The grass is always greener in the garden next door

An exploration of the potential and necessities for gardens in urban climate-resilience planning

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26-7-2018

Abstract

The global climate is changing because of natural and anthropogenic factors. The extent to which this affects regions differ, but there is a general global trend of more extreme weather patterns. These extreme weather patterns form a particular risk for urban centers since these environments are characterized by a large share of built-up area. This built-up area has two factors that, when combined with the effects of climate-change, form a distinct risk to livability in the urban environment. First, in the case of extreme rain, the built-up or soil-sealed urban environment has fewer capabilities of absorbing water, making it reliant on gardens, parks and the sewage system to absorb and transport rainwater. If these systems are unable to deal with rainwater, this could lead to flooding. Secondly, the urban environment can be up to eight degrees warmer than surrounding areas, meaning that in case of droughts or warm periods the city can heat up, bringing with it risks to vulnerable populations.

These risks for the urban environment force institutions to re-evaluate the fabric of the urban environment and to increase climate-resilience. This is often done through climate adaptations in public space, like the construction of new parks, wadi's or changing sewage systems. However, climate change is a complex issue that cannot effectively be dealt with by technical measures alone. This means that climate-resilience is not only determined by the ability of public space to deal with more extreme weather events, but it also means that private space and institutions have a role to play in climate-resilience.

The role that private space- and institutions play in climate resilience can be seen in the importance of gardens in urban climate-resilience. The amount of public space in the urban environment is often limited and subject to many demands, making an intervention in this space complex. This means that private space has an important role in climate adaptation and mitigation through its supply of private green-spaces. This role can be both positive and negative linked to the land-use in the garden. On the one hand, backyard land-use can positively influence climate resilience by providing green space that can be useful for rainwater absorption in the case of extreme rainfall and have a cooling effect in times of drought. On the other hand, a soil-sealed garden negatively influences climate-resilience in urban environments through increased rainwater runoffs and heat-absorption. A research conducted by the Social en Cultureel Planbureau [Netherlands Institute for Social Research] concluded that gardening is becoming a less-popular pastime activity and the paved garden is becoming more popular. Meaning that gardens could negatively impact urban climate-resilience and make the public climate-adaptation projects less effective. This has led to different programs and projects that aim to promote private climate-adaptations.

This research is evaluating the effect private space could have on urban climate-adaptations by evaluating climate-adaptive planning in the city of Groningen in the Netherlands. This research uses scientific literature on complexity and climate-adaptive planning, a survey based case-study in three neighborhoods, geographical information system analysis and policy reviews in order to gain insight into the following subjects. Firstly, how should planners promote climate-resilience from a complexity perspective and how does this translate into planning practice. Secondly, what are the social institutions and practices underlying soil-sealing and climate-resilience? And lastly, what is the effect of private space on urban flood-resilience. Together, these elements give insight into the extent to which the private sector could contribute to climate-resilience and how planners should deal with climate-resilience in the urban environment.

This research has found that private gardens form around 11% of the urban environment and around 39% of all potential urban green spaces are located in gardens. These private parcels have an important impact on urban liveability through an increase in runoffs of around 5%. There are a number of factors that impact private-land use decisions, with this research finding that both public space as housing-sizes and garden-sizes are physical factors that determine soil sealing and ownership and ease of use being the most important socio-economical factors. The valuation of gardens in climate-adaptation is limited, with most policies focussing on public adaptation rather than private adaptation and most individuals looking to the government for climate-adaptation.

This research therefore concludes that, even though gardens form an important pillar on the urban liveability and urban-green spaces, the spatial, socio-economical and political complexities of the urban socio-ecological system are limiting the extent to which gardens are included in urban climate-resilient planning. This complexity is present on the macro, meso and micro level and further inclusion of gardens in policy making and planning practice requires a shift towards an approach that is more focussed on learning-by-doing and citizen engagement and integral planning.

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1. Introduction

1.1 Introduction and Research Focus

Urban environments are dense and complex networks of actors, goods, services and the environment (Healey, 2007). In the Netherlands, urban centres house the majority of the population and are estimated to grow even further in the future (Centraal Bureau voor de Statistiek & Planbureau voor de Leefomgeving, 2016). This continuing trend of urbanisation creates a demand for new housing developments in and around the city, in time resulting in more and more developed space in order to further grow the urban economy. These economic developments negatively impact the ecological carrying capacity of urban environments, as an increase in developed areas will often result in a loss of green- blue and agricultural spaces (Rees, 1992). This loss of local environmental carrying capacity will become more important in the coming years due to the effects climate change will have on weather patterns. It is expected that over the coming decades, weather patterns will become more extreme, resulting in longer periods of heat and drought and more intense rainfall (Koninklijk Nederlands Meteorologisch Instituut, 2014).

These changes in weather patterns affect the urban environment in multiple ways. One the one hand, more heat will result in changes in liveability through negative impacts on public health and productivity and most notably forming a risk for vulnerable demographics (Harlan, et al., 2006). On the other hand, more extreme rain will increase the risks of flash-floods through an increased pressure on existing draining infrastructure and green- and blue spaces in the urban environment. This creates an economic risk in the form of flood damages. Both these factors form a cause for a critical re-evaluation of urban space, focussing on increasing the resilience of the urban socio-economic system.

One of the most important factors in dealing with the effects of climate change and more extreme weather patterns are an increase of the amount of Urban Green Spaces. These spaces offer a number of ecological-, social- and public health services that contribute to climate resilience through the mitigation of the negative impacts the changing climate has on the urban environment. This research will focus, in a broad sense, on urban green spaces. Urban green spaces are all the vegetated areas in the urban environment, these being: *"all parks, recreational spaces, gardens, lawns, brownfields, wasteland areas and woodlands in the urban environment*." (Francis & Chadwick, 2013).

Urban Green spaces offer a variety of services, including ecological, social and health services to urban residents. However, the extent to which urban green spaces provide these services are often determined by, but not constricted to, its size. There is a general consent that especially parks have an important positive influence on the urban environment and climate-resilience (Chiesura, 2004; Nielsen, et al., 2014). But even though there is a clear consensus on the importance of urban parks, there is a growing interest in other forms of urban green space that could contribute to improving climate resilience, being the garden and lawn. These forms of private urban-green spaces are currently still broadly underrepresented in scientific research, this while gardens and gardening are widespread throughout the city (Freeman, et al., 2012)

In order to prepare urban environments for the effects of climate change, the Dutch Climate Institute has stated that every municipality in the Netherlands is required to perform a climate scan in order to calculate the risks of flooding and heat in their jurisdictional boundaries (Kuijken, 2018). The outcomes of these scans are meant to be used to increase climate resilience in municipalities through the making of better policies and spatial interventions to adapt to and mitigate the effects of climate change, through either increasing the amount of urban green- and blue spaces or technical infrastructural means.

Climate scans are based upon the knowledge of the local governments, which often is contrived from their own property, in other words, these scans are most commonly based upon public space and know built up areas. In the Netherlands, public space and built up space are thoroughly documented in several public and open data sources. Most notably the Basisregistratie Grootschalige Topography (Basic Registration of High Scale Topography, from here on: BGT), the Actueel Hoogtemodel Nederland (Current Height Registration of the Netherlands, from here: AHN) and the Basisregistratie Adressen en Gebouwen (Basic Registration on Adresses and Buildings, from here: BAG). These three datasets together give an in-depth understanding in the functioning of public space through a combination of height, build-up areas and land-usages. However, this focus on public space and buildings often does not fully account the land-use in private space. This while private space makes up a large portion of the urban environment. With several European studies finding that gardens occupy somewhere between 16 to 27 percent of all urban space in the United Kingdom and Stockholm (Colding, et al., 2006; Loram, et al., 2007; Tratalos, et al., 2007). How these spaces are used is not monitored in the Dutch basic registrations, which leads to presumptions of land-use in these spaces in climate-models, policies and spatial interventions. However, it is clear that private properties have an important impact on climate resilience, with a research finding an increase of run-offs and temperature due to soil-sealing in these spaces (Zwaagstra, 2014).

The addition of private-gardens in climate scans and in planning for climate-resilience requires a shift in planning methods from government to governance, a shift that is in line with the current planning paradigm. This shift from government to governance shifts the planning process from a centralized state-driven format to a more cooperative form of planning where the public and private sectors act together in order to adapt and change space (Bulkeley & Betsill, 2010) In this integrated approach, climate resilience: "...starts with little things, like getting people to remove the concrete pavement from their gardens so the soil underneath absorbs rainwater, it ends with a giant storm surge barrier..." (New York Times, 2017). In this shift from government to governance, private gardens have to be seen as a privately owned green network rather than small insignificant places of private property (Scottish Government, 2011).

One of the main factors that determine the functioning of the urban private green network is the concept of ownership. This is also what makes it complex as, the land-use for this network is determined by the preferences of separate owners rather than centralized institutions like governments or companies. These private preferences determine the functioning of the network through one mayor determinant, being an owner's preference for either a green or soil-sealed garden. This decision between a greener and a more soil-sealed garden will determine the usefulness of a garden as a spoke in the urban private green network and the impact a garden will have on urban climate-resilience and liveability. When a garden is greener, it will have a positive effect on the urban system as a whole (Operatie Steenbreek, 2017). However, the number of soil-sealed gardens is increasing, meaning that more gardens are covered by paving stones or concrete (Zwaagstra, 2014). This negatively influences the functioning of the network as a whole through increased heat-absorption and decreased water-absorption, which contribute to the heat-island effect and increasing flood-risks in the urban environment (Fokaides, et al., 2016).

The concept of a private-green-network and the subjective nature of garden-owners contribution to this network, in the light of the government to governance transition in urban climate-resilient planning create an important question as to how to maximize land-owners contribution to climate-resilience. There are two main lines of thought in this discussion. The first being a cooperative approach where governments and other institutions aim to convince home-owners to re-evaluate private land-use and stimulate green gardens through information and aid. This approach often focusses on informing home-owners about their influence on urban biodiversity, health and climate-resilience and offering means to change. The second approach focusses more on the application of market-based policies and instruments in order to stimulate having a greener garden (Dewaelheyns, et al., 2016). An example of this is the taxation of soil-sealing or giving people with a greener garden a tax-benefit, stimulating land-use changes (NPO Radio 1, 2017).

The focus of this thesis is on the effect private property could have on climate scans in the urban environment. Focussing on the extent to which private land-use impacts urban pluvial-flood-resilience and how different levels of government integrate private households in urban climate-resilient planning and how these household see their role in improving climate-resilience. This thesis uses a combination of Geographic-Information-System analysis, statistical analysis, surveys and a policy review in order to gain insight in the extent, effects and dynamics of private land-use decisions in climate-resilience. This together will give an overview in how the private domain impacts the urban climate and testing whether or not private households can play an important role in climate adaptation, as well as gaining a deeper scientific understanding in private green-spaces.

1.2 Research Background

1.2.1 Climate Change and the urban environment

There is a general scientific consensus that the global climate is changing. This can be attributed to natural factors, or the natural greenhouse effect. Through the greenhouse effect, gasses and clouds capture infrared radiation in the atmosphere, warming up the surface of the planet. In addition to the natural greenhouse effect is a contribution of human activities. This effect is mainly seen through the effect humans have on the environment through the use of fossil fuels, adding more greenhouse gasses to the atmosphere, contributing to the warming of the surface of the planet (Grace, 2012; McClatchey, 2012; United Nations Environment Programme, 2012). It is estimated that by the year 2050, the planet will have warmed up by average of one degree Celsius, with some areas being affected more and others being affected less (Intergovernmental Panel on Climate Change, 2001; Nrc, 2018).

The warming of the globe has numerous effects on both the global and the local scale, while there are a number of effects that are still speculative. One of the effects that is most commonly linked to the temperature increase in the atmosphere is the the occurrence of more extreme weather patterns. This occurs due to changes in the atmospheric heat engine that were described by the Brundtland Commission in 1987 and formed the basis of the sustainable development movement, which forms the basis of climate-resilient planning (World Commission On Environment and Development, 1987; Holden, et al., 2014). This change in weather patterns will cause weather to become more extreme and will most likely cause more storms, droughts and other forms of extreme weather, however, it must be noted that the extent to which weather patterns are altered are heavily dependent on geography (Intergovernmental Panel on Climate Change, 2001). However, in their 2014 report, the intergovernmental panel on climate change found it relatively plausible that many risks of climate change are concentrated in urban areas, with a high plausibility that: *"Heat stress, extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, and* *water scarcity pose risks in urban areas for people, assets, economies, and ecosystems"* (Intergovernmental Panel on Climate Change, 2014).

The focus of this thesis is on the change in precipitation patterns in the urban environment. The effects changing weather patterns have on the urban environment can both be seen in the water cycle (Figure 1). The water cycle gives insight in the relationships between different processes in the atmosphere, the surface of the planet and the subsurface and how these different processes are interrelated (National Aeronautics and Space Administration (NASA), 2010)

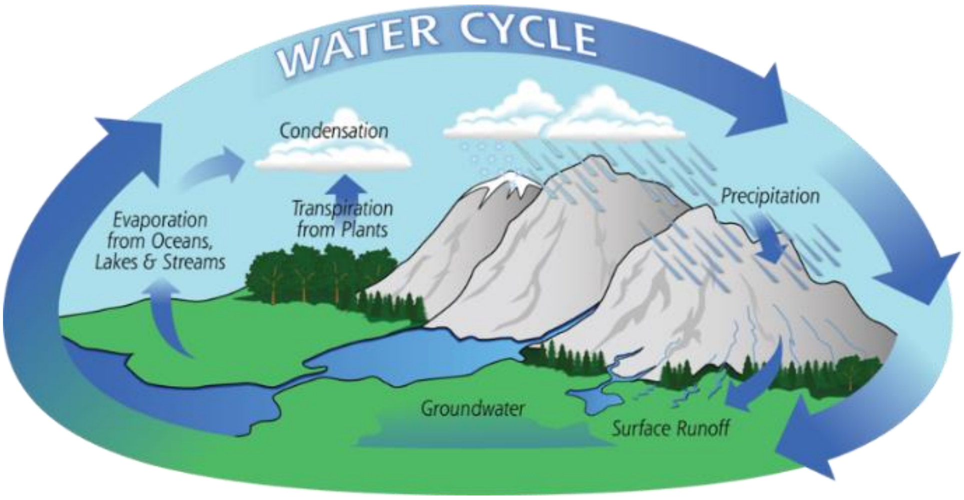


Figure 1: The Hydrological (National Aeronautics and Space Administration (NASA), 2010)

When determining the most important elements for urban hydrology in the water cycle, there are two major factors that have the largest impact, these being surface runoffs and evaporation. Both of these factors are closely related to the important characteristics of most urban centres. These characteristics are that they are often densely constructed and know a dense network of infrastructure. With around 15 to 20 percent of all space being occupied by road infrastructure and around 50 percent of urban space being used by residential and commercial parcels (Centraal Bureau voor de Statistiek, 1999; United Nations Habitat, 2013). This high share of built-up area creates a large area where water is unable to flow through the soil towards the groundwater and results in higher shares of runoffs over the surface (Figure 2) (Pötz & Bleuzé, 2012). This higher share of runoffs means that more water has to be transported through sewage systems or other means of water-draining infrastructure and increases the vulnerability to flash-floods.

In addition to more runoffs, the built-up environment of the city is more efficient at trapping heat, resulting in an environment that can be up to four degrees Celsius warmer than its surroundings, often referred to as the Urban Heat Island Effect (Kuypers, 2007). This, in combination with the higher share of runoffs in urban environment, creates a warm environment where evaporation rates are higher than the surrounding areas, which warms up the environment even further, resulting in heat (Wolters & Brandsma, 2011; Arnfield, 2003). This urban heat island effect has numerous effects on the urban liveability as well as on rain in the urban environment. There are a number of studies that imply that the heat island effect “enhances the intensity and frequency of rain showers” (Intergovernmental Panel on Climate Change, 2001; Changnon, 1992).

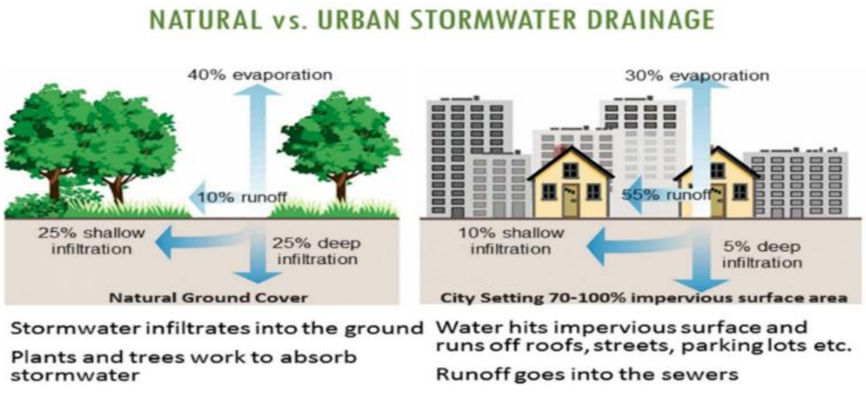


Figure 2: Effects of soil-sealing on the water-cycle (United States Environmental Protection Agency, 2003).

1.2.2 Urban Liveability and Climate Change

Climate Change will lead to an increase in pressure on existing urban ecological services through an increase in heat and water runoffs, as discussed in the previous paragraph. This pressure could lead to a number of effects on the liveability of urban centres since heat and runoffs are not only a climatological issue but have an impact on the entirety of the complex urban system through its interconnectedness to socio-economic and socio-cultural systems (World Bank, 2010).

The focus of this thesis is on the risks of pluvial flooding, but in order to gain a better understanding in the policy making and planning processes of institutions involved in increasing climate resilience, it is important to have an understanding of the implications of climate change on the broadest scale. In their article "Successful Adaptation to Climate change across scales", Adger et al found that the success of climate adaptive and resilience increasing policies are context dependent. And in order to be effective, take their temporal, spatial, political and possible external effect into account to create the best possible solution for a certain issue whilst limiting the possible negative impacts of a development (Adger, et al., 2005). This concept of context dependency makes it important to discuss both the effects as pluvial flooding as the effects of heat and biodiversity on urban liveability. There are a number of effects that climate change can have on urban liveability, which can be broadly categorized in two, often interrelated, categories. These categories being: social and economic effects.

The social effects of climate change can be attributed to the effects of heat on the city. An increase in temperature can have a negative impact on vulnerable population groups, like the elderly and sick, which can result in hospitalization and early death (Harlan & Rudell, 2011; Baccini, et al., 2011). This effect of heat on public health comes from two main effects. First, a physiological effect where heat causes some higher risks of bodily malfunctions. This could result in exhaustion and heat strokes, which increases the risks of other illnesses or accumulated failures in bodily functions. This accumulation of problems can in turn lead to death, meaning that heat does not directly lead to mortality, but leads to preliminary mortality (Knowlton, et al., 2009).

The other effect heat has on public health is through the effects of Heat Inversions on air-quality. Heat inversions are a climatological phenomenon where an air mass is trapped by another air mass (figure 3). Air inversions often occur when the air temperatures lower on evenings with little winds and result in warm evenings and the trapping of pollutants and the formation of smog in urban centres (National Oceanic and Atmospheric Administration's National Weather Service, 2009; Wilby, 2007). This higher chance of smog could have negative impacts on public health through an increased chance of respiratory problems and diseases like asthma or cancers, which could all result in higher hospitalization rates and mortality (Intergovernmental Panel on Climate Change, 2001).

One last social effect of climate change is a change in lifestyle for many people that are more revolved around living outside of their houses rather than inside. This could lead to more social cohesion and positive effects on health as people spend more time in urban green spaces (London Climate Change Partnership, 2002). This increase in use of green-spaces and the health-effects of these spaces discussed in paragraph 1.2.2 raise questions regarding equity, accessibility and the availability of these spaces under increasing urban temperature (Maas, et al., 2006).

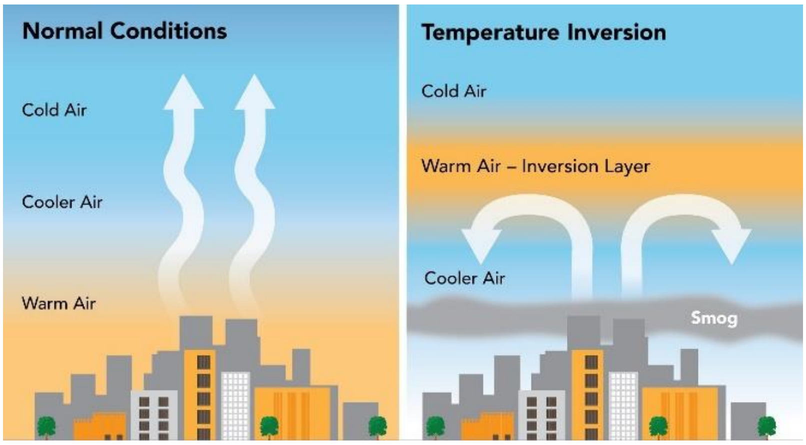


Figure 3: Temperature Inversions Image source: (UAV Coach, 2016)

Besides the social effects, there are also a number of economic effects that climate-change could have on the urban environment. Firstly, the increase in extreme precipitation can result in more flash-floods and storms (Hurk, et al., 2006; Changnon, 1992). This increase in extreme rainfall will put an increasing pressure on existing water-draining infrastructures. In an environment with little height differences between public and private spaces on the street level, this increases the risk that water flow towards the lowest points, which are often private properties like cellars or parking garages (Kennisplatform CROW, 2010). Furthermore, the increase in run-offs will put an increasing pressure on the capacity of sewage systems to transport water. This will require both investments in increasing the sewage capacity, as this is often based upon a certain rain-event, e.g. precipitation quantities of X millimetres an hour, occurring once every X year. More extreme rain-events will require investments in order to maintain the draining capacity, as well as lead to more water needing to be transported and or treated, increasing drainage costs (Bor & Mesters, 2018). This occurrence of more extreme rainfall is not only seen in higher peak discharges, but also in the effects of the longer expected of drought. In these periods it can be expected that the capacity of the drinking water systems could come under increasing pressure. The drought could also have effects on the infrastructure, increasing risks of damaged water pipes, which both require more investments in infrastructure and have risks of economic damages (Drunen, et al., 2007)

In the case of extreme heat, research into productivity has shown that an increase of temperature on the workplace to between 26 and 30 degrees Celsius reduces work capacity (Kjellstrom, et al., 2009). Furthermore, most people in temperate climate zones are comfortable with evening temperatures around 24 degrees Celsius, with sleep being disrupted when temperatures exceed 26 degrees Celsius (Hacker & Holmes, 2007). When the effects of inversion, which mostly occur at night, are taken into account, this means that heat could have an important impact on urban economics and development (Drunen, et al., 2007).

1.2.3 Urban Green and Blue Networks

The socio-economic and environmental risks of climate change on the urban environment put an increasing pressure on the urban environment as a system. In this system, the main sources of environmental and ecological services are the urban green and blue networks. This network consists of both the urban green as the urban blue spaces (Pötz & Bleuzé, 2012). Urban green spaces are all the vegetated areas in the urban environment and the term embodies "all parks, recreational spaces, gardens, lawns, brownfields, wasteland areas and woodlands in the urban environment" (Francis & Chadwick, 2013). Urban blue areas are all open waters, flows and streams that are found within the urban environment (Pötz & Bleuzé, 2012). Together, these two systems create an interconnected network that provides various services for urban populations. These services urban green- and blue spaces provide can be described using two similar, yet fundamentally different, approaches. These approaches are the environmental and ecological services and ecosystem services approach. The environmental and ecological services is a more subject-based approach which focusses mainly on the processes and effects of urban green spaces, whereas the ecosystem services approach focusses on a valuing urban green and blue spaces based upon the use humans derive from them (Chiesura, 2004; Millennium Assessment Report, 2005). The following paragraphs will further elaborate on these two approaches.

1.2.3.1 Environmental- Ecological Services

The environmental- and ecological approach is mainly focussed on the biological value of urban green- and blue networks (Chiesura, 2004). This view is mainly focussed on the ecological and climatological aspects of green spaces without linking it directly to the benefits for urban populations. In this view, urban green and blue spaces provide habitats for species and the network of green and blue infrastructure is a key element in keeping population of urban dwelling creatures diverse and healthy (Forman, 1995).

In the environmental- and ecological services, green- and blue spaces are furthermore seen through their impact on the climate in the urban environment. Urban green and blue spaces provide space for water drainage and water retention (Unesco Aquatic Habitats, 2002). Furthermore, urban green and blue spaces have a positive effect on the microclimate in their vicinity as more water in these areas is evaporated, cooling down the air in its vicinity. In addition to the evaporation, green spaces offer spaces of shade, furthermore limiting heat absorption on the ground level and limiting heat (Forsyth & Musacchio, 2005; Pötz & Bleuzé, 2012).

Lastly, green spaces offer compensation for pollutants and increase air quality. Most important in this are trees, which are known to be able to process carbon- and sulphur dioxide, leading to a lower concentration of these pollutants in the vicinity of trees, however, it is not proven whether or not this effect on pollutants has a significant effect on the ecosystem (Forsyth & Musacchio, 2005; Pötz & Bleuzé, 2012; Wesseling, et al., 2011).

1.2.3.2 Ecosystem Services

The Ecosystems Services (ES) approach to urban green- and blue spaces is more anthropogenically focussed and defines ecosystem services as: “the benefits people obtain from ecosystems” (Millennium Assessment Report, 2005). This approach categorises these benefits in four categories: these being: supporting, provisioning, regulating and cultural services. This approach is founded in gaining a better understanding in the nature-society relationship and to offer researchers and practitioners a way to better understand and analyse this relationship (Lele, et al., 2013). This framework is therefore often used by planning practitioners as a means to put economic value on urban green spaces within the context of urban development, often referred to as Ecosystem Services economic Valuation (ESV) (Laurans, et al., 2013). This utilitarian view on green spaces has its downsides when translated to policy, however, in their article, Lele et al (2013) conclude that the use of ES is a useful framework for policy advocacy and has led to a better integration of biotic factors in policy making.

The four categories that the Ecosystems Services approach used are the supporting, provisioning, regulating and cultural services. First, the supporting services refer to the broad ecological processes like nutrient cycles and soil formation; these processes form the basis of all other ecological services. The second category of ecosystem services is provisioning services, these services are the goods that can be derived from an ecosystem, in the context of the urban environment, and these can be the produce grown in gardens or urban farms. The third category are regulatory services, these services are the services nature offers to the microclimate, like the positive effects green spaces have on pollution, air quality and heat reduction in the microclimate discussed under paragraph 1.2.3.1. Lastly, the cultural services of ecosystems refer to the cultural connection humans have with nature, in the urban context these can be the recreational value and aesthetics of urban green areas and parks (Barthel, et al., 2010; Gómez-Baggethun & Barton, 2013; Pauleit, et al., 2017; Millennium Assessment Report, 2005). In the context of climate change and climate adaptation, there will be an increasing importance of the regulatory and cultural effects of urban green spaces.

1.2.3.2.1 Regulatory Effects

The regulatory effects of urban green- and blue spaces are positive effects on air quality and temperature. When translated to ecological services or the value humans derive from an ecosystem. These effects are mostly beneficial for the health of the urban population. In a research conducted in the Netherlands, it was found that there was a link to the availability of green areas in a 1 to 3-kilometre radius and the perceived health. With around 15% of people feeling less than good in areas with little to no (<10%) green areas in the vicinity and around 10% of people reporting this in greener (90%) areas (Maas, et al., 2006). Research has furthermore linked better air quality perception to a decrease in stress, which is also beneficial for health. However, it is important to note that even though there is a high probability that contact and vicinity of green spaces have health benefits, it is important to note that the extent to which these effects are measurable are highly dependent on the form and context of urban green- and blue spaces (Hartig, et al., 2014).

1.2.3.2.2 Cultural Effects

The cultural effects of green spaces can be broadly categorized in three categories, these being health- social- and economical effects. In many urban environments, urban green- and blue- spaces are spaces that are attractive areas to walk or exercise in, promoting physical activity, which is beneficial for individual health (Konijnendijk, et al., 2013). Green spaces are also often seen as spaces of rest and contemplation, offering spaces of therapeutic and aesthetic value that contribute to reducing stress in individuals and increasing mental and psychological health and well-being (Nordh, et al., 2009; Ulrich, 1986). A research by Heliker et al. (2001) that concludes that gardening is an important activity in in both the mental and physical well-being of the elderly. This in addition to the regulatory effects of urban green- and blue spaces make that especially green spaces are important in promoting and sustaining a healthy urban population.

The second cultural effect of urban green- and blue spaces is an increase in social cohesion and perceived safety. Studies have shown linkages between quality and quantity of green spaces in neighbourhoods and social cohesion between neighbours (Brown, et al., 2003; Hartig, et al., 2014; Ruijsbroek, et al., 2017). Some studies attribute this to the attractiveness of these spaces to an increase in social support and contact between people, which increases the social cohesion as well as increasing mental health (Vries, et al., 2013; Sugiyama, et al., 2008). However, this relationship between green-spaces, social cohesion and mental health is not strong, with many studies not being able to confirm this relation (Maas, et al., 2009; Ruijsbroek, et al., 2017). There might also be a relationship between safety and urban green spaces, with a study showing that buildings with greener surroundings having less reported crimes (Kuo & Sullivan, 2001). All of this indicates that especially green spaces have a role in social cohesion and safety in neighbourhoods, the extent to which this creates additional effects, like better health and to what extent this contributes is still somewhat debated.

The last cultural effect of green- and blue spaces is economic. It is shown that the vicinity of green- and blue infrastructure has a positive effect on the price of real-estate and urban developments (Pötz & Bleuzé, 2012). Research has shown that a green-strip in direct view of a house can increase housing prices by five percent for houses in the Netherlands (Luttik, 2000). Another research shows that house-prices drop with every 100-meter increase of distance to a green area (Morancho, 2003). This indicates that urban green- and blue spaces also have significance in urban economic development.

1.2.4 Urban development, green- and blue spaces and climate change

Climate change is going to put an increasing pressure on urban environments through changes in weather patterns, which can negatively impact liveability. An important factor in limiting the increased pressure of the climate are urban green- and blue areas, however, there are also a number of other factors in urban environments that have an impact on climate-resilience and the ability to adapt and mitigate the effects of climate-change.

When compared to rural communities, the urban environment is at a particular risk because: “Many large urban centres are located along coasts or in low-lying areas around the mouths of major rivers, placing economic capital and human populations at risks of climate-related hazards including sea level rise and flooding from severe precipitation” (Gasper, et al., 2011). In addition to urban centres often being located on vulnerable locations, the urban environment is also characterized by density, with populations and economic capital both being concentrated on a relatively small spatial context. It is also expected that this density will only further increase due to continuous urbanization (Cohen, 2006). This ongoing urbanization creates a need for further densification, seen in new housing developments, the planning of new industrial and commercial zones, road infrastructure and modernization and adaptation of energy- water and other crucial underground infrastructures (Prokop, et al., 2011). This density and continuous development of socio-economic, cultural and natural systems co-existing in a limited space make the urban environment a complex environment (Kennisplatform CROW, 2010). All of these developments and characteristics of the urban environment make climate-adaptation a spatial challenge (Roggema, 2009).

The most important element in increasing climate-resilience and climate-adaptation is the creation of spaces where it is possible to drain and store water and to negate the effects of extreme heat. These capacities to negate the effects of climate change are most commonly found, but not limited to, the green- blue networks (Pötz & Bleuzé, 2012). Therefore, an important element of increasing climate resilience is increasing and improving the amount and quality of this green- blue network, whilst decreasing the amount of soil-sealed area in the urban environment. Soil-sealing is the covering of soil by completely or partly impermeable artificial material like asphalt or paving stones (European Commission, 2012).

Soil-sealing is found through the entire urban environment and is not limited to public or private spaces, meaning both public- as private institutions have an impact on climate-resilience and contribute to climate-adaptation. Decreasing the amount of soil-sealed areas in public space is an important challenge, since a large share of this space is occupied by crucial infrastructure (e.g. roads, sewage, parking spaces) which limits the extent to which these spaces can be adapted for climate change (Kennisplatform CROW, 2010). In their research, the United Nations Habitat Program concluded that in many western cities, around twenty-five percent of city centres and around fifteen percent of suburbs are occupied by road infrastructure (United Nations, 2013). Furthermore, in public space, soil-sealing is mostly driven by the densification and demands driven by urbanization

(Prokop, et al., 2011). These developments and demands limit the extent to which public space can be adapted, as interventions in public space are often dependant on many institutions and other developments (Kennisplatform CROW, n.d.). This makes the adaptation of public space a complex issue, as there are many stakes, developments and ideologies that impact the planning process. However, as these spaces are most commonly owned by local governments, this makes adaptation of these spaces possible through the means of policies, programs and developments (Silva & Costa, 2018).

On the other hand, private space, even though it is also bound to regulations, institutions and trends, is comparatively less complex when adapting space, since adaptation in private spaces is dependent on less actors, institutions and demands. However, citizen engagement in climate-adaptation requires a different approach, as private investments in climate adaptation are often based upon financial gains like energy consumption (Enzi, et al., 2017; Pfoser, et al., 2007). Nevertheless, private space might be an important factor in climate adaptation as research by the Dutch Centre Bureau of Statistics has shown that around thirty percent of the urban environment is occupied by housing and around twenty percent by industrial and business zones (Centraal Bureau voor de Statistiek, 1999). Research has also shown that in many European cities, between sixteen and twenty-seven percent of all urban space is occupied by gardens (Colding, et al., 2006; Loram, et al., 2007; Tratalos, et al., 2007). This makes private space an interesting space for climate adaptation, even though it requires a non-conventional planning approach.

Even though private green spaces are widespread throughout the cities, a research by Freeman et al conclude note that: “Given the widespread occurrence of gardens and the scale of gardening as an activity, the domestic garden is “curiously” under-researched” (Freeman, et al., 2012). A large-scale research in the Netherlands has concluded that the extent to which private space is part of the green- blue network is decreasing from 46 percent in 2008 to 39 percent in 2011. This decrease in the percentage of private green space can be attributed to an increase in popularity of semi-paved gardens (Kullberg, 2016; Linssen, 2011). A research by Zwaagstra in 2014 has concluded that for three neighbourhoods in Groningen, the Netherlands, soil sealing in gardens is the cause of a 0.3 to 3.4 percent increase of runoffs to the sewage system and an increase in temperature during the day of 0.7 to 0.8 degrees Kelvin (Zwaagstra, 2014). This indicates that, however private space can contribute to climate adaptation, the current paradigm in private land-use decisions seems to dismiss climate-adaptation in decision making.

1.3 Research outline

The focus of this research is on the contribution of private gardens to urban climate-resilience, focussing on the following research question: "To what extent can private gardens play a role in climate adaptations and how can planner intervene in the usage of private spaces". This research question will be answered through a mixed-methods research on the municipality of Groningen, the eight largest cities in the Netherlands. The main goal of this research is to research to determine the effects soil-sealing of private spaces has on urban climate-resilience, the underlying arguments for actors to seal their garden and the extent to which planners can intervene and monitor backyard usage. In addition to the main research question, the following secondary research questions have been determined.

The first secondary question being: "What is the effect of land use in private spaces on climate resilience?" This question will contribute to gaining understanding into the extent in which gardens contribute to climate-resilience. This will be analysed using geographic information systems to determine the extent to which soils are sealed in different neighbourhoods of Groningen and how this affects flood-risks.

Secondly, the question: "What are the underlying factors in land-use in private gardens" aims to gain an understanding in some of the mechanics of soil-sealing, giving understanding in possible methods of intervention. This research question will be answered by using scientific literature on soil-sealing and a survey and geographic information system-based case-study in three neighbourhoods to gain an understanding in the dynamics underlying soil-sealing in the case-study area.

The third and fourth questions are: "how policies can intervene in backyard usage" and "how the effectiveness of policies can stimulate land-use changes are monitored". These question both aim at determining the extent to which planners could possibly intervene in backyard usage and aims to find differences and similarities in how complexity should be dealt with according to scientific literature and how this translates to the empirical setting in the case-study area of Groningen. An insight in the planning-practice of Groningen is given by a policy-review of their climate-resilient project and policy papers.

Together, these questions will give a better insight in the subjects of climate-resilience, adaptive-capacity, complexity planning, urban planning and how these subjects translate to the empirical setting of Groningen. Furthermore, this research aims to build a way of monitoring urban land-use using Geographical Information Systems in order to better evaluate and monitor the effects of climate-adaptation and mitigation projects.

2. Theoretical Framework

2.1 Socio-Ecological Systems

The urban environment, citizens and the climate are all parts of a socio-ecological system. A social-ecological system is a complex and adaptive system that is bounded by space and function (Glaser, et al., 2012). In a social-ecological system, biological and societal systems interact with each other on a set scale; this can be both globally as locally. Social-Ecological Systems are complex systems, since through this interconnectedness one change might have non-linear effects on other elements in the system (Berkes, et al., 2003). In the case of soil-sealing in the urban environment the social-ecological system is bounded by the outskirts of the city and the actors in the system are all citizens, different landscape elements (e.g. buildings, parks, gardens) and the linkages between these actors are seen through the ecological services and urban developments (e.g. urbanization, green-space planning). A change in one of the elements of this system has impacts on all other elements in the system, an example of this can be how the development of new housing has impacts on both the socio-economical (e.g. an increase of housing prices) as ecological services (e.g. groundwater flows and drainage capacity) in a neighbourhood. As one change can have important impacts on the socio-ecological system a whole, it is important to have a thorough understanding of the interplay between social and ecological components (Gallopin, 2006). In their article Walker et al. (2004) argue that these interplays can be related to three main principles, these being the concepts of vulnerability, resilience and adaptive capacity. Having an understanding of these concepts is therefore a useful way to gain more in-depth insight in the system and reduces uncertainty when interacting with the system.

2.1.1 Vulnerability, Adaptive Capacity and Resilience

Climate change is a complex issue that has important implications in the planning of the urban social-ecological system. These implications are seen through the concepts of vulnerability, adaptive-capacity and resilience and together determine the extent to which climate-adaptation and mitigation strategies are effective. These concepts are interconnected with each other and are important determinants in gaining understanding in the effects that a change in the system like climate change might have on the socio-ecological urban system (Gallopin, 2006).

2.1.1.1 Vulnerability

Vulnerability is a concept that has a different meaning that is dependent on its application in a certain system. However, throughout its different usages, its often conceptualized as exposure to external stresses that limit or change the functioning of the social-ecological system as a whole (Adger, 2006). Vulnerability comes forth from the exposure to perturbations and threats and the impact these factors have on the system. Perturbations are major spikes in pressure that exceed the threshold of a social-ecological system. Stress is an ever present or slowly increasing pressure that is always present in the system (Turner, et al., 2003). Vulnerability also refers to the sensitivity and coping capacity of the system. This means that vulnerability is the interplay between internal and external forces that impact the social-ecological system.

Perturbations are often found externally while stresses are mostly found internal but there are studies suggesting that they can both also originate from both internally as externally within the social-ecological system (Turner, et al., 2003; Young, 2009). Forms of external stress are mostly dependant on the spatial boundaries of the social-economic system (Gallopin, 2006). For a large-scale system, like the global system, most threats are internal threats, as they occur and function as parts of the system while only threats from outside the system, like meteors or solar flares, can be classified as external threats. When the scale becomes lower, the distinction between perturbations and stresses becomes more subjective and context-dependant. Perturbations and stresses can originate from both the ecological as social systems and range from climatological (e.g. hurricanes) to economical (e.g. overfishing) (Young, 2009). This means that the definition of perturbations and stresses are highly dependent on the conceptualization and spatial- and institutional bounds of the social-ecological system. In the case of soil-sealing and climate-change in the urban environment, the effects of climate-change, being more drought and extreme rain, could be seen as perturbations as these events are relatively sudden shocks that exceed the ‘average’ weather that the urban environment was designed for, the processes of continuous urbanization and soil-sealing can be seen as stresses that are continuously affecting the urban environments liveability.

The extent to which vulnerabilities affect the social-economic system is dependent on the sensitivity of the system and the exposure to the shocks, these two concepts are strongly dependant on one another, and is often referred to as exposure-sensitivity (Luers, 2005; Smit & Wandel, 2006). The sensitivity and exposure are dependent on: “the degree, duration and the extent in which the system is in contact with, or subject to, the perturbation” (Gallopin, 2006). The relationship between sensitivity and exposure determines the potential effect a shock might have on the system as a whole. In the case of climate-adaptation and the urban environment, the sensitivity to climate-change is based upon the before mentioned continuous stress of urban land-use decisions and the exposure is driven by the perturbation effects of climate-change.

2.1.1.2 Adaptive Capacity

Whereas exposure-sensitivity determines the effect of a shock on the system as a whole, the adaptive-capacity determines the effect that shocks have on the social-ecological system. In the field of climate-change studies, adaptive capacity is most commonly framed as: "the ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities or to cope with the consequences" (Intergovernmental Panel on Climate Change, 2001). In his article Gallopin (2006) frames adaptive capacity as consisting of two distinct components being: "(1) the capacity of the SES to cope with environmental contingencies (to be able to maintain or even improve its condition in the face of changes in its environment(s)) and (2) the capacity to improve its condition in relation to its environment(s)". Both of these definitions frame adaptive capacity as a pro-active force related to both vulnerabilities and resilience, which not only is aimed at dealing with change, but to using change for development.

The adaptive capacity is determined by a number of factors including: Variety, Learning Capacity, Room for autonomous change, Leadership, Resources and Fair Governance (Gupta, et al., 2010). These factors are all determined by the strength of the bonds between different elements in the social-ecological system and together influence the extent to which adaptive-capacity can be reactive or pro-active. In their article, Gupta et al. argue that an evaluation of the adaptive capacity is possible using the adaptive-capacity wheel (Figure 4). The adaptive-capacity-wheel is a useful way to evaluate and communicate about adaptive capacity, and when evaluating the wheel, it becomes clear that there is a distinct role of stakeholder involvement in adaptive capacity. When translated to the urban environments, where there are numerous stakeholders present in the form of communities, organizations, businesses and other forms. All of these stakeholders have their own ideas and capacities regarding adapting and reacting to the effects of climate change. This indicates that community-engagement and individual choices are important factors in dealing with urban climate change (Olsson, 2004).

2.1.1.3 Resilience

Whereas vulnerability refers to the exposure and sensitivity to external and internal changes and adaptive capacity refers more to the ability of the social-ecological system to adapt and continue developing despite vulnerability, resilience can best be framed as: ''the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks—in other words, stay in the same basin of attraction"

(Walker, et al., 2004). In other words, resilience is the ability to recover from shocks and perturbations and is often seen as the antonym of resistance (Vis, et al., 2003). Resilience is the factor that stands between vulnerability and adaptive capacity and is a characteristic of the social-ecological network as a whole.

When operationalizing resilience in the context of climate change and the urban social-economic system. It can be seen that resilience is determined by three factors. Being: the robustness, adaptability and transformability of a system (Folke, et al., 2010; Restemeyer, et al., 2015). The robustness of an urban social-economic system refers to the ability of a system to withstand environmental pressures by increasing drainage capacities and other spatial adaptations. Adaptability refers to the ability of the system to avert problems to another regions, a good example of this is constructing parking garages in a way that water can be stored in case of flooding. Lastly, the transformability of the urban social-ecological system implies: “a capacity to change based on new insights, searching for the most appropriate way to deal with flood risk” (Restemeyer, et al., 2015). In practice, the robustness and adaptability aspects of climate-resilience can be linked to existing structures in the physical environment, like the extent of paving, green spaces and increasing resilience in this field requires both hard and soft engineering (Hallegatte & Dumas, e.g.). On the other hand, the transformability is more of management strategy where people and other actors in the system are required to learn to deal with the risks of climate change, which can be closely linked to the adaptive capacity of individuals.

Figure 4: The Adaptive Capacity Wheel (Gupta et al, 2010).

2.1.1.4 The Interrelatedness of Resilience, Vulnerability and Adaptive Capacity

Resilience, vulnerability and adaptive capacity are all elements that can be used to refer to the different aspects of the social-ecological system. With vulnerability often referring to developments and occurrences that drive change in the system, adaptive capacity refers to the ability to deal with these changes and occurrences and resilience giving insight in the extent to which a system can deal with changes and occurrences without changing form. In his article, Gallopin (2006) states that these different elements are so strongly interlinked that they can't be viewed without taking other into account (figure 5). This notion is supported by Smit & Wandel (2006) (Smit & Wandel, 2006), who describe the hierarchy of resilience, vulnerability and adaptations as following: "a system (e.g. a community) that is more exposed and sensitive to a climate stimulus, condition or hazard will be more vulnerable, Ceteris paribus, and a system that has more adaptive capacity will tend to be less vulnerable, Ceteris paribus." He states that the concepts of vulnerability, resilience and adaptive capacity are most clear when seen as interrelated and that there is no generally accepted meaning for these concepts on their own.

The interrelatedness of resilience, adaptive capacity and vulnerability is also seen in the operationalization of the concept of resilience. With "robustness and adaptability" referring to decreasing vulnerability through increasing the resilience of the system and "transformability" referring more to the increasing of adaptive capacity in the urban context.

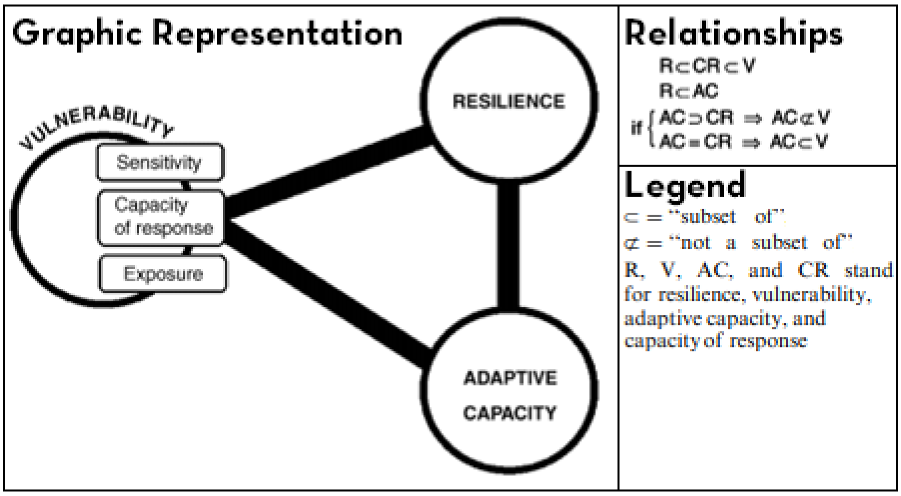


Figure 4: The Conceptual relationships between resilience, vulnerability and adaptive capacity. (Gallopin, 2006)

2.2 Complexity in the Urban Social-Ecological System

The urban social-ecological system is a system that consists of all entities and the linkages between these entities in the urban environment. The urban system is vulnerable to the effects of climate change through the threat of extreme rain-events and the effects of continuous development and other processes in the urban environment. The complexity in this network is seen in non-linearity, in other words, the process through which a change in one element of the system can have unexpected outcomes in other aspects of the network. This non-linearity creates uncertainty in planning (Duit & Galaz, 2008). This uncertainty in planning, when seen in the light of urban climate-resilience can create regarding the making of effective policies and spatial interventions in order to increase resilience. This uncertainty can be limited by thorough research into the different relationships and linkages between actors in the urban environment.

2.2.1 Uncertainty and Climate Change

Climate change is the catalyst that drives the necessity to increase climate-resilience. However, the effects climate change has on the urban environment are complex in their own and make it difficult to make effective and general policy. This complexity is seen in three factors, these being: a weak profile, externalities and economies of scale (Zuidema, 2016). In addition, this complexity is also present in the actions required to deal with climate change, also known as the adaptation-mitigation dichotomy

2.2.1.1 Weak Profile, Externalities and Economies of Scale

First, climate change has a weak profile; this is seen in two ways and makes increasing climate-resilience rather subjective. One the one hand, climate-change is a phenomenon which has different effects based on geography. This means that the effects of climate-change can differ greatly between regions, making it difficult to have a centralized approach to increasing resilience. Secondly, the effects of climate-change are highly subjective on the individual level. This subjectivity can be seen in the differences in capacity of response between individuals. For example, extreme rain in a city might not cause a lot of problems for people that life in an apartment on the second floor but might cause significant damages and problems for citizens that have a cellar or live in lower-lying areas (Gallopin, 2006). This geographical and interpersonal subjectivity make that communicating and negotiating has a key role in increasing climate-resilience.

Secondly, climate-change has strong external effects, this is seen in both the causes and the effects of climate change. The causes of climate change are global rather than local, meaning that in order to limit temperature rise, global action is required rather than just local action. However, global action is difficult to govern as intragenerational inequalities and power imbalances limit the extent to which global action can be taken, limiting the capacity to change and limit the emissions of greenhouse gasses (Zuidema, 2016). On the other hands, the effects of global climate change, being an increase in the occurrence of more extreme weather in the local context are not only bound to one region but can create problems over a larger area. However, this relation can also be positive; an increase in climate resilience in one region might have positive effects on all surrounding regions (Hallegatte, 2009). An example of this is how an increase of climate-resilience in one region through the application of parking garages as water-basins to store water in case of storms might decrease the peak-discharge of a river, resulting in a decrease in flood-risks in a city further downstream. This also creates the potential problem of free-rider behaviour, where positive developments in one region positively affect climate-resilience in other regions, resulting in other regions limiting their contribution to increasing resilience (Helm, 2008). These factors make that it is important to have interregional cooperation in increasing climate-resilience.

Lastly, economies of scale apply to climate-change, mostly in the form of decreasing global carbon emissions, the application and development of technologies that limit greenhouse emissions often require large investments and are most effective when they are applied on large scale. On the governance side, centralized governments have a greater capacity to attract knowledge and common policy formats ensure that every region contributes to climate-resilience (Zuidema, 2016). On the urban scale, it can be stated that adaptation on the large scale e.g. the construction of one large dyke instead of a larger number of smaller dykes, can be a more cost-effective solution (Rietveld, 2010). However, this does not imply that climate-resilience can only be increase through large-scale project and centralized governmental control, since private small-scale actions also can have significant contributions to increasing climate resilience that is founded in local knowledge and necessity (Zuidema, 2016).

2.2.1.1 The Adaptation-Mitigation Dichotomy and Climate Resilience

As climate-change is a global phenomenon with local effects and an ongoing process. The temporal aspect of climate-change adds to the complexity of dealing with climate change. When translated to increasing climate-resilience, this temporality requires two different strategies for the long- term and short-term. The first of these strategies is mitigation; this long-term strategy is aimed at preventing or limiting the causes of climate change. The aim of these strategies is to limit the extent to which global temperatures rise and the effects of the climate-change (e.g. more extreme weather) occur (Biesbroek, et al., 2009). For the urban environment, this mostly implies a limitation on the emittance of greenhouse emissions and an increase in the capture of greenhouse emissions. One of the strategies that can be used for better capture is increasing and improving the capture of carbon-dioxide in the top soil and vegetation through increasing the amount of tree-covered green spaces (Nero, et al., 2017). However, mitigation strategies require (inter)national cooperation and action in order to be effective.

One the other hand, adaptation strategies are required to address the more short-term effects of climate change. Adaptation is a more local-based strategy often aimed at increasing the ability to cope with the effects of climate change (e.g. more extreme weather). In the case of urban climate resilience, adaptations strategies often aim at increasing the number of water-draining infrastructures to retain water and limit peak-discharges or the increase of green-space to decrease the effects of urban heat islands in periods of drought (European Climate Adaptation Platform, 2015; Yu, et al., 2017).

Adaptation and mitigation are two different approaches in solving the same problems and their main difference is in time, space and stakeholder involvement. Adaptation is often more short-term, local and aimed at interest groups and local/regional governments, whereas mitigation is more aimed at the long term, national/international scale levels and deals with the national/international stakeholders. These differences of mitigation and adaptation are also referred to as the Adaptation-Mitigation Dichotomy and are an important element in climate-resilient planning (Biesbroek, et al., 2009).

2.2.2 Complexity and the Urban Environment

Climate-change is putting an increasing pressure on the liveability of the urban environment and requires adaptation and mitigation strategies. However, the extent to which the urban environment can react and adapt to these changes is not only a question about space and time; it is also dependent on other developments and systems within the urban environment that also require time and resources. The urban social-ecological system in itself can be seen as a complex network consisting of different ecological, economic and social actors, processes and resources that influence one another.

The interaction between these networks has linear and nonlinear effects. In their research, Liu et al (2007) state that: “The ecological and socioeconomic impacts of human nature couplings may not be immediately observable or predictable because of time lags between the human-nature interactions and the appearance of ecological and socioeconomic consequences”. The effects that different elements of the system have on one another are driven through positive- and negative feedback cycles. Positive feedback cycles are processes that reinforce a phenomenon or process and negative feedback cycles are more aimed at keeping a system balanced or under control. These feedback cycles create a complexity in space, as the nonlinear nature of their effects can have unexpected outcomes on the entire system. These effects can occur suddenly, like flooding, or can also not appear until a certain threshold has been reached (Duit & Galaz, 2008). This makes having an understanding of the different positive and negative feedback cycles key in increasing resilience; this requires a deep understanding of the urban fabric.

In the urban system, positive feedback cycles can be seen as the stresses of vulnerability. Positive feedback cycles are the ongoing processes that, either through thresholds or cascading effects can negatively influence climate-resilience. An example of this is the process of ongoing urbanization that goes hand in hand with soil-sealing. This process influences both groundwater flows as the quality of the soil itself, as often in construction organic soils will get replaced by finer soils impacting water permeation (Harbor, 1994). This in turn has impacts on the quality of vegetation, the capture of carbon dioxide through vegetation and increases vulnerability to heat and extreme rainfall.

In the urban system, negative feedback cycles are processes that maintain and determine resilience. An example could be the water-retaining capacity of urban green spaces that limit peak discharges and decrease the risk of flooding or other ecological processes that help in stabilizing the urban climate. Governance can also be used as a negative feedback cycle; a good example of this is the dynamic adaptive approach. In the dynamic adaptive approach, this approach used negative feedback cycles through monitoring the vulnerabilities and opportunities in a system and takes action when set thresholds are set. The focus of monitoring in this approach creates a flexible approach to governance, where vulnerabilities and negative impacts can be limited, while opportunities for improvement are used to optimize and stimulate growth in the system (Wall, et al., 2015).

2.2.2.1 Spatial Complexity, Urbanization and Urban Development

One of the most important negative feedback cycles, or stress on urban climate-resilience are urban developments. Developments in the urban context are driven by the tension between the socio-economic, socio-ecological, ecological and demographic systems within the boundaries of the urban environment. In the urban environment, space is scarce, but this space is also contested by different forms of development and processes. The urban system requires three broad categories of land use in order to function properly. The first is infrastructure, the “arteries” of the urban environment and the system through which goods- and services can flow through the environment. The second element is the built-up area, these areas are necessary for living spaces, working spaces and places of production, enabling development in the urban environment. Lastly, the green-and blue areas form the main regulatory system of the city, providing ecological services to keep the city healthy and liveable (Salingros, 2000). All of these systems co-exist and interact with each other to determine urban climate-resilience.

The ratios of infrastructure, buildings and green and blue spaces determine urban climate-resilience. Keeping the ratio of these different land uses in balance is therefore a key governance objective in increasing and maintaining urban climate-resilience (Jasmani, 2013). However, there are a number of processes that impact this ratio. The processes of economic development and urbanization create a demand for new spaces to construct infrastructure and residential, commercial, office and industrial zones. This demand can be supplied by either developing previously undeveloped green areas or by redeveloping parts of the city. New developments will lead to a decrease in green areas and negatively impact climate-resilience whereas re-development can help in maintaining the ratio of green and developed areas. Both of these developments however, will put an increasing pressure on, especially smaller, urban green spaces through increased disturbances (e.g. noise, wear and tear due to increased use etc.) and impact the ecological functionality of green spaces (Francis & Chadwick, 2013; Grimm, et al., 2008; Nordh & Østby, 2013).

The process of increasing climate-resilience in the light of continuous urban development requires a “greater appreciation of urban green areas” (Ernston, et al., 2010). This evaluation can be done by using the ecosystem services approach, where green- and blue spaces are valued through the services they provide to humans (Millennium Assessment Report, 2005). However, the valuation of urban green spaces is difficult due to the processes of non-linearity and time-lags, meaning that it is important to monitor the effects of development on urban climate-resilience and to have a governance approach that links social, ecological and cultural aspects of urban development and space (World Health Organization, 2017; Jasmani, 2013). This importance of urban-developments in climate-resilience is also the conclusion of a search by Grimm et al. (2008), where they conclude their paper by stating: “Urban ecology has a pivotal role to play in finding those solutions and navigating a sustainable urban future”. This means that urban green spaces have an important impact on climate resilience, and balancing development with ecology is an important factor the future of urban developments.

2.2.2.2 Urban Ecology and Decision making

space is complex because it encompasses a large number of functions and elements in a dense environment. Underlying the ratios in these functions and elements are institutions. Institutions are "stable, valued, recurring patterns of behaviour" (Huntington, 1968). Institutions can be both formal as informal. Formal institutions are defined by formal rules and practices, an example of this can be how governments use law in order to improve climate-resilience through the designation of nature reserves and laws on water-drainage on the household level. But underlying these formal institutions are informal institutions, which can be seen as important in determining the usefulness, efficiency and effects of formal institutions (Gretchen & Levitsky, 2004). This effectiveness of formal institutions is determined through the mechanisms of power, bureaucracy and clientelism.

Informal institutions are important in determining the effectiveness of formal institutions. Informal institutions can be complementary, accommodating, competing and substitutive to formal institutions. Complementary informal institutions synergize with formal institutions and helps in making rules more effective. Accommodating informal institutions create room for improvising or changing effects of formal rules, creating more stability and room for change in the formal institutions. Competing informal institutions ignores the formal institution and create a new form in institutions. Lastly, substitutive informal institutions often occur where formal institutions are too vague or unstable and often aim to provide what the formal institutions are unable to provide (Lauth, 2000).

Informal institutions in the field of urban green space are the competing informal institution of increased soil-sealing in private spaces that is counteracting public policies and regulations to increase water storing capacity or the cultural value of urban parks as spaces of recreation that put a pressure on ecological services. These examples of informal institutions impacting urban climate-resilience demonstrate how increasing climate-resilience will require an institutional change (Tompkins & Adger, 2004). However, informal institutions are hard to change due to path dependency, making that they have “tenacious ability to survive” (North, 1990).

Increasing urban climate-resilience through urban green spaces is a process of institutional change. Institutional change often happens through the changing context of society; however this can often be a slow process. As institutions are a construct of human society, it is also possible to change institutions, this intentional change process is often referred to as institutional design (Kim, 2011) (Klijn & Koppenjan, 2006). Institutional change is driven through processes of de-institutionalization, re-institutionalization, and institutionalization (Olsen, 2009). This process can be illustrated by discussing the emergence and disappearance of public vegetable gardens in the First World-War where the scarcity of food quickly led to an institutionalization of community vegetable gardening to increase food-security, after the first world war this behaviour was de-institutionalized as food-scarcity decreased and in time community gardens disappeared. However, this informal institution re-institutionalized again when it was needed to maintain food-security in the Second World-War (Armstrong, 2000). This example shows how the necessity and form or urban-green spaces is formed through societal needs and formal and informal institutions, showing that urban land-use decisions can be influenced when there is a high urgency for land-use changes.

2.3 The Multi-Level Perspective

Increasing urban climate-resilience through green space planning has a high extent of uncertainty due to the complexity of climate-change, urban space and urban institutions. These elements all relate to each other in the urban social-ecological system on three distinct levels, these being the macro-, meso-, and micro level (Figure 5) (Geels, 2002).

In planning for climate resilience, the different scales of complexity can be found these levels. Firstly, the macro level is the landscape level; in the case of climate-resilience this is the level where the perturbations that put pressure on climate-resilience are found like urbanization or urban development, as well as the social values, institutions and physical entities that represent them. In other words, the landscape is determined by climate change and the effects it will have on the urban environment. The meso level is the level of regimes, on this level you will find the dominant formal and informal institutions and the current urban design that comes forth from these regimes. On the micro level you can find new forms of technology, institutions or other factors that drive institutional change. All of these layers affect one another and in using this multi-level perspective, the relationships between the different factors (environment, urban, institutions) in the light of climate-resilience can be understood better.

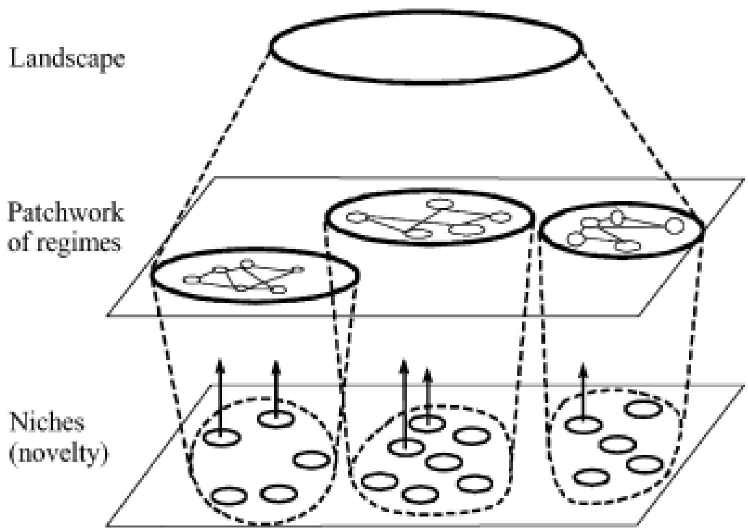


Figure 5: Multi-level perspective (Geels, 2002)

The multi-level perspective not a static framework that is useful for examining a complex issue, the multi-level perspective gives insight in the possible developments occurring in a social-ecological system. The multi-level perspective is also a useful framework to evaluate possible sociotechnical developments and gain insight in technological transitions. As seen in figure 6, the multi-level perspective offers insight in transitions. Most changes start on the niche level, where innovations and new strategies are thought up, when a new innovation is successful it can become part of the regime, being embedded in current practice and through that, altering the planning landscape (Kemp, et al., 1998; Rip & Kemp, 1996).

This concept of development from niche level towards regimes and landscape forms the basis of transition management approaches. Transition management is a governance approach that seeks to make policies through long-term learning and innovation with a broad group of actors that range multiple domains and levels, finding solutions for problems (e.g. climate change) through the development through flexible innovation (Loorbach, 2007). This multi-level approach and transition management might be a useful framework for climate-resilient planning through its focus on the niche level for innovations and the broad participation, meaning that it can help in making policies and strategies for climate-resilience that focusses on changing the institutions rather than maintaining the status quo.

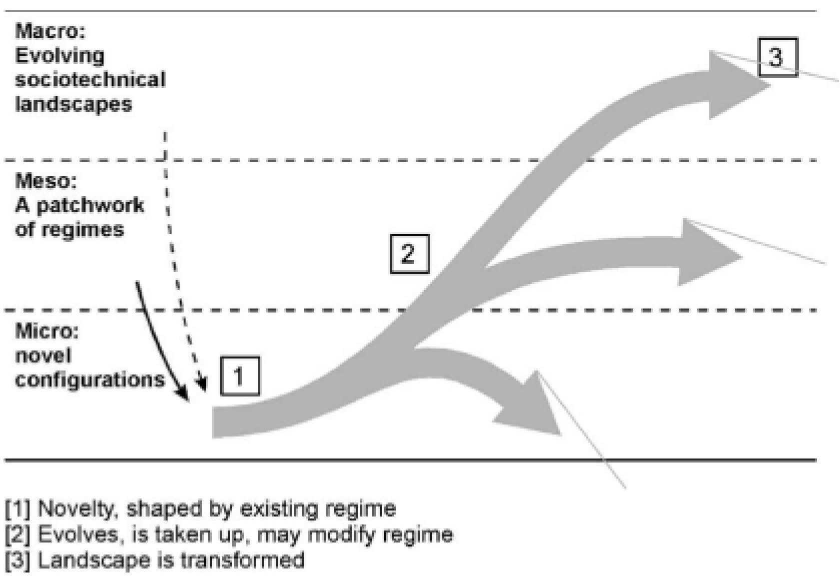


Figure 5: Transitions through multiple levels (Rip & Kemp, 1996)

2.3.1 Urban Green Spaces and the Macro level

The macro level contains the current sociotechnical landscape, consisting of all factors that form the basis of interactions and actors (Geels, 2002). In the case of urban-resilience through the planning of green spaces. When applied to climate-resilience and urban green spaces, three distinct levels can be found here. The first is the actual landscape, or the current ratio of green and soil-sealed spaces in an urban environment, this level is an important factor in determining the resilience of the urban development. On the second level there are the developments in the urban environment that impact this landscape and are the basis of policies and developments. These include climate change, urbanization and economic development and form the demand for different land-usages. Lastly, there are the cultural values that are on the basis of policies, in the case of urban green-space, the cultural values that determine resilience are mostly the cultural value of green spaces and the roles of citizens and governments within a government. Together, these three levels form the basis of the "fight over spatialized power" or the negations process that determines how the urban society, economy and the urban landscape are developed (Westerink, et al., 2013).

2.3.2 Urban Green Spaces and the Meso level

The meso level is strongly connected to the landscape level and consists of all policies, programs, research and formal and informal institutions that aim maintaining or changing the macro level (Geels, 2002). This level is formed by the current paradigms in planning, which is mostly focused on public green spaces rather than the private green spaces (Freeman, et al., 2012). This level is also formed by the current "common practices" that form policies seeking to balance the different demands on urban space, examples of these policies include compact city policies, which is the current planning paradigm in balancing ecology and development (Tappert, et al., 2018). Another form of "common practice" that is found on this level is the planning-approach, most importantly the extent to which communities and other actors are included in the planning of green spaces, which has impacts on community engagement and planning strategies (Buizer, et al., 2015). Lastly, this level contains all current trends in gardening and the use of public and private green spaces, which in turn determines land-use and disturbance, impacting the ecological value of urban green spaces. An example of this is the impact of building density on garden design, with current research indicating that higher building-densities are often related to higher shares of soil-sealing and lower ecological values and the current popularity of having a soil-sealed garden (Tratalos, et al., 2007; Operatie Steenbreek, 2017). Together, these developments, policies, strategies and knowledge form the landscape level. Making this level the most important in determining the current resilience and adaptive capacity of urban social-ecological systems.

2.3.3 Urban Green Spaces and the Micro level

On the micro level, new developments, technologies and approaches are found. This is the most important level for innovation and the basis of change of the macro and meso levels (Geels, 2002). On the micro level for urban green spaces, new policies and governance approaches are found. Like the application of more resilient-based approaches in increasing climate-resilience through linking ecological, social and cultural aspects in the planning of small urban parks in order to maximize ecological benefits (Jasmani, 2013). New planning approaches that focus more on individual participation in climate-adaptation through the use of community based approaches. Lastly, technological developments in the field of monitoring urban public and private green-spaces for the use in dynamic adaptive approaches can be found here. However, not all developments are necessarily good, a good example of this can be seen in the rise of the car and the impacts this has had on soil-sealing through increased demands of parking spaces (Perry & Nawaz, 2008; Zwaagstra, 2014). These niche-developments have the potential to change the meso and macro levels and positively or negatively impact urban climate-resilience.

2.4 Urban Private Green Spaces

One of the niche developments is an increase in scientific interests in urban private green spaces, the dynamics of soil-sealing in the private domain and the impact of individual choices on climate-resilience. Urban private green spaces consist of all vegetated gardens in the urban environment. Unlike public space, private space is not governed by one actor, but by private owners. Together, this form of green space takes up sixteen to twenty-seven percent of urban area (Colding, et al., 2006; Loram, et al., 2007; Tratalos, et al., 2007). What house-owners do with their garden is a personal decision, that decision is often based on the information that an actor has access to at a certain point in time (Forester, 1982). This while: “Domestic gardens help provide improved thermal comfort to their residents, have potential to reduce domestic energy consumption and minimize storm run-off” (Cameron, et al., 2012). This subjectivity in private-property land use decisions has implications on the extent to which gardens are green or soil sealed. Or in other words, private-land use decisions are important factors in determining the contribution to climate-resilience. There are a number of factors that research show has impact on these decisions, which will be discussed in the following paragraphs

2.4.1 Socio-Cultural Factors

The socio-cultural value of a garden is highly subjective, this is illustrated by the conclusion of an article by Cameron et al (2012), in the conclusion of this article, and the socio-cultural importance of gardens is described as following: “Domestic gardens are undoubtedly an important component in many people’s lives, but attitudes towards them are not uniform. To some, they are an essential element of life providing opportunity for engagement with nature, self-actualization, creativity or wellbeing; to others, they are at best a parking lot, or worse, represent an additional chore to an already busy lifestyle”. In this subjectivity, there are a number of factors that previous research indicates as possible indicators for private land-use decisions, these are: gender roles, the concept op home and trends.

A research by the Dutch Social and Cultural planning agency indicates that the increase of workforce participation of females has led to an increase in soil-sealing in gardens (Kullberg, 2016). This indicates that gender plays a role in garden-design, however, a research by Bhatti & Church (2000), implies that gender does not play a role in garden-design, stating that: “The garden then is, like home, a gendered space and is often filled with shared creative pleasures, but also escape from domestic drudgery or from other members of the family. But crucially men and women relate to the garden in significantly different ways, often related to availability of ‘spare’ time and the pressure from other activities”. This seems to indicate that the socio-economic factors related to worktime and off time have a more important role to play, which could be an explanation for the increase in soil-sealing corresponding with increasing female workforce participation. This notion of age an

Another factor that contributes to private-land use decision is the position of the garden in the concept of home. The concept of home, in the past, referred mostly to the inside of a home. Gardens were a separate entity that co-existed with the house, with the house being more focussed on the concept of homeliness, and the garden being a space of getting in touch with nature and relaxation (Bhatti & Church, 2004). Nowadays, the concept of home applies more too both the house as the garden, with the garden being an extension of the home. The focus of the garden has shifted from a place of being in contact with nature, more to a space of social behaviour. This can be seen in the trend of bringing homely elements into the garden, like furniture and kitchen elements like barbecues. In order to facilitate these homely elements, part of the garden often has to be soil-sealed (Linssen, 2011). This seems to indicate that the change in the positions of the home and garden are an important factor in the increase of soil-sealing and a limiting factor in climate-resilience.

The concepts of trendiness have important implications on garden design. This is seen both in the impact of neighbours as the impact and popularity of gardening shows and centres as sources of inspiration. Both of these factors can be attributed to a wish to conform to both societal as neighbourhood. In his article, Bonabeau (2004) argues that the increase in access to information and modern information technology has led to more imitation behaviour, stating that: “When information is plentiful, we often use it not to make better decisions based on the intrinsic characteristics of a situation but rather to imitate others-and their mistakes. When there is simply too much information to process, imitation becomes a convenient heuristic”. This need to meet societal standards through the imitation of others is also seen at the neighbourhood level, with indications that the decisions of neighbours impact individual land-use decisions (Nassauer, et al., 2009). These two factors form the basis of the concepts of ‘spatial contagion’ and ‘gardening trends’.

A number of researches indicate that both soil-sealing as private-green are bound to the concept of ‘spatial contagion’. This spatial contagion means that neighbours are likely to conform their gardens to other gardens and public space in their neighbourhood. This concept of spatial contagion is mostly seen in front gardens, with a number of researches concluding that neighbouring front gardens were more likely to display a form of copying behaviour (Kullberg, 2016; Larsen & Harlan, 2006). A research by Hunter & Brown (2012) for the design of easement gardens concludes that for easement gardens conclude that is 2.4 times more likely for people to make use of these forms of gardens when a house in a 30 meter radius is doing likewise. Furthermore, researches by Zmyslony and Gagnon (1998;2000) conclude that environmental factors in the vicinity of a garden, both in public as private space, can be used to explain spatial patterns in front-yards usage. All of these researches together make it quite likely that there is an extent of spatial contagion in private-land use decisions, especially in front-yard design. There is little research in spatial contagion for back yards, with one research concluding that whereas front-yards often comply with neighbourhood design, back yards were often a less similar (Larsen & Harlan, 2006). This means that, for urban private-green spaces, the extent to which spatial contagion occurs can be expected to be mainly dependant on garden forms, mostly indicating that there is a certain need to meet neighbourhood expectations (Nassauer, et al., 2009). Indicating that neighbourhood design can be an indicator of spatial-contagion, with neighbourhoods where parcels have larger front-yards being more likely to be influenced by public space and neighbours than neighbourhoods where parcels have smaller-back-yards.

Land-use decisions are often determined by the information an actor has present as a certain time. This information is partly derived from external factors (e.g. neighbours and media) and from internal factors (e.g. personal knowledge, preferences). These two forms of information together form the informal institutions that determine private-land use and the position of the garden in the home (Bhatti & Church, 2004). One of the informal institutions that drive change is ‘gardening trends’. With the rise of modern media gardens have become more and more commercialized through media and garden-centres. This has made the garden a space to showcase contemporaneity and status as a gardener. These commercial processes are mostly driven by trends, seen in the emergence of the garden as a space of meeting and cooking (Linssen, 2011). This trend has been linked to an increase in soil-sealing (Kullberg, 2016; Perry & Nawaz, 2008). This relationship between the position of the home, gardening trends and neighbourhoods are all potential factors that influence private-land use decisions and the form of the private green network.

2.4.2 Socio-Economic Factors

There are a number of socio-economic factors that contribute to soil-sealing in private spaces. The first of these factors is the socio-economic status of a household. However, the extent to which is an explanatory factor in garden design is not yet clear, with Heezik et al (2013) concluding that: "The explanatory power of ''socio-economic status'' was not as high as in some other studies but the inclusion of a variable representing knowledge about native and exotic species contributed significantly to the explanatory power of most models". The socio-economic status is the combination of employment types, family income and education level all of these factors have been concluded to have an impact on private land-use decision in several researches.

The employment type of a household can be seen as the indicator of how much time individuals have for gardening. In a report on gardening in the Netherlands, Kullberg (2016) concludes that it is more likely that elderly have a green garden, whereas it is more likely that families were both partners work are more likely to have a soil sealed garden. In addition, a number of researches find a relationship between household income and the number of plants in gardens, indicating that an increase in socio-economic status (e.g. wealth) leads to more attention for garden design (Heezik, et al., 2013; Hope, et al., 2003).

The effect of wealth can however not only is attributed to the ability to decorate a tree, as an increase of wealth is also reflected by the ability to buy a house rather than renting. This is an important factor in garden designs as: "A garden of similar size is less likely to be paved when a house is owned by its resident rather than rented" (Kullberg, 2016). In addition, Hope et al. suggest that, in the Arizona area, more wealthy residents move to higher altitudes of the city, increasing the opportunities to grow more vegetation (Hope, et al., 2003). This notion of wealth increasing opportunities for gardening is further supported by the research of Goddard et al (2009) that indicate that parcels sizes have an important impact on the design of gardens. This equity element of gardens is also reflected in housing prices, as houses in the direct vicinity of green spaces tend to have higher housing prices than similar houses that are not in the vicinity of green areas (Hussain, et al., 2014; Luttik, 2000).

The last effect is the effect of knowledge, in a research by the Dutch Social and Cultural Planning Agency focused on the design of front-gardens, it was found that people with a higher level of education were more likely to have a green garden and lower levels of education were linked to higher shares of soil-sealing (Kullberg, 2016). However, this effect of education and knowledge is not supported in other researches, with Heezik et al concluding that: "householders with knowledge about diversity and pro-environmental orientation do not necessarily have larger vegetated spaces". Meaning that there is not any clear consensus on the effect of education level of gardens as a whole.

2.4.3 Physical and Neighbourhood Factors

There are also a number of factors in public and private space that contribute to garden design. The effect of public space is seen through two factors, the overall appeal of public space and the availability of parking space. Research has shown that the design of all gardens and public space on one side of a street has an impact on private-land use decisions, with more green neighbourhoods often having more green front-gardens and more soil-sealed neighbourhoods having more soil-sealed front gardens (Larsen & Harlan, 2006; Zmyslonly & Gagnon, 1998; Zmyslonly & Gagnon, 2000). This indicates that neighbourhood design and planning has implications for the form of private-green spaces and climate-resilience. This importance of neighbourhood planning is further reinforced by a research by Goddard et al (2009) that conclude that there is a high likeliness that is an optimal parcel size and design for promoting private-green spaces. This notion is supported by the research of Kullberg (2016) for the Dutch Social and Cultural Planning Agency which concludes that gardens are no longer a choice in the purchase of a house as many new neighbourhoods offer gardens. However, research also indicates that it is not only the design of public space, but also the availability of parking spaces that influences land-use decisions, with neighbourhoods with less parking spaces often showing more soil-sealing due to the creation of private parking spaces (Perry & Nawaz, 2008) Lastly, housing price is an important indicator of land use. With more high-priced real estate in urban centre often being greener than gardens on the verges of the city. This is likely caused by the scarcity of gardens in city centres, promoting use of this space (Kullberg, 2016). On the other hands, in high-density city-centres with smaller gardens, the share of soil sealing is higher than in other areas of the cities, implying that building density has an effect on garden design (Tratalos, et al., 2007). All of these factors make that neighbourhood design appears to be an important factor in determining the form of private green spaces through its impact on private land-use decisions.

2.5 Urban Green Planning and Climate Resilience

Climate change is going to put increasing pressure on the urban environment and requires adaptation and mitigation strategies to be applied. One of the most promising ways to improve resilience is through ecosystem-services approaches, where green- and blue spaces are used in order to adapt (e.g. store water, supply cool air) and mitigate (e.g. capture carbon) (Gill, et al., 2007). The use of these approaches is still limited and information on the ecosystem services of urban regions in lacking, this requires more research into the subject (Niemelä, et al., 2010). Increasing resilience requires a deep understanding of the urban social-ecological system and strategies that use the knowledge of this system in a way that is flexible and robust in order to address both current- as future developments (Figure 6) (Smit & Wandel, 2006). This approach requires a governance strategy that integrates both public as private space. This integrative strategy can be most beneficial in order to maximize the urban green network and increase climate resilience (Pötz & Bleuzé, 2012). This integrated approach will require a shift from governmental planning of public green spaces to governance that focuses on connecting different stakeholders and urban green spaces, resulting in more effective policy measures and spatial interventions that combine ecology and economy (Jordan, 2008). Furthermore, this shift from government to governance will provide more room for innovation and more opportunities for change and enable communities and stakeholders to have more impact on increasing climate resilience (Loorbach, 2009). Together, this form of scale-crossing multi-actor governance can help in strengthening the urban green network in public and private space and increase climate-resilience in the urban environment (Ernston, et al., 2010).

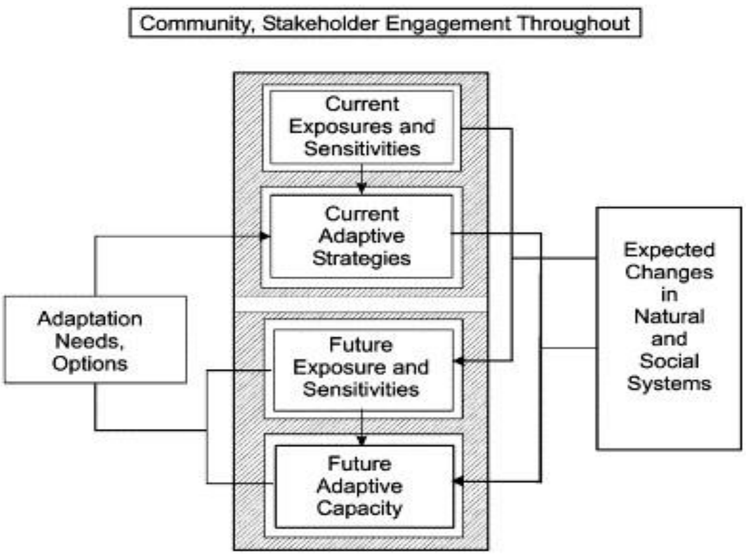


Figure 6: Increasing Resilience (Smit & Wandel, 2006)

2.5.1 Multi-Level Governance, Monitoring and HEPI and VEPI

Climate-change has a weak profile and externalities; this creates problems regarding subjectivity and free-rider behaviour in the creation and application of adaptive and mitigating strategies and policies (Zuidema, 2016). This creates a need to ensure cooperation throughout different levels of the socio-ecological urban system and between different systems in order to ensure that climate-resilience is increased in the entirety of the system and systems. This requires multi-level governance inside and outside of the social-ecological system. This multi-level approach can be achieved using the subsidiarity approach, an approach that aims to aims to: "ensure that decisions are taken as closely as possible to the citizen and that constant checks are made to verify that action at the EU level is justified in light of the possibilities available national, regional or local level" (EUR-Lex, e.g.).

For urban-green and blue spaces, the subsidiarity approach will ensure that climate-adaptations are taken as close to the citizen as possible and integrates and applies local knowledge and structures as efficiently as possible. On the other hand, the subsidiary approach helps in ensuring that climate-adaptations fit in with a more integrated approach on a higher scale-level, which increases the efficiency of planning interventions and can help in improving the green-blue networks at higher scale levels (e.g. the urban, regional or national scales) (Zuidema, 2016). In addition to subsidiarity, which can be seen as a form of vertical environmental policy integration (VEPI), where increasing resilience becomes a part of all layers of government. Horizontal environmental policy integration (HEPI) is required to ensure that climate-resilience and the importance of urban green-spaces in this field is adapted in all different elements of planning, ensuring that it is considered in all forms of policy and strategy development (Lafferty & Hovden, 2003). Together, HEPI and VEPI can ensure that the importance of ecosystem-services provided by urban green spaces is integrated in all forms of policy making.

In addition to the integration of climate-resilience in all forms of governance, an approach where urban green area is in the 'heart' of all developments, it is important to monitor these green spaces and potential problems that limit climate-resilience. Monitoring enables planners to be more flexible in policy making and intervening in space, and in the case of urban green-areas, monitoring enables policies to maximize the urban public-private green network by adapting and changing policies to stimulate actors to participate in climate-resilience (Wall, et al., 2015). This approach fits in well with the transition management approach that focusses on learning-by doing and improving climate-resilience through multi-actor participation and innovation (Loorbach, 2007).

2.5.2 Private participation in Urban Green Space Planning

As space is limited in the urban context and the effects of climate-change are going to affect the entirety of the urban environment, be it that the effects are highly subjective. This means that in order to increase climate-resilience, multiple actors on multiple levels will have to co-operate. This is demonstrated by the subsidiarity effect and transition management approach. However, as climate-adaptation through ecosystem-based approaches requires citizens to be activated and participate in improving climate-resilience, they are a fundamental part of the planning process and have to be activated. This can be reached through two main routes; the communicative approach and market based approach and is currently a large debate in planning practice (NPO Radio 1, 2017).

2.5.3.1 Communicative Approach

One of the main discourses in activating citizen participation in climate-resilient planning is through communicative planning. Community based approaches seek to connect stakeholders and actors that are affected by policies and strategies in order to find solutions that best fit in with the local context (Healey, 1996). One of the main factors that influence the planning process in this approach is the access to information and the role this has on the communicative planning. One of the main factors in the success of this approach is enabling every actor with objective information. This makes the spreading of information and raising awareness on an issue a large component in the planning process.

When applied to urban climate-resilient planning, this approach can be illustrated by Operatie Steenbreek (Translated: Operation Break the Stones). This organization seeks to stimulate urban private-green space through informing citizens on the benefits of having a green garden, focused on all benefits, but mainly on those that matter to local residents. The Operatie Steenbreek organization cooperates with local governments and citizens in coming up with solutions and actions that fit in with local context (Operatie Steenbreek, 2017). Increasing knowledge of climate-resilience under citizens, but also working to make governments aware of the effects of private green-spaces is a key factor in this communicative approach.

One of the major downsides of this approach is the focus on importance and cooperation, which can create power imbalances at the negotiation table and lead to long-winding planning processes (Jänicke & Jörgens, 2006). Another factor is raised by Reid (2010) who states that the concept of resilience is not only determined by government and that: “Resilient’ peoples do not look to states to secure their wellbeing because they have been disciplined into believing in the necessity to secure it for themselves”. These downsides, being the possibility of power imbalances and the long planning process focused on consensus, make that communicative planning might not be the most efficient route for an urgent issue like urban climate-resilience.

2.5.3.2 Market Based Approach

The second discourse in activating citizen participation in climate-resilient planning is through the application of market based approaches. Market based approaches are aimed at the application of market mechanisms to stimulate actors to change or adapt behaviours. Examples of this can be taxations or subsidies. Market based approaches offer a way of distributing costs of a certain phenomenon (e.g. soil sealing) evenly across all citizens (Lemos & Agrawal, 2006).

An example of a market based approach in the field of urban climate-resilience and the protection and stimulation of contributing to urban-green spaces is the Dresden soil compensation account. In this policy, the city of Dresden started asking for compensation fees for the desealing of soil-sealed areas of twenty euros per square meters. In this compensation account, developers had two choices, either to pay the fee or to take compensation measures by themselves. Through this choice, either developer were forced to take climate-resilience into account in their development plans, or the governmental agencies gained an influx of money to fund governmental projects aimed at improving climate resilient. This project seems successful, with monitoring indicating a decrease in soil-sealed areas of around four hectares per year (European Communities, 2011). Indicating that taxations and subsidies form a good incentive for behavioural change.

However, these approaches rely heavily on monitoring, which can come at great costs depending on the techniques used. Furthermore, this approach also has community-based aspects in the sense that they rely heavily on the spreading of awareness and information on how citizens can contribute to climate-resilience and avoid extra taxation. Lastly, free-rider behaviours are also prone to occur in this approach, as taxation will become a decreasing incentive when wealth increases. Lastly, it can be hard to put prices on climate-resilience, as effects are highly subjective and depending on the scale level, the costs of monitoring can make this approach inefficient (Lemos & Agrawal, 2006).

2.6 Conceptual Framework for urban climate resilience

The conceptual framework for this research can be seen in figure 7; this framework gives an overview of all the different aspects, feedback loops and determinants of urban climate-resilience. What can be seen in this framework is that whereas government formats have direct control over public space and public green works through the processes of zoning and development. The control over private green spaces is less direct and influenced either through policy measures, demand and supply or via spatial design.

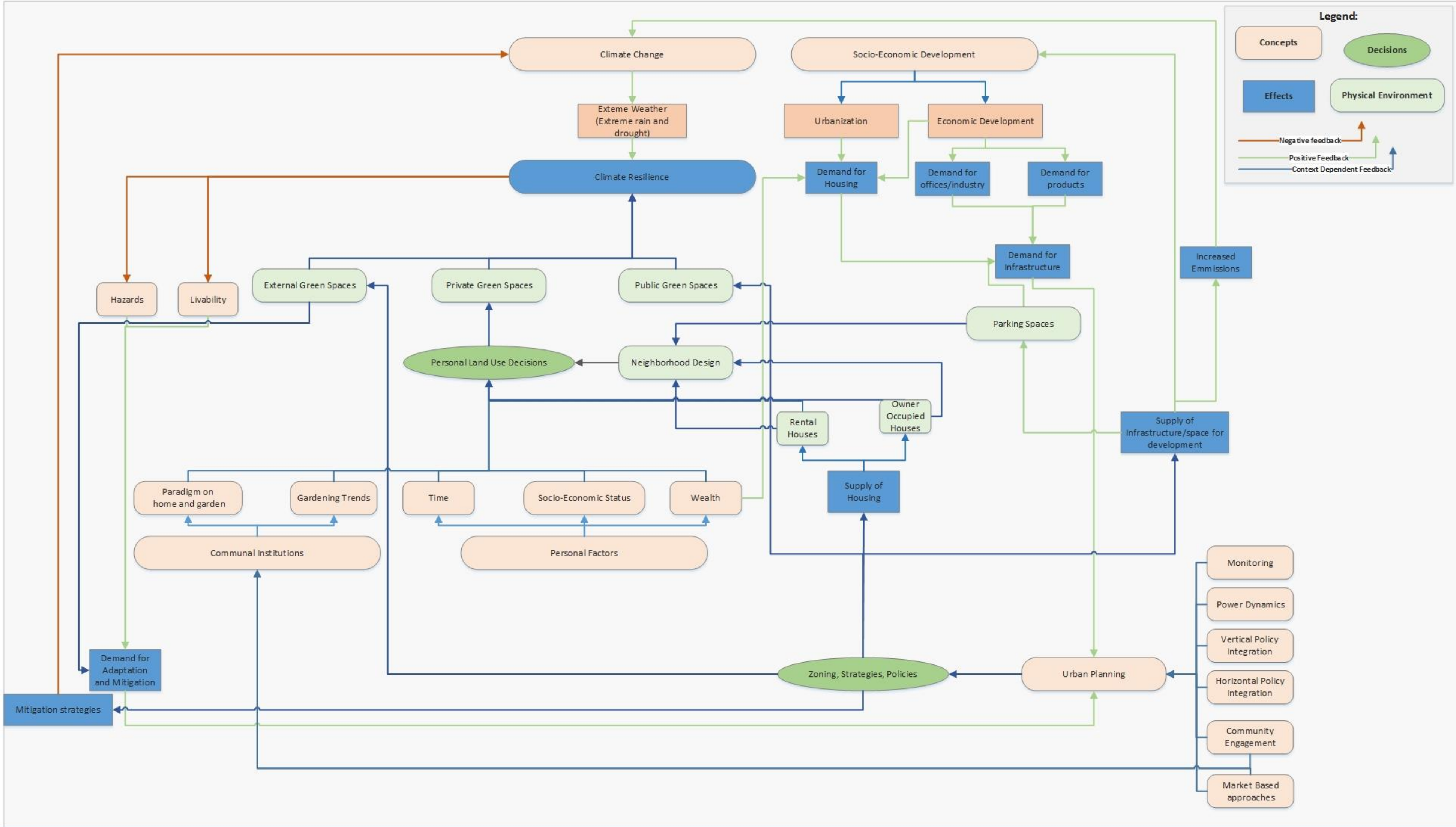


Figure 7: Conceptual framework for climate Resilience

When looking into the dynamics that impact private land-use decisions, it becomes clear that there is a distinction between three mayor forces. First, there is the physical entity that consists of the ratios between green areas, infrastructure and housing which directly impact personal land-use decisions. Secondly, there are informal institutions like trends, paradigms on the relationship between home and the garden, that are influenced by policy instruments like market based approaches and community engagement. Lastly, there are the personal indicators of personal land-use decisions. This framing emphasizes that private land-use decisions are not that personal, but are dependent on many neighbourhood and societal factors.

Lastly, the conceptual framework highlights that urban planning can not only focus on the impacts of climate change, but it also has to deal with the other spatial demands in the urban environment. These demands are driven by both internal (wealth accumulation, infrastructural developments, economics) as external (urbanization, trade) factors. Lastly, the effects of climate change are shown to create a demand for adaptation and mitigation, but external developments to increase climate-resilience can also limit this demand.

In conclusion, the theoretical framework of figure 7 gives insight in the complex relationships between urban development, climate change, governance and personal decisions in increasing urban climate-resilience and the linkages between the different aspects that together form the adaptive capacity of the urban environment. These relations are often dependent on the governance approach, but in the case of urban developments these processes can be self-reinforcing (e.g. economic development, and the demand/supply in infrastructural developments, or self-destructive (e.g. the relationship between climate-change, vulnerabilities and climate-mitigation).

3. Methodology

3.1 Research Design

In order to determine the effects of private-properties, either through soil-sealing or private green spaces, to urban climate-resilience, or furthermore to determine how urban planning might benefit from- and intervene in backyard usage this research applies a mixed-methods methodology. Through the combination of Geographical Information system (from here: GIS), Remote Sensing (from here RS) and Statistical analyses with an open-ended survey, observations and policy review, both the quantitative as qualitative factors that contribute to urban private climate-resilience can be determined. Mixed methods are not a combination of quantitative and qualitative research methodologies, but a new form or scientific research (Johnson & Onwuegbuzie, 2004). In a research where different definitions of mixed methods were analysed and synthesizes, it was concluded that mixed methods consisted of the following aspects: “Mixed methods research is the research paradigm that (a) partners with the philosophy of pragmatism in one of its forms (left, right, middle); (b) follows the logic of mixed methods research (including the logic of the fundamental principle and any other useful logics imported from qualitative or quantitative research that are helpful for producing defensible and usable research findings); (c) relies on qualitative and quantitative viewpoints, data collection, analysis, and inference techniques combined according to the logic of mixed methods research to address one’s research question(s); and (d) is cognizant, appreciative, and inclusive of local and broader socio-political realities, resources, and needs” (Johnson, et al., 2007). This research seeks to follow these guidelines through (a and c) the combination and combination of quantitative outcomes of models and test with the qualitative applications in real life through either policy or personal decision, combining theory with practice. Producing outcomes that are (b and d) useful and in line with the local context of the case study area. This mixed methods approach, that stands between qualitative and quantitative methods, also fits in well with the concepts of complexity and nonlinearity that apply to planning for urban climate-resilience, as this approach requires a thorough understanding of the entirety of a system, requiring both insight in the rational and subjective aspects of a system (Duit & Galaz, 2008).

This chapter will give insight in the different methods used in order to answer the main- and secondary research questions of this research and will be structured by secondary research question, being:

- What is the effect of land use in private spaces on climate resilience
- What are the underlying factors in land-use in private
- How can policies intervene in backyard usage

- How can the effectiveness of policies stimulating land-use changes be monitored

This research will focus on the municipality of Groningen, a city in the North of the Netherlands (Figure 8). Groningen is the fifth city of the Netherlands with around two-hundred-thousand inhabitants. As a municipality Groningen is self-governing and is divided in 10 districts and 105 neighbourhoods (Figure 8) (Gemeente Groningen , 2018).

3.1.1 Climate-Resilient Planning in the Netherlands and Europe

Groningen, as a part of the Netherlands and Europe, has a number of centralized guidelines for climate-resilience that form the local policy context. First and foremost, Groningen is part of the European Union and through that, participates in the European Adaptation Strategy, a policy on a high level that aims to connect and inform different member states and regions in the goal of increasing climate-resilience throughout Europe (European Commission, 2013). This approach forms a framework, giving the different states the flexibility to adapt region-specific strategies. For the Netherlands, policy dictates that all regions should work to increase climate-resilience. The progress and planning process for climate-resilience overseen by a National Counsellor in the central government and agreed upon by all municipalities, waterboards, provinces and state government. This national strategy forms the framework for regional climate-resilient planning (Deltacommissaris, 2017).

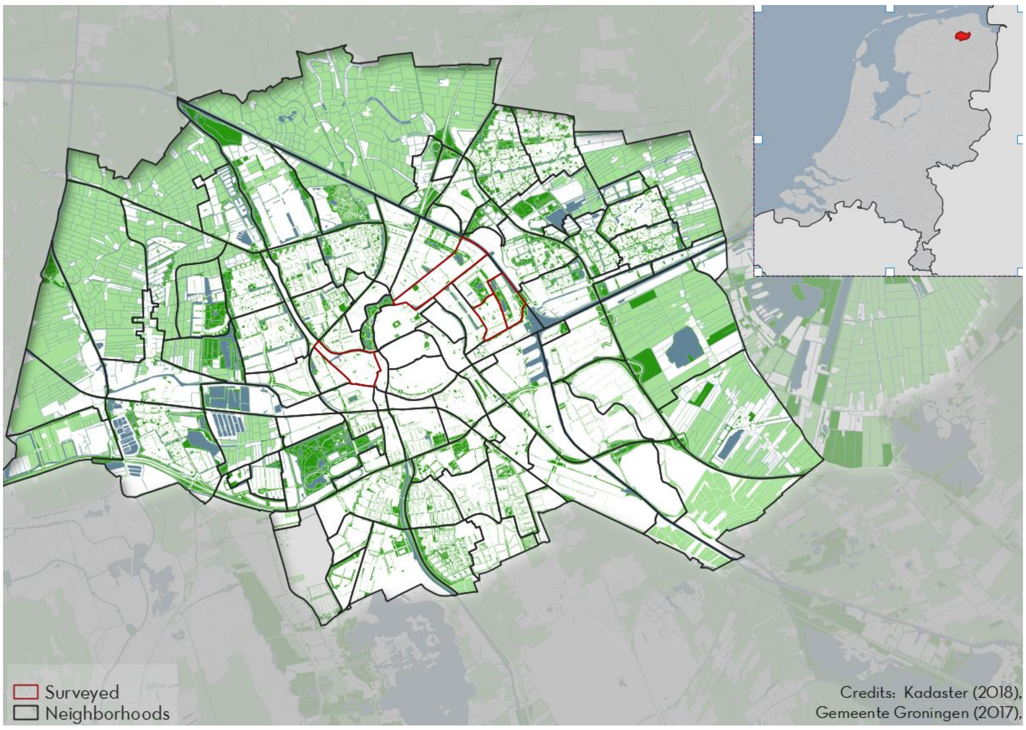


Figure 8: Neighbourhoods of Groningen, Position of Groningen

3.1.2 Urban characteristics of Groningen

The city of Groningen was founded in 1040 B.C. on the foothills of the Hondsrug, a long crest that starts on the city of Groningen and stretches towards the German border. This crest formed a strategic location for a city due to its altitude and access to the north sea through the Hunze. This strategic position made Groningen an important trade hub and a part of the Hanseatic confederation. This position as a major regional trade-hub has remained throughout the Renaissance and into the 19th century. This is still seen in the present day, as Groningen has a large number of market squares in its city centre (Gemeente Groningen, 2017).

The position of the Groningen throughout its history has been as a trade hub, mainly seen in a large share of market squares in the city centre. However, due to the dynamics of warfare in history it was important for the city to be walled of and properly defendable, which has limited city growth in this period to the present day city centre, limiting sprawl. Groningen started expanding from the 20th century onward, during this period, many different neighbourhoods were added and smaller towns around Groningen became part of the urban system. The development of neighbourhoods Groningen can be seen in Figure 9 and 10, these figure shows the average building-age and building density per neighbourhood.

The expansion of Groningen has led to the city having a broad range of planning-styles and neighbourhood designs that show the development of urban planning through the 20th century. This richness of different neighbourhood designs is useful in the study of urban green-space, since this offers the opportunity to see potential differences and similarities in different planning era's and testing the theory of the effect of neighbourhood design on garden land-use (Larsen & Harlan, 2006; Zmyslonly & Gagnon, 1998; Zmyslonly & Gagnon, 2000).

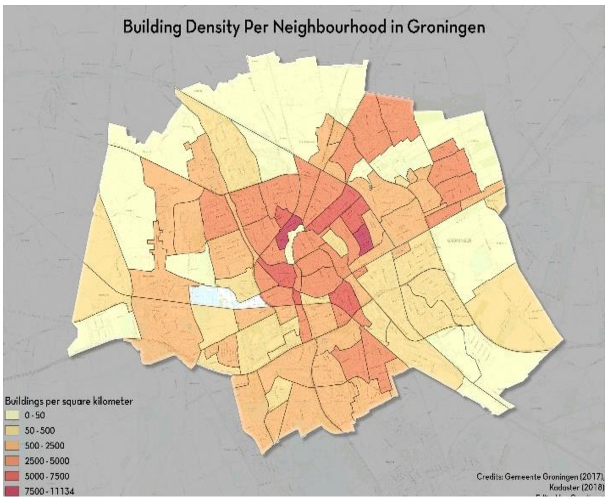


Figure 9: Building density in Groningen

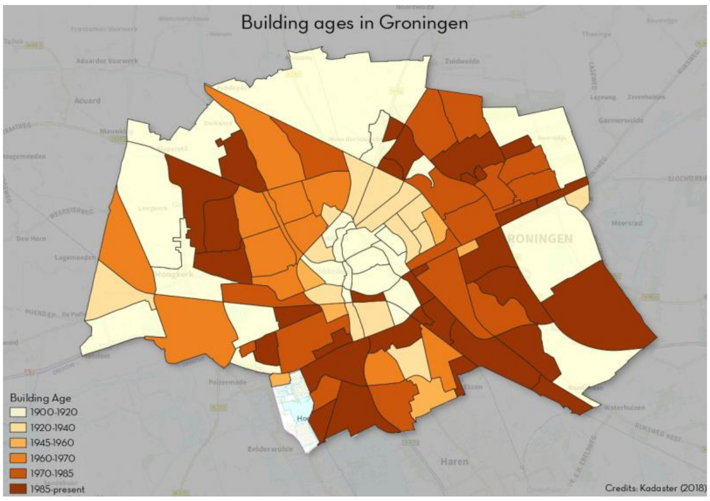


Figure 10: Neighbourhood age in Groningen

The quantative analysis of this research focusses on the entirety of Groningen, testing the hypotheses of the effect of neighbourhood design and building density on private land-use decisions on the urban scale. The survey was conducted in three neighbourhoods in Groningen that were advised by the municipality of Groningen for their relatively high risk of flooding and the presence of a shared sewage system with ranging socio-economic statuses. These neighbourhoods were the Schildersbuurt, Professorenbuurt and Oosterparkwijk

3.1.2.1 Schildersbuurt

The Schildersbuurt (figure 11a) is a neighbourhood in the municipality of Groningen dating back to the late 19th century. As seen in table 1, the schildersbuurt has a relatively high percentage of 15-25% year olds, indicating that the neighbourhood has a relatively high student population; furthermore the neighbourhood has the highest population density of all the surveyed neighbourhoods and a high share of owner owned and rental properties (table 2). Lastly, as seen in figure 11a, the neighbourhood has very little public green space. And relatively large backyards, making this neighbourhood interesting in testing the hypotheses of public space and temporary living arrangements as an indicator for private land-use decisions.

3.1.2.2 Professorenbuurt

The Professorenbuurt (figure 11b) is a neighbourhood in the Korrewegwijk of Groningen and is inhabited by a relatively young population with the second highest share of 25 to 45 year olds in the neighbourhood (table 1). The professorenbuurt is relatively similar to the schildersbuurt in its demographics and housing stock (table 1 and 2), however, the professorenbuurt has a relatively higher working-class and young-families. The parcels in this neighbourhood are relatively smaller and there are some small urban parks in the neighbourhood, lastly, many houses have a small front yard, which makes it useful in determining the effect of small parks on front yard design and the effect of workforce participation.

Figure 11: Survey Neighbourhood Layout

3.1.2.3 Oosterparkwijk

The last neighbourhood in the survey is the Oosterparkwijk (Figure 11c), this neighbourhood forms a contrast to especially the Schildersbuurt in its demographics, housing mostly families and people that belong to the labour force (table 1). With the lowest share of owner-owned properties and the high share of association-owned properties and rental properties, this neighbourhood can therefore give insights in the effects of corporations on household garden design (table 2). In addition to this, the oosterparkwijk has the largest amount of green space in the vicinity of the neighbourhood (figure 11c).

3.2 Measuring the effects of private-land use decisions

3.2.1 Determining the land use in private-land using RS and GIS

In order to determine private land-use a combination of Remote Sensing and Geographical Information System analyses were used in this research. Remote sensing can be defined as a science and technology that aims to classify measure and analyse spatial units, phenomena and objects without direct contact (Japan Association on Remote Sensing, 1993). This analysis technique is common practice in the field of urban land-cover classification and the monitoring of urban sprawl and climate (Jiang, et al., 2012).

Remote sensing can be active or passive, depending on the method of sensing data. For active remote sensing, a sensor both sends and receives a signal, measuring the time between sending and receiving and spectral images. An example of this is the measuring and construction of height models. This research will be using passive remote sensing data, passive remote sensing uses the reflected signals from an external source (e.g. the sun) to measure and create data (GISGeography, 2018).

Neighbourhood	0-15 years olds	15-25 year olds	25 to 45 year olds	45-65 year olds	65 years and older	Population Density (Inhabitants/ sq. km)
Schildersbuurt	4%	46%	27%	14%	8%	16061
Professorenbuurt	7%	42%	34%	12%	5%	11508
Oosterparkwijk	10%	23%	38%	19%	9%	7865

Table 1: Demographics in the survey neighbourhoods (Centraal Bureau voor de Statistiek, 2018)

Neighbourhood	Housing-Stock	% of owner-occupied properties	% of association-owned rental properties	% of rental properties
Schildersbuurt	2555	38	11	49
Professorenbuurt	2931	33	19	48
Oosterparkwijk	6872	24	52	22

Table 2: Housing stocks in the survey neighbourhoods (Centraal Bureau voor de Statistiek, 2018)

This research used a semi-automatic classification method in QGIS; semi-automatic classification is a form of remote sensing that applies a user-defined training sample in order to determine land use (Congedo, 2018). This training sample was created by manually drawing polygons over certain land-uses, in the case of this research; a distinction was made between vegetated and non-vegetated (paved) areas through a binary variable. This training sample was then used in order to create a spectral signature and used in a model that determines land use in two separated areas.

3.2.1.1 Data and Indices

The data used for semi-automatic classification were an aerial photograph shot by Slagboom&Peeters (2016) with a resolution of 8 centimetres and three spectral bands (Red, Blue, Green) and data from the European Sentinel-2 program with a resolution of 10 meters with 12 spectral bands. For the Aerial photo, all three spectral bands were used in classification. For the Sentinel-2 data, the RGB bands, Near-Infrared (NIR) and Shortwave Infrared (SWIR) bands were used in their raw form, but also in a number of indices (European Space Agency, 2018).

Indices in remote sensing are combinations of different spectral signatures. The first index that was used is the Normalized Difference Vegetation Index (NDVI) (formula 1); an index that used the reflectance of red- and near-infrared light in order to determine the extent surfaces photosynthesises. The outcomes of this index give insight in the quality of vegetation, with outcomes above 0,2 indicating the presence of vegetation (NASA: The Earth Observatory, 2000).

The second index used was the Bare-Soil Index (BI) (formula 2); this index can be used to gain insight in the differences between soil-areas and vegetation. This index was used in order to distinguish between vegetated and soil-sealed/barren areas (Duy & Giang, 2012). This index was used to determine the difference between unhealthy vegetation and bare soils.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Formula 1: NDVI

$$BI = \frac{(Red + SWIR) - (NIR + Blue)}{(Red + SWIR) + (NIR + Blue)}$$

Formula 2: BI

The last index, the Normalized Difference Water Index (NDWI) used was calculation through the application two different formulae. The NDWI is an index that is useful in the detection of bodies of water and vegetation-water content based on the formula used. Through using the Shortwave Infrared (SWIR) and Near-Infrared (NIR) bands (formula 3a), the water content of vegetation can be calculated, giving insights in evaporation rates and vegetation health, which can be useful in the study and monitoring of urban heat and flooding risks (Gao, 1996). Where the application of the Green and NIR wavelengths gives more insight in urban blue-areas, which can also be useful in determining flood-risks and effects in the urban environment (McFeeters, 1996).

Together, these indices were mainly used in order to determine the usefulness of monitoring (see: 3.5) and to gain insights in the usefulness of these several indices in determining private-land use in the urban environment.

3.2.1.2 Analyses and outcomes

This semi-automatic classification was applied to both public as private space in two separate models for each of the 105 neighbourhoods in Groningen; this had to be done in order to limit calculation time. The data on public and private spaces were based upon the BGT (NL: Basisregistratie Grootschalige Topografie, EN: Basic Registration of High-Scale Topography) and GBBG(NL: Gemeentelijk Bestand BodemGebruik, EN: Municipal Registration on Land-use). These two topographic registrations contain vector information on different land uses. In this data, private space was defined as “private properties” whereas the rest of public space was separated based on land-use (IMGeo, 2018). In this research, the BGT was the most important dataset in determining public and private space, however, the metadata of the BGT is still being constructed for Groningen, this has led to a share of the urban environment begin classified as ‘in transition’ meaning there was no data for these polygons. In order to fill these gaps in the data, the data GBBG was used.

$$NDWI = \frac{(NIR - SWIR)}{(NIR + SWIR)} \quad A) \qquad NDWI = \frac{(Green - NIR)}{(Green + NIR)} \quad B)$$

Formula 3: NDWI

The two datasets derived from this semi-automatic classification were than used to determine land-use per private parcel, using the mean of the binary variable to determine whether properties were: Soil-sealed (average <0.25), Mostly Soil Sealed (average 0.25 – 0.5), Mostly Green (average 0.5 – 0.75) or Green (average >0.75) and to calculate the exact size of the green space through multiplying the average land-use with the shape-area, the outcomes of these calculations were than merged for the each neighbourhood in Groningen to calculate the effects of private soil-sealing. In addition to the parcel information, the information on public space, as derived from the BGT and GBBG was also joined to the neighbourhood areas.

3.2.2 Determining model usefulness

In order to determine the usefulness of the classification model, two controls are performed. First, while performing the survey (see: 3.3.2), the surveyors will make observations regarding the front gardens in the three neighbourhoods. Through plotting this data and connecting it to the outcomes of the classification model, two things can be analysed. When there are a large number of mismatches where the front yard is more paved than the entire garden, this might indicate that the mismatch between front and backyards, as discussed by Larsen & Harlan (2006). However, when there is either a high share of front yards being greener, or there is no general tendency in the direction of mismatching there might be indication that the classification model is not trustworthy.

In order to decrease uncertainty when there is a potential mismatch between observations and the classification model. The classification model is also used in order to determine land-use in public space. Using the exact same model as private space and creating a binary dataset it will become possible to crosscheck the outcomes of the model to the well-recorded public space. This will be done using two methods. First, the outcomes of the classification model (i.e. the raster dataset) will be joined to the neighbourhood in order to determine average soil-sealing. For this dataset, the average and standard deviation will be taken and compared to the outcomes for the most complete dataset, being the GBBG.

The second method used will be determining the average land-use per GBBG polygon and determining whether the average is in approximation to the actual data or not, this will give more insight in the small-scale usefulness of the dataset and give a percentage that indicates usefulness.

3.2.3 Determining Flood-risks

In order to determine flood-risks, the average drainage coefficient for both green as soil-sealed areas was used. The drainage coefficient is the share of water that runs of a certain land-use, these average numbers were based upon the drainage coefficients as described by Pötz & Bleuzé (2012)(Formula 4). These drainage coefficients were used in order to determine to determine the sewage capacity of the sewage in Groningen, which was designed to be capable of draining a category 8 shower (20 mm of rain/hour) (Gemeente Groningen, 2014; Stichting RIONED, 2015). As Dutch dictates that citizens are responsible for draining water from their own properties and there are no strict guidelines for sewage design outside of the fact that it should be able to drain water from public space, five scenarios were used in this research, these being:

- 1: Sewage capacity is based solely on public space
- 2; Sewage capacity is based on public space and 25% green gardens
- 3: Sewage capacity is based on public space and 50% green gardens
- 4; Sewage capacity is based on public space and 100% green gardens
- 5; Sewage capacity is based on public space and 100% soil sealed gardens

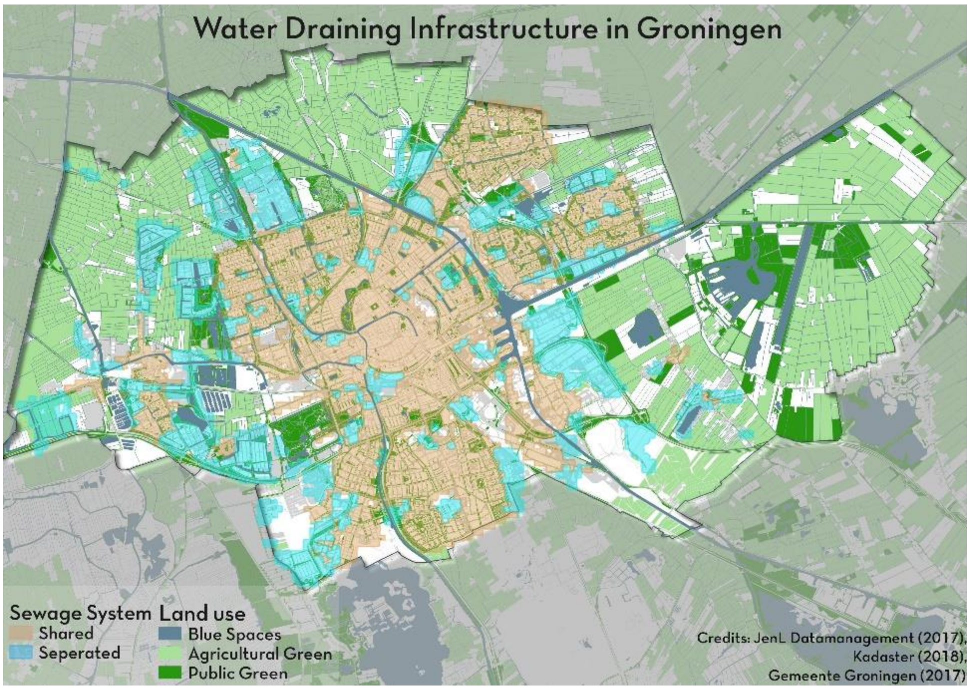


Figure 12: Sewage systems in Groningen

In the calculation of sewage capacities, buildings were not added to the formula as the focus of this research is on the surface land-use and the difficulties that roof-shapes add to the calculation of sewage-capacities. The sewage map by J&L datamanagement (2017) was used to determine the area that required water drainage (Figure 12) The sewage capacities for the three scenarios were calculated using formula 4 and then compared to the amount of runoffs according to current land-use in public and private space on the urban scale. Together, this gives some insight in the contribution that green space could have on urban climate resilience.

$$C_{sum} = C_{st} \times R \times \frac{(C_g \times (A_{og} + A_{pg}) + C_p \times (A_{op} + A_{pp}))}{(A_{og} + A_{pg} + A_{op} + A_{pp})}$$

Where:

C_{sum} = *sewage capacity for all space in* $\frac{mm}{hour}$

R = *rainfall in* $\frac{mm}{hour}$

C_{st} = 85%, *runoffs to the sewage system*

C_p = 70%, *water runoffs on paved areas*

C_g = 17%, *water runoffs on green areas*

A_{og} = *open greenspace in* m^2

A_{op} = *open paved space in* m^2

A_{pg} = *private greenspace in* m^2

A_{pp} = *private paved space in* m^2

-

Formula 4: Sewage Capacities

3.3 The underlying factors in soil-sealing

3.3.1 Quantitative approach

3.3.1.1 Spatial patterns in Soil Sealing

The data on private land-use gathered using remote sensing (see 3.1.1.2); in addition to the data on land-use already available through the use of the BGT and GBBG were statistically analyses in GIS in order to find spatial patterns in soil-sealing and urban private-green spaces. The aim of these analyses was to determine the potential effect of neighbourhood design, planning, building density and the effects of neighbours in garden design.

These analyses were performed in QGIS using the Hot Spot Analysis plugin, a plugin that implements the Getis-Ord GI in QGIS (QGIS, 2018). The first statistical analysis, focussing on finding spatial patterns, is done using the Getis-Ord Gi test. The Getis-Ord Gi test is used in order to determine spatial clustering of a certain phenomenon, focussing on finding hot- and cold spots of a certain phenomenon. Hotspots are areas where a certain phenomenon occurs statistically more than average, cold spots are areas that are statistically underrepresented compared to other areas (Ord & Getis, 1995). This hot- and cold spot analysis is useful for finding spatial patterns and was also used by Hunter & Brown (2012) in their research into the spatial patterns of easement gardens. This research will be using the social contagion factor that was found in the by Hunter & Brown (2012), a distance of 30 meters.

In order to determine both the effects of public space as private space on land-use decision, the hot-spot analysis was performed twice on two datasets. The first analysis used only the private-parcels in order to determine the effects of neighbours and possible parcel sizes on land-use decisions. The second analysis was performed using the BGT and GBBG, clipped with a fishnet of 25 meters, this was done in order to determine the effects of the public space in the direct vicinity of a house, rather than the effects of long stretches of green space and compensate for the effects of possible polygon sizes. Together with the survey outcomes these two analyses should give insight in the dynamics of neighbours and neighbourhood in private land-use decisions

3.3.1.2 Data preparation for Statistical Analysis

In order to find patterns in the relationship between garden design and the indicators ownership, garden size, housing size and building age, the municipality of Groningen provided their building-registry, which gives information on this on the address level. In order to prepare this data for statistical analysis, it was joined to individual houses, after which the data was joined to the parcels and exported as a csv for further analysis in SPSS

3.3.1.3 Statistical Analysis

In order to find relationships between different indicators of garden design and greenness, two different types' statistical tests were used. First, a chi-square test, binominal regression and Somers D were used to test the relationship between different indicators with garden design (Moore, 2006). These indicators were: building age differentiated by planning era (table 3), house size, garden size and ownership. For these analyses, the average greenness of gardens was transformed into a binary variable, determining whether a garden was (4) green (3) mostly green, (1) mostly soil sealed or (0) soil sealed.

In addition to the chi-square test, a linear regression and correlation analysis were used to determine whether or not there was a relationship between both house size and greenness and parcel size and greenness, testing the hypotheses of Goddard et al. (2009) that there is an ideal size for gardens/houses for having a green garden (Moore, 2006).

3.3.2 Qualitative approach

3.3.2.1 Survey Design

The survey used in this research was constructed out of 4 segments, with the research by the Netherlands Institute for Social Research being the main inspiration for the question. This source was used because the research performed by the Netherlands Institute for Social Research described the trends and developments of gardening in the Netherlands as a whole, with its foundation in a research that was spread out over the entire country (Kullberg, 2016). In order to gain more qualitative insights in the dynamics of soil-sealing, the survey used the combination of multiple-choice questions for general information with open questions to gain more insight in personal decisions underlying garden design.

3.3.2.1.1 Segment 1

Segment 1 of the survey and was also used in the observations part of the research and had respondents picking one of 3 pictures that best depicted their garden design (Figure 13). This closed question was followed by a question were respondents were free to fill in a personal response, which was then coded into one of 10 reasons. These were related to the literature, with the following classes. First, there was the code of inability to change, which relates to the concept of ownership. The second group of codes were related to socio-economic factors, these being: Children and Availability of time. The third group were related to cultural aspects of gardening with the codes of aesthetics, nature, ease, vegetable gardening, relaxation and a combination of aesthetics with ease. Lastly, there was a code for special cases that did not fit in any of the indicators found in the literature on the subject.

Figure 13: Garden types for survey question 1.

3.3.2.1.2 Segment 2

Segment 2 consisted of three multiple choice questions regarding socio-economic status and ownerships. The socio-economic questions were on the household type, differentiating between singles, couples living together, couples living together with children and student houses and whether this affects their garden design. The last question in this segment was on family income and was used to check whether family-income was an indicator of garden design. These questions were then used to correlate with garden design and underlying factors (coded) to check whether garden-design decisions could be correlated to socio-economic indicators.

The ownership question was a three layered questions. With two binary questions used to determine the possible effects of ownership on garden design and a last (open) question where people were asked as to how ownership affected them. These answers were coded into three categories. The first category was on ownership as a concept, with codes referring to ability to make changes, people stating the concept of ownership as their motivation and the feeling of temporariness. The second category is on socio-economics, with codes referring to investment and the ability to purchase. The last category is a combination of the first two categories, with people indicating that both ownership as investment are drivers in their decision.

3.3.2.1.3 Segment 3

The last segment of the survey was aimed at familiarity with the concept of climate-resilience in the context of flood-risks. This question asked people whether they knew that there was a shared sewage system in their neighbourhood, with the surveyor explaining what this implies with respects to water-drainage from gardens. The last question was an open question that asked if people were aware of climate-resilience in their garden design, or whether they would be willing to contribute to climate resilience.

3.4 Policies for urban climate-resilience

In order to determine linkages and differences between climate-resilient planning theory and practice, a number of policy documents of the municipality of Groningen will be analysed in order to gain insight in the extent to which the planning-formats useful in complexity planning are used in planning practice this research has performed a policy analysis. This analysis uses policies on the national, provincial and municipal level in order to determine to what extent the concepts of complexity and citizen engagement are part of the planning process and how climate-resilience is integrated both horizontally as vertically.

3.4.1 Policies used for analysis

On the national and provincial level, there are a number of guidelines for individual municipalities and regions that have to be followed, these guidelines are described in the following documents that were analysed:

- Deltaprogramma 2018 [Delta Programme 2018], Dutch Ministry of Infrastructure and Environment, 2018
- Waterwet 2017 [Water Law 2017], Dutch Law Book
- Groningen, Groen van Wad tot Westerwolde, Beleidsnota Natuur 2013-2021 [Groningen, Green from Waddensea to Westerwolde, Policy Document Nature 2013-2021], Province of Groningen
- Milieuplan Provincie Groningen 2017 - 2020 [Environmental Plan Province of Groningen 2017 - 2020], Province of Groningen

These documents will be analysed in order to determine the importance of Urban Green Space, Citizen engagement and the policy, laws and guidelines that underlie the governance of privately owned green spaces in the Netherlands/the Province of Groningen.

The municipality of Groningen has a number of policies that relate to urban green spaces and climate adaptations. For this research, the following policy documents were analysed:

- Waterwerk, Groninger Water- en Rioleringsplan 2014-2018 [Waterwork, Groninger Water- and Sewage Plan 2014-2018], 2014
- Meerjarenprogramma Wonen 2017-2020
- Meerjarenprogramma Verkeer en Vervoer 2018 – 2021
- Groningen Klimaatbestendig, programma voor klimaatadaptatie en -mitigatie
- Groningen geeft energie, programma 2015-2018

The aim of these policy documents is to gain insights in the linkages between central government guidelines and the regional approach, these documents are also analysed to determine the Urban Green Policy goals of the Municipality of Groningen, vertical integration of climate-resilience and to determine how both public as private green spaces are governed.

3.4.2 Analysis

All of the policy documents mentioned are analysed to determine the focus of each document in the light of private climate adaptation, climate resilience and policy integration. Furthermore, these policy documents are linked to the outcomes of survey segment 3 to gain insight in the fit between central policy and civilian interest. In order to analyse and compare these documents, each policy document is examined following these main questions:

- Does the document aim at a centralized or decentralized approach to climate adaptations?

- What are the main planning approaches adapted by the policy (e.g. market based instruments or communicative planning)?
- What is the role of the urban environment and/or citizens in this policy document?
- How does a policy relate to other policies or fields of development (e.g. a multilevel approach, coupling developments)?
- Does the document lay a direct claim on urban space for development?

3.5 Monitoring urban green space and climate-resilience

As climate-resilient planning and citizen participation in climate-resilience relies heavily on incentivising individuals and changing informal institutions and the complexity of the urban environments creates uncertainties for increasing climate-resilience. Monitoring developments and the effects of policies is a key factor in increasing resilience. This research will evaluate the usefulness two datasets for assessing the success of policy and the form/functioning of the public/private green- blue network. These datasets are the aerial photograph of Slagboom & Peeters and the satellite photographs of the Sentinel-2 program (European Space Agency, 2018; Slagboom & Peeters, 2016). These reasons that these datasets were selected were because of their open accessibility and characteristics, as seen in table 3.

In order to determine the usefulness of monitoring, the following criteria were used throughout the use of the data:

- How much time does it take to process the data in a model?
- What different products can be derived from a dataset
- Is the data useful for the micro (parcel) scale?
- Does the data provide useful insights for policy makers?
- Is the data useful in gaining insight in climate-resilience?

These results were than linked to the policy goals and strategies to determine the extent to which monitoring is useful, or might become useful, for the process of increasing climate resilience in a complex environment.

Dataset	Spatial Resolution	Revisit time	Spectral Bands
Sentinel-2	10*10m	10 days	12
Aerial Photograph	0.08*0.08m	1 year	3

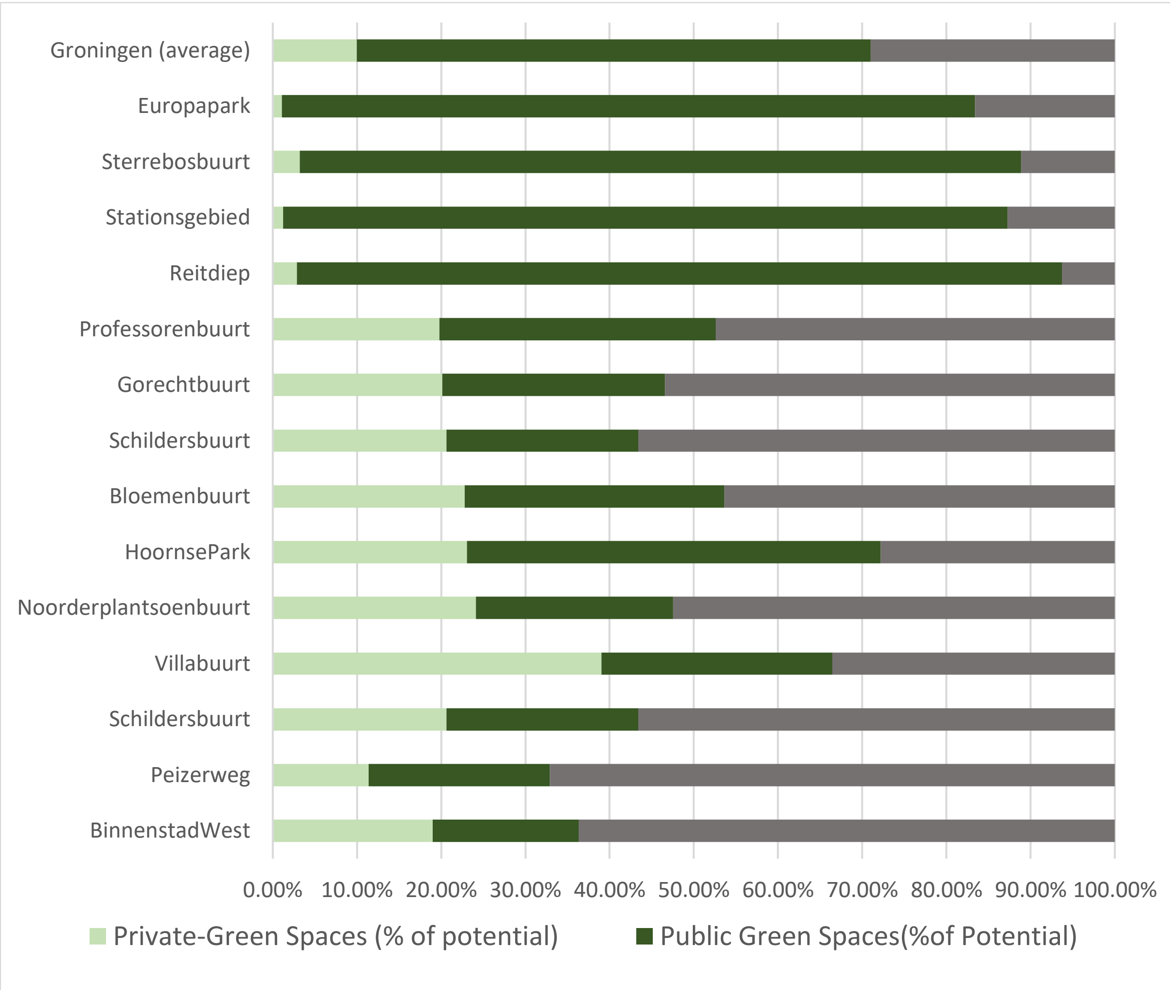
Table 3: Advantages and disadvantages of monitoring

4. Results

4.1 The effects of private-land use decisions

4.1.1 The extent of soil-sealing and private green space in the city of Groningen

The extent of paving and green private green spaces can be view in Graph 1, in this graph, the greenest and least green neighbourhoods are shown based on their potential green areas (Appendix A:1 for the full overview as a graph, Appendix A:2 for the tables). What is noteworthy in this graph is that neighbourhoods with a limited amount of public green spaces have relatively high shares of private green spaces and limited soil sealing when compared to the city of Groningen (last row). This indicates that a lack of communal green-spaces increases the necessity for private green-spaces in order to supply ecological services. What can also be seen is that in a number of neighbourhoods, private space can have a major role in providing local ecological services and increasing both liveability as climate-resilience. Lastly, 39% of all potential green space in Groningen is located in gardens and around 11% of all non-built-up space consists of gardens in the city of Groningen



Graph 1: Greenest and most sealed neighbourhoods in Groningen

When looking at the contribution of private green spaces to the urban green- blue network (figure 14 & 15). It can be seen that private parcels increase connectivity between different major green spaces, forming an ecological value through connecting habitats for other urban dwelling creatures. When looking at these corridors in the light of ecosystem services, these corridors can increase liveability, decrease heat and improve air quality through the system. What is also noteworthy when examining both figures is the effect industrial areas have in disrupting the urban green-blue network, seen in the lack of green-spaces in the south-eastern and south western parts of Groningen?

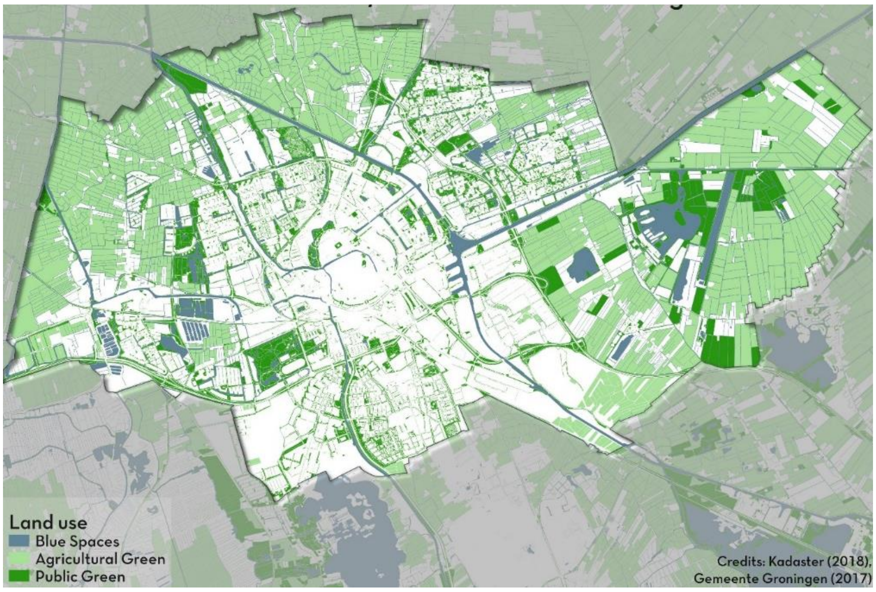


Figure 14: The public Green/Blue Network of Groningen

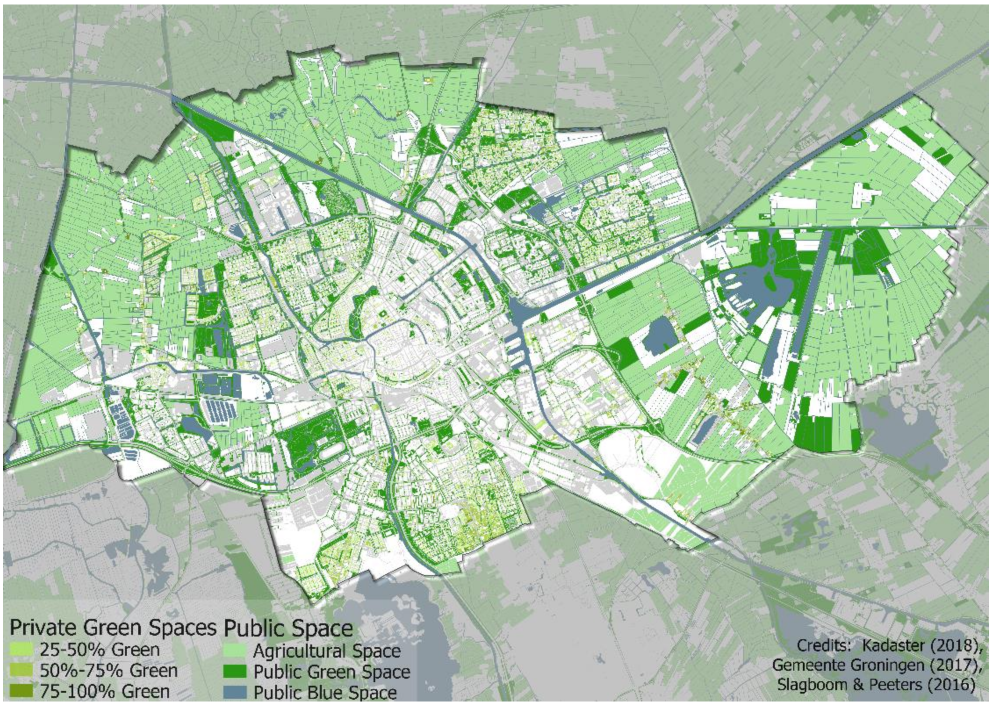


Figure 15: The total Green/Blue Network of Groningen

Further examination of the private green network of Groningen (figure 16) shows the effects of building density and urban on the green/blue network. With the most dense parts of the city having less green parcels (e.g. the city centre) and less dense areas of the city, mostly around the transition from urban area to agricultural areas, having more green gardens. Lastly, the effect of spatial planning can be seen through the overall greenness of two neighbourhoods in the North-East of Groningen (Beijum and Lewenborg) both designed and developed in the 1970's, when urban planning focused on urban liveability through the creation of small patches of urban green and a infrastructural network that encourages walking and bicycling rather than using the car. Another neighbourhood that is noteworthy in its overall greenness is the relatively wealthy 'Villawijk Zuid' which is known for having large parcels and houses. Lastly, the neighbourhoods in the Northwest of Groningen show a relatively fragmented private-green network with relatively low values overall greenness.

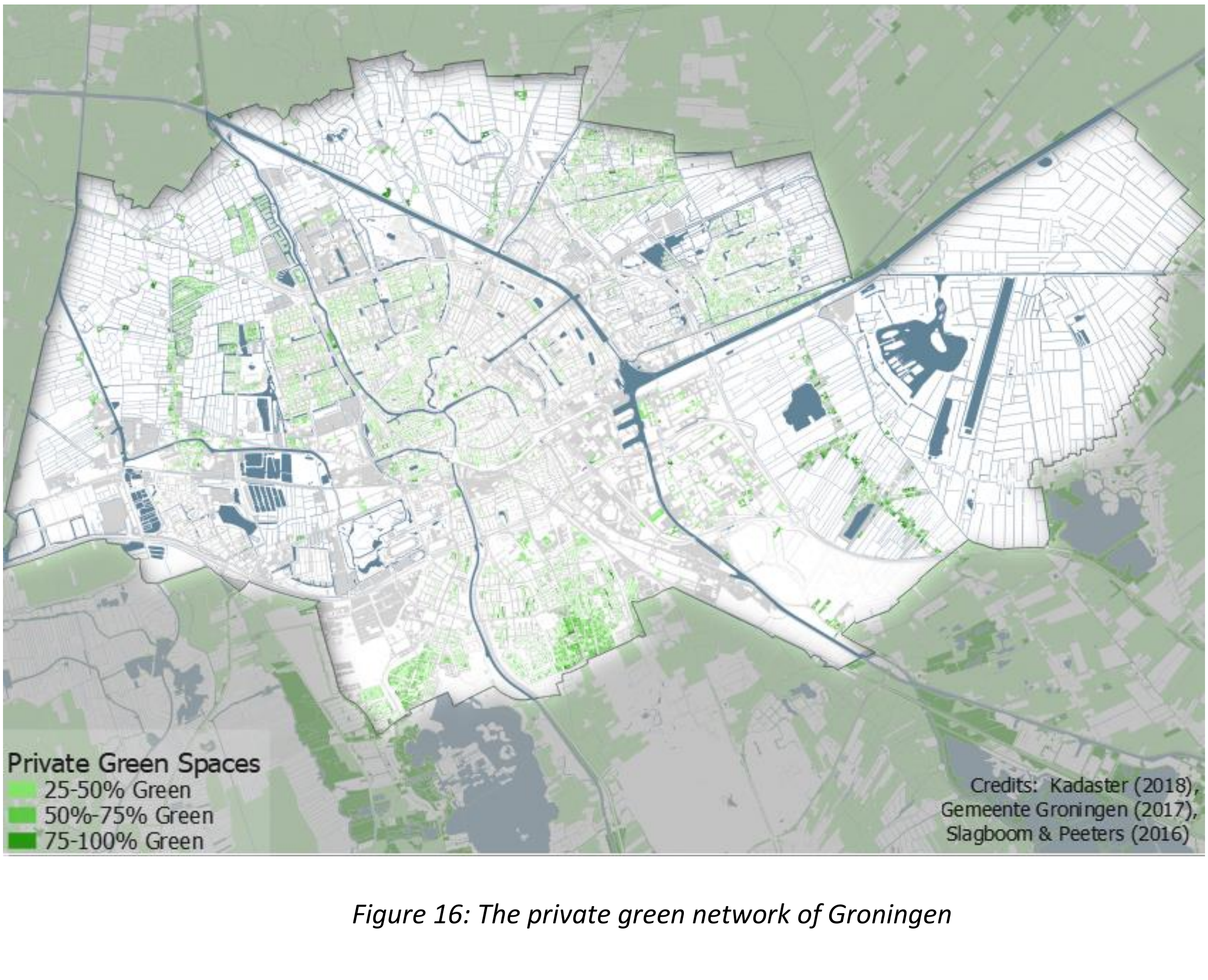


Figure 16: The private green network of Groningen

The Sentinel-2 data was not useful for determining the extent of paving per parcel, the only index that resembled the patterns discussed in the previous paragraph were the NDVI and NDWI (Green/NIR) (figure 17 and 18). These shows the green-blue network of Groningen based on the NDVI (all values >0.2) and NDWI (all values >0.3) (figure 17) and the most soil-sealed areas based on the NDVI (all values <0.2) overlaid with the outlines of the private parcels. This map closely resembles the green-blue network of figure 15. However, this data was not useful in determining values per parcel and was therefore not used for the rest of the analyses

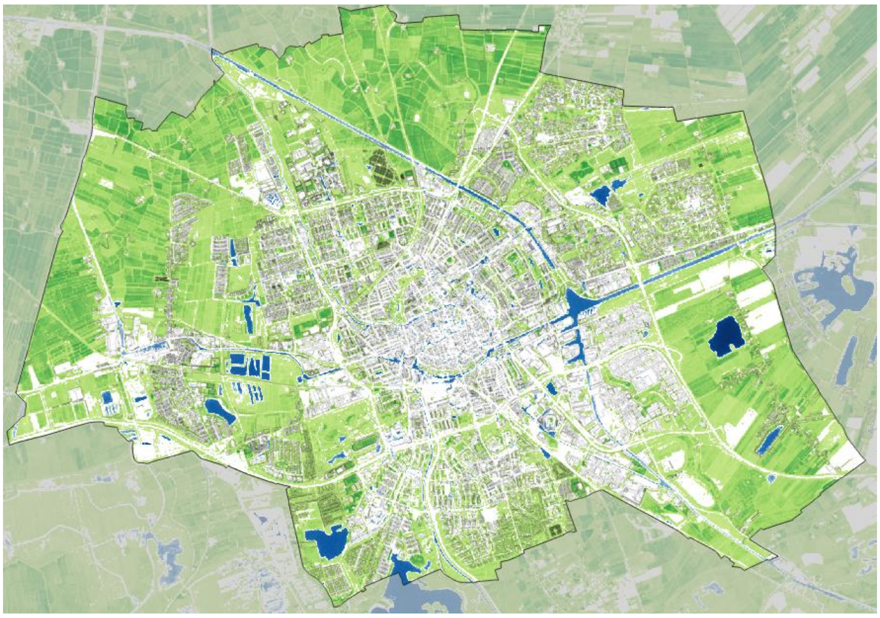


Figure 17: The total Green/Blue Network of Groningen based on NDVI/NDWI (Green/NIR)

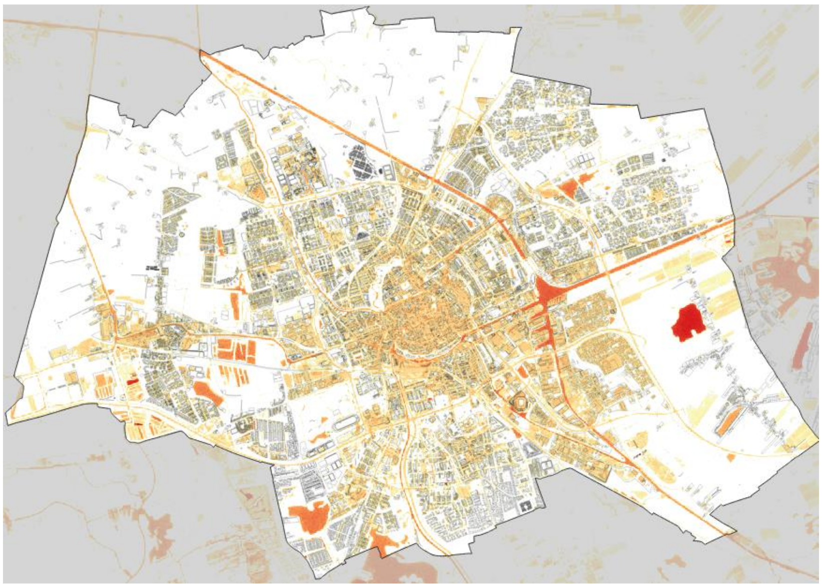


Figure 18: Soil Sealing in Groningen based on the NDVI (Deep red/orange equals paving and water)

On the neighbourhood level (Figures 18 & 19), when comparing public green spaces with private green spaces, in both figures the effects of building density can be seen. The main differences between these images can be seen in the industrial and office zones (North, Southeast, Southwest) and missing data on parcels (East). What can be seen in figure 20 is that as building density decreases, overall greenness of parcels increases, further supplementing the idea that building density and parcel sizes important factors in private land-use decisions.

Figure 19: Public Greenness per Neighbourhood in Groningen

Figure 20: Garden Greenness per Neighbourhood in Groningen

The concept of parcel sizes and garden greenness can be further elaborated on when examining figure 20 and 21. In figure 20, the average greenness per garden is seen and figure 21 displays the ratio of gardens and housing, showing that gardens get bigger the farther you get from the city centre. When comparing the garden greenness with the garden sizes, it can be seen that in many of the neighbourhoods with larger gardens, the overall calculated greenness is higher if there were gardens in the case-study.

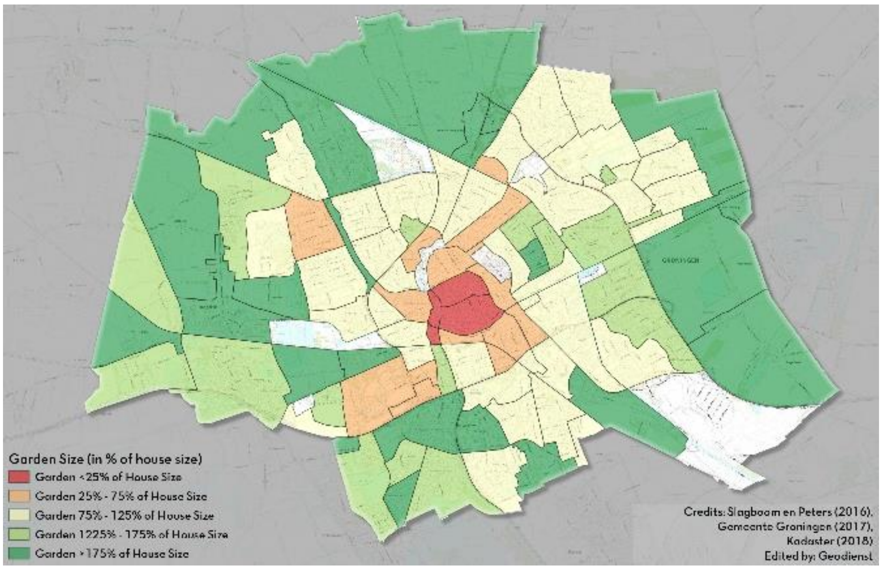


Figure 21: Garden/House rate per neighbourhood

4.1.2 The usefulness of the model

The usefulness of the model was determined using two methods. First, the land-use was checked in comparison to the observations, this can be seen in figure 21. What is notable here is that, whereas most observations indicate a soil-sealed front yard, this often isn't the case, which indicates either a high uncertainty in the model or a disconnection between front and backyards. This has led to a second run of observation in order to check the differences between front- and backyards that indicated that the chances of disconnection between land-uses are probable. Especially considering the patterns seen when comparing the two different datasets used.

This conception of a disconnection of the front and the backyard is further supported by the analysis of the public space using the GBBG (figure 22). This map shows that the classification based on the Aerial photograph leads to only minor differences, often found in industrial zones. In addition, the comparison between GBBG polygons and the average raster value in that polygon has led to a correct classification for 90% of polygons, indicating that the model used is relatively robust.

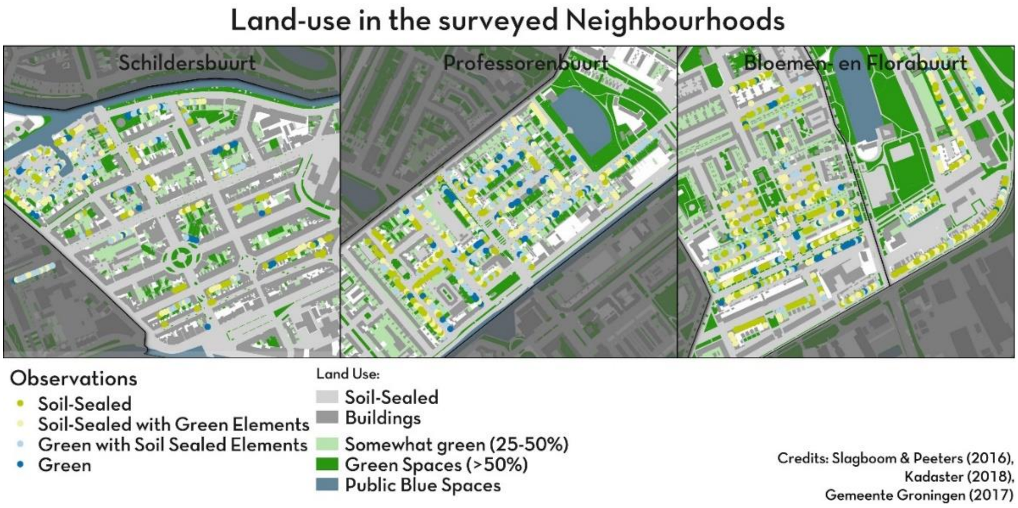


Figure 22: Differences between observations and gardens

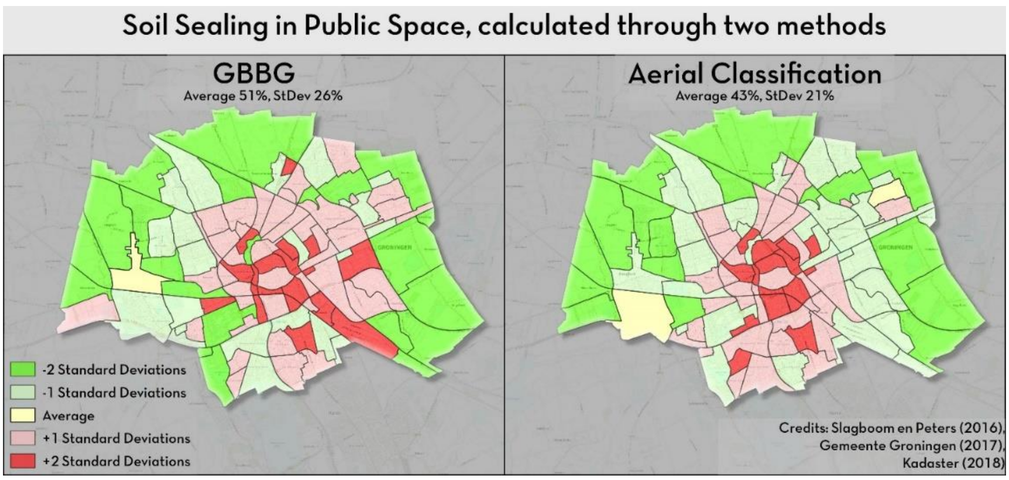
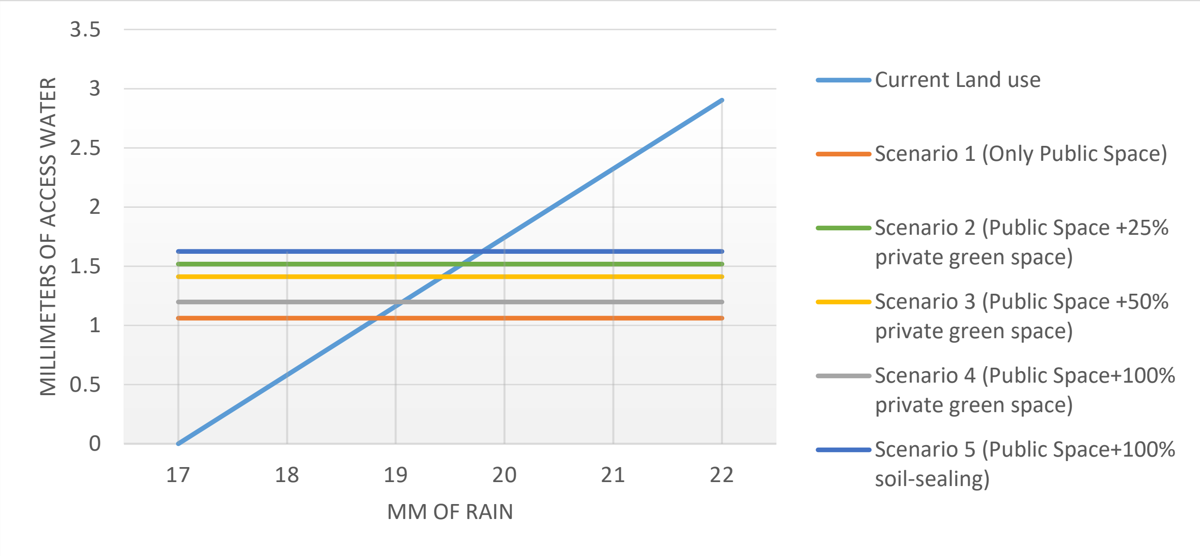


Figure 23: Public space classification using the model and vector data

4.1.3 The effects of soil sealing

Determining the effects of soil-sealing on the sewage capacity on the cities surface was done by comparing scenarios. In graph 1, the relationship between the scenarios on soil-sealing in sewage design and garden design on the urban are plotted. What is notable in this graph is that when gardens are not taken into account, the sewage capacity shifts by 4%. More information on the effects of private-space in the sewage system is seen in Table 5, here, it is seen that on the urban wide scale, increasing the amount of green-space in its current form can lead up to 31% more drainage capacity as when the current trend of soil-sealing continues the sewage capacity can be lowered by 12%. This indicates that citizens can have a significant effect on urban climate-resilience.



Graph 1: Soil-Sealing in Groningen (urban area)

Scenario	Sewage Capacity	Shortage	Percentage
Current Land use	11.3796683	100%	0%
Scenario 1 (Only Public Space)	10.93095775	96%	4%
Scenario 2 (Public Space +25% private green space)	11.38810465	1%	99%
Scenario 3 (Public Space +50% private green space)	11.28136991	-10%	110%
Scenario 4 (Public Space+100% private green space)	10.1663446	-31%	131%
Scenario 5 (Public Space+100% soil-sealing)	11.49483939	12%	88%

Table 5: Private space drainage capacities

4.2 Factors underlying Soil-Sealing

4.2.1 Spatial Contagion

The hot-spot analyses for private and public space in Groningen can be seen in figure 24 and 25. Figure 20 shows the private hot spots, when analysing this picture, there are three areas of the city of Groningen that have a rather high concentration of green gardens, these are Beijum and Lewenborg in the Northeast, Villawijk Zuid in the South and Corpus den Hoorn in the Southwest. This further adds to the idea that neighbourhood design and parcel sizes are relevant for determining urban private green-spaces. This is also seen by the hot spots around the Noorderplantsoen and Stadspark (the two largest green areas in the city). Lastly, the effects of building density become clearer, with some 95% confidence cold-spots in and around the city centre and the Oosterpoortwijk. The most significant cold-spots are the office-zones near the Martini hospital in the southwestern part of Groningen.

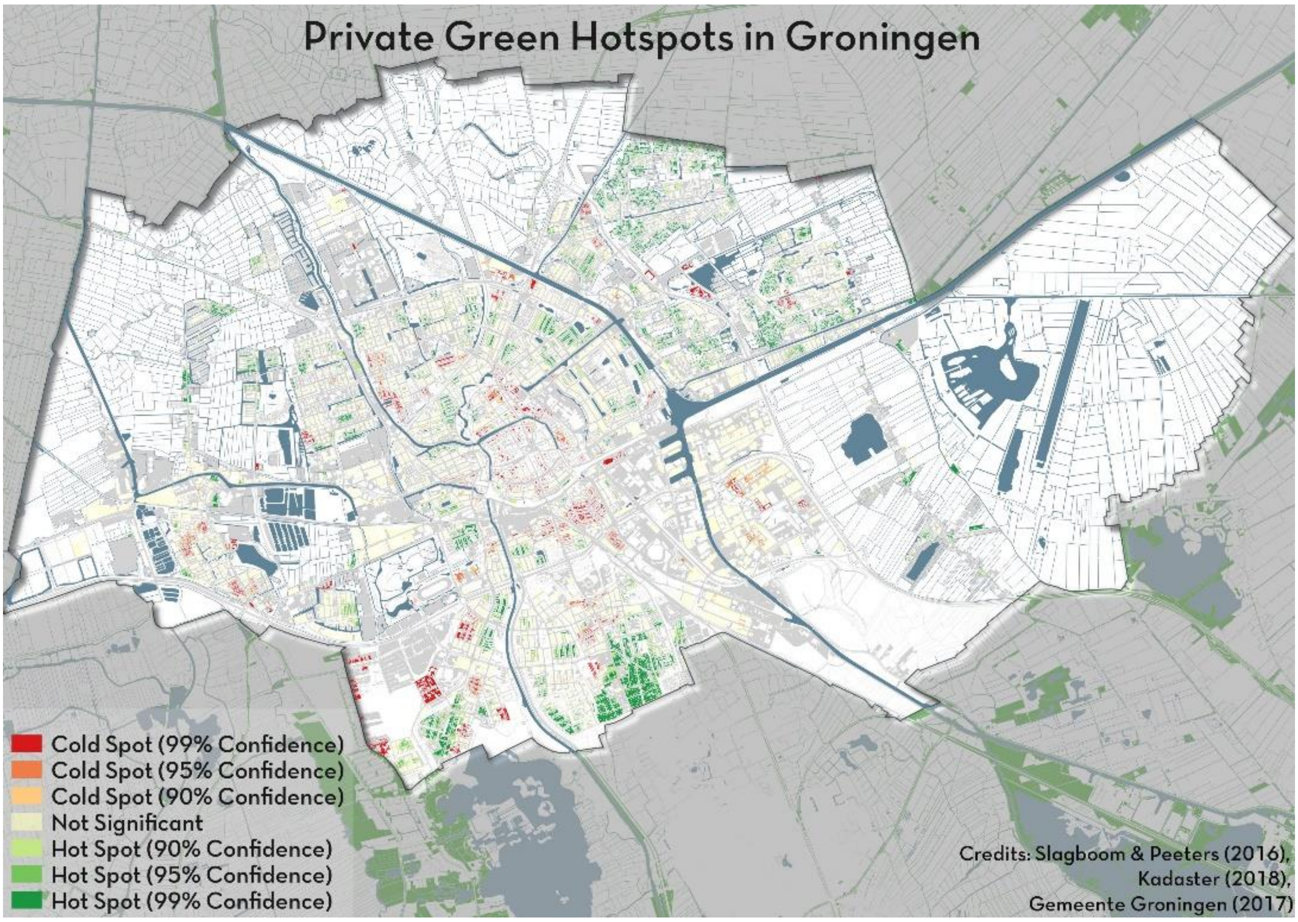


Figure 24: Private hot spots in private green space.

The conception that public space has a role in private-land-use decisions becomes less likely when examining figure 25. In this figure, the hot- and cold spots of urban private-green are analysed, however, this image mostly shows the difference building density for a large part of Groningen, with the only noticeable hot spot being a graveyard in the North of Groningen. This indicates that there are either very limited connections to public space, which contradicts the findings discussed in table 4.

What is most likely is that the method of determining public land-use within the 25 meter radius around houses has led to problems with the calculation of hot-spots due to the rather high share of car-infrastructure when compared to roadside trees, which, when expressed in a vector, leads to a low amount of rather small polygons for green space and large and connected polygons for soil-sealed areas, resulting in many cold-spots as seen in figure 25.

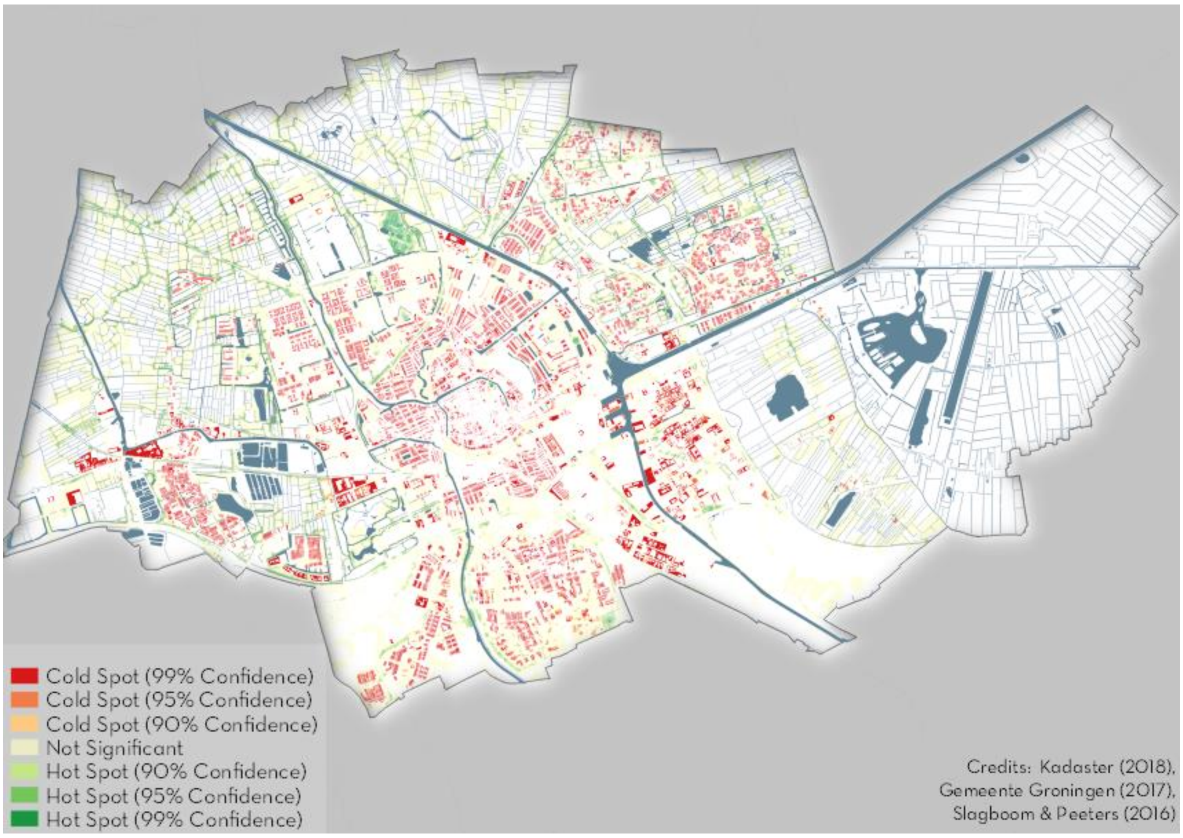


Figure 25: Public-Private hot spots in private green space.

4.2.2 Ownership and parcel sizes

Table 6 shows the outcomes of the chi-square and Somers D tests. What can be seen in this table is that all factors are significant, meaning that there is a relationship between each factor with garden design. However, due to a high percentage of values <5 and an expected count of below one, the ownership variable did not pass the chi-square, meaning that its outcome is useless.

As for the other factors, garden size seems to be the most relevant indicator for garden size, with the indication that a larger garden is greener. In addition, there are weak relationships between both house-size as house-age with garden design. The relationship between house size, garden size and garden greenness was further evaluated using an ANOVA (table 7). This ANOVA was significant, with the coefficients indicating that as gardens get larger, gardens get greener and that as houses get smaller, gardens get more soil-sealed. However, it should be noted that this effect is rather weak.

The relationship between house sizes, garden sizes and garden greenness indicates that spatial design matters in some extent in increasing climate-resilience. With larger properties often being more green, however, in many urban environments this might not only be a matter of size, as often housing prices for larger properties will be higher. This raises the question whether garden design is also partly dependent on socio-economic standing rather than just spatial design.

Factor	Chi Square	Asymptotic Significance (2-sided)	Degrees of Freedom	Values <5	Percentage	Somers D	Approximate Significance
Garden Size	4110.568	0.000	9	0	0	0.308	0.000
House Size	352.64	0.000	9	0	0	0.069	0.000
Ownership	171.668	0.000	12	4	20	-0.031	0.000
Construction era	1894.818	0.000	24	2	5.6	0.078	0.000

Figure 6: Chi Square for indicators of Garden Design.

ANOVA	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Regression	13.67	2	6.835	94.642	0.000
Residual	2209.031	30588	0.072		
Total	2222.701	30590			

Table 7: ANOVA for relationships in size and garden greenness

Variable	B	Std. Error	Significance
Constant	0.275	0.002	0.000
House Size	-0.0000112	0.000	0.000
Garden Size	0.0000531	0.000	0.000

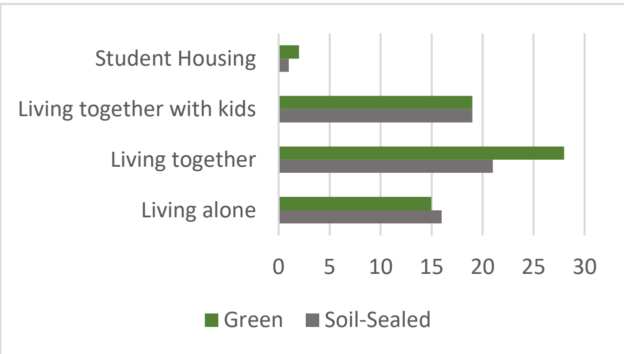
Table 8: Relationships between garden size, house size and garden greenness

4.2.3 Socio-economics, ownership and personal preference

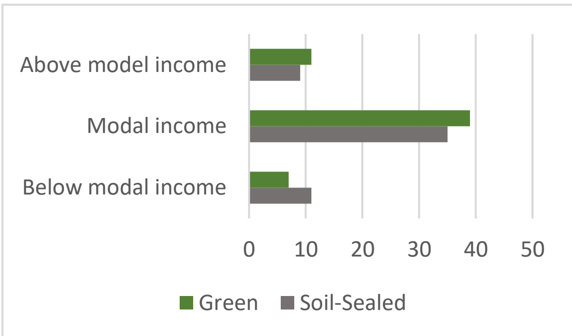
three neighbourhoods of Groningen were aimed at gaining a more qualitative insight in the reasoning underlying private land-usage. The main focus of the thesis was gaining an understanding in the dynamics between on the one hand garden designs, and on the other hand factors like household composition, ownership, neighbourhood effects and other possibly unknown factors that underlie land-use decisions. Lastly, there were questions regarding familiarity with climate-adaptation for rainfall and a question regarding the willingness to make changes in order to better deal with intensive rainfall and flooding.

The survey was filled in by 123 people living in the professorenbuurt, oosterparkwijk and schildersbuurt in the city of Groningen. Of these 123 people, 52 percent had a garden in the green categories (Green and green with paved elements) and 48 percent had a soil-sealed garden. Of the 120 people that filled in the question regarding ownership, 72 percent owned their houses and 28 percent rented their house (the view survey results can be reviews under Appendix B).

The household factors of this survey can be seen in graphs 2 and 3, these tables show the prevalence of green- and soil-sealed gardens connected to the demographic and socio-economic variables of household composition and income. What can be seen for these variables is that there is no clear pattern in the data. With only slightly more children less people that live together having a green garden and a slightly higher amount of green gardens for modal incomes and more soil-sealing for below-modal incomes. This indicates that wealth and family composition have no direct effect on private land use decisions. However, demographics still have an effect in the form of time and the ability. With especially by older respondents mentioning this, as seen in this quote: "We have a terrace now, since my husband is in a wheelchair".



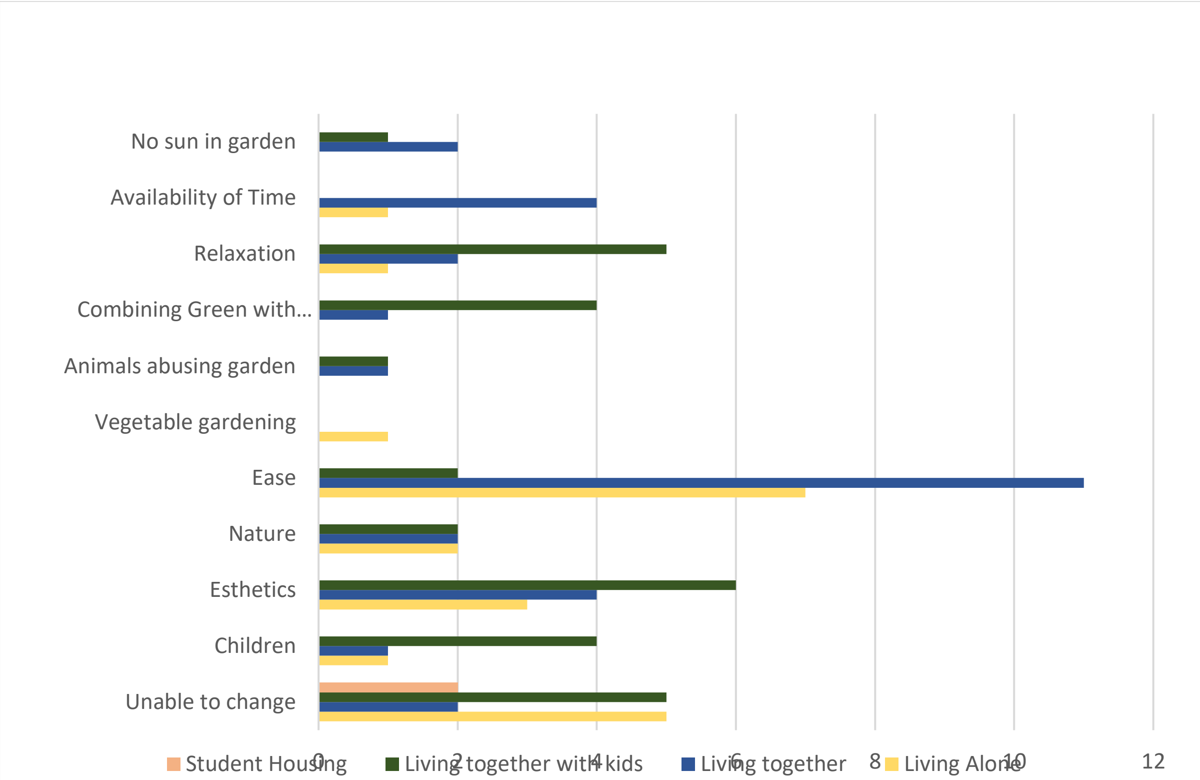
Graph 2: Family Composition and land-use



Graph 3: Income and land-use

When examining the relationship between personal factors that contribute to soil-sealing and household composition (graph 4) you can see there is an interesting pattern in the form of the frequency of arguments relating to ease and availability of time for both single as two-person households. This indicates that the availability of time is an important factor in garden designs for these demographics. Furthermore, it can be seen that for households with children, aesthetics, relaxation, having green with little maintenance and children are important indicators in their garden designs.

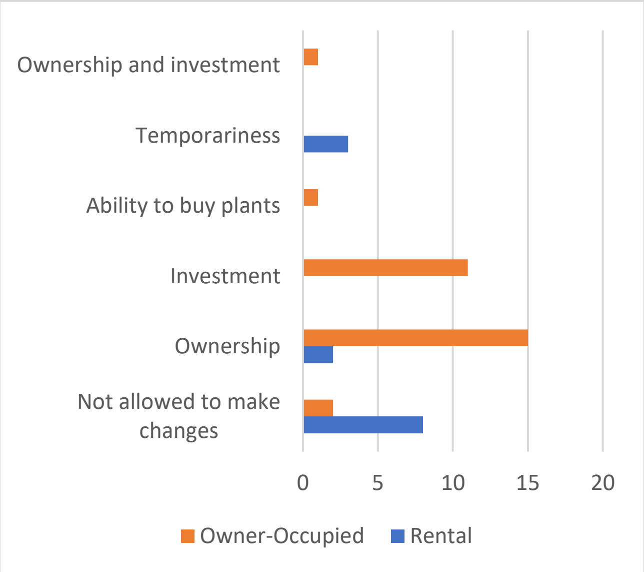
When examining the relationships between ownership and land-use decisions (graph 5 & 6). Two main discourses can be seen. First, there are clear differences in reasoning behind land-use decisions related to ownership between the two groups, with owner occupied houses having a tendency to view garden design as an investment in a property and seeing their ownership of the house as the most important factor for its design, a good example of this is seen in this translated quote from the open question: "I choose to soil-seal my garden, because it is my property". However, the fact that home-owners see garden design as investment does not indicate a preference for either a soil-sealed or green garden (graph 6), this indicates that trends and the personal concept of home and gardens might play a role in garden design, with the investment in a certain design being an expression of this idea.



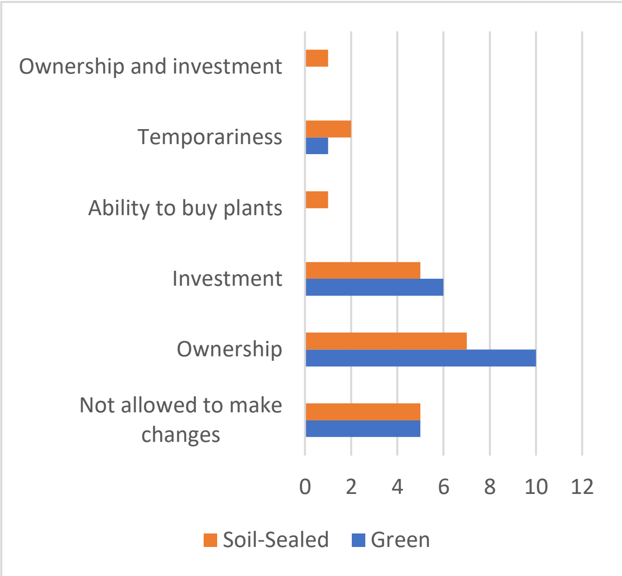
Graph 4: Family Composition and personal factors

The relationships between rental properties and ownership are clearer, with nearly all responses reflecting the concepts of ownership or temporariness of a living arrangement. This indicates that personal land-use decisions of the person are almost non-existent, this is reflected in the following open answers: “the association designed the garden”, “A change in my property will not be useful for me in the long run” and “if I were to own this property I would view garden design as an investment, but I rent so I don’t really do anything with it”. This indicates that housing association and home-renters could be an important actor for making a large part of the city more climate-resilient, as these institutions determine the design of these properties

Lastly, when examining the personal factors that contribute to private land use decisions; three main categories of answers are overrepresented when compared to the rest, these being: the ability to change a garden, aesthetics and ease. The first reason highlights the importance of ownership in the field of private green space and garden design. As the first question of this survey was open, indicating that ownership is not only a formal institution (i.e. a contractual agreement) but also plays into the reasoning of renters, a noteworthy answer that highlights this was: “I received the house like this, I would like to change it, but I don’t have the time to arrange and execute it”. Indicating that dealing with a house lord or association could possibly be a factor that inhibits personal decision making.



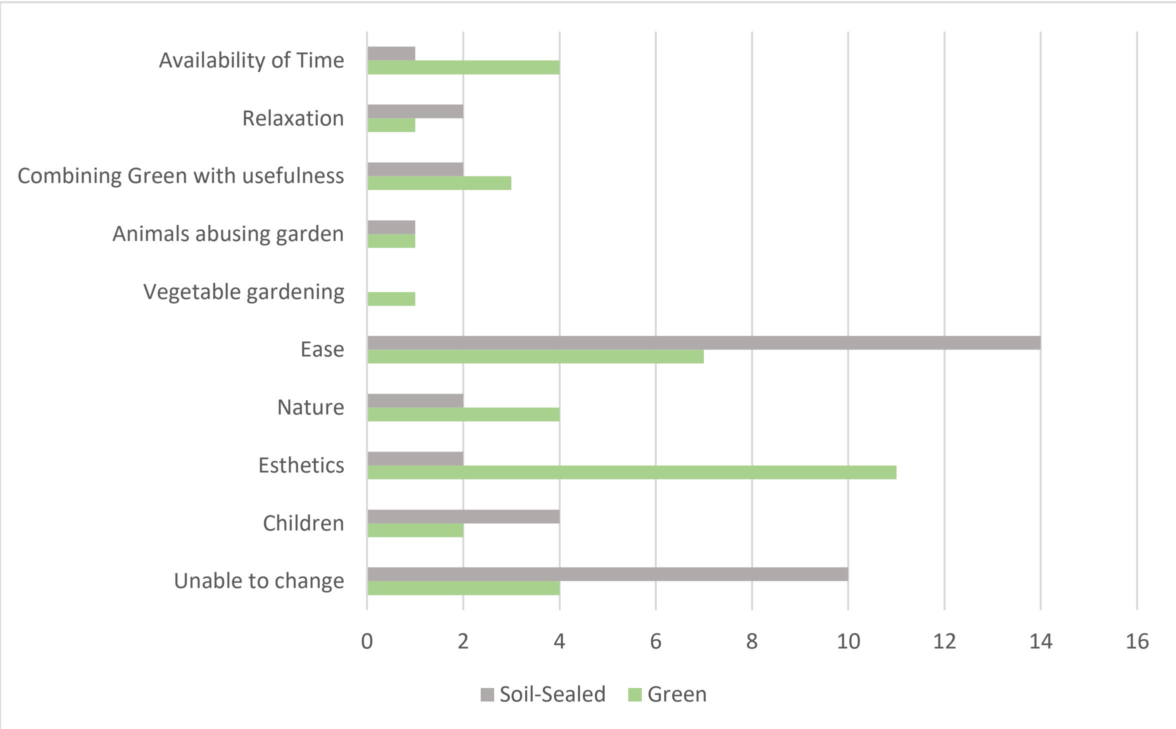
Graph 5: Ownership and personal factors



Graph 6: Ownership and land-use

Secondly, it can be seen that for greener gardens, the aesthetic elements are most important and for soil-sealed gardens, ease of use is most important. There were also respondents that actively used climate-resilience as a factor in garden design; a good example of this is the following response: "Too many paving stones are aesthetically unpleasing, but we wanted a garden with little maintenance. Semi-paved as a solution to combine ease with water drainage" and "we wanted to keep green elements, every house should be able to drain its own water". These quotes underlie the potential of change from the micro level, where small groups of actors change the status quo of climate-resilience through personal choice.

Factors that were not considered before this research, but could provide interesting insights are the effects of animals as a driver of personal land use decisions, with both a personal as a communal aspect. This answer was not given often in the survey, however, these answers did stick out from the other answers, with the respondents of this question stating that: "my dog would dig up the garden if we had one" and "there are too many cats in the neighbourhood that make a mess of things".



Graph 7: Personal factors and land-use

Lastly, as for climate adaptation and the familiarity with the problems of gardens, sewage and runoffs, the vast majority of the surveyed households indicated that they were not familiar with the problems of mixed drainage systems and limits to the systems. And hardly any respondents indicate that they would make different land use decisions if they knew about the problems of run-offs on the sewage system. However, in analysing the data, it became clear that 56% of respondent that were aware of the effects of land-use decisions had a green garden, whereas this was 51% for the population that was unaware of the problem (table 9). Lastly, in evaluating the responses people gave regarding their personal contribution to climate-resilience, the fast majority of respondents answered that they would not consider climate-resilience in garden design. With some respondents indicating that they think it was the municipality's responsibility or that citizens already had to do enough in this field. However, of all respondents around 9% answered that they would consider climate-resilience if there was a need for it (table 10). Indicating that citizen engagement and education might help in increasing climate-resilience and the urban private green-network

Familiarity with the problem	Soil-sealed	Green	Average
Aware	19	24	56%
Non-Aware	37	38	51%
Sum	56	62	53%

Table 9: Awareness and Land-use

Answer	Aware	Non-Aware	Total
No	15	34	49
No, enough is being done by either me or the municipality	2	7	9
No, maintenance and ease are more important	2	2	4
Yes	1	11	12
Yes, garden and climate are linked	5	7	12
Maybe, if there is enough support	1	3	4
Maybe	0	4	4

Table 10: Awareness and willingness to act

4.3 Policy outcomes

4.3.1 Urban Climate-Resilience in centralized policies and law

In the Netherlands, the Deltaprogramme and Waterwet can be seen as the most important policies and laws for both climate-adaptation as mitigation. First, the Deltaprogramme policy document uses a combination of law and broader guidelines to steer all governmental bodies in the Netherlands towards increasing climate-resilience. The most important aspect of the Deltaprogramme 2018 is its emphasis on climate-modelling and monitoring, dictating that all municipalities in the Netherlands should perform a stress test to gain more insight in municipal climate-resilience, vulnerabilities and possibilities for improving resilience. This program, as the basis of municipal climate-policies, emphasizes the importance of learning by doing and mostly vertical policy integration to reduce free-rider behaviours and to increase interregional resilience. Furthermore, this documents emphasizes the importance of civilians as a partner in increasing resilience and promotes public-private cooperation. However, when examining the spatial aspects of the policy, it can be seen that the document mainly sees urban environments as being vulnerable to the urban heat island effect, laying the focus of adaptation on this aspect. The focus of increasing flood-resilience is more being aimed at rural areas. The waterwet is a hard institution that sets environmental standards for development, seen through the watertoets (water-test), and compulsory test for developments where the effects on the water-system have to be evaluated. In addition, the waterlaw states that municipalities are responsible for draining water from public space and citizens are responsible for draining water from their own properties. This law forms the basis on which many water and climate policies in the Netherlands and allows space for both community as market based approaches in increasing private climate resilience

This emphasis of flood-resilience and rural areas is also seen in the provincial policies, with both the provincial nature policy (Groningen, Groen van Wad tot Westerwolde) and climate policy (Milieuplan Provincie Groningen 2017-2020) laying the focus of climate-adaptation and cities being concentrations of development that can be used in reducing climate-stress on rural areas. The differences between this policies is that the nature policy sees households as an important and emerging factor in climate-resilience, whereas the environmental program sees citizens as something that has to be protected. This is also seen in the policies approach, with the nature policy having a more decentralized approach where vertical policy integration and strategies are used and the environmental policies being a centralized policy with strict guidelines for development.

Together, these policies and strategies on the state and provincial levels form the basis of municipal climate-resilient planning. All of these policies influence the policy making process either through (1) giving direct guidelines or (2) via informal institutions and expectations. Out all of these policies, the

Deltaprogramma can be seen as the most important document for institutional change and citizen engagement through (1) its emphasis on learning by doing, (2) promoting public-private cooperation and (3) its guidelines for monitoring of climate-resilience.

4.3.2 Municipal climate planning

On the municipal level, the aspect of spatial complexity becomes a more important part of policy making. This is also reflected in the policies that seek to guide infrastructural, housing and water-resilient developments, making these policies particularly driven by the spatial complexities of the urban environment.

These complexities are also shown in a large share of the policies. Even though most policies seek to integrate climate-adaptation in their strategies, this is done in many different ways. What becomes clear from the policies is that Groningen has structural visions that force policy makers to include different aspects of climate into their policies. These aspects are mostly focusses on either the energy-transition (e.g. making new houses energy neutral) or liveability (e.g. limiting emissions from cars). With all of the evaluated policies from the municipality addressing either energy or emissions in their policy.

When looking at climate-adaptation, the amount of policies that offer concrete goals is limited, with only the energy program, climate program and water making climate-adaptation clear goals in their plans. For the water-plan, this goal is mainly focussed on improving the ability to drain and store water in the urban environment to maintain liveability and increasing climate-awareness amongst citizens. In the energy program, the framework of climate-adaptation ranges the entire spectrum of problems, with the policy aiming to increase climate-resilience through maintaining and improving on ecological networks and sewage system. The policies on infrastructure and housing developments don't focus on the ecological- services or climate-mitigation, both aiming to increase liveability but mainly focussing on socio-economic development through housing and infrastructure planning. This might lead to tensions in planning, with conflicts of interest between the different departments.

When looking at citizen participation, the extent to which this is used is rather limited. A good example of this is the Groningen Klimaatbestendig document, a document focussed on informing policy makers how to include climate-resilience in project- and program management, no information on community participation is given. Furthermore, in all documents except for the water policy, the role of citizens in planning is mainly focussed on health. A good example of this is the energy policy only mentioning citizens in the context of climate-resilience as stimulating growing vegetables in addition to giving information. The only program that has clear plans in including and informing citizens in the process of making policies and strategies is the water policy of the municipality of Groningen.

After analysis of the municipal environmental policies, it can be seen that, despite having climate-adaptation and mitigation as a pillar in making plans the overall status of planning in Groningen still seems rather segmented. Every department of the municipality has their own ideas as to how to increase climate resilience, with only the climate and water departments attempting to make integral strategies. Overall, the municipalities planning policy seems more top-down, with limited aspects of public-private partnerships rather than adaptive and communicative. Creating a disconnection between planning practice and theory in the field of climate-resilient planning.

However, for this research, only a section of the department policies were included, meaning that, even though the researched policies make it seem that horizontal policy integration and many of the aspects involved in climate-resilient planning approaches are not present in current policies, these approaches might be present in other policies or strategies outside of the scope of this research.

4.4 Monitoring outcomes

Monitoring is an important element in both the Deltaprogramme as in the literature regarding complexity and climate-resilient planning. In this research, the usefulness of different methods of analysis was examined in order to determine the usefulness of the date used in this research for the monitoring process. In the research of individual parcels, it was concluded that the RGB image was the most useful. However, due to the time constraints of both the collection of the data as calculation times on the computer, the Sentinel-2 data proved to be more effective at long-term monitoring of changes in the network and the indication of possible problem areas.

As for the usefulness of the indices discussed under methodology, the outcomes of these analyses can be viewed in Figure 26. What can be seen is that the density of the urban environment makes the use of the Bare soil Index (figure 26 B) impractical for monitoring soil-sealing in the urban context, the same goes for the NDWI based upon NIR/SWIR (figure 26 D), this method of calculating the water content of vegetation was not useful due to the resolution of the image used, however, it can be seen that for the areas with lower densities, an indication of vegetation can be seen. The most useful indices for detecting changes in urban land-use are a combination of the NDVI and NDWI Green/NIR (figure 26, A and C). These indices together provided a good approximation of the green blue/network based upon the analysis of basic registrations and the high-certainty RGB classification.

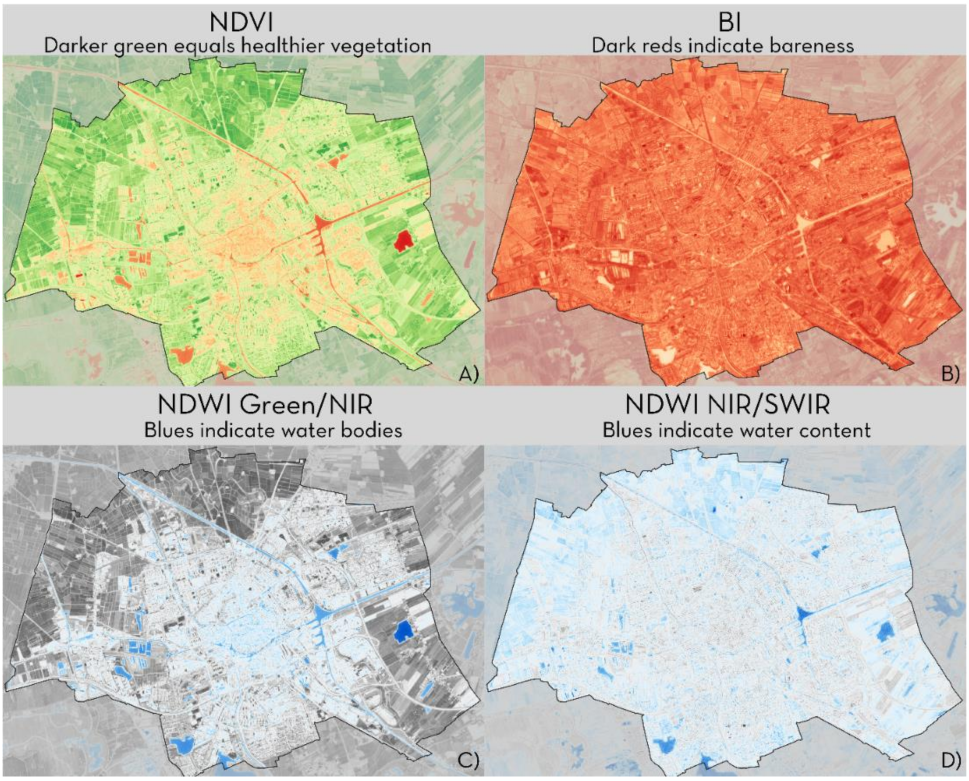


Figure 26: Land-use indices

5. Discussion

5.1 The effects of private-land use decisions

5.1.1 The effects of soil sealing

This research found that for Groningen around 11% of all surface level area is private space, which is lower than the 16 to 27 of space in other European cities (Colding, et al., 2006; Loram, et al., 2007; Tratalos, et al., 2007). However, when viewing this percentage in the light of the current green network, it can be stated that around 39% of green space is found in gardens. This research used this distinguish as private space is more easily changed than public space and to highlight the potential of public-private partnerships as a way to increase climate-resilience together (Bulkeley & Betsill, 2010).

In addition, this research has found that, on the urban scale, soil sealing leads to a decrease in sewage capacity of around 5% with the current land use, which slightly higher the 3.4% change found in a previous research into soil-sealing in Groningen (Zwaagstra, 2014). This difference might be explained through the different methodologies and scopes of the researches, with Zwaagstra (2014) researching three neighbourhood using a spatial hydrological model and this research focusing on the entirety of the city using a static model.

5.2 Factors underlying Soil-Sealing

5.2.1 Spatial Contagion

This research has found no direct indications of the concepts of spatial contagion in gardens; however it was found that in certain areas in the city there were certain hot-and cold spots in the private green network. These hot- and cold spots indicate that there might be some form of spatial contagion in the design of gardens where neighbours copy each other, indicating that the research of Hunter & Brown (2012) into easement gardens and the researches of Kullberg (2016) and Larsen & Harlan (2006) might also apply to the entirety of the garden. The concept of spatial contagion in the design of front yards is a phenomenon that is likely as supported by the observations in the three neighbourhoods of Groningen. A factor that limits the extent to which this research can take a definite position in either confirming nor disproving the concept of spatial contagion is due to the lack of support of this theory in the survey, with no respondents answering that neighbourhood design had an impact on their personal land-use decisions, indicating that either this is not a real factor and that personal-land-use decisions are more dependent on other factors. Or that the concept of spatial contagion and imitation behaviour is happening passively.

Where this research was unable to either prove or disprove the concept of spatial contagion between neighbours. The effects of building-age, parcel size, building density and neighbourhood design, as implied by Larsen & Harlan (2006), Zmyslonly & Gagnon (1998; 2000) and Tratalos et al (2007), is more clear in this research. With the hot-spot analysis and statistical analysis clearly showing that building age and certain neighbourhood designs have a relationship, indicating that planning paradigm has an impact on climate-resilience. Furthermore, both the chi-square as the ANOVA test confirm that house size and parcel size have an impact on the amount of green-space on a parcel, with garden greenness decreasing with house size and increasing with parcel size, which is in line with the theory of Goddard et al (2009) that there is an optimal parcel/house ratio for promoting green space. Lastly, this research has found indications that higher density neighbourhoods know relatively less private-green spaces than neighbourhoods that are less dense, as seen in the hot- and cold spot analysis, supporting the research of Tratalos et al (2007). This research was not able to find a relation between parking space and garden design, as this was not mentioned in the survey and hot-spot analysis of individual neighbourhoods showed no pattern that could be linked to potential availability of parking space (Perry & Nawaz, 2008).

5.2.2 Ownership

This research found strong indications that ownership has an important role to play in private-land use decisions. Analysis of both the GIS data as well as the survey data indicate that owning or renting a house, these findings are in line with the conclusions of Kullberg (2016) for their research into garden design in the Netherlands, furthermore, this result offers potential for policy makers as housing associations and renters often work in direct contact with local governments in the development of new housing, making it possible for policy makers to have direct impact on their decision making.

5.2.3 Socio-economic and Socio-Cultural Factors

This research has found no strong connections between socio-economics in the form of wealth and garden design, supporting the claim of Heezik et al (2013) that socio-economic status has no direct relationship on land-use decisions, but that the availability of money is more of an enabler for more personal preferences in garden design. In other words, wealth is not a direct influence on the design of a garden, but more of an enabler of the modification or maintenance of one's personal taste in gardening. The effect of high-priced real estate in city centres was also not conclusive in this research without the existence of a significant green-space in the city centre, contradicting the notion that housing prices in urban centres promote having more green space (Kullberg, 2016).

There are strong indications that the availability of time is important in the design of a garden. With couples without children and singles being more prone to soil-sealing. Furthermore the survey indicates that the availability of time is a factor in garden design and that having children also is a factor in soil-sealing. As all of these factors can be attributed mainly to the time and in lesser extent to gender, this research finds enough indication to support Bhatti & Church (2000) notion that the garden is a genderless space. Furthermore, this suggests that the effect of increased female work-force participation in the research of Kullberg (2016) might be caused by time-availability rather than indicating that gardening is a feminine activity.

This research has found a particular set of socio-cultural factors that impact backyard design, mostly in the form of personal preferences, with a large share of respondents stating in the open question that having a terrace was an important reason in the decision of their gardens. This is in line with the reasoning of Linssen (2011) stating that the garden is becoming an extension of the home. However, there is also a large share of respondents that indicate they have green garden for the aesthetics and nature, linking back to the concept of the garden being a space to get in contact with nature. The large set of arguments behind garden design is representative of the statement of Cameron et al (2012) that: "Domestic gardens are undoubtedly an important component in many people's lives, but attitudes towards them are not uniform. To some, they are an essential element of life providing opportunity for engagement with nature, self-actualization, creativity or wellbeing; to others, they are at best a parking lot, or worse, represent an additional chore to an already busy lifestyle."

5.3 Policy and monitoring outcomes

The policy review gave insight a changing institutional landscape, with large differences between the different planning approaches and forms of integration. What can be noted is that the Deltaprogramme is best in line with the current paradigm on complexity planning for climate resilience, with an emphasis on learning by doing, monitoring and public-private cooperation in increasing climate-resilience as described by Smit & Wandel (2009), Wall et al (2015) and Loorbach (2007). The open-ended nature of the Deltaprogramme where the programme dictates that steps need to be taken to increase climate-resilience, but leaves the development of policies and strategies in the hands of regional and interregional governments also fits in well with the concepts of vertical policy integration and decentral planning, where, through setting guidelines, increasing climate-resilience becomes a part of all forms of planning, focusing on finding solutions as close to the citizen as possible (Zuidema, 2016).

However, where the central government states guidelines and makes climate-resilience an element in all fields of government, this is not done by the provincial government. This body of government seeks to focus more on increasing the climate-resilience of their socio-ecological system (Glaser, et al., 2012). With the province focusing on increasing climate-resilience on the province wide scale, with project to designate rural areas for water storage in case of flooding and designating cities as spaces of development and concentration of emissions. This form of decision making indicates that the Province is focusing on the resilience in their personal system rather than the individual systems that make up this macrosystem, forming a missing link between state and municipality in the sense of horizontal policy.

On the municipal level, it is clear that there is a transition from sectoral planning towards a system of horizontal integration, with climate change forming a factor in all forms of evaluated policy. However, the complex relationship between climate-resilience, economic development in a compact space is apparent here (Grimm, et al., 2008). As the different policies still make claims on space, focusing on the development of their own individual fields without making clear linkages between different developments, resulting in increased vulnerabilities and limited carrying capacity through the possible impacts of developments on existing urban climate-resilient infrastructures (Francis & Chadwick, 2013; Nordh & Østby, 2013)..

The concept of community based approaches is an approach that is starting to be applied in more and more fields of the municipality, most prominent in the water policies. However, these community based approached are still mainly focused on communicating with- rather than cooperating with citizens, this while a small minority of people in the survey could be moved to become more climate-resilient through this approach. In their climate-related policies, the municipality focusses mostly on maintaining and improving on their own public green- and blue spaces rather than increasing resilience through public participation.

As for the potential of new policy instruments on the municipal level, the analyses of this research indicate that a hybrid approach will work best in increasing climate-resilience. First, it is seen that public participation can lead to a significant increase in sewage capacity. Secondly there are already indicators that there is a transition in the citizens view on climate-resilience seen through the survey, indicating that a group of citizens would be willing to help in increasing climate-resilience. Lastly, there is a potential for the application of monitoring and market-based approaches for increasing urban private green areas on rented properties, as the informal institutions and extent of soil-sealing by a limited amount of actors on the market side could be stimulated to change their behaviour through economic incentivization as seen in the case of soil-sealing taxes in Dresden (European Communities, 2011)

6. Conclusion

The aim of this research was to answer the following research question: “To what extent can private gardens play a role in climate adaptations and how can planners intervene in usage of private spaces in Groningen?” and the following secondary research questions:

- What is the effect of land use in private spaces on climate resilience
- What are the underlying factors in land-use in private
- How can policies intervene in backyard usage
- How can the effectiveness of policies stimulating land-use changes be monitored

First, this research can conclude that private space has an impact on urban-climate resilience, with this research indicating that, even though only 11% of the urban surface space is owned by individuals. When translated into the potential green-space, which is an overview of the public green space, private green spaces and easily transformable private spaces in an attempt to include the complexities of public space in climate-resilience, this amount is increased to 39 percent. This potential is also seen in the contributions gardens can have on sewage capacities, with the sewage capacity increasing by 35% if all private space would be green space.

Secondly, the dynamics that determine land-use in private space are complex, with a broad assortment of personal, spatial, institutional and communal factors having a role in garden design. This research has found the contribution of spatial design to be one of the most important aspects in determining private-land use, with clear indications that there is an optimal configuration of space to promote private green space. Socio-economics and wealth have the smallest contribution to private-land use decisions, functioning mainly as an 'enabler' for other factors in making private land-use decisions to be displayed. Ownership also has a role in garden design, with rental properties displaying an informal institution where renters do not feel the need to change due to the effects of temporariness or lack of investment opportunities. Climate-resilience, as of now, is not a major factor in garden design, however, awareness of the effects of private land on climate-resilience as well as a policy approach that focusses on increasing adaptive-capacity of citizens might lead to the formation of new institutions of garden design on the micro scale and the prevalence of urban-green areas as climate-resilience spaces.

Thirdly, policy design can be an important factor in urban climate resilience, with the rise of more communicative or market based approaches, citizens may become more incentivized to make changes. Governance approaches on higher levels might help in stimulating this change by setting central guidelines for regions and stimulating areas to create more insight in their socio-ecological system. This might lead to an increase in the valuation of public- and private green spaces by governments and more focus on public-private partnerships in increasing climate-resilience. However, the complexities of urban development and the scarcity of space in the urban environment limit the extent to which this approach can be applied without an transition from sectoral to more integral policy making. This together makes that increasing climate-resilience through public-private cooperation is a complex issue, requiring change from the micro level as well as the broad support of both government, the market and citizens to change.

This transition from government to governance and the shift of focus from sectoral developments towards integral developments require an approach that is flexible and focused on learning by doing; this requires monitoring of both the success of the policy as potential vulnerabilities and threats in the urban environment. One of the methods that can be used for this is the application of remote sensing, this can give insight in the form, functioning and changes of the urban ecological system and allow policy makers to adapt and transform policies and strategies as the need arises.

In conclusion, a better valuation of the impacts of private-green spaces in urban climate-resilience can lead to better spatial planning and, through increasing linkages between often segmented urban public green spaces, strengthen both the resilience as the ecological-services in the urban environment. Creating both ecological as economical value for the city through ecosystem-services. This transition towards a better appreciation of private green spaces will require a planning transition where climate-resilience is no longer a part planning of governmental policies and strategies, but through cooperation will become a societal process. The role of the government in this new approach will have to shift more towards a source of information and a link between different developments in the city, requiring a learning by doing approach focused on monitoring and adjusting space to reduce vulnerabilities and increase climate resilience. This research has found a number of socio-economical, demographic and spatial factors that contribute to urban climate-resilience, however, more research into these factors is required in order to design effective policy strategies for urban public-private climate-adaptation strategies.

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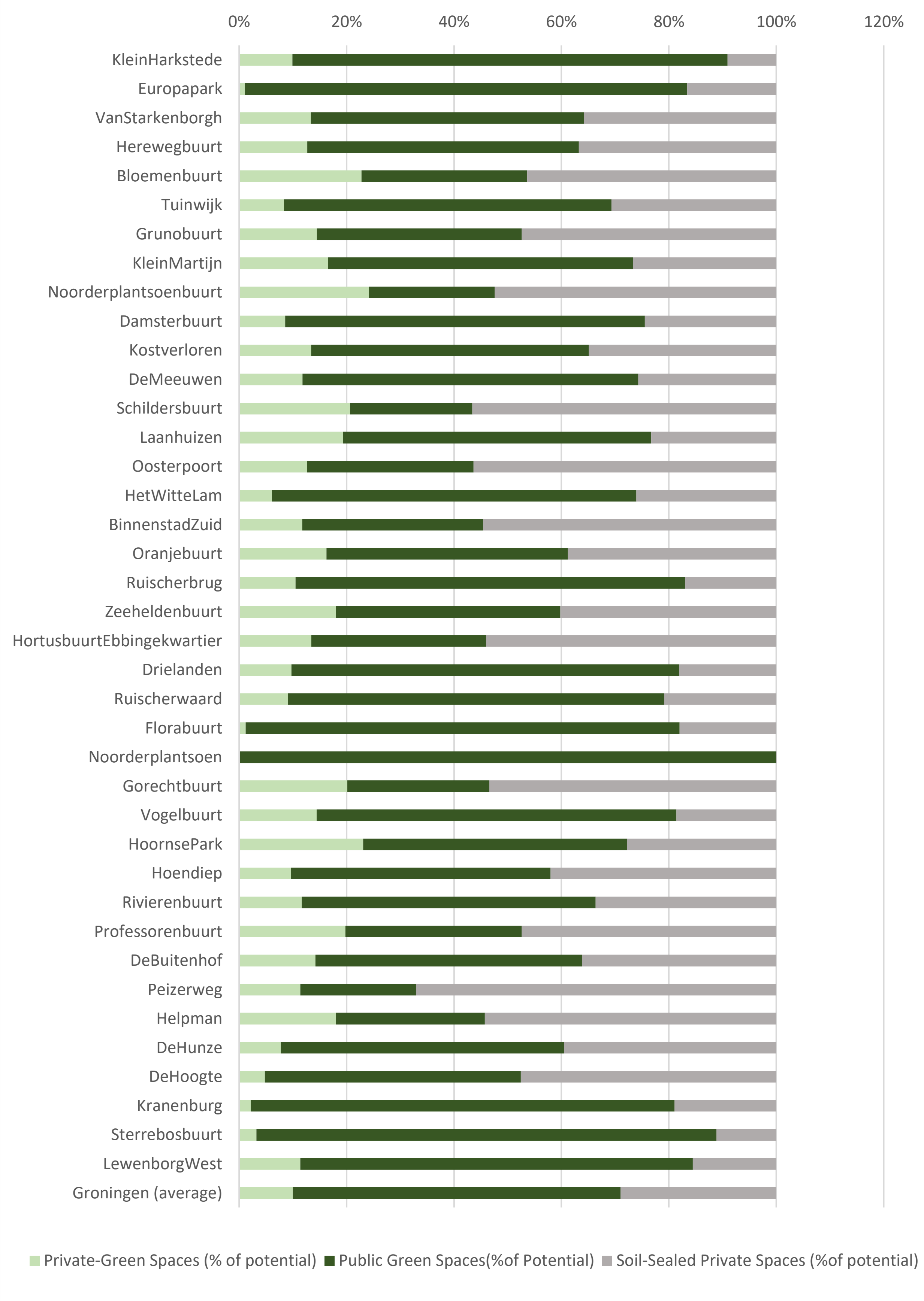
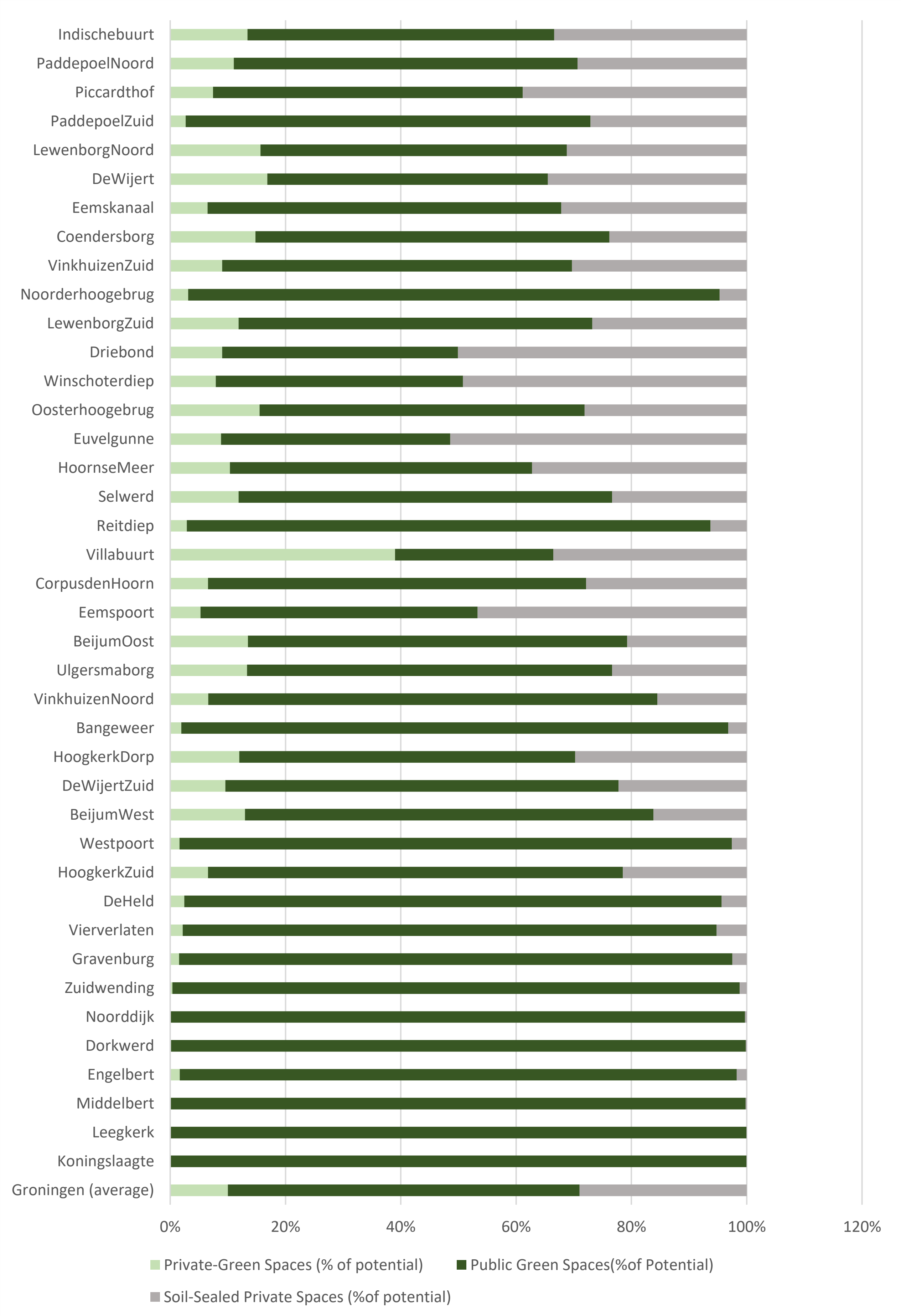
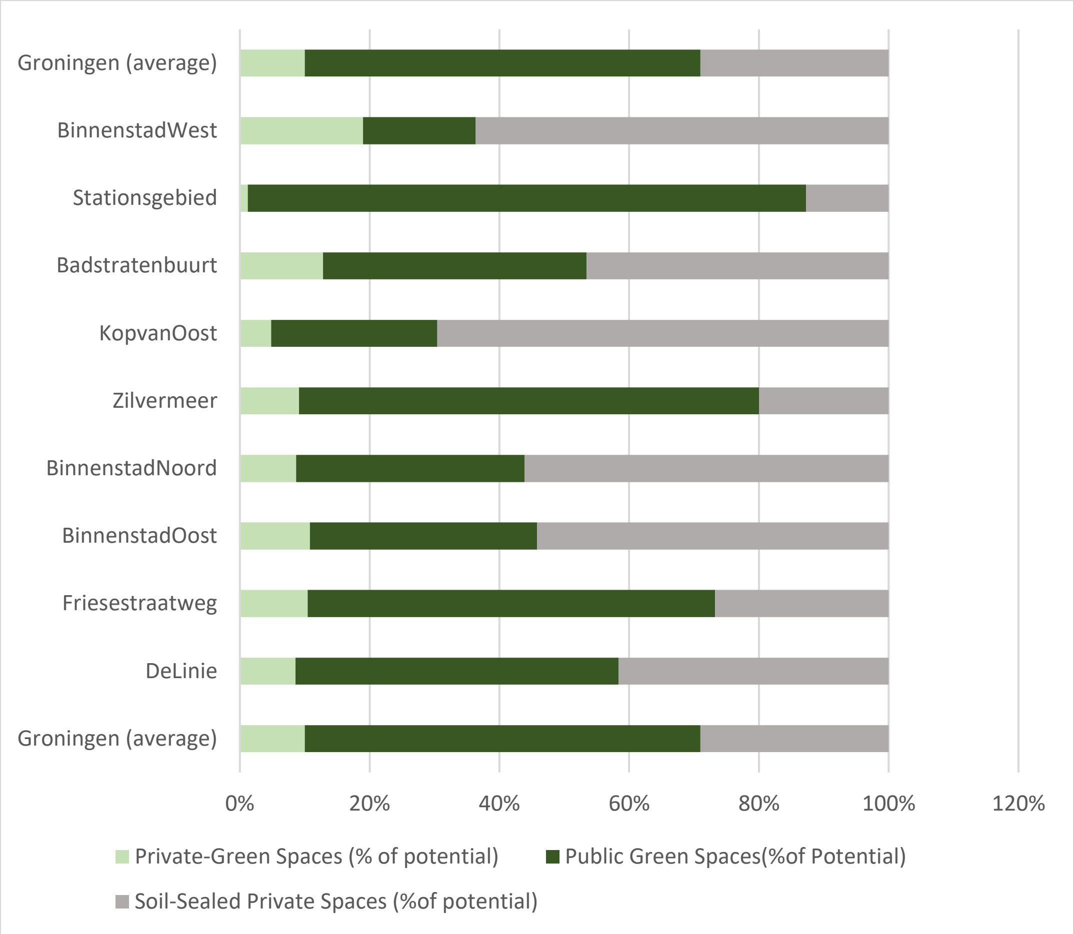
Appendix A1: Public-Private Greenness per Neighborhood as graphs





Indischebuurt
PaddepoelNoord
Piccardthof
PaddepoelZuid
LewenborgNoord
DeWijert
Eemskanaal
Coendersborg
VinkhuizenZuid
Noorderhoogebrug
LewenborgZuid
Driebond
Winschoterdiep
Oosterhoogebrug
Euvelgunne
HoornseMeer
Selwerd
Reitdiep
Villabuurt
CorpusdenHoorn
Eemspoort
BeijumOost
Ulgersmaborg
VinkhuizenNoord
Bangeweer
HoogkerkDorp
DeWijertZuid
BeijumWest
Westpoort
HoogkerkZuid
DeHeld
Vierverlaten
Gravenburg
Zuidwending
Noorddijk
Dorkwerd
Engelbert
Middelbert
Leegkerk
Koningslaagte
Groningen (average)
0%
20%
40%
60%
80%
100%
120%
Private-Green Spaces (% of potential)
Public Green Spaces(%of Potential)
Soil-Sealed Private Spaces (%of potential)


Groningen (average)
BinnenstadWest
Stationsgebied
Badstratenbuurt
KopvanOost
Zilvermeer
BinnenstadNoord
BinnenstadOost
Friesestraatweg
DeLinie
Groningen (average)
0%
20%
40%
60%
80%
100%
120%
Private-Green Spaces (% of potential)
Public Green Spaces(%of Potential)
Soil-Sealed Private Spaces (%of potential)

Appendix A2: Public-Private Greenness per Neighbourhood as table

Buurtnaam	Private-Green Spaces (% of potential)	Soil-Sealed Private Spaces (%of potential)	Public Green Spaces(%of Potential)	Total Potential Green Area (sq. Km)
Woonschepenhaven	Nodata	Nodata	Nodata	Nodata
Stainkoeln	Nodata	Nodata	Nodata	Nodata
Roodehaan	Nodata	Nodata	Nodata	Nodata
Waterhuizen	Nodata	Nodata	Nodata	Nodata
Hunzeboord	Nodata	Nodata	Nodata	Nodata
Hunzepark	Nodata	Nodata	Nodata	Nodata
Bruilweering	Nodata	Nodata	Nodata	Nodata
Suikerfabriekterrein	Nodata	Nodata	Nodata	Nodata
DeKring	Nodata	Nodata	Nodata	Nodata
VanSwieten	Nodata	Nodata	Nodata	Nodata
Kardinge	Nodata	Nodata	Nodata	Nodata
UMCG	Nodata	Nodata	Nodata	Nodata
Selwerderhof	Nodata	Nodata	Nodata	Nodata
ZernikeCampus	Nodata	Nodata	Nodata	Nodata
Stadspark	Nodata	Nodata	Nodata	Nodata
MartiniTradePark	Nodata	Nodata	Nodata	Nodata
Westpark	Nodata	Nodata	Nodata	Nodata
Koningslaagte	0.02%	0.02%	99.96%	5651205.362
Leegkerk	0.04%	0.02%	99.94%	2672410.653
Middelbert	0.03%	0.18%	99.79%	2221885.271
Engelbert	1.65%	1.74%	96.60%	2023586.559
Dorkwerd	0.17%	0.16%	99.67%	1682081.105

Buurtnaam	Private-Green Spaces (% of potential)	Soil-Sealed Private Spaces (%of potential)	Public Green Spaces(%of Potential)	Total Potential Green Area (sq. Km)
Zuidwending	0.39%	1.21%	98.40%	1125070.001
Gravenburg	1.52%	2.48%	96.00%	1106684.847
Vierverlaten	2.16%	5.22%	92.62%	811921.8258
DeHeld	2.46%	4.35%	93.19%	802274.5262
HoogkerkZuid	6.56%	21.47%	71.97%	771148.7963
Westpoort	1.63%	2.55%	95.81%	690921.444
BeijumWest	12.98%	16.19%	70.83%	561887.4051
DeWijertZuid	9.57%	22.24%	68.19%	471679.5593
HoogkerkDorp	11.96%	29.74%	58.30%	460332.9616
Bangeweer	1.92%	3.18%	94.90%	446166.2373
VinkhuizenNoord	6.59%	15.50%	77.91%	384991.4959
Ulgersmaborg	13.33%	23.34%	63.33%	373331.5533
BeijumOost	13.47%	20.73%	65.80%	367345.7256
Eemspoort	5.26%	46.68%	48.07%	361412.7757
CorpusdenHoorn	6.57%	27.83%	65.60%	358683.5883
Villabuurt	39.02%	33.55%	27.43%	354586.759
Reitdiep	2.88%	6.29%	90.83%	346596.3821
Selwerd	11.88%	23.35%	64.77%	321647.9861
HoornseMeer	10.37%	37.20%	52.42%	314565.7463
Euvelgunne	8.80%	51.42%	39.78%	310561.1719
Oosterhoogebrug	15.51%	28.14%	56.36%	302185.3027
Winschoterdiep	7.89%	49.20%	42.90%	301893.3701
Driebond	9.00%	50.06%	40.93%	271081.4975
LewenborgZuid	11.87%	26.77%	61.37%	270412.0193
Noorderhoogebrug	3.13%	4.69%	92.18%	269727.9429
VinkhuizenZuid	9.03%	30.31%	60.66%	268610.1777

Buurtnaam	Private-Green Spaces (% of potential)	Soil-Sealed Private Spaces (%of potential)	Public Green Spaces(%of Potential)	Total Potential Green Area (sq. Km)
Coendersborg	14.77%	23.81%	61.41%	268007.4929
Eemskanaal	6.48%	32.17%	61.35%	259113.7606
DeWijert	16.83%	34.51%	48.67%	235922.29
LewenborgNoord	15.67%	31.19%	53.13%	225638.7154
PaddepoelZuid	2.66%	27.08%	70.25%	221118.7292
Piccardthof	7.41%	38.85%	53.73%	215310.9009
PaddepoelNoord	11.02%	29.37%	59.61%	213824.8076
Indischebuurt	13.42%	33.39%	53.19%	212982.676
LewenborgWest	11.37%	15.53%	73.10%	208662.7124
Sterrebosbuurt	3.21%	11.12%	85.67%	206503.1121
Kranenburg	2.16%	18.96%	78.88%	201533.8599
DeHoogte	4.77%	47.57%	47.66%	187462.3652
DeHunze	7.78%	39.50%	52.72%	185945.8875
Helpman	18.03%	54.27%	27.70%	183456.7953
Peizerweg	11.39%	67.07%	21.53%	180733.5138
DeBuitenhof	14.19%	36.15%	49.65%	166439.7282
Professorenbuurt	19.78%	47.41%	32.81%	162359.175
Rivierenbuurt	11.65%	33.65%	54.71%	161658.3621
Hoendiep	9.67%	42.05%	48.28%	154492.132
HoornsePark	23.07%	27.80%	49.13%	148591.8379
Vogelbuurt	14.41%	18.58%	67.01%	126258.0987
Gorechtbuurt	20.14%	53.44%	26.42%	122417.1595
Noorderplantsoen	0.00%	0.00%	100.00%	110814.2909
Florabuurt	1.19%	17.98%	80.83%	109086.7242
Ruischerwaard	9.07%	20.87%	70.06%	108739.6832
Drielanden	9.75%	18.05%	72.20%	108403.2888

Buurtnaam	Private-Green Spaces (% of potential)	Soil-Sealed Private Spaces (%of potential)	Public Green Spaces(%of Potential)	Total Potential Green Area (sq. Km)
HortusbuurtEbbingekwartier	13.45%	54.04%	32.51%	105550.0233
Zeeheldenbuurt	18.03%	40.18%	41.79%	92403.69574
Ruischerbrug	10.51%	16.93%	72.56%	91548.7362
Oranjebuurt	16.27%	38.84%	44.90%	90315.28364
BinnenstadZuid	11.74%	54.58%	33.68%	88023.12228
HetWitteLam	6.11%	26.02%	67.87%	87639.87999
Oosterpoort	12.66%	56.39%	30.96%	83951.49804
Laanhuizen	19.34%	23.27%	57.39%	83909.19938
Schildersbuurt	20.64%	56.59%	22.77%	76922.67159
DeMeeuwen	11.81%	25.71%	62.48%	73534.75328
Kostverloren	13.42%	34.94%	51.64%	73149.57378
Damsterbuurt	8.57%	24.47%	66.96%	70208.31622
Noorderplantsoenbuurt	24.14%	52.43%	23.43%	66345.67885
KleinMartijn	16.53%	26.68%	56.79%	63333.91247
Grunobuurt	14.46%	47.38%	38.16%	63212.29276
Tuinwijk	8.35%	30.67%	60.98%	60562.87007
Bloemenbuurt	22.79%	46.36%	30.85%	59920.97499
Herewegbuurt	12.71%	36.76%	50.54%	56795.27996
VanStarkenborgh	13.35%	35.79%	50.87%	52311.83706
Europapark	1.08%	16.58%	82.34%	41669.38331
KleinHarkstede	9.93%	9.05%	81.01%	40517.88136
DeLinie	8.59%	41.65%	49.75%	36723.22505
Friesestraatweg	10.43%	26.73%	62.84%	36202.92311
BinnenstadOost	10.79%	54.19%	35.02%	35934.32804
BinnenstadNoord	8.66%	56.12%	35.22%	32079.58234
Zilvermeer	9.12%	20.01%	70.87%	21925.25335

Buurtnaam	Private-Green Spaces (% of potential)	Soil-Sealed Private Spaces (%of potential)	Public Green Spaces(%of Potential)	Total Potential Green Area (sq. Km)
KopvanOost	4.82%	69.55%	25.63%	13253.12556
Badstratenbuurt	12.84%	46.57%	40.59%	8838.249638
Stationsgebied	1.23%	12.73%	86.04%	6475.029449
BinnenstadWest	19.01%	63.65%	17.34%	6334.887915

Appendix B: Survey responses

Garden Design	Reasoning	Family Composition	Influence?	Income	Living Arrangement	Influence ?2	Elaboration	Aware of relation between garden and runoffs	Elaboration(doesthismattertoyou?)
groene tuin met versteende elementen	Geen respons	samenWonend met kinderen	Ja	Modaal	Huurhuis	Ja	Geen sterke veranderingen maken	Ja	
versteende tuin	Woningbouw	alleenstaand	Nee	Modaal	Huurhuis	Ja	Woningbouw heeft het ingericht	Ja	
versteende tuin			Nee	Modaal	Koophuis	Ja	Als het huur was zou er niks zijn aangepast	Nee	Afhankelijk van hoe belangrijk het is
groene tuin met versteende elementen	Kinderen, zon op terras	alleenstaand	Ja	Onder Modaal	Huurhuis	Ja	Woningbouw	Ja	
versteende tuin met groene elementen	Staat mooi	alleenstaand	Nee	Onder Modaal	Huurhuis	Nee		Ja	
versteende tuin met groene elementen	Onderhoudsvrij	samenWonend	Ja	Modaal	Koophuis	Ja	Waardevermeerdering, je hebt iets dat van jezelf is tov huurhuis	Ja	Bewust op riool aangesloten door gemak
versteende tuin met groene elementen	Het was al zo	samenWonend	Nee	Modaal	Koophuis	Nee		Nee	Ja

groene tuin	Mooi, belangrijk voor natuur	samenWonend met kinderen	Ja	Modaal	Koophuis	Ja	Zelf invloed	Ja	Geen invloed, echter wel kleigrond dus slechte waterafvoer
versteende tuin met groene elementen	Geen licht door boom	samenWonend	Nee	Modaal	Huurhuis	Ja	Was al aangelegd	Nee	Nee
versteende tuin met groene elementen	Kundvriendelijk	samenWonend met kinderen	Ja	Modaal	Koophuis	Ja	Eigen invloed	Ja	Nee er Wordt al gebruik gemaakt van stadstuintjes
groene tuin met versteende elementen	Zo lag het al	alleenstaand	Ja	Modaal	Koophuis	Nee		Nee	Nee
versteende tuin met groene elementen	Oorspronkelijke staat	alleenstaand	Nee	Modaal	Koophuis	Nee		Nee	Nee, Onderhoud te groot
versteende tuin met groene elementen	Makkelijk, maar groen wel mooi	samenWonend	Nee	Modaal	Koophuis	Ja	Meer geld te besteden	Nee	Nee, helft wel goed
groene tuin	Ziet er mooi uit	samenWonend met kinderen	Nee	Modaal	Koophuis	Ja	Investering in eigendom	Nee	Nee het is al geschikt
versteende tuin met groene elementen	Groenliefhebber	samenWonend	Nee	Modaal	Koophuis	Nee		Nee	Nee
groene tuin	Was al zo	samenWonend met kinderen	Nee	Modaal	Koophuis	Ja		Nee	Ja waarschijnlijk

groene tuin met versteende elementen	Ziet er mooi uit	samenWonend	Nee	Modaal	Koophuis	Ja	Eigendom, meer reden om aanpassing te doen	Ja	Misschien in de toekomst, maar het liefst weinig onderhoud
versteende tuin	Gemak	samenWonend met kinderen	Nee	Modaal	Koophuis	Nee		Ja	Nee
versteende tuin met groene elementen	Geen respons	samenWonend met kinderen			Koophuis				
groene tuin met versteende elementen	Mooi	samenWonend met kinderen	Nee	Modaal	Koophuis	Ja	Eigendom	Nee	Nee
groene tuin met versteende elementen	Onderhoud, terras en kinderen kunnen spelen	samenWonend met kinderen	Ja	Modaal	Koophuis	Nee		Nee	Nee
versteende tuin met groene elementen	Vanwege kinderen. Weinig ruimte	samenWonend met kinderen	Ja	Modaal	Koophuis	Nee		Nee	Nee
versteende tuin	Makkelijk	samenWonend	Ja	Modaal	Koophuis	Nee		Nee	Misschien, waarschijnlijk wel
versteende tuin	Gemak								
versteende tuin	Was al zo	samenWonend met kinderen	Nee	Modaal	Koophuis	Nee		Nee	Nee
groene tuin met versteende elementen	Zoveel mogelijk groen	samenWonend met kinderen	Ja	Modaal	Koophuis	Ja	Leuk proberen te maken	Ja	Nee

versteende tuin	Gemak	alleenstaand	Nee	Onder Modaal	Huurhuis	Nee		Nee	Nee
groene tuin met versteende elementen	Was al zo/gemak	alleenstaand	Nee	Modaal	Huurhuis	Ja	Is tijdelijk	Nee	Nee
versteende tuin	Gemak	samenWonend	Nee	Modaal	Huurhuis	Ja	Verandering is later niet voor zichzelf van toepassing.	Ja	Nee
groene tuin	Gemak	alleenstaand	Nee	Onder Modaal	Huurhuis	Ja	KoopWoning --> meer mooi maken	Nee	Nee
groene tuin	Gemak	samenWonend	Nee	Modaal	Koophuis	Ja	HuurWoning: zou onnodig zijn	Nee	Ja
groene tuin met versteende elementen	Moestuintje	alleenstaand	Ja						
groene tuin	Was al zo, en mooi	alleenstaand	Nee	Modaal	Huurhuis	Nee		Ja	Ja
versteende tuin	Was al zo, gemak	alleenstaand	Nee	Onder Modaal	Huurhuis	Nee		Nee	Ja
groene tuin met versteende elementen	Mooi zo	samenWonend met kinderen	Ja		Huurhuis	Nee		Nee	Nee
versteende tuin met groene elementen	Was al zo	alleenstaand	Nee	Modaal	Huurhuis	Ja	Tijdelijk	Ja	Nee
versteende tuin met groene elementen	Was al zo	samenWonend	Ja	Modaal	Huurhuis	Nee		Nee	Nee

groene tuin met versteende elementen	Makkelijk	samenWonend met kinderen	Nee	Modaal	Koophuis	Ja	Eigen keuze	Nee	Nee
versteende tuin	Hond graaft anders	samenWonend met kinderen	Ja	Modaal	Koophuis	Nee		Nee	Nee
versteende tuin met groene elementen	Gemak	samenWonend	Nee	Modaal	Koophuis	Nee		Nee	Nee
groene tuin met versteende elementen	Praktisch	samenWonend	Ja	Onder Modaal	Koophuis	Nee		Nee	Nee
versteende tuin	Het was al zo aangelegd door de Woningbouw	student(enhuis)	Ja	Modaal	Huurhuis	Ja			Nee
groene tuin met versteende elementen	Was al zo Woning bouw	student(enhuis)	Ja	Modaal	Koophuis	Ja	Eigendom	Nee	Ja medereden
versteende tuin	Geen respons	samenWonend met kinderen	Nee	Onder Modaal	Huurhuis	Ja	Weinig invloed	Nee	Nee
versteende tuin	Geen zon	samenWonend met kinderen	Ja	Modaal	Koophuis	Nee		Ja	Nee
groene tuin met versteende elementen	Meer groen is mooi	samenWonend	Nee	Onder Modaal	Koophuis	Ja	Is van mezelf	Nee	Ja
groene tuin met	De hoeveelheid katten in de	samenWonend	Nee	Modaal	Koophuis	Nee		Nee	Ja indien de gemeente faciliteert

versteende elementen	buurt die troep maken								
versteende tuin met groene elementen	Groot terras praktisch op te zitten. Groene elementen voor de sier en voor zwembad	samenWonend met kinderen	Ja	Modaal	Koophuis	Ja	Keuze van stenen om het eigendom is	Nee	Ja
versteende tuin met groene elementen	Zo was het al ingericht bij de koop. Weinig mogelijkhede n	samenWonend met kinderen	Ja	Modaal	Koophuis	Ja	Vanwege eigendom	Nee	Nee, de wil is er wel
groene tuin met versteende elementen	Vanwege smaak. Het is mooi.	samenWonend met kinderen	Nee	Modaal	Koophuis	Ja	Meer investering vanwege eigendom	Nee	Nee
groene tuin met versteende elementen	Terras voor lekker zitten. Groen voor de esthetische kant	samenWonend	Ja	Modaal	Koophuis	Ja	Investering, eigendom	Nee	Nee, gemeente had betere grond moeten faciliteren.
groene tuin met versteende elementen	Steen praktisch, groen voor de mooi	samenWonend	Nee	Modaal	Koophuis	Nee		Ja	
versteende tuin	Was al zo, gemak	samenWonend	Nee	Onder Modaal	Huurhuis	Nee		Nee	Nee
groene tuin met	Gemak en mooi	samenWonend	Ja	Modaal	Koophuis	Nee		Nee	Nee

versteende elementen									
groene tuin met versteende elementen	Groen combineren met toegankelijkheid	samenWonend	Ja	Modaal	Koophuis	Ja	Ja tuinarchitect ingehuurd	Nee	Nee, want al groen genoeg
groene tuin met versteende elementen	Houden van groen, ieder tuin zou hun eigen water moet kunnen laten wegzakken	samenWonend	Nee	Modaal	Koophuis	Nee		Ja	Nieuwe regenton gekocht met dakgootje
groene tuin met versteende elementen	Voor de mooi	samenWonend met kinderen	Nee	Modaal	Koophuis	Ja	Keuze voor veranderin	Nee	Ja
versteende tuin met groene elementen	Voornamelijk ruimte om te spelen voor de kinderen. Te kleine tuin voor veel gras. Veel schaduw.	samenWonend met kinderen	Ja	Modaal	Koophuis	Ja	Eigen invloed op indeling en meer investering	Ja	
versteende tuin met groene elementen	Was al zo bij aankoop in de toekomst meer groen	samenWonend met kinderen	Ja	Modaal	Koophuis	Nee		Nee	Nee sms al meer groen van plan
groene tuin met	Gebruiksgemak, groen voor de mooi	samenWonend	Nee	Modaal	Koophuis	Ja		Nee	Nee het is al groen genoeg en er is een drainage aanwezig

versteende elementen									
versteende tuin	Schoon	alleenstaand	Nee	Onder Modaal	Huurhuis	Nee		Nee	Nee
versteende tuin met groene elementen	Klein kindje, ongedierte	samenWonend met kinderen	Ja	Mavo	Huurhuis	Nee		Nee	Nee
versteende tuin met groene elementen	Het was al zo. Bij eigen aanleg misschien iets meer groen, maar weinig tijd om het te regelen en uit te voeren	samenWonend met kinderen	Ja	Modaal	Koophuis	Ja	Investering	Nee	Over nadenken wel iets om rekening mee te houden.
versteende tuin	Geen Respons	samenWonend met kinderen	Nee	Onder Modaal	Huurhuis	Ja	Weinig invloed	Nee	Nee
versteende tuin met groene elementen	Voor kinderen een combinatie van steen en groen	samenWonend met kinderen	Ja	Onder Modaal	Koophuis	Ja	Iets meer investering	Ja	
versteende tuin met groene elementen	Gemakkelijk	samenWonend	Nee	Onder Modaal	Huurhuis	Ja	Dan meer groen	Nee	Misschien
groene tuin met versteende elementen	Te veel verstening niet mooi. Maar toch een tuin met	samenWonend met kinderen	Nee	Modaal	Koophuis	Ja	Anders minder investerin	Nee	Wel enigszins rekening mee houden

	weinig onderhoud. Halfverharding als oplossing. Toch afvoer van water.								
groene tuin met versteende elementen	Wat groen is mooi	alleenstaand	Ja	Onder Modaal	Huurhuis	Nee		Ja	Nee
versteende tuin	Gemak	alleenstaand	Ja	Modaal	Koophuis	Ja	Bestrating is duur	Ja	Nee
groene tuin	Veel groen, leuk voor de diertjes	alleenstaand	Ja		Huurhuis	Nee		Nee	Nee, is al groen
versteende tuin met groene elementen	Zongebrek	samenWonend	Nee	Modaal	Koophuis	Ja	Eigendom	Nee	Ja
groene tuin met versteende elementen	Praktisch en mooi	samenWonend met kinderen	Nee	Onder Modaal	Huurhuis	Nee		Ja	Is al groen
groene tuin	Milieu	alleenstaand	Ja	Modaal	Huurhuis	Nee		Ja	Was al op de hoogte
groene tuin met versteende elementen	Vriendin	samenWonend	Ja	Modaal	Koophuis	Ja	Eigendom	Ja	Tuin is al ingericht voor milieu
versteende tuin met groene elementen	Ontspanning	Alleenstaand	Nee	boven Modaal	Koophuis	Ja	Ja, meer aandacht voor de tuin en onderhoud	ja	

versteende tuin met groene elementen		Alleenstaand	Ja	onder Modaal	Koophuis	Ja		nee	Nee
versteende tuin met groene elementen		SamenWonend met kinderen	Ja	Modaal	Koophuis	Nee		nee	Nee
versteende tuin met groene elementen	Omtspanning	SamenWonend	Ja	boven Modaal	Koophuis	Ja	Investering	ja	Nee
groene tuin		SamenWonend	Nee	boven Modaal	Koophuis	Nee		nee	
groene tuin		SamenWonend	Ja	zeg ik liever niet	Koophuis	Ja	Investering	ja	
versteende tuin		SamenWonend	Ja	boven Modaal	Koophuis	Ja		nee	Nee
versteende tuin met groene elementen		Alleenstaand	Nee	Modaal	Koophuis	Nee		ja	
groene tuin met versteende elementen		Alleenstaand	Ja	Modaal	Koophuis	Nee		nee	Ja wat ik kan doe ik
groene tuin met versteende elementen		SamenWonend	Nee	boven Modaal	Koophuis	Nee		nee	
versteende tuin met	Moet er netjes uitzien	Alleenstaand		boven Modaal	Koophuis	Ja	Waardebehoud	ja	Nee

groene elementen									
groene tuin met versteende elementen	Gemak	Alleenstaand	Ja	boven Modaal	Koophuis		Nee	nee	Nee
groene tuin		SamenWonend	Nee			Nee		nee	Nee
groene tuin		SamenWonend	Nee	boven Modaal	Koophuis	Nee		nee	Nee is al groen
groene tuin met versteende elementen		SamenWonend	Nee	boven Modaal	Koophuis			ja	
versteende tuin met groene elementen	Onderhoudsarm	SamenWonend	Ja	boven Modaal	Koophuis	Nee		ja	Nee
groene tuin met versteende elementen	gepensioneerd, meer tijd	Alleenstaand	Nee	Modaal	Koophuis	Nee		ja	
versteende tuin met groene elementen	iets meer tijd	SamenWonend	Nee	Modaal	Koophuis	Nee		nee	Niet zelf, te grote ingreep
versteende tuin		Alleenstaand	Nee	Modaal	Huurhuis	Nee		nee	ja
versteende tuin		Alleenstaand	Nee	Modaal	Huurhuis	Nee		ja	
versteende tuin		SamenWonend		Modaal	Huurhuis	Ja	Eigendomssituatie	ja	
groene tuin met versteende elementen		SamenWonend met kinderen	Nee	boven Modaal	koop	Nee		ja	

versteende tuin met groene elementen	SamenWonend met kinderen	Nee	boven Modaal	koop	Nee	ja	Nee
versteende tuin met groene elementen	Alleenstaand	Ja	Modaal	koop	Ja	nee	Nee
versteende tuin met groene elementen	Alleenstaand	Nee	onder Modaal	koop	Nee	nee	Ja
groene tuin met versteende elementen	SamenWonend		Modaal	huur	Ja	nee	Ja
versteende tuin met groene elementen	SamenWonend	Nee	boven Modaal	koop	Nee	nee	Nee
versteende tuin met groene elementen	SamenWonend met kinderen	Nee	boven Modaal	koop	Nee	nee	Nee
groene tuin met versteende elementen	SamenWonend met kinderen		Modaal	koop		nee	Ja
groene tuin met versteende elementen	Alleenstaand		Modaal	koop	Nee	ja	Nee
groene tuin	Alleenstaand		boven Modaal	huur	Ja	nee	Nee
groene tuin met versteende elementen	StudentenWoning (met huisgenoten)	Ja	zeg ik liever niet	huur	Nee	nee	
groene tuin	SamenWonend met kinderen	Ja	boven Modaal	koop	Ja		Ja
groene tuin	SamenWonend	Nee	onder Modaal	huur	Ja	ja	Ja
versteende tuin	SamenWonend	Nee	boven Modaal	koop		nee	
groene tuin met versteende elementen	SamenWonend met kinderen	Nee	Modaal	koop	Nee	nee	Ja
groene tuin met versteende elementen	SamenWonend met kinderen	Ja	boven Modaal	koop	Ja	ja	Nee

groene tuin		SamenWonend	Ja	boven Modaal	koop	Nee		ja	
versteende tuin met groene elementen		SamenWonend	Nee	zeg ik liever niet	koop	Nee		nee	Ja
groene tuin met versteende elementen		SamenWonend	Nee	Modaal	koop	Nee		ja	Nee
groene tuin		SamenWonend met kinderen	Ja	Modaal	koop	Nee		nee	
groene tuin	Vooral tijd en energi	SamenWonend	Nee	boven Modaal	koop	Nee	Als investering zorg ik voor de tuin, maar ik wil er niet teveel tijd aan kwijt zijn	ja	Ja, maar ik was al van plan om meer groen te hebben in de tuin
groene tuin	Tijd	SamenWonend	Nee	zeg ik liever niet	koop	Ja		ja	In eerste instantie niet, omdat ik weinig problemen merk
groene tuin	Door tijd	SamenWonend	Nee	Modaal	huur	Nee	Anders zou ik het waarschijnlijk zien als investering, dus daarom doe ik er nu vrij weinig aan, ondanks dat de tuin behoorlijk groen is.	nee	Mijn tuin is al groen
groene tuin		Alleenstaand	Ja	Modaal	koop	Ja		nee	Ja
groene tuin met versteende elementen		SamenWonend	Nee	Modaal	huur			nee	Nee
versteende tuin		SamenWonend	Nee	Modaal	koop	Ja		nee	Ja
groene tuin		SamenWonend		Modaal	koop	Ja		ja	
groene tuin met versteende elementen		SamenWonend	2	Modaal	koop	Ja		nee	