was also mentioned in the interviews with the municipality, landscape architect, HDSR, and province to be the most appropriate [interview 1, 2, 3, 4]. In addition was mentioned in the RSU2040 by Aarts et al. (2021), that greenery within the city is important, improving health while is crucial for creating a climate-proof environment. The strategy of the city is divided into 5 different scales mentioned by Aarts et al., (2021):

1. **Adding green in the streetscape:** this would be done by removing excessive paving, rearranging parking lots, and reducing traffic speeds.
2. **Green and blue tracks through the city:** following watercourses and enhancing greenery on its shores.
3. Green lungs: adding new and extending existing parks; or creating park-like conditions within streets.
4. **Connecting urban and rural green:** forming hedges by adding eclosed green arms into the city of around 60 to 100 m.
5. **Greenery on the outskirts of the city:** making more use of the surrounding areas to create more natural and recreational opportunities.

Additionally, the approach for climate adaptation is also specified per city zone. For the city centre, also including the station district, heat stress is the most predominant effect. It would be proposed to introduce different types of intensive greening in the area, as shown in *figure 14* (Aarts et al., 2021). This is in line with an "environmental Impact Report" [MER] that was conducted in 2017. The two neighbourhoods in the station district Beurskwartier and Lombokplein that are in development were visioned to have a park zone and green avenue to enhance climate adaptation (Arcadis, 2017).

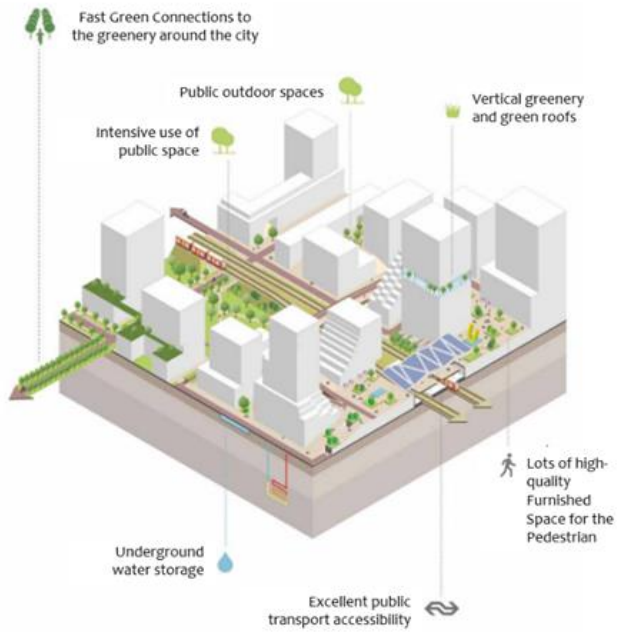

Figure 14: A visual of the different aims within the city centre zone of the RSU2040 (Aarts et al., 2021).

Other non-green measures that could enhance climate adaptation were the inclusion of wadi's, being a water storing trench with additional volume underneath the surface [Interview 3 and 4] (De Vree, n.d.; Bogaard, 2020). This was also addressed in interview 2, suggesting that this technique may influence its environment. In addition, did the landscape architect mention the use of lighter materials to reduce temperatures with the albedo effect [interview 2]. the positioning of buildings and the positioning of windows could contribute to the heat inside of a building, this could also be done when adding sunshade in and around the building [interview 5]. This was also mentioned by in interview 2, stating that this technique is already further developed in Germany.

6.1.1 combining functions

Combining functions is beneficial in several ways, being more suitable for urban planning. By merging functions, space and materials may be used more efficiently (Bakker et al., 2012). This is especially crucial for the station district, where space is both limited and valuable. Aarts et al. (2021) also mentions this in their vision for the city centre. Economically, this approach is advantageous because it reduces costs while improving outcomes. However, combining functions should not be implemented in a top-down manner, as it requires careful planning and integration into its environment (Bakker et al., 2012).

Green spaces in cities are an example of climate adaptation which offers numerous advantages. Including vegetation promotes mental as well as physical wellness. Green spaces naturally convey a calming environment, lowering stress levels. Lowering stress levels reduces the risk of cardiovascular disease and depressive symptoms. Furthermore, vegetation enhances the living conditions for plants and animals. Biodiverse vegetation aids the prevention of diseases and allergies, as monocultures are more vulnerable to such issues. Biodiverse greenery is also less prone to extreme weather and contributes to decreased air pollution (De Vries et al., 2022). As mentioned in section 5.2, the province of Utrecht's subsidy programme "Green, healthy, and climate-resilient cities and towns" reflects these benefits of greenery in one subsidy.

6.2 EFFECTIVENESS OF MEASURES

This sub-chapter addresses various techniques for climate adaptation to combat heat stress and waterlogging. The main goal here is to implement

Table 2: Different types of measures, with its intended scale and time of effect. In addition, is the type of cooling mentioned (Kluck et al., 2020b)

Type	Measure		Effective during type of day		Schale when effective		Cooling Effect		
							Temperature [°C]		Perceived Temperature [°C PET]
			Day	Night	City	Local	City	Local	Local
Vertical	Green Facades		x	x		x	0 – 1.9	0.2 – 1.5	?
	Light Facades		x			x	-	0.1 – 0.7	?
	Orientation Buildings		x			x	-	Max 0.4	Max 10.2
Horizontal	Trees		x		x	x	0.2 – 2.7	0.7 – 2.7	3.4 – 19.0
	Grass/ Hedges		x	x	x	x	0.1 -1.1	0.9 – 1.2	0.4 – 4.9
	Park		x	x	x		?	1.1 – 2.0	1.9 – 4.2
	Green Roofs	Local		x	x		0 – 1.7	0 – 0.8	-
		City-wide	x	x	x		0 – 1.7	1 – 1.6	-
	Light paving		x			x	-	Max 1.9	?
	White roofs		x		x		Max 0.9	-	-

methods that reduce heat stress, identified in chapter 4 and section 6.1 as the most threatening and underdeveloped issue among policy and stakeholders. The potential measures discussed in this study are summarized in *Table 2*, which highlights the effects of each measure.

6.2.1 Vertical Measures

One effective way to reduce heat stress in urban areas is by using greenery on building facades. Installing green walls can lower the temperature of both the exterior and interior of buildings. This not only cools the buildings but also helps reduce temperatures in the surrounding street areas (Hoelscher et al., 2016; Djedjig et al., 2017). In street canyons, the process of evapotranspiration can cut temperatures by up to one-third (Djedjig et al., 2017) Djedjig et al. (2015) note that green facades prevent heat from being released into the atmosphere during the day [while also reducing slightly at night]. This is particularly noticeable in the summer, where green walls can significantly improve thermal comfort. However, the impact of green facades can vary depending on urban design. For instance, the more direct sunlight a green facade receives, the greater the cooling effect compared to other materials (Djedjig et al., 2017). In the Dutch context, facades facing north don't have a significant impact on their environment. Additionally, green facades are more effective in narrower streets (Kluck et al., 2020a). It's important to ensure these green walls are well-irrigated to maintain their cooling benefits (Hoelscher et al., 2016). However, watering can become an issue during droughts when water supplies are limited, a problem that's becoming more frequent due to climate change.

A method that does not use vegetation to reduce heat is by using materials with a higher albedo. Using these highly reflective materials or paints can help lower the average ambient temperature, especially at peak times (Synnefa et al., 2008; Bretz et al., 1998; Rosenfeld et al., 1995). This method works best in specific areas like narrow street canyons, where it can noticeably cool things down. The best times to notice the effects are in the late afternoon and at dawn, when the sun its energy hits vertical surfaces the most (Zhang et al., 2018). Increasing the albedo on building facades is a practical and cost-effective solution that can be easily adapted to various environments. When done correctly, it can help reduce temperatures (Nazarian et al., 2019). However, in the wrong setting, it might have little

impact or even be undesirable due to high reflections (Nazarian et al., 2019). Still, it has the potential to lower local temperatures by about 0.7 °C (Kluck et al., 2020a). Therefore, using the right materials can significantly impact street-level temperatures.

The design of buildings can significantly impact heat stress. Singular rectangular buildings, a very common architectural style, might allow solar radiation to penetrate more deeply into their surroundings, making them less comfortable during heat stress. On the other hand, square buildings, especially those with courtyards, offer a good alternative. Courtyards create shaded areas with reduced solar radiation, developing their own microclimate. This lower temperature can be seen as a reduced PET has a minor effect on the actual temperature, according to Taleghai et al. (2015). This approach could be effective in the Netherlands, where courtyards are not yet widely used (Taleghai et al., 2015).

6.2.2 Horizontal Measures

Horizontal measures could be applied to the surface level and roofs. The first of these actions is to improve the urban environment by planting trees. When compared to the night, trees are most effective at reducing heat stress during the day. Trees provide shade throughout the day, which primarily lowers the PET considerably (Lee et al., 2016). Measurements show a reduction in PET of over 10 °C in spaces shaded by trees [and buildings] compared to sunlit areas (Klok et al., 2019). Like façade alterations, it has also been demonstrated that the greatest reduction of trees produces cooling in the morning and afternoon (Wong & Jusuf, 2010). Nonetheless, the heat of the day is retained in the tree canopies at night, minimizing any cooling effect at night (Lee et al., 2016). Furthermore, trees exhibit a significant decrease in wind speed; yet the impact of declining temperatures has been shown to be greater in the street canyon (Spangenberg et al., 2008).

Grass is another factor that can affect urban cooling. Compared to impermeable surfaces, grass can lower the PET by up to 4°C, though the actual cooling effect is less pronounced. The reduction in air temperature in these green urban areas is about 1°C (Klok et al., 2019). People tend to perceive shaded areas as cooler and more comfortable than sunlit ones. However, urban spaces near water and grass are not necessarily perceived as cooler or more comfortable, according to a survey by Klok et al. (2019). This highlights the importance of shade for comfort, while lower vegetation types do not have a significant direct impact on people's perceptions. However, grasslands have a greater cooling impact at night than trees do, which results in greater drops in UHI and PET (Lee et al., 2016).

Urban parks that combine clusters of trees with short ground vegetation create a greater cooling effect than individual trees, grass, or water bodies alone (Amani-Beni et al., 2018). Air temperature drops significantly, up to more than five times lower with grouped trees compared to individual ones. During the day, from 10:00 AM to 2:00 PM, temperature reductions range from 0 to 2.8°C for standalone trees and 0.3 to 15.7°C for grouped trees. However, with respect to PET, individual trees have a greater impact than clusters of trees (Abreu-Harbich et al., 2015). Parks play a significant environmental role due to their potential to lower both daytime and nighttime temperatures thanks to the biodiversity they contain.

To accomplish citywide greening ambitions, green roofs might offer more effective because they increase the total amount of greenery in cities without taking in precious street-level spaces. (Lee & Jim, 2019). At the rooftop level, green roofs can significantly raise thermal comfort. However, this effect does not reach the ground level and does not have significantly impact the surrounding environment (Peng & Jim, 2013; Jin et al., 2018). Widespread installation can bring improvements to district and city temperatures, creating cool enclaves over large areas. At the rooftop level, green roofs can significantly raise thermal comfort (Peng & Jim, 2013). Table 2 shows that local temperature

variations are unaffected by the intensity of green roofing, but city temperatures may decrease by twice as much with widespread green roofing (Kluck et al., 2020a). This indicates the high impact it may have when implemented on a large scale.

Ouldboukhitine et al. (2014) noted that street canyon temperatures could still decrease by 0.8°C. The protective layer of green roofs can delay peak temperatures for several hours, shielding roofs from extreme heat. This improves the street's microclimate and reduces building energy use in oceanic climates (Ouldboukhitine et al., 2014). However, green roofs are prone to drying up due to their thin bases. Without irrigation, dehydration could threaten rooftop vegetation, especially with climate projections for decreased summer rainfall. Studies modelling drought stress on green roof vegetation often do not make this assumption (Gill et al., 2007).

According to Santamouris (2014a), reflective roofs can provide substantial benefits in sunny climates, while green roofs perform better in mild and cold climates. Table 2 shows that light roofs could reduce city-wide temperatures by up to 0.9°C. An increase in albedo by 10% could result in a temperature drop of 0.1 to 0.3°C (Kluck et al., 2020a). However, weather conditions pose significant risks to reflective roofs. Miller et al. (2002) and Cheng et al. (2001, 2012) found that natural processes such as condensation, dust accumulation, and wind can reduce the reflectance of rooftops. The main cause of reduced reflectiveness is the dust accumulation of carbon particles (Santamouris, 2014a). In the first year, albedo could drop to 0.15, but it can be restored to up to 90% (Bretz & Akbari, 1997).

When reflective or green roofs are installed in high rise buildings, the expected climatic impact and mitigation potential is very limited (Santamouris, 2014a; Jin et al., 2018).

6.3 EVALUATION OF INTERVENTIONS

Adaptation strategies that are opposed in development plans pose show a level of ambiguity. Analysing numerous projects' environmental strategies, as the “Zoning Plan 1 and Land Development Beurskwartier” by De Nijs et al. (2023), stated measures imposed for climate adaptation as:

> The layout of the area considers the consequences of climate change, such as flooding and high.
>
> The way in which the location of buildings contributes sufficiently ..... to the consequences of climate change

Such requirements are qualitative in nature thus do not include any hard quantitative requirements [Interview 1, 4, and 5] (De Nijs et al., 2023). According to the municipality, waterlogging is less noticeable and more easily quantified. Technological implications can be concretely evaluated per measure by estimating the difference in water volume [interview 1]. The HDSR also looks at studies on various measures that were tested, which will be considered when recommending interventions [interview 4].

Heat, on the other hand, is especially qualitative since it is an underdeveloped topic within city planning. One reason for this underdevelopment is the disagreement among researchers about the causes and effects of issues such as the UHI according to the municipal employee [interview 1]. This development of heat stress may further enhance its “shallow” qualitative approach. Nonetheless, the municipality uses research from the HvA to analyse which actions could theoretically be the most beneficial, as well as discussing the effectiveness according to district type [interview 1] (Kluck et al., 2020a, b). The

In practice, different measures are often not evaluated in advance. The municipal employee admitted in interview 1 that no calculations were performed when imposing vegetation in the

station district. HDSR also stated that calculations were not performed for small-scale projects; instead, they rely on general rules of effects in such situations. However, for larger-scale developments, HDSR does perform tailored calculations to adjust to specific circumstances. In these cases, the development is loaded into an online area and simulations of different rainfall volumes are conducted. This allows for the identification of nuisance areas and the effectiveness of various measures [Interview 4]. The HDSR employee also noted that it is tough to calculate the impact of uncommon instances, such as an intense downpour that occurs once a century. These rare events are the standards that must be considered when evaluating measures. Additionally, the evaluation assumes that the measures will be adequately maintained [Interviewee 4]. Given the rarity of such events, even a water management expert believes the requirements for addressing them are excessively ambitious. This was complemented by the landscape architect of interview 2, mentioning that it is often not worth evaluating these measures, stating:

"...in that balancing matrix there are 1000 other things, and they are all about very important things, but in the end a lot about money and just money and power."

6.3.1 Toolbox as method

There are some toolboxes available for climate adaptation, including HvA its "Coolkit" research and the "Toolbox Climate Adaptation" [TKS]. These tools can aid decision-makers in selecting preferred measures. The Coolkit by Kluck et al. (2020b) focuses solely on heat stress and how to optimize it for different neighbourhood types. It begins with general guidelines from the vision of the municipality of Utrecht. Furthermore, it examines which measures could have significant effects in various neighbourhood types. *Figure 15* shows the effects of measures within high-rise districts in city centres. According to this tool, high-rise zones in the city facades account for more than half of the surface, indicating a high potential for opportunities in this area (Kluck et al., 2020b). However, this toolset is relatively generic and lacks support for case-specific calculations.

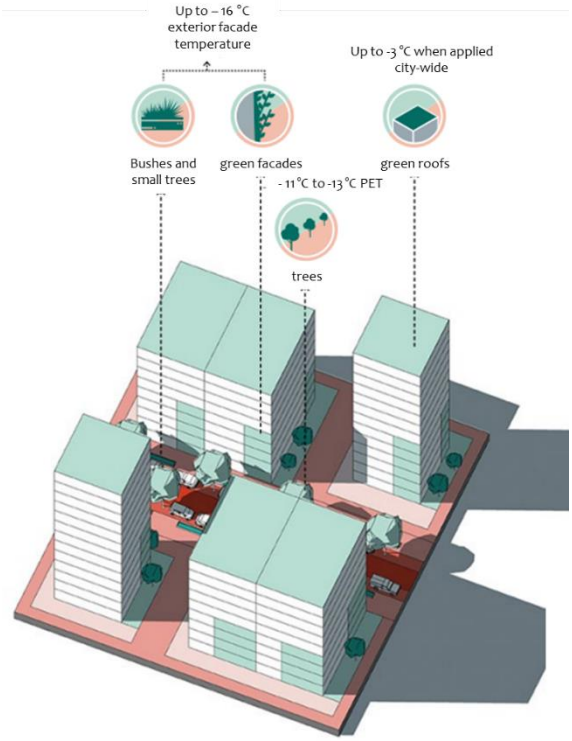

Figure 15: A visual of the different measures imposed in highly urbanised city centres (Kluck et al., 2020b).

The TKS, in contrast, is area specific. Two neighbourhoods in development in the station district will be used to explore measures planned to be implemented according to their environmental design. These two projects are envisioned within the district in *Figure 16*.

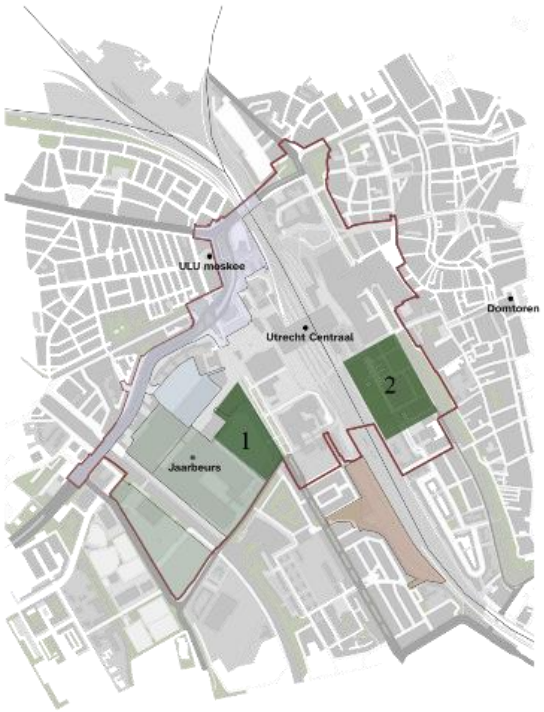

Figure 16: The two areas discussed with the TKS in the station district [figure based on (CU2030, n.d.a)].

Area 1: Beurskwartier 1

According to the architectural guidelines of Beurskwartier 1 by De Nijs et al. (2023), Beurskwartier 1 will be a diverse and dense neighbourhood functioning as a part of the city centre. A low-traffic layout featuring various green spaces, such as parks, will serve as the foundation for a tranquil way to connect with other areas. The typical building height is 25 meters, with some buildings reaching 12 meters for added light and others up to 45 meters as accents in the area. Additionally, there will be towers between 70 and 90 meters high (De Nijs et al., 2023). All these heights are illustrated in the sketch in *Figure 17*.

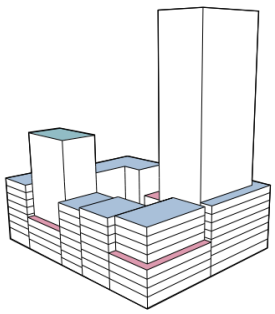

Figure 17: height sketch of a typical block in Beurskwartier 1 (De Nijs et al., 2023).

The Beurskwartier's plan aims to be sustainable and environmentally friendly, featuring green roofs, green setbacks, and green façades. These elements are valuable for residents to observe and utilize, and they are crucial for biodiversity and climate resilience (De Nijs et al., 2023). According to the municipality, a rooftop should be considered a green roof if the building's peak is 25 meters or less in height. When needed, this can be combined with solar panels mounted on the roof [Interview 1]. Climbing vegetation should cover the façades, especially within courtyards, bridging the height of the setback as

Figure 18: Full plan for Beurskwartier 1, with the region studied in the TKS marked in dark green. (De Nijs et al., 2023).

Table 3: The data obtained when including all measures within the design of Beurskwartier 1 at the TKS (TKS, n.d.).

Measure	Climate				Costs	
	Water Storage [M^3]	Evapotranspiration [mm/ year]	Heat Reduction [°C]	Number of cool Areas	Construction [€]	Maintenance [€/ year]
Green Facades	17.59	0	0.05	0	2,639,097	263,910
Light facades	0	0	0	0	1,213	1,617
Adding Trees to Streetscape	489	89.08	0.53	4	111,460	37,9
Urban forests	2,798	85.78	0.76	5	13,991	700
Green Roofs	179	45.44	0.98	0	2,142,138	101,107
Total	**3.483**	**220**	**2.33**	**9**	**4,907,899**	**373,371**

shown in Figure 16. Additionally, the colour palette of the plan varies from dark red to beige (De Nijs et al., 2023). The full plan can be seen in *Figure 18*.

Table 3 illustrates the potential outcomes of applying and sketching all these measures within the TKS for Beurskwartier 1 at the highlighted location in *Figure 17*. This measurement shows that the costs of green façades are relatively high compared to their benefits, reducing the temperature by only 0.05°C. The use of light façades in the area is also shown to be ineffective. In terms of efficiency, urban forests outperform other options when comparing costs and benefits. However, this does not account for the lost potential sales land, which makes the cost of such a park comparatively higher if the plot is not sold in such a highly urbanized centre. Nonetheless, studies indicate that the property values of dwellings near parks are increased.

In general, it can be concluded that the measures in the street canopy are perceived as cheap. the most expensive interventions are seen at building level, accounting for around 80% of all costs.

Area 2: Moreelsepark

Moreelsepark is a development located in the Station District's south-east. In comparison to the Beurskwartier 1, this development only affects public spaces. The neighbourhood is well known for its large structures and the presence of several monumental buildings. Most of those structures are employed as offices [over 90%], housing large organizations such as ProRail (Eerenberg, 2021).

In the previous arrangement, the area was defined by the presence of car-related infrastructure. This could be seen by the high number of parking spots found within the area [331]. This focus resulted in the impaired room for cycling and pedestrian traffic. According to Eerenberg (2021), proximity to Utrecht Central Station increases the importance of traffic intensity for various active modes of transportation. This implies that there should be a greater emphasis on high-quality infrastructure for different transportation options in the area. This is consistent with the Moreelsepark its founding principle of focusing on nature. Paving will only be employed in locations where it is required, such as building entrances and pathways. Within the development plan there are multiple waterlogging plans mentioned, such as the "climate avenue" which is a lowered stroke of green next to the road that could house excessive water. *Figure 19* illustrates the concept of the remaining space, which will be used for vegetation of

Figure 19: Sketch of different vegetation at Morreelsepark (Eerenberg, 2021).

Figure 20: Environmental design of Moreelsepark its public space (Eerenberg, 2021).

various heights and species (Eerenberg, 2021). The full plan is shown in *figure 20*.

The interventions used in TKS will only consider the public space because the neighbourhood has some monumental structures that are difficult to modify, and the development exclusively restores the public realm. Furthermore, section 4.3 demonstrated that when extreme precipitation occurs, the area initially experiences waterlogging. The interventions in *table 4* will thus demonstrate how measures primarily intended for waterlogging reduce heat stress in the area.

In *Table 4*, different measures may be found. According to the toolkit, traditional greening approaches, such as adding trees to the streets and creating an urban forest, offer significant environmental benefits. However, while these measures significantly impact water capacity, initiatives like Climate Avenue and lowering part of the garden have no apparent effect on temperatures in the area. The Wadi, although having a small impact, would pose a difference in temperature.

Table 4: The data obtained when including all measures whitin the design of Moreelsepark at the TKS (TKS, n.d.).

Measure	Climate				Costs	
	Water Storage [M^3]	Evapotranspiration [mm/ year]	Heat Reduction [°C]	Number of cool Areas	Construction [€]	Maintenance [€/ year]
Adding Trees to Streetscape	526	63.83	0.38	3	120,038	40.81
Remove pavement add green [2 – 3 m wide]	297	16.13	0.14	0	108,767	3,959
Lowering of terrace [Climate Avenue]	446	0.92	0	0	85,683	1,140
Bioswale [Wadi]	181	- 0.16	0.02	0	38,734	387
Lowering part of Garden	582	- 0.2	0	0	33,198	1,328
Urban Forest	2,853	58.19	0.52	2	14,266	713
Total	**4.884**	**139**	**1.06**	**5**	**400,685**	**7,568**

6.3.2 Implications of toolboxes

Toolboxes could be used as a method of indicating measures, helping decision making. When a [greenspace] toolbox is not used, it frequently becomes a lower priority for any forthcoming or existing project when there is no framework, model, or tool to assist decision makers effectively (Tefera et al., 2024). So, such initiatives open the conversation to include climate adaptation within projects.

The guidelines in the Toolkit of the HvA are a tool that could give general insights for initiatives. The TKS could then be utilised in a more area specific manner and could be more helpful. However, such tools should not be used as a leading factor within decision making. During interview 2, the landscape architect asserted that there is a widespread belief in urban planning that people are experts on certain topics, such as climate adaptation. These tools have the potential to improve this approach by reassuring individuals that they have learned adequately regarding climate adaptation thanks to the TKS tool. It could be argued that, even when using tools, specialists should be the primary force in urban planning (Ven et al., 2016).

The need for external expertise arises from the general manner of calculating within the TKS, which is not immediately visible. Details such as building height and city-wide effects are not considered specifically in the tool. However, these components are extremely important in determining the effectiveness of measures, especially in highly urbanized areas. For example, the use of green façades is considered unproductive in the TKS, even though it accounts for a significant portion of the total surface area in the Coolkit. and poses high significance in the vision of Aarts et al. (2021). This could be related to the model used for heat reduction, calculating the surface area added. However, when considering the top view, this area is relatively small.

Furthermore, costs are stated as the maximum within the TKS but are not defined throughout the entire program and are explained in an external link. This could result in prejudicial findings. Such clues might be used to make decisions without fully understanding the details of the computations.

Regarding the results imposed for the Coolkit, the measures are in line with the studies mentioned in "Vision" and "Effectiveness of Measures" [section 6.1 and 6.2]. The Coolkit uses measures from RSU2040, aiming to add as much green as possible within the streetscape. Additionally, buildings are used for the intensification of greenery with green façades and roofs (Aarts et al., 2021).

In general, toolkits can aid in decision-making processes and provide guidance on suitable types of interventions. However, expertise is crucial to include in the process, as toolkits are not waterproof.

6.4 MONITORING

When discussing intervention monitoring, it was repeatedly noted that monitoring does not occur after climate adaptive measures are implemented in a development. The Landscape Architect remarked, as previously discussed in the evaluation section, that there are simply too many factors to consider, and that power and expenses take precedence over monitoring. He also mentioned that when a project appears to be functioning, it is usually deemed successful since the environmental conditions have improved [Interview 2]. The HDSR does not monitor either, opting for a "reactive" approach by awaiting responses whenever an action is insufficient, stating the following in interview 4:

> "...if there is a situation where things do not work and therefore there is nuisance, then the People call..."

The province later declared that monitoring is a point of attention. Climate adaptation is still in its pilot phase. The relevant department within the province has only been in operation for four

years, so its staff is gradually building indicators. However, the advisor at the province feels that progress will still take a while. Various techniques are still challenging to monitor in terms of their success. It is possible to measure differences, such as temperature, within a region. The challenge, however, stems from the measure's current state. For example, a tree takes more than four years to fully mature and reach its optimum adaptive capability. Furthermore, meteorological conditions may affect this monitoring data, requiring additional time to become valid [interview 5]. The accuracy of any numerical analysis highly depends on the accuracy of inputs and assumptions. However, access to detailed and realistic urban data is often limited due to the complexity of microclimate analysis in real neighbourhoods (Nazarian et al., 2019). This means that monitoring in the area ought to be challenging.

6.5 CHAPTER SUMMARY

The vision of the municipality and other stakeholders indicates that greenery is the primary approach for implementing climate adaptation. This is mainly achieved by adding pockets of parks as well as greening the streetscape. Due to the limited space in the station district, the vision emphasizes that greenery should be added intensively, including the use of building façades and roofs. Greening offers its highest value through the integrated results it generates. Combing functions can enhance the probability of success in projects.

Measures that could enhance project success are mainly seen in the streetscapes, demonstrating the power of combining different vegetation types. However, the inclusion of green roofs, when implemented citywide, could also result in significant temperature drops.

Evaluation of measures is typically not done, often relying on basic rules of thumb to indicate the success of interventions. Different toolboxes could enhance the decision-making process. However, toolboxes should be used as indicators, while still incorporating expertise. The same issue is seen in monitoring, which is rarely conducted due to financial and political considerations being made. Additionally, climate adaptation is difficult to monitor because of the innovation stage of the field and the complexity of microclimate measures.

7 CLIMATE ADAPTATION IN THE GLOBAL SOUTH

Chapter 7 will discuss the effects this result could have on the "global south" showing how governance of sustainable developments could be implemented in such regions. The chapter first starts with the situation of the global south. Afterwards, this situation would be applied to the results found in this study. The chapter centres on the study question:

What potential significance could the study have for the global south?

7.1 GLOBAL SOUTH

The term "global south" refers to less developed or developing nations contrasted to the wealthy global north. This used to be regarded as the third world, though that was modified because of its negative categorisation and consequent colonial associations (Sud & Sanchez-Ancochea, 2022). The nations of Latin America, Africa, and Asia make up most of this region as shown in *figure 21* (Nye, 2022). The term, which has little to do with global geography, instead distinguishes nations based on economic and political characteristics. Countries in the global south endured similar experiences. Unstable political regimes and economic dependence represent a couple of its traits (Chitadze, 2023).

The Global South is home to a variety of intricate problems. Firstly, these nations are experiencing significant environmental damage. Due to their colonial pasts, places like South Africa witnessed widespread land exploitation, which exhausted their environments. Consequently, these nations are more vulnerable to ecological changes, particularly those brought on by climate change (Meadows & Hoffman, 2003). This is also evident in the rapid pace of deforestation in the Global South, which raises greenhouse gas emissions globally (Pearson et al., 2017).

Citizens in the Global South have insufficient access to essential resources such as water and sanitation. The lack of these resources decreases public health and hinders economic development. Additionally, rapid urbanization is driven by migration streams from rural to urban regions, combined with high rates of natural growth (Smit, 2021; Hossain et al., 2016). For example, Delhi has experienced explosive growth in just a few decades, whereas similar growth took around a century in London (Birch & Wachter, 2012; Isaac, 2018). This rapid urbanization typically does not occur in an organized manner, leading to inadequate infrastructure (Hossain et al., 2016; Horn, 2018). The high rate of unorganized urbanization is a major problem, increasing metropolitan vulnerability to the effects of climate change.

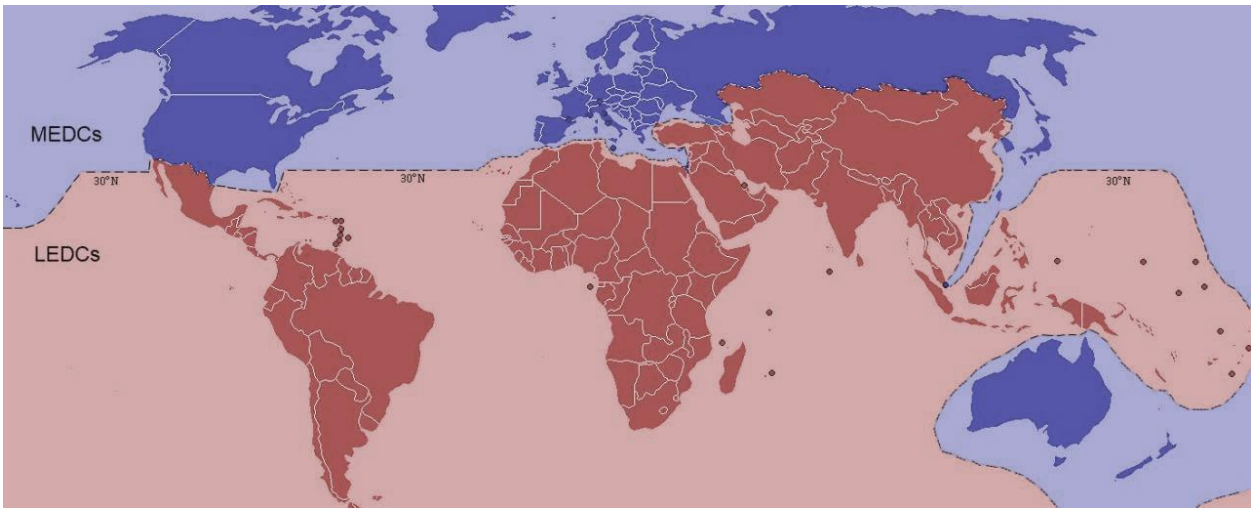

Figure 20: The division of the global south and global north shown on a world map (Nye, 2022).

7.2 SUSTAINABLE DEVELOPMENT

Sustainable development could be divided into brown, grey, and green measures according to Rana (2009). The brown measures look at sanitary initiatives increasing the health of its citizens. This brown agenda tackles problems like solid waste accumulation, unsanitary living conditions, and dangerous pollutants in urban air and rivers. Grey measures try to tackle measures that tries to reduce the impact of its urban effects. Examples of this is to reduce air pollution because of increased traffic volumes. Lastly, the green agenda looks at the addition of vegetation, trying to impact the ecosystem, instead of trying to improve human health what occurs with the brown and grey agenda (Rana, 2009).

These agendas indicate that developing cities are not yet thinking about adaptation, first trying to implement mitigation measures within its environment. The combining of functions that is also seen as beneficial in the global south in addition to the station district. Adding vegetation, could reduce air pollution while also reducing temperatures and waterlogging effects.

The previously mentioned unstable political system, combined with uncontrolled urban growth, indicates that a top-down governance approach, such as in the Station District, does not work in the global south. Therefore, complex issues should start on a smaller scale. This suggests that measures like green roofs will not reach their full potential if not implemented citywide. Instead, small-scale initiatives, such as removing paving and adding vegetation, could be more effective. Gradually increasing the number of these measures could help reduce heat and waterlogging events. While formal evaluation might not be necessary due to the small scale per intervention, long-term monitoring could be beneficial. These microclimates, however, are not considered easier to assess then in the context of the station district. Financial constraints for monitoring could indeed be higher. It might be more prudent to invest financial resources in addressing other pressing issues in the global south, even more so then in the station district.

7.3 CHAPTER SUMMARY

In the Global South, numerous issues are predominant. For the development of climate adaptation, struggles mainly stem from low levels of governmental stability and high rates of unorganized urbanization, which exacerbate the region its existing environmental vulnerabilities.

Large top-down interventions are unlikely while more pressing issues, such as mitigating pollution in urban areas, demand attention. Combining the functions of various interventions could also enhance climate adaptation. These efforts should start on a small scale and gradually be scaled up to eventually create a significant effect.

8 DISCUSSION

Climate adaptation represents a pivotal strategy to address the uncertainties posed by climate change, particularly within urban planning. Despite the pressing need for such measures, the integration of climate adaptation into urban planning has been limited. This hesitancy can be traced back to the nature of the concept itself, which still lingers in the "regime" phase of socio-technological transitions, a theory proposed by Geels in 2002. In this phase, while infrastructural elements related to climate adaptation are under development, a comprehensive understanding and legislative integration remain elusive.

Urban planners have yet to fully embrace climate adaptation due to its complexity and the high degree of variability it introduces, especially in nuanced urban environments like the Station District. Each development site within the district presents unique challenges and opportunities, necessitating a highly tailored approach that considers multiple aspects, such as the utilization of underground spaces and the diverse functionalities of the area. This complexity is often perceived as technical and beyond the grasp of the average citizen, thereby limiting public participation in climate adaptation efforts.

The recent enactment of the new environmental act, which mandates the consideration of various environmental impacts on a case-by-case basis, might pose additional hurdles for climate adaptation. Since climate adaptation has not yet advanced to the "landscape" phase—where it would be recognized as a critical component of standardized political agendas—it risks being sidelined in priority lists. This lack of prioritization could delay its integration into routine urban planning and policymaking. Yet, the vision of the Municipality of Utrecht indicates that the priority of climate adaptation is becoming more pronounced. However, there is potential for accelerated change. The Environmental Program could play a crucial role in elevating the significance of climate adaptation, potentially hastening its transition into the landscape phase. This shift could be further facilitated by the adoption of concrete, standalone plans that explicitly incorporate climate adaptation into city redevelopment projects.

Additionally, an approach that could motivate this transition of the “innovation” is the integration of multiple functional roles into climate adaptation initiatives. By linking climate adaptation more closely with other urban planning objectives such as health and biodiversity, it can gain more traction in decision-making processes.

Modes of governance could also be enhanced within the process. Currently, governments primarily support climate adaptation through subsidies. Other methods, such as regulating and facilitating, are still in development. Regulations are often too qualitative, failing to create significant impacts. However, facilitation has shown promise in the visions and designs of the Station District, which demonstrate improvements in already developed areas.

As municipal governments continue to decentralize, exemplified by the processes underway in Ow, there is an opportunity to reflect on these developments and adjust strategies accordingly. This reflective approach, coupled with enhanced public participation and governance reforms, could substantially improve the prospects of integrating climate adaptation into mainstream urban planning. This would ensure that cities are better equipped to respond to the dynamic challenges posed by climate change.

9 CONCLUSION & RECOMMENDATIONS

Chapter 9 will discuss the main conclusions and recommendations that could be made from this research. The chapter answers the main research question:

How do policy instruments and stakeholder involvement play a role in developing and implementing climate adaptation strategies in the Utrecht station district?

At this moment the concept of climate adaptation is still in development, posing weak arguments for interventions within developments. Within the context of the station district of Utrecht, this should be mainly carried out by the municipality. This is the stakeholder opposing legislative and executive authority to enhance the concept in the urban context. The biggest thread is considerations that must be made in decision-making processes of developments. An Environmental plan could boost the significance of climate adaptation and create a detailed implementation scheme.

Development and implementation in dense urban areas such as the station district oppose difficulties with namely heat stress. Implementation should be carried out in an intensive matter, using all space possible. Vegetation would pose the best solution. This is due to the erasing of paving. In addition, would it combine functions, making it more feasible to approve, and saves space in such a dense neighbourhood. Measures of high volumes could respectively pose high impacts, also on a city level. This is difficult in the global south to implement, making progression slower.

However, evaluations and monitoring are underdeveloped. This could mean that the impact of measures is difficult to see for future projects.

Recommendations are future research on the following:

- Conduct a feasibility study on the implementation of an environmental program.
- Pose research on methods to ensure better evaluations and monitoring of heat stress.

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