Overcoming barriers to green roof adoption

A study on barriers to green roof implementation by private actors

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MSc Thesis

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Summary

Green roofs are adaptation measures to mitigate the effects of climate change in urban areas. Green roofs and other adaptation measures are hardly implemented or being led by local governments and public authorities with a modest role of private actors (Mees, 2014; Stamatelos, 2012). The involvement of private actors is beneficial to share risk, bring resources and skills to the green roof adoption process (Harman, Taylor, & Lane, 2015). A strong involvement of private actors and the establishment of hybrid governance arrangements would contribute to expand the implementation of climate adaptation measures, but there are barriers that impede this involvement to happen (Mees, 2014; Biesbroek, 2014). The following research aims to obtain a deeper understanding of those barriers. Among all private actors, this research focuses on private roof owners since those are directly responsible for implementing green roofs on their rooftops.

This research focuses on private roof owners from urban areas in the Netherlands. This research explores the barriers that roof owners experience in the process of implementing green roofs. The information of the present research is based upon interviews.

This research aims to achieve a better understanding of the barriers that affect private actors who own properties with roofs. Firstly, these barriers are identified and their relevance is calculated. Secondly, the underlying causes of these barriers are analysed. Thirdly, the acceptance of potential policy tools to overcome such barriers are analysed. With this understanding, the final goal of this research is to draw advice about how to design strategies to overcome barriers to climate change adaptation. The final output of this research is a set of recommendations on how to effectively involve private actors in the adoption of green roofs in urban areas. The scientific relevance of this research is to gain insight of the causality of the barriers to climate change adaptation. This advice is societally relevant because it can help policymakers to draw policies towards a more effective implementation of green roofs and contribute to adapt the city to the unavoidable consequences of climate change.

The results of this research are that the main barriers to green roof adoption are the competition between climate change adaptation and mitigation measures, the perception the costs of green roofs are higher than its benefits, the lack of resources and the problem alienation. These barriers should be overcome by policies that target their causes and are perceived as acceptable by roof owners.

Contents

1. Introduction

1.1 Climate change in urban areas

1.1.1 Urban areas as the centre of the human world

Urban regions are becoming the centrepieces of the human world. They concentrate economic activity, scientific and cultural production, human population and political power (Nel·lo & Muñoz, 2007). The urban population of the world has grown from 746 million in 1950 to 3.9 billion in 2014 and cities are still expected to add 2.5 billion more people by 2050 (UN, 2015). This growth, fuelled by the technological and scientific improvements, provoked the emergence of severe environmental concerns (De Vries, 2013).

It is estimated that cities produce between 31 to 80 % of total greenhouse gas emissions and their economic, demographic and structural relevance makes them particularly vulnerable to climate hazards (Reckien et al., 2014). Bigger cities will concentrate sustainable development challenges and therefore, urban management should integrate complex policies to improve the lives of its dwellers (UN, 2015).

The urbanisation process has deep roots in history. The human world has settled in the Earth through a structure of urban and rural settlements for at least the last 7.000 years (Lampard, 1955). In that time, most people traditionally lived in rural areas. Paul Bairoch (1988) estimated that the urban population in Europe (excluding Russia) was approximately 13 million people in the year 1.700 (Bairoch, 1988). Before the Industrial Revolution, the bigger cities in the world were the political centres of big Empires (such as Rome, Paris or Granada), capital cities of maritime Empires (such as Amsterdam or Lisbon) or near strategic or merchant harbours (such as Antwerp, Seville or Naples) and most of the small urban centres were small markets dependent on agriculture (Nel·lo & Muñoz, 2007). This traditional structure started to evolve since the second half of the 18th century with the beginning of the Industrial Revolution and the start of the urbanisation process. Since then, urban centres evolved alongside technological and economic growth and the world population started moving from rural areas to big cities. New industrial cities started to emerge such as Chicago, New York or Manchester (Nel·lo & Muñoz, 2007).

The need for adaptation to a new urban scale appeared as soon as the process of urbanisation began. Old cities were structurally unprepared for its big demographic growth and industrialised cities were dramatically affected by epidemic outbreaks such as cholera. The emergence of bigger and denser cities provoked an emerging interest in urban studies already on the 19th century. Also, local governments gained relevance as key actors to adapt urban areas to the new appearing challenges (Nel·lo & Muñoz, 2007). Technological solutions were implemented as cities expanded and new challenges appeared. Sewage systems were created and expanded, public transportation networks

were built and urban planners started drawing large avenues and parks in cities. Gradually, the urban morphology changed radically in its structure and scale. The model of political and geographical concentration characteristic of the Fordist economy evolved to a new paradigm of administrative decentralisation and urban sprawl. Around 1990, cities already expanded and adopted new geographical scales (Nel·lo & Muñoz, 2007). Also during this decade, it became obvious that humans were a driving force in all ecosystems on Earth. Cities had to be managed as a new ecosystem and the human impact on cities had to be closely monitored by urban ecologists (Parlange, 1998; Rio, 1992).

Big urban regions come with new trends; a stronger impact of the human footprint, bigger vulnerability to climate events, a reduction on the ecosystem services in the city, a larger geographical area to manage, more connectivity and communication, a strong administrative decentralisation and urban sprawl (Nel·lo & Muñoz, 2007). Urban areas need to adapt to this new coming trends.

1.1.2 Climate change consequences

Since the early stages of the Industrial Revolution, the process of economic development has been a key driver for both population growth and environmental degradation (Edenhofer et al., 2014). The lack of integration between the economic system and the environment led to a major human impact in most of world's ecosystems (Naredo, 2007). From the period 1970 to 1980, civic society organisations and scientists played an important role in terms of raising awareness about the consequences of the human impact on the environment (De Vries, 2013; Naredo, 2007). From then on, climate change became solidly established as an agenda topic for national and for international institutions. This topic became a priority for academia as well as being of essential importance to precisely forecast the consequences of climate change to mitigate its impact (De Vries, 2013).

The available knowledge about climate change means that very specific data on how much the human activity changed the climate is available. Since 1900, the global average temperature has increased by 0.8ºC (Hansen, Ruedy, Sato, & Lo, 2006) and more drastic events such as the European heat wave of 2003 have occurred (Beniston, 2004; Jendritzky & Schär, 2004). The latest scenario projections for climate change in Europe suggest an intensification of heat waves, precipitation and winter storms (Beniston et al., 2007).

Research published by Beniston et al, (2007) based on regional climate model simulations produced by the PRUDENCE project, built a basic set of scenarios to forecast the evolution of the climate in Europe during the coming Century. In that report, heat waves are expected to occur more frequently, for a longer period and more intensely across Europe. Heavy summer and winter precipitation will increase in northern Europe and it will decrease in the south. Extreme wind speeds will increase between the latitudes of 45°N and 55°N except in the south of the Alps (the latitude of Copenhagen (Denmark) is 55° N and the latitude of Milano (Italy) is about 45ºN). The mean sea level pressure can

reduce, leading to an increase of storms in the North Sea and therefore increasing storm surges along the coastlines of the Netherlands, Denmark and Germany (Beniston et al., 2007).

1.1.3 Climate change consequences in the Netherlands

The Netherlands is also vulnerable to climate change. The Royal Meteorological Institute of the Netherlands (KNMI) has developed and published various climate scenarios over the years to prepare the country for possible changes to come. The latest report, published in 2014, highlights the impact of floods in river and sea areas, heat stress, heavy precipitation and droughts (Hurk, Siegmund, & Klein Tank, 2014).

1.1.3.1 Floods in river and sea areas

Ocean warming and the melting of the polar caps is expected to increase the water level in both rivers and the sea (Attema & Lenderink, 2014; Hurk et al., 2014). This will force regions along river banks and the sea to deal with flood control and it could make water pumping more costly and difficult.

1.1.3.2 Heat stress

All scenarios of KNMI'14 expect milder winters and hotter summers, with an increase of tropical nights due to a general temperature increase. Besides a general increase of average temperatures, the Netherlands is expected to suffer more intense and longer heat waves (Hurk et al., 2014). Heat waves can damage infrastructures, can provoke electricity outages and most importantly, it can mean an increased mortality rate among vulnerable groups of the population such as the elderly, sick or small children (Oostenbrugge et al., 2014).

1.1.3.3 Heavy precipitations

During winter, precipitation is expected to increase whilst during summer, heavy precipitation is expected to be more intense (Hurk et al., 2014). More intense precipitation can lead to floods in urban areas, damage buildings, block roads and lead to overflowing sewers (Attema & Lenderink, 2014).

1.1.3.4 Droughts

Droughts are the less obvious consequence of the KNMI'14 scenarios. During summers, periods of drought are likely to become more intense and common due to more irregular rain patterns (Attema & Lenderink, 2014). Water scarcity can mean salinisation and degradation of water quality, which in turn will worsen the environment (Hurk et al., 2014).

The consequences of climate change are unambiguously a threat for our society and for the environment. To mitigate the impacts of climate change is necessary to lower the impact as much as possible. In this sense, the European Union ratified in 2016 the willingness to meet the Paris

Agreements of 2015 to limit the global temperature rise to between 1.5ºC-2ºC and is working on peaking the global CO_2 emissions as soon as possible (Wurzel, Connelly, & Liefferink, 2016). However, it is already too late to avoid the consequences of climate change and the climate mitigation strategies need to improve and be implemented in order to prepare society for the impact of climate change (Tijhuis, 2015).

1.2 Adaptation to climate change

1.2.1 The need for adaptation measures

The increasing size of urban areas and the lack of ecosystem services make those areas especially vulnerable to climate events. This vulnerability is even larger due to climate change. The occurrence of severe heatwaves and heavy rainfall will intensify due to climate change, making urban areas more vulnerable to extreme events (Brian Stone, Jeremy, Hess, & Howard Frumkin, 2010; IPCC, 2008; Runhaar, Mees, Wardekker, Sluijs, van der, & Driessen, 2012; WMO, 2013). Another additional element that will make future cities even more vulnerable is the ageing process of the human population. The number of inhabitants over the age of 75 years will double to 2.5 million by 2040, and the elderly are more vulnerable to climate impacts such as heat stress than younger generations (Ligtvoet, van Oostenbrugge, Knoop, Muilwijk, & Vonk, 2015).

The combination of climate change and an increasing urbanisation process can worse the living conditions in urban areas and make them vulnerable in terms of climate events (WMO, 2013; IPCC, 2008; Rio, 1992). Therefore, it is necessary that urban areas implement proper adaptation measures. For example, insufficient permeability of the soil makes urban areas vulnerable to inundations, the heat island effect makes cities more vulnerable to heat waves and air pollution negatively affects the health of the population (Runhaar et al., 2012).

There are adaptation measures available for most of the environmental problems that affect urban areas, but these adaptation measures are not yet being widely implemented in urban areas (Georgi et al., 2012; Harman et al., 2015). The reason for this lack of implementation is the existence of several barriers hampering progress towards a successful adaptation to climate change. Those barriers have an environmental, economic, informational, social, attitudinal and behavioural nature (IPCC, 2008).

The Netherlands is also affected by heat waves and heavy rainfall (Huynen, 2016; Ligtvoet et al., 2015; Oldenborgh & Lenderink, 2014; Wuijts et al., 2014). However, most of local governments in the Netherlands are not developing or implementing policies to adapt to climate change (den Exter, Lenhart, & Kern, 2015; Hoppe, Berg, & Coenen, Frans H J M, 2014). This lack of action is not exclusively found in the Netherlands but also in other places (Bulkeley, 2013; Hoppe et al., 2014; Niles, Lubell, & Brown, 2015). A study published in 2014 analysed data from 200 cities in 11 countries in Europe. That study revealed that 72% of European cities do not have an adaptation plan to adapt the city to respond to the consequences of climate change (Reckien et al., 2014). Therefore, it is

necessary to overcome this implementation deficit and prepare the society, especially urban areas, for coming changes in the climate.

1.2.2 Green roofs as a climate adaptation measure

Several measures are being developed to mitigate or to adapt modern cities to climate change. Part of these measures aim to transform roofs from being structural assets to multifunctional elements of the city. Green roofs are a short-term climate adaptation measure that bring benefits to urban areas in several ways (Stamatelos, 2012). Green roofs are also considered as a no-regret strategy because they would provide environmental benefits even in the absence of climate change (Hallegatte, 2009). Green roofs are an example of an adaptation measure not yet widely implemented. A vast body of literature analyses the potential benefits of green roofs and advocates for its implementation as part of the solution to several of the current urban environmental challenges (Peck, 2012).

1.2.2.1 Efficient strategy to increase green surfaces in urban areas

In American cities, roofs represent between 20% and 25% of the urban area (Santamouris, 2014). This area has no other use than covering the building in most cases and this is done by using materials like dark stones or bitumen, that amplify the heat island effect (Dikkenberg, 2012). To expand green areas in urban regions is costly given the scarcity and expensive price of ground in urban areas. In that context, green roofs became a cost-effective and efficient measure to increase the amount of green areas in cities (Santamouris, 2014).

1.2.2.2 Inundation mitigation

Green roofs have the capacity to absorb rainwater and mitigate floods. By absorbing rainwater, green roofs alleviate the pressure that the urban sewage system suffers in the case of extreme rain events. Green roofs are expected to prevent inundations if applied in the long term (Brian Stone et al., 2010; Peck, 2012; Runhaar et al., 2012). Therefore, green roofs can be used as an adaptation measure and as an alternative to the expansion of the sewage system (Berardi et al., 2014; Karachaliou, Santamouris, & Pangalou, 2016). Additionally, green roofs can filter the rainwater, reducing water pollution in urban areas (Vijayaraghavan & Joshi, 2014).

1.2.2.1 Heat alleviation

Green roofs contribute to the alleviation of the heat island effect in cities with evapotranspiration and the creation of shadow. (Akbari, Pomerantz, & Taha, 2001; Foster, Lowe, & Winkelman, 2011; Peck, 2012; Runhaar et al., 2012; Santamouris, 2014). The precision on how much green roofs can contribute to the reduction of the heat island effect is a topic of discussion due to the lack of empirical data. Some researchers such as Lisette Klok argue that the extreme heat in summer should be alleviated by increasing the present shadow in cities (Borren, 2017).

1.2.2.1 Urban biodiversity

The increase of green surfaces in a city is expected to be good for the biodiversity of the city (Madre, Vergnes, Machon, & Clergeau, 2014; Peck, 2012). Green roofs have the potential to improve the biodiversity in the city. According to the research of Benvenuti (2014), if the species are selected carefully, green roofs have the capacity to be used as ecological corridors, facilitating the continuity of urban–rural surroundings and allowing species to travel. Roofs could be used as new conservation reserves to promote the persistence of biodiversity in urban landscapes and even become a new habitat for birds (Benvenuti, 2014; Fernandez & Gonzalez Redondo, 2010).

1.2.2.1 Improved air quality

Plants in green roofs have the capacity to filter some pollutants from the air and improve the air quality of a city. Some studies attempted to quantify the capacity of green roofs to contribute to the improvement of the air quality in urban areas (Peck, 2012). The results show a low but existing impact both for carbon sequestration (Getter, Rowe, Robertson, Cregg, & Andresen, 2009) and for urban pollutants (Yang, Yu, & Gong, 2008).

1.2.2.1 Improved urban aesthetics

Green roofs contribute to improve the esthetical value of urban areas. Some studies claim that including green areas in urban areas have positive psychological benefits for its citizens (Peck, 2012). The aesthetic benefits of green roofs can be divided between (1) its function of recreation and well-being and (2) the consequences for human health (Haq, 2011). Green spaces are necessary for citizens to relax and receive emotional warmth (Heidt & Neef, 2008). In terms of public health, a study published in 1999 observed how green areas helped decrease the general levels of stress. The same study observed how hospital patients who could observe green areas from their window would recover 10% faster and used up to 50% less pain killers than patients who would have to observe a concrete wall (Bolund & Hunhammar, 1999). If green roofs increase the amount of green area in cities, it is safe to assume that those psychological benefits would be increased as well.

In conclusion, green roofs are an example of a measure that lessen the burdens of climate change, but several barriers delay or block the implementation of this adaptation measure (Peck, 1999; Williams, Rayner, & Raynor, 2010; Zhang, Shen, Tam, & Lee, 2012). These barriers can be reduced or overcome (Eisenack et al., 2014) but governments need to develop climate adaptation policies that help to overcome these barriers.

1.3 Climate adaptation policies

1.3.1 European and national strategies

Climate change adaptation is still a relatively new topic for most governments and should be encouraged. The European Commission created a website called Climate-ADAPT to support the development and implementation of adaptation policies across all levels of governance by providing relevant information, such as best practices, case studies, and tools (EEA, 2015). The European Commission encouraged national governments to implement adaptation planning. As a result, 20 member states adopted national adaptation strategies by 2014 (EEA, 2015).

The implementation of adaptation measures is still at an early stage (Georgi et al., 2012). A study conducted in 200 cities in the EU by Reckien et al, (2014) found that 65% of the analysed cities had at least a climate change mitigation or an adaptation and mitigation plan. However, the main focus of the governments was on the mitigation process and 72% of the analysed cities lacked a climate change adaptation policy (Reckien et al., 2014).

In the Netherlands, several studies have been conducted to better understand the risks and opportunities of climate change in the Netherlands. The PBL (Netherlands Environmental Assessment) published a study in 2015 in collaboration with the KNMI (Royal Dutch Meteorological Institute) to evaluate, among other things, the main reasons as to why the Netherlands needs to adapt to prepare for climate change. This report emphasised two main elements; the need to make the national infrastructure more climate resilient and the need to influence urban planning in order to make urban areas more resilient (Ligtvoet et al., 2015). The report advised the national government of the Netherlands to play a facilitating, coordinating and governing role for climate change adaptation by sharing information and best practices with other government authorities, companies and NGOs (Non-Governmental Organisations) (Ligtvoet et al., 2015). As a result of these reports and the incentives from the European Environment Agency, the Dutch Ministry of Environment published its National Climate Adaptation Strategy, called "*Aanpassen met ambitie*" [Adapting with Ambition] on 2$_{nd}$ December 2016 (MINIENM, 2016). This strategy incorporates a diagnose of all the expected changes in the environment and defines a set of informational tools to promote adaptation to climate change among policy-makers, students and teachers, private parties and residents, such as the knowledge portal[1], the climate impact atlas [2], or the climate agenda[3] from the ministry of infrastructures and environment.

[1] http://ruimtelijkeadaptatie.nl/english
[2] http://www.klimaateffectatlas.nl/en/
[3] http://klimaatagenda.minienm.nl/

1.3.2 Municipal policies

The Dutch government is increasingly shifting its approach from being less hierarchical to having a bigger focus on collaboration and facilitation with more stakeholders. The national government has a 'systems responsibility' to integrate and share responsibilities among several governmental levels to prevent problems growing on a national scale (Ligtvoet et al., 2015) and it is suggested that municipalities establish a similar approach to develop climate change adaptation strategies (den Exter et al., 2015; Klok et al., 2011).

A study developed by Tijhuis (2015) concluded that most of adaptation policies performed at municipal level are water-related adaptation measures, probably led by the action of the water boards, whilst non-water related risks (such as heat stress) are in general less recognised and acted upon (Tijhuis, 2015). The lack of awareness on non-water related risks among Dutch municipalities has been acknowledged by other researches (Runhaar et al., 2012). In terms of heat-related adaptation measures, most municipalities are still thinking how best to formulate adequate solutions in order to adapt to this problem. Until now, local governments who have active strategies to incentivise the adoption of climate adaptation technologies opt mostly for the use of financial and communicative tools (Klok et al., 2011).

Most of the policies to promote the installation of green roofs can be found at the municipal policy level (Wolfgang & Appl, 2014). Municipal governments are responsible for developing their own strategy and policies in order to encourage the expansion of green roofs through the rooftops of the city (Groenedaken.net, 2013). In 2013, most of municipal policies to encourage green roofs in the Netherlands were subsidies (Groenedaken.net, 2013). For example, the municipality of Amsterdam offers a partial allowance that covers up to 50% of the costs of the roof without surpassing the price of 50 €/m^2, with some exceptions. In the case of Rotterdam, Nijmegen and The Hague, the allowance is 25 €/m^2. Finally, Utrecht offers an allowance of up to 30 €/m^2 for a green roof (Groenedaken.net, 2013).

The policies to promote the adoption of green roofs are not solely based upon public allowances and some municipalities define visions and specific goals to expand green roofs. Besides the policy of allowances, the municipal government of Amsterdam defined in its *Agenda Groen* its ambition to have up to 50.000 m^2 of green roofs in 2018 (Gemeente Amsterdam, 2015).

1.3.3 Public-private partnerships

Alongside the existing public policies that aim to promote green roofs, other public-private partnerships also work to promote the adoption of green roofs in order to help cities adapt and prepare for climate change.

One example of the partnerships is Amsterdam Rainproof, an organisation that advocates for an efficient use of rainwater and wants to promote solutions to increase the resistance of Amsterdam to

rain related events. It works as a platform, aiming to bring together all ideas, initiatives and information possible to create awareness about the need to invest in solutions to make water management as efficient as possible. Amsterdam Rainproof[4] is a partnership between the municipality of Amsterdam, Waternet[5], private consultancies, education centres such as Hogeschool Amsterdam or TU Delft and private companies. Green Deal Groene Daken is more specifically focused in the promotion of green roofs. This partnership aims to concentrate knowledge and experience about green roofs to help to promote the implementation of green roofs through the city. The Green Deal Groene Daken is integrated by public administrations, private companies, scientific organisations and users[6]. Its working fields are differentiation taxes, building labels, biodiversity, mindset, environmental law, innovation and fist rules and models (Tigelaar, 2017). Finally, the Rooftop Revolution is a non-profit organisation that seeks to mainstream green roofs and to increase the amount of green surfaces in the Dutch urban areas. The Rooftop Revolution seeks to influence in the decision making, to collaborate with parties and to create and distribute information on the possibilities of green roofs (Tigelaar, 2017) [7].

These examples of partnerships aim to bring together public and private efforts to create knowledge and awareness on the need to implement climate adaptation measures in urban areas such as green roofs.

1.4 Problem description

Green roofs are a climate adaptation measure that is being encouraged by several policies and programmes, but are not being widely adopted by roof owners. This adaptation deficit has not been widely explored yet by researchers. This research focuses on the causes of barriers to green roof adoption that roof owners experience as a main problem.

The Netherlands is an example of a country where it is highly necessary to implement measures as green roofs to reduce its vulnerability to the effects of climate change. However, the level of green roof implementation in the Netherlands is relatively low. These two conditions make the Netherlands a very interesting country where to perform a research on barriers to green roof implementation.

1.4.1 Barriers to the adoption of adaptation measures

Barriers emerge through the adaptation process. An adaptation process can be described as a rational decision-making process divided in three phases; (1) understanding the problem, (2) the implementation of solutions and (3) evaluating its performance (Moser & Ekstrom, 2010). Barriers can block the adaptation process at any stage, especially during the stage of implementation, where actors other than the policy makers undertake the adaptation process (Uittenbroek, 2016). Barriers

[4] https://www.rainproof.nl/netwerk
[5] Waternet is the water board that manages the water levels in Amsterdam.
[6] http://www.greendealgroenedaken.nl/index.php/partners/
[7] http://www.rooftoprevolution.nl/over-ons/

prevent different stakeholders from implementing adaptation measures, leading to an adaptation deficit and a bigger vulnerability to climate change (Eisenack et al., 2014). A more detailed definition of barrier can be bound in sub-section 2.4.

There currently is not specific research that focuses on the causes of barriers that roof owners face in terms of implementing green roofs in the Netherlands. However, there is descriptive research about barriers to green roof implementation in Australia (Williams, Rayner, & Raynor, 2010), Hong Kong (Zhang, Shen, Tam, & Lee, 2012) and Canada (Peck, 1999). In the case of the barriers for rooftop greening in Australia and Canada, both Peck (1999) and Williams et al. (2010) point to the same four main clusters of barriers. Those clusters are closely related to the clusters defined by Biesbroek (2014): (1) the lack of knowledge and awareness, (2) the lack of incentives to implement, (3) the barriers based on the cost of technology and finally (4) the technical issues and risks associated with uncertainty (Peck, 1999; Williams et al., 2010).

In the case of Hong Kong, the barriers identified by Zhang et al (2012) are (1) the lack of promotion from the government and social communities among the public and private sectors, (2) a lack of incentives from the government towards the owners of the existing buildings and green roof developers, (3) the maintenance costs, (4) the lack of awareness on extensive green roof system in public and private sectors, (5) the age of existing buildings and its weak structural load capacity, (6) the technical difficulties during the design and construction process, (7) the design and construction costs, (8) the weak affordability of extensive roof to withstand wind load and the poor utilities arrangement (Zhang et al., 2012).

Thus, the available knowledge on the causality of barriers to green roof adoption in the Netherlands is rather limited. The process of green roof adoption is blocked by the emergence of barriers, but the available knowledge about these barriers is merely descriptive. It is still necessary to specifically research the cause main barriers to green roof implementation in the Netherlands and how to overcome those barriers.

1.4.2 Acceptance of policy instruments

Private stakeholders are relevant actors for the process of climate change adaptation. They bring local knowledge and resources and their action is crucial to guarantee the adoption and enforcement, especially of long-term plans (Harman et al., 2015; Twigg, 1999). The importance of the involvement of private actors in the adaptation process is also recognised in the report of the Netherlands Environmental Assessment Agency (PBL) of 2015 (Ligtvoet et al., 2015). The report recognises the importance of societal and governmental changes to effectively adopt a national adaptation strategy (Ligtvoet et al., 2015, p11.).

In the case of green roof adoption, roof owners are key actors because their involvement is critical for the implementation of green roofs on their rooftops. Policy tools need to enhance private involvement in climate adaptation through the establishment of new governance arrangements between public and

private actors, resulting in a mixing and blurring of responsibilities (Mees, 2016). In order to ensure that all parties take on responsibility for the adoption of green roof, policy tools must be accepted by their targeted stakeholders. Accepted policy tools are more likely to be recognised by the targeted stakeholders and they are more willing to participate (Bekkers & Edwards, 2007).

Policy tools based on hierarchical arrangements that use regulatory policy instruments tend to be more successful in expanding the implementation of green roofs than other arrangements, suggesting that enhancing public responsibility is a key factor for the implementation of green roofs (Mees, 2014). The steering role of local authorities proved to be indispensable for promoting the adoption of green roofs. Consequently, the implementation of green roofs has more possibilities to be successful when green roofs are promoted from hierarchical arrangements with a prominent role of local authorities (Mees, 2014; Stamatelos, 2012). However, despite the success of hierarchical arrangements, they are not perceived as acceptable in all political contexts.

In order to successfully involve roof owners in the climate adaptation process, policy tools need to be perceived as acceptable by them. However, the acceptance of policy tools differs among different political contexts and it depends upon structural factors, such as the national administrative tradition or the dominant political ideology (Mees, 2016). Therefore, it is necessary to assess what policy instruments are considered as acceptable for the specific context of green roof promotion in the Netherlands. This assessment is relevant to ensure that the measures to promote green roofs are being positively perceived by roof owners and therefore more effective.

1.5 The knowledge gap

Biesbroek (2014) wrote a Literature Review on the climate adaptation barriers and found that most studies only performed generic explorations and categorisations of barriers. Research on barriers to adaptation is still in its infancy and there is a large knowledge gap about their impact on a successful governance of adaptation to climate change. Biesbroek (2014) suggests that there is a need to build effective interventions to reduce or overcome the barriers to adaptation. To do that he suggests further work on explaining the reasons why barriers to adaptation occur and to detail the operative mechanisms of those (Biesbroek, 2014).

Similarly, Eisenack et al. (2014) suggests that the next step would be to go beyond describing and enumerating barriers to provide clear and valid analyses leading to identification of entry points and strategies for intervention. Eisenack et al (2014) proposes the use of a comparative, actor centred and time-sensitive framework to further advance explanatory adaptation research. Future research should identify common causal patterns, interdependencies and dynamics of adaptation to better explain the occurrence of barriers and find effective ways to overcome them (Eisenack et al., 2014).

As suggested by Biesbroek (2014) and Eisenack et al. (2014), this research aims to address the causality and the operative mechanisms behind the main barriers of climate adaptation for private roof owners in the case of green roofs in the Netherlands. To address this issue, the study will firstly focus

on the barriers that affect private roof owners. An analytical framework is developed to identify the most relevant barriers that need to be addressed and finally this research will go deeper into the causal mechanisms behind the main barriers.

With the improved understanding about barriers to climate change adaptation, the main objective of this research is to draw a policy advice to overcome such barriers. This advice should be a powerful tool to develop policy instruments as an alternative to the hierarchical cases observed in countries with high adoption rates such as Germany. New policy tools regarding green roofs that are accepted by roof owners are expected to be more effective due to its higher level of acceptance by the targeted stakeholders.

1.6 Research questions

The main research question is:

1. - What are the causes to the main barriers that block the adoption of green roofs as climate adaptation measures for roof owners in the Netherlands?

The sub-questions are:

1. - What are the main barriers that stop the implementation of green roofs in urban areas by roof owners?
2. - What are the causes behind the main barriers?
3. - Which policy instruments are being perceived as acceptable by roof owners to overcome those barriers?

The main barriers that prevent roof owners implementing green roofs need to be overcome. The theories on understanding and overcoming barriers are advancing and further case studies are needed to contribute to this advancement. This research aims to describe the underlying mechanisms that provoke the appearance of barriers to adapt to climate change for roof owners in the Netherlands. This research also aims to contribute to science by identifying and sizing the barriers that affect private roof owners. The results of this research will contribute to society by giving advice to draw strategies to successfully implement green roofs, overcoming the main barriers that are affecting private roof owners and therefore contributing to preparing urban cities to combat the side effects of climate change.

1.7 Research framework

This research is divided in four main phases. Firstly, a Literature Review on the topic of barriers to climate change adaptation will be conducted. The purpose is to review the existing knowledge on barriers to climate change adaptation and to build a conceptual framework. The second part of the research is the data extraction conducted through a set of interviews during the research process. The third section is a description of the applied methods for the collection and analysis of data presented in this research. The fourth sections is the results of the processed data and the answer to the research sub-questions. The fifth and final section is where the answers to the main research question are answered and a policy recommendation is crafted using the findings developed in the previous section.

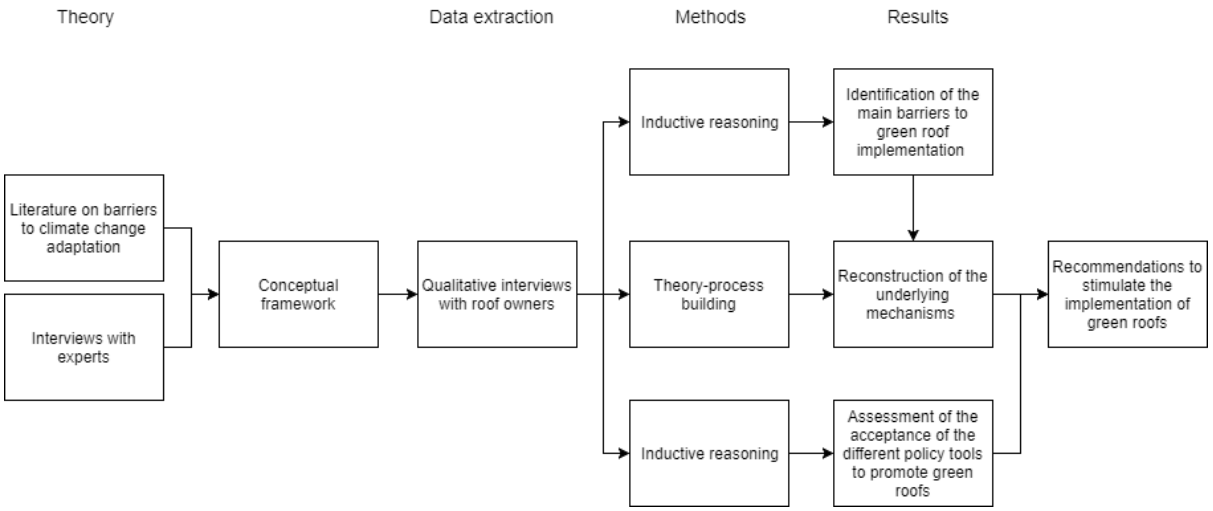


Figure 1: Research framework diagram.

2. Conceptual framework

2.1 The mechanistic view

The mechanistic view is a framework that aims not to merely describe barriers or the correlation between variables and outcomes, but also to put the focus on the causal process that explains the adoption of a certain behaviour. This framework assumes the existence of a mechanism that influences the outcome of a decision-making process (Beach & Pedersen, 2013; Biesbroek, 2014). This framework also aims to reveal the interlocking parts that constitute the structure of causal mechanisms, and understand the dynamics and interactive influences of causes on outcomes (Beach & Pedersen, 2013). The investigation of causal mechanisms enables the researcher to deepen into the study of causal relationships by giving a specific description of the existing intermediate factors between the structural cause and its purported effect (Beach & Pedersen, 2013).

The reasoning behind creating a mechanism-based explanation is to go beyond the mere observation and to understand how and why barriers emerge under a certain condition (Rohlfing, 2013; Beach & Pedersen, 2013). In coherence with this framework, barriers should not be understood as an observed element but as the visible consequence of an underlying mechanism. Barriers emerge because of the activation of this mechanism and have a causality that needs to be understood if the take-off process of green roof adoption is to be encouraged.

There are few examples that apply this framework to the climate change adaptation literature. The most extensive research that uses the mechanistic view framework in a research on Earth system governance is applied by Biesbroek (2014). In 2014, Biesbroek published a dissertation about barriers in the governance of climate change adaptation. When critiquing Biesbroek (2014), it could be said that the previous literature on climate change adaptation did not move beyond itemising the barriers to adaptation and developed static and linear views on how to overcome them. By adopting the mechanistic view framework, Biesbroek (2014) develops a theory-making framework to explain the emergence of barriers instead of describing them (Biesbroek, 2014). This framework is based on the process-tracing method, which is further explained in section 3.3.2.

2.2 The decision-making process

The decision-making process is the process for stakeholders to adopt a certain decision. This process has been defined in different ways in all of the adaptation literature. Moser & Ekstrom (2010) adopt a definition for the decision-making process that assumes that this process is rational and divided into nine phases. This approach is criticised by Moser & Ekstrom (2010) themselves as being too simplistic (Moser & Ekstrom, 2010).

Biesbroek (2014) instead starts from the assumption that the decision-making process on complex issues is not a process focused on simply finding the best solution to a single problem, but about a cluster of problems that interact with each other. This cluster interacts with different actors biased by frames, values and beliefs (Biesbroek, 2014). This idea coincides with the approach of Beach & Petersen (2013), that defines the decision-making process as a black box influenced by a multitude of elements.

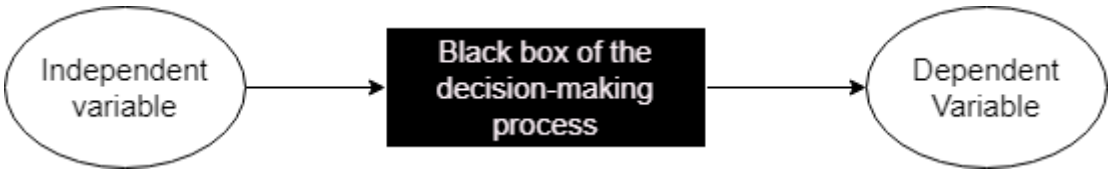


Figure 2: Decision-making process Source: Own work based on the information from Beach & Petersen (2013) .

2.3 Obstacles

When roof owners want to implement a green roof, they may be interrupted from implementing a green roof. To analyse the elements behind this interruption, a difference between the concepts obstacle, barrier and causal mechanism have been established by the author of this paper.

An obstacle is an element that a specific stakeholder finds in his or her own process of green roof implementation and that prevents him or her from adopting a green roof. Obstacles are directly found in the interview and its specific and different for every stakeholder. Obstacles are the raw information that is directly extracted from interviews without any generalisation or abstraction and they are used to construct the barriers.

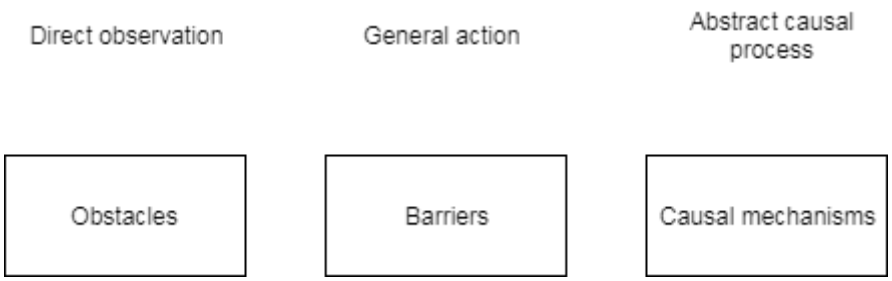


Figure 3. Differentiation between obstacle, barrier and causal mechanism.

2.4 Barriers

The concept of barriers to adaptation has been widely defined by multitude scholars over the last decade. According to Eisenack et al, (2014) a barrier is traditionally defined as an impediment to specified adaptations for specified adaptations for specified actors in their given context that arise from a condition or set of conditions (Eisenack et al., 2014). Moser & Ekstrom (2010) define barriers as obstacles that can be overcome with concerted effort and other elements (Moser & Ekstrom, 2010). Biesbroek (2014) finds the concept barrier as a simplified social construction created by actors' experience with a limited analytical value. Barriers prevent different stakeholders from implementing adaptation measures in the pace needed, leading to an adaptation deficit (Eisenack et al., 2014). If these barriers are not overcome, they can lead to a lack of preparation and a bigger vulnerability to climate change. For this reason, the IPCC (2008) recommends to research further on the nature and understanding of adaptation barriers (IPCC, 2008). To explain barriers for the implementation of green roofs, the process needs to be studied in detail to reveal the non-obvious hidden causal levers that should have caused the outcome pattern.

Barriers act in the decision-making process by creating negative feedbacks or discouraging key decisions. Barriers can be present in all the stages of the decision-making process. Moser & Ekstrom (2010) provide a framework where barriers are linked to the three different stages of the decision-making process; the understanding phase (1), the planning phase (2) and the managing phase (3) (Moser & Ekstrom, 2010). Barriers act differently according to the phase they appear, the context and the actor that experiences them. This is because barriers can be valued differently by different actors (Biesbroek, Klostermann, Termeer, & Kabat, 2013).

Not all the elements that block the process of green roofs can be considered as barriers. Moser & Ekstrom (2010) establish a difference between barriers and limits; barriers are a result of the social interaction and they can be overcome, while limits are static physical factors that cannot be overcome. Beach & Petersen (2013) also differentiate the concept barriers from the concept contextual conditions, where contextual conditions are specific conditions generated outside of the decision-making process and not linked to the analysed stakeholders, and barriers are a result of a mechanism (Beach & Pedersen, 2013; Biesbroek, 2017). Barriers are the result of abstracting the obstacles described in section 2.3.

2.4.1 Classification of barriers

Biesbroek (2014) identifies seven clusters of barriers: (1) conflicting timescales, (2) substantive, strategic and institutional uncertainty, (3) institutional crowdedness and institutional void, (4) institutional fragmentation, (5) insufficient awareness and communication, (6) motives and willingness to act, and (7) insufficient resources (Biesbroek, 2014). So far, this classification acts as a mere observation of the identified barriers but does not go further (Biesbroek, Klostermann, Termeer, & Kabat, 2011). These clusters of barriers are important for this research because they are used to

analyse the underlying mechanisms that obstruct the adoption of green roofs. In this sense, the understanding of these clusters of barriers is an important step to structure the interviews, further explained in section 3.2.3.

Conflicting timescales are the most important cluster of barriers identified by Biesbroek (2014) and by Eisenack et al, (2014). Those refer to the existing difficulties in dealing with the long-term impacts of climate change and the prevailing short-term timing in politics (Biesbroek, 2014).

Substantive, strategic, and institutional uncertainty refers to various forms and sources of uncertainty in the potential impacts of climate change. There are three kind of uncertainties; the uncertainty about the available knowledge, (epistemic uncertainty), uncertainty about the reflexive behaviour of humans in this system (human reflexive uncertainty) and uncertainty about the variability of the natural systems (natural stochastic uncertainty) (Adger et al., 2007; Biesbroek, 2014; Dessai, Hulme, Lempert, & Pielke Jr, 2009).

Institutional crowdedness and institutional voids refers to the set of rules, norms and values that disturb the decision making in the process of climate adaptation (Biesbroek, 2014). The term "institutional void" refers to a lack of an institutional setting that facilitates or stimulates the adoption of measures to adapt to climate change (Biesbroek, 2014; Eisenack et al., 2014). A lack of shared rules, principles, values, or norms about adaptation makes the communication among actors more difficult, provokes a lack of a common understanding and hampers the creation of a shared sense of urgency to start adapting. The term "institutional crowdedness" refers to the opposite situation: an overabundance of institutions competing to promote conflicting adaptation strategies can provoke confusion, a divergence of perceptions about the nature of the problem and the most necessary solution (Biesbroek, 2014; Eisenack et al., 2014).

Fragmentation refers to the lack of coordination among institutions, strategies, organizations and individuals at different levels and scales. Fragmentation appears frequently in front of complex policy problems and it can affect the diffusion or accessibility of knowledge or the lack of coordination of the different institutions at different levels (Biermann, 2009; Biesbroek, 2014; Moser & Ekstrom, 2010).

The lack of awareness and communication is a barrier that can keep the public uninformed about its role and about the public efforts on adaptation. This poor communication can provoke unawareness, scepticism, overconfidence, or denial (Biesbroek, 2014; Moser & Ekstrom, 2010).

The absence of motives and willingness to act are a central factor to explain why individuals choose to engage or not to engage in adaptive behaviour, and what factors lead to this behaviour (Biesbroek, 2014). This barrier is also called "values and beliefs" by other authors such as Moser & Ekstrom (2010). In some cases, extreme events can become major motives to adopt an adaptive behaviour, while a lack of leadership, or a lack of policy entrepreneurship, may be a motivational barrier that keep stakeholders from engaging in adaptive behaviour (Biesbroek, 2014; Moser & Ekstrom, 2010).

Finally, the availability of resources is the last cluster of barriers that hamper adaptation. Resources are considered key components of adaptive capacity and an absence of them, or its inaccessibility, can be a profound barrier to climate change adaptation (Biesbroek, 2014; Moser & Ekstrom, 2010).

2.5 Causal Mechanisms

Causal mechanisms are the centrepiece of the mechanistic view to explain the causality of the emergence of barriers through the decision-making process. Several scholars provide diverse definitions to define causal mechanisms. Glennan (2002) for example, defines mechanisms as complex systems where the different parts interact, and because of this interaction they produce an outcome (Glennan, 2002). Hedström (2005, p25) defines mechanisms as a social or causal mechanism consisting of entities and the activities that these entities engage in either by themselves or jointly with other entities. These activities provoke change, and the type of change depends on the properties of the entities or in the way they are linked to one another (Hedström, 2005). Bennett (2008) defines causal mechanism for the context of social sciences as a process in '*which agents operate in specific contexts to transfer energy, information or matter to other entities*' (Bennett, 2008). Beach & Pedersen (2013) define causal mechanism as a '*theory of a system of interlocking parts that transmits causal forces from the independent variable to the dependent variable*', where causality can not be understood as a mere link from the independent variable to the dependent variable but as a more complex mechanism embedded between the independent variable and with the explanatory knowledge to understand the outcome of the dependent variable (Beach & Pedersen, 2013).

From the definitions above, a set of conditions that causal mechanisms have can be extracted. Causal mechanisms must consist of different parts that interact with each other, they must start from an independent variable, and finally, causal mechanisms must produce an outcome. These conditions must be applied in the methodological framework in section 3.3.2.

2.6 Policy instruments

Policy instruments are defined by Verdung (1998, p.21) as '*the set of techniques by which governmental authorities wield their power in attempting to ensure support and effect or prevent social change*' (Verdung, 1998). Policy instruments are crucial elements of a policy. Public policies are formulated in dynamic contexts where multiple actors interact at multiple levels. These dynamic contexts demand that policy instruments are formulated to correspond with the contexts where they are embedded (Driessen et al., 2012). For this reason, it is relevant to review the existing groups of policy instruments and to review evaluate how appropriate are the different policy tools in the context of green roof implementation (section 2.7).

Lascoumes & Le Gales (2007) propose a framework to divide policy instruments into five different groups according to their source and type of legitimacy (Table 1). This framework will be used in this research to evaluate the level of acceptance of the different policy instruments to foster the implementation of green roofs among roof owners (Lascoumes & Le Gales, 2007). In this research, only four of the five typologies of the described policy instruments will be analysed, leaving behind the de facto and de jure standards best practices. This is because that last group does not directly involve private roof owners in its application.

The legislative and regulatory instruments are successors from the conventional legal forms that constitute the paradigm of state interventionism (Lascoumes & Le Gales, 2007). Vedung (1998) defined those instruments as 'measures taken by governmental units to influence people by means of formulated rules which mandate receivers to act in accordance to what is ordered in these rules' (Vedung, 1998). Those instruments are the first and most common policy instruments traditionally used by governments. Glasbergen (1992) divides those instruments between prohibitions and regulations. Prohibitions are the less attractive of the policy tools to exist, they limit the capacity of stakeholders to make decisions and they require the implementation of a system of monitoring and sanctions (Glasbergen, 1992).

Economic and fiscal instruments follow the same route than the legislative and regulatory instruments. However, they differ in the use of monetary techniques and tools to create a system of burdens or allowances to incentivise specific behaviours (Lascoumes & Le Gales, 2007). These instruments avoid the creation of obligations. In Western Europe, subsidies and grants are popular policy instruments (Vedung, 1998). Glasbergen (1992) differentiates subsidies and taxes as two different kind of instruments. In the case of subsidies, those are easy to implement and governments avoid an opposite reaction from the target group . However, this tool can generate dependencies from the private sector, it requires the creation of a monitoring system to ensure that public resources are properly spent (Glasbergen, 1992).

Agreement-based and incentive-based instruments are a less interventionist form of public regulation. It differs to the previous instruments because it aims to organise a different kind of political relations between government and target group, based on communication and consultation. With these policies, the government retreats from its archetypical functions, renouncing to use its capacity of constraint and adopting a role of coordinator focused on the mobilisation and integration of resources.

Information-based and communication-based instruments information aim to influence the behaviour of target groups by providing reasonable arguments, transferring knowledge or through persuasion (Vedung, 1998). Governments take the responsibility to inform citizens (Lascoumes & Le Gales, 2007). High-impact information campaigns are relatively inexpensive and can receive some positive answers from target groups. Private partners also react positively and tend to collaborate with public institutions. However, this sort of policy can be ineffective, especially when it aims to promote a behavioural change that is expensive for private partners (Glasbergen, 1992).

De facto and de jure standards best practices organise specific power relations within civil society. These power relations can be between economic actors or among economic actors and NGO's. These practices are based on a negotiated development and a cooperative approach of the policy. They seek to combine scientific and technical rationality to neutralise the political significance of the policy (Lascoumes & Le Gales, 2007; Le Gales, 2011).

Table 1: Types of policy instruments. Source: Lascoumes & Le Gales (2007).

Policy instrument	**Type of legitimacy**
Legislative and regulatory	Imposition of a general interest by mandated elected representatives.
Economic and fiscal	Seeks benefit to the community social and economic efficiency.
Agreement-based and incentive-based	Seeks direct involvement.
Information-based and communication-based	Explanation of decisions and accountability of actors.
De facto and de jure standards best practices	Mixed: scientific/technical, democratically negotiated and/or competition, pressure of market mechanisms.

2.7 Acceptance of policy instruments

Acceptance is a virtue of a policy instrument to be regarded favourably by its targeted stakeholders. A policy tool is accepted when the stakeholders targeted by this tool consider it satisfactory or adequate (Merriam-Webster, n.d.). As said in section 1.4.2, it is crucial for the policy tools to be perceived as acceptable by the relevant stakeholders in order to ensure a certain degree of legitimacy and effectiveness of that policy (Bemelmans-Videc et al., 2011).

Acceptance has been used in several investigations as a variable to evaluate how stakeholders perceive policy instruments (Mees et al., 2014), such as in the case of policy instruments to regulate private forest management (Serbruyns & Luyssaert, 2006), or in the evaluation of the distribution of responsibilities for urban adaptation to climate change (Mees, 2014). Therefore, it is necessary to evaluate the acceptance of the different policy instruments, previously defined in section 2.6. In this

sense, section 3.3.3 defines an analytical framework to assess the acceptance of the mentioned classifications of policy instruments.

3. Research methods

This section describes and justifies the selection of methods to perform the empirical research. This research analyses the experience and perceptions of roof owners. Due to the interpretative nature of this research, it makes use of qualitative data and methods to extract and analyse the data from the interviews. Section 3.1 explains the preliminary research that was conducted to build the introduction. Section 3.2 explains the process of data collection. Section 3.3 focuses on the methodology of sections 4, 5 and 6.

3.1 Research design

This research is a case study that analyses the cases of several roof owners that will be affected by climate change. The technique of the case study is defined by Yin (1981) as a research strategy that aims to analyse '*a contemporary phenomenon in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*' (Yin, 1981). The case study is a strategy that aims to generate a hypothesis from an intensive study of a single case. This method has an explorative nature and it aims to analyse the mechanisms that affect one single case (Gerring, 2007; van Laerhoven, 2016). The objective of this case-study is to make a research that generates a set of hypotheses in the form of causal mechanisms.

3.2 Preliminary research

The first part of this research is the collection of relevant data to build a consistent picture of the current stage of the green roof implementation process in the Netherlands. This process was done by interviewing experts, experts from the green roof industry, and through a literature review of scientific research and legislation. The output of this research is the introduction of this research, as it contributed in the design of other parts of the present research, such as designing the selection of interviewed stakeholders or the questions in the interviews.

3.3 Data collection

This section describes the methods and the justification of the data collection process. Firstly, the method of collection is explain in section 3.2.1. Section 3.2.2 explains how the contacts for the research were approached. Section 3.2.3 explains how the interviews were structured and finally, section 3.2.4 explains which stakeholders were selected to conduct interviews.

3.3.1 The method of collection

The nature of the adaptation process to climate change is a new and highly complex topic (Moser & Ekstrom, 2010). The complexity of the process and the lack of knowledge of it from most private stakeholders makes it necessary to analyse the topic using qualitative methods (Turner, 2010). Qualitative research allows to gather in-depth information, perceptions and opinions of participants by interacting with the subjects of study and considering the context and the meaning expressed by the interviewees (Krauss, 2005).

The procedure used by this research and the most commonly used procedure in qualitative research is the use of semi-structured interviews (Turner, 2010). Semi-structured interviews allow the researcher to adopt a more dynamic role by giving him or her the freedom to alter the order of the questions and make new questions during the interview (Turner, 2010). In this research, considering the diversity of stakeholders that were interviewed, semi-structured interviews appear to be the most appropriate method in order to extract data from stakeholders for several reasons. Firstly, structured interviews are too inflexible and do not allow the interviewee to deepen into the specifics of his or her case. Open-ended interviews are difficult to code, interpret, and are vulnerable to biases due to the interpretative nature (Turner, 2010). Therefore, semi-structured interviews achieve an adequate balance between the depth of the responses needed and the capacity to keep them similar enough to establish comparisons among cases.

From each interview of a roof owner, a narrative of a case is reconstructed and the details of each individual case are compared. The use of a semi-structured questionnaire ensures that the interview is flexible enough to allow roof owners to explain their specific case and to ensure that the discussed topics follow a common structure to establish comparisons between cases.

3.3.2 Approach

The stakeholders interviewed in order to conduct this research were provided by the author's supervisor. At the same time, some of these contacts were asked if they could refer additional contacts to interview. Interviewees help to contact more interviewees from among their acquaintances, this technique is called snowball sampling. This set of stakeholders complemented other contacts that were made during an internship that I realised in the municipality of Amsterdam. Finally, other relevant stakeholders were contacted by contacting strategic companies and organisations that could potentially be useful in order to conduct this research.

All the contacts were firstly contacted by e-mail or by phone and asked to participate in the research. The contacts were asked about their role in the company to ensure that they were the appropriate or most knowledgeable available person for this research. Once the right person was approached, an appointment was arranged to conduct the interview face-to-face. The interviewees do not officially

represent their company but they bring their own experience, perception and opinions as experts in a relevant position within their company in the interview.

It is important to clarify that in the interviews, the selected stakeholders expressed their visions, opinions and knowledge about the topic of green roof adoption. The interviewees do not intend to be representative or act as spokesperson of the organisations for whom they work but to express their visions and opinions about the questions of the interviews.

3.3.3 The interviews

For this research, a total number of 21 interviews were conducted; 6 of the interviewees are experts in the related field and 15 of the interviewees are roof owners. The interviewees were all from urban areas in the Netherlands, mostly from the provinces of Zuid-Holland, Noord-Holland and Utrecht but three of the interviews were conducted with roof managers from the city of Enschede.

Table 2. List of interviewees.

Type of stakeholder		**Number of interviews**	**Area where the interviewees work**
Experts	Green roof industry members	3	The Netherlands
	Policymakers	1	Amsterdam.
	Members of lobby groups to promote green roof adoption	2	The Netherlands.
Roof owners	Members of real estate managers	4	Amsterdam, Utrecht and The Netherlands.
	Experts involved in the installation of big green roofs	2	Enschede, Rotterdam,
	Members of housing corporations	3	Enschede, Rotterdam, The Hague.
	Small private roof owners	6	Amsterdam, Rotterdam, Nieuwegein.
Total		21	

Most of the interviews were conducted face-to-face. The option of using face-to-face interviews was selected to avoid potential losses or distortion of contextual and nonverbal data. It was also chosen to create a more relaxed relationship where interviewees feel free to speak and comfortable with sharing sensitive information (Kassianos, 2014). Only in two cases, when it was not possible to meet the selected stakeholders, were the interviews conducted by phone call.

3.3.4 Stakeholders selection

This research is primarily based on interviews of private stakeholders who either own or manage a roof or set of roofs. The selected interviewees are from urban areas in the Netherlands, specifically from the cities of Utrecht, Amsterdam, Rotterdam, Enschede, Nieuwegein and the Hague. This geographical selection was made to ensure that the political landscape, the regulations and the environmental threats derived from climate change are fairly similar among all the interviewed stakeholders but that they are not exact meaning that a bigger diversity of barriers can be identified.

The selection of stakeholders was made to ensure diversity among them. This diversity is based upon two criteria, (1) the level of interest to adopt green roofs and (2) the amount of power that stakeholders have. To ensure this diversity among stakeholders, several profiles of roof managers were selected ranging from small owners or even tenants who rent their houses in housing corporations to real estate corporations and housing corporations. Some interviews had been conducted with key experts such as members of the green roof industry or civil servants from municipal governments. This is because those experts are frequently in contact with private roof owners and have experience on the barriers that those stakeholders face when implementing green roofs.

The selected stakeholders can be classified into four groups. Those groups consist of (1) house owners who own their own roof, members of an association of owners or tenants that live in a house from a housing corporation, (2) managers or technical staff involved in the management of a big roof, (3) staff working for a housing corporation (*woningbouwcorporatie* in Dutch) or (4) staff of real estate organisations that manage the real estate of bigger organisations. Among these four groups, stakeholders were selected that are as diverse as possible in their position towards green roofs.

All the groups of house owners follow profiles as diverse as possible to collect differing opinions. In this group, a house owner from Nieuwegein was interviewed who does not have any information about green roofs, a house tenant who lives in Amsterdam and who is aware of the existence of green roofs but has not tried to install one, two members of two different owner associations in Rotterdam who are interested in both installing green roofs or solar panels but are still gathering information about all the possible options, a house owner in Amsterdam who is interested in green roofs but did not succeeded in installing a green roof due to external factors and a house owner who in her previous house had a green roof in the municipality of Amsterdam. This group of interviews is complemented by interviewing members of the green roof industry and private companies who do

work closely with roof owners and are familiar with the most habitual barriers that roof owners experience when they try to install green roofs in their buildings.

The second group of big roof managers is smaller due to the difficulties faced in effectively contacting and interviewing them. A civil servant from the municipality of Enschede was interviewed who participated in the installation of a green roof on a shopping centre and a civil servant who collaborated with the installation of a green roof in the rooftop of a famous shopping centre in Rotterdam. Moreover, a member of the green roof industry was spoken to who had contact with big roof owners and has second-hand experience in supporting this profile of stakeholders to consider the installation of green roofs.

The third group of stakeholders are housing corporations. This profile of stakeholders was especially difficult to contact due to a lack of interest in the matter. Three employees from two different companies were interviewed, one located in The Hague and a second company located in Enschede.

Finally, the fourth group of stakeholders were the real estate managers. The real estate managers are organisations embedded in bigger institutions who have the role to manage the real estate properties of the bigger institution where they belong. An employee from the department that manages the real estate properties from the municipality of Amsterdam was interviewed, from the municipality of Utrecht, Enschede, from Universiteit Utrecht and from Nederlandse Spoorwegen, which is the company that owns the train stations in the Netherlands.

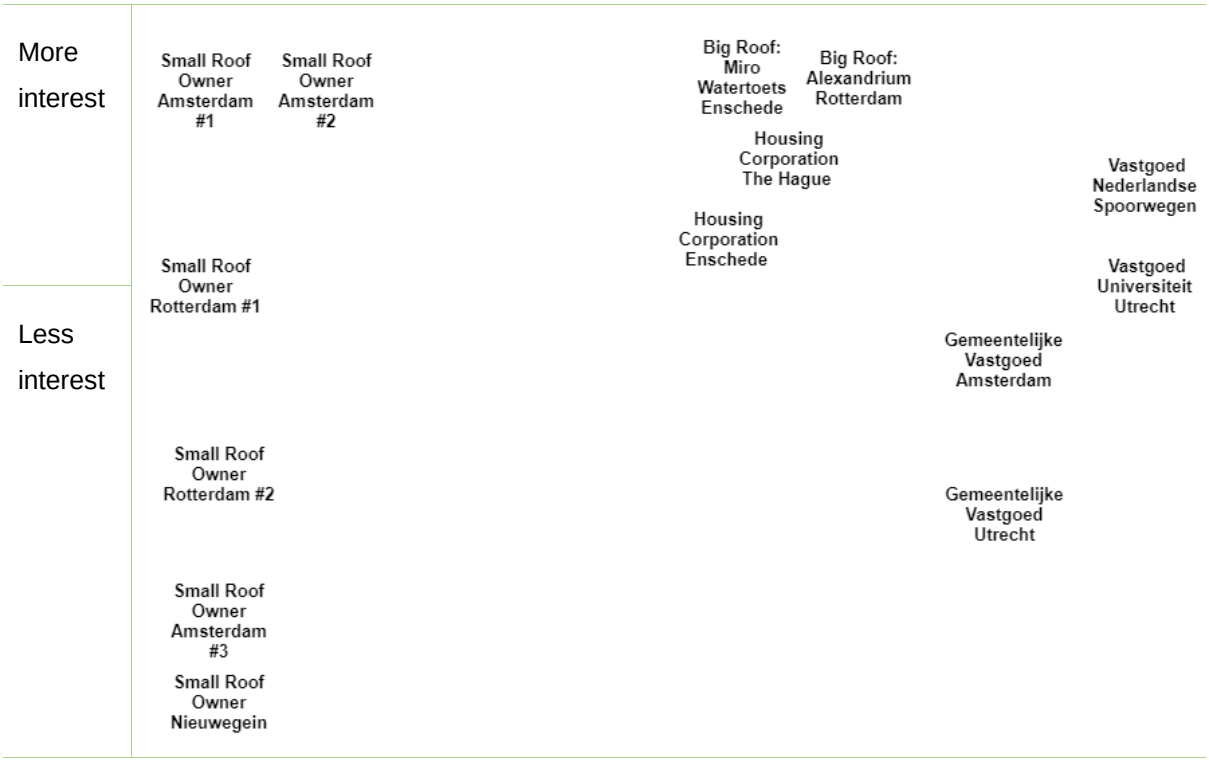
Next to this group of stakeholders, a group of experts, members of the green roof industry and scholars were interviewed to check the facts, examine any contrasting and conflicting information and put the information received by the interviewees into perspective.

3.3.4.1 Stakeholder map

The stakeholders are represented in a power versus interest grid. This representation is a technique to array stakeholders on a two-by-two matrix where the dimensions are the stakeholder's interest in installing climate adaptation technologies such as green roofs, and the stakeholder's power to financially make free decisions without restrictions on their roofs. Four categories of stakeholders emerge: (1) roof owners who have both an interest and power, and are likely to be frontrunners; (2) subjects who have a strong interest but little power; (3) roof owners who have power but little direct interest; and (4) stakeholders with little interest or power (Eden & Ackermann, 2013). This division is done to ensure and make explicit the diversity among the interviewed stakeholders.

Table 3. Stakeholders map

	Interviewed stakeholders	
	Less power/resources	More power/resources



3.3.5 Limitations

The quality of research can be assessed using three concepts: (1) validity, (2) reliability and (3) generalisability (Golafshani, 2003). Validity is defined as the extent to which a researcher is able to measure what he or she intends to measure. Reliability is the ability to replicate the research within a different context, with the same or a similar methodology, and obtain similar results. Generalisability is the ability to generalise the findings to a larger population group (Golafshani, 2003).

This research aimed to ensure its validity by performing a good literature and policy review of the stage of the adaptation process in the Netherlands. This Literature Review is reinforced by conducting interviews with different experts in the field of green roof implementation to maximise the accuracy of the information used. The use of appropriate and detailed research methods explained in this section brings transparency to the research. The fact that most of the interviews were conducted face-to-face, recorded and transcribed maximises the honesty of respondents and minimises the possibility of misunderstandings. Finally, the continuous feedback sessions between the researcher and the superiors contribute to the credibility of the research.

The reliability of the research relies on the transparency of the selection of the methods and the research process itself. This transparency is achieved by describing and justifying all the methodological choices behind the research process. By doing that, this research allows other

researchers to replicate the same research. A second measure to ensure the reliability of the research is that four interviews were conducted with four relevant stakeholders to discuss the results and to check if the reconstructed mechanisms correspond to their experiences as green roof experts.

With respect to the generalisability, many researchers claim that qualitative investigations should not aim to perform generalisable outcomes. Instead, these investigations should present sufficient descriptive data to allow for comparison (Krefting, 1991). In this sense, the selection of stakeholders of this research aimed to extract information from a sample as diverse as possible. However, there is a certain level of bias in the selection of stakeholders since the capacity to reach certain groups of real estate managers is certainly limited. There is an assumption that results are representative of the roof owner's population since the selection is diverse.

3.3 Data analysis

3.3.1 The identification of the main barriers

The information about the existing barriers to green roof adoption is gathered by conducting semi-structured interviews with roof managers and experts who interact with roof managers. During these interviews, the contacted people were asked about what obstacles they find when trying to implement green roofs. The questions concerning the possible obstacles that the roof owners could find were formulated based on the clusters identified by Biesbroek (2014) explained in section 1.4.1. After the first round of interviews, a chronological diagram of each process was drafted to reconstruct the chain of events of each case and to spot the different obstacles that interviewees found.

Once this set of obstacles was gathered, the similar obstacles were grouped and a set of general barriers were generated. These barriers gather together all obstacles that result in the same process coming from different roof owners or in different situations to avoid repetitions. The identified barriers were classified according to the clusters of barriers defined by Biesbroek (2014) and specified in section 2.4.1.

Once all the present barriers are identified, a filtering process is performed to ensure that the relevant barriers are in-depth analysed. To perform this filtering, an analytical framework details how the weight or impact of the barriers, in order to assess which barriers are the main ones.

3.3.1.1 Operational framework

The impact is quantified using three criteria: (1) the perception of the interviewee, (2) the number of stakeholders that reported this barrier and (3) if the barrier had been overcome or not. These three variables are weighted equally for methodological reasons, mainly due to the varying difficulty in valuing each one.

The present framework is based on a numerical system that translates verbal descriptions into scores. The numerical scoring system that is being applied in this assessment scores the three criteria in a range from 0 to 2. If one variable has a score of “0”, it means that this barrier has a low or null impact. A score of “2” indicates that this barrier highly affects stakeholders.

Table 4: Operational framework to weight barriers.

Variable	Description	Value
Number of stakeholders	Only one stakeholder has reported this barrier.	0
	Two or three stakeholders are affected.	1
	Four or more stakeholders are affected.	2
Perception of stakeholders	Most stakeholders do not perceive this barrier as relevant.	0
	Most stakeholders perceive this barrier as little influential.	1
	Most stakeholders perceive this barrier as highly influential.	2
Can it be overcome	Stakeholders overcome this barrier without problems.	0
	Stakeholders can overcome this barrier with some efforts.	1
	Stakeholders can overcome this barrier with much efforts.	2

The second step will be to combine the results of the three variables together to score all barriers in one single score. By doing so, it becomes easy to select the most impactful barriers of the extracted sample for its in-depth analysis.

Table 5. Integration of the barrier scoring system

Barrier	Amount stakeholders (0-2)	Perception stakeholders (0-2)	Can it be overcome (0-2)	Total weight barrier (0-6)
barrier 1				
barrier 2				

barrier 3				

The output is an extensive list of barriers that stakeholders find during the process of green roof adoption and a classification between the most impactful barriers and the least influential barriers of the extracted sample. Due to the limited scope of this research, only the barriers with a score higher than five will be analysed. It is important to highlight that, as it is stated in section 3.2.5, this part of the research has a descriptive approach, therefore it does not aim to identify the barriers that are most impactful among the Dutch society but the barriers that are most impactful among the interviewed stakeholders.

3.3.2 Analysing the causality of the main barriers

The information about the causality of the identified barriers is extracted from the interviews with roof managers and experts mentioned in section 3.2.4. During these interviews, the contacted people were asked about the cause of the obstacles they experienced during the installation or non-installation of a green roof.

The resulting information on perceived causes should be analysed and processed to reconstruct the mechanisms behind the emergence of barriers. The identification of the possible processes relies on the researcher's capacity of induction (Biesbroek, 2014). Beach and Pedersen (2013) propose a more specific method that follows the conditions explained above and gives clearer instructions to researchers on which methods to apply to trace causal mechanisms in the context of social sciences. These methods are called process-tracing methods and aim to trace causal mechanisms and '*to identify the intervening causal process, the causal chain and causal mechanism between the independent variable the dependent variable*' (Beach & Pedersen, 2013).

Process-tracing methods can have three different aims: (1) theory- testing, (2) theory- building and (3) explaining-outcome. Each of these purposes are associated with a different methodology and different guidelines are proposed for the tracing of the causal mechanisms.

Table 6: Summary of the Main Differences between the Three Variants of Process-Tracing. Source: (Beach & Pedersen, 2013)

	Theory- Testing	Theory- Building	Explaining-Outcome
Purpose of analysis-research situation	Correlation has been found between X and	Build a plausible causal mechanism	Explain particularly puzzling historical

	Y, but is there evidence that there exists a causal mechanism linking X and Y?	linking X:Y based on evidence in case.	outcome by building minimally sufficient explanation in case study.
Ambitions of study	Theory-centric	Theory-centric	Case-centric
Understanding of causal mechanisms	Systematic (generalizable within context).	Systematic (generalizable within context).	Systematic nonsystematic (case-specific) mechanisms and case-specific conglomerates.
What are we actually tracing?	Single, generalizable mechanism.	Single, generalizable mechanism.	Case-specific, composite mechanism that explains the case.
Types of interferences made	(1) Parts of causal mechanism present/absent. (2) Causal mechanism is present/absent in case.	Observable manifestations reflect underlying mechanism.	Minimal sufficiency of explanation.

This research has a theory-building ambition because it aims to reconstruct single and generalisable mechanisms behind the barriers to green roof implementation. This reconstruction has to be made from the observation of the manifestations that reflect an underlying mechanism.

The theory-building process-tracing seeks to build a generalisable theoretical explanation based upon observable empirical evidence. This process starts from the assumption that a general causal mechanism exists from the facts of a specific case (Beach & Pedersen, 2013). Beach & Petersen (2013) propose to use this approach when an outcome is detected but its causality is still uncertain.

The steps suggested by Beach & Petersen (2013) to perform a theory-building process-tracing start from (1) the collection of empirical material to detect potential hypothetical causal mechanisms. Once this material is gathered, (2) the researcher should make use of inductive reasoning to reconstruct the underlying mechanism behind a process. At the end of the inductive process (3), the researcher should detect a systematic and relatively simple mechanism that contributes to produce an outcome.

The specific steps performed to build the causal mechanisms are the following: Firstly, stakeholders who experienced the same barriers are grouped together. Secondly, the author of this paper verifies that the independent variable (input) and the dependent variable (output) of all the reported experiences by roof owners are the same. This is important to ensure that all the analysed processes correspond to the same causal mechanism. Thirdly, a diagram is drawn of the individual processes experienced by all the gathered stakeholders and similarities and differences will be sought after. Finally, a general diagram can be made and description of the analysed mechanism using the similarities and differences of the third step.

For example, if in several interviews, diverse roof owners report that they do not have enough resources to invest in green roofs. And after a brief explanation, they all report that they have other priorities more relevant to allocate their resources, such as provide cheap housing, improve their maintenance or to go on holidays abroad. In this case, the dependent variable (output) would be the situation where they do not have enough resources, while the independent variable (input) would be the distribution of priorities along their options. The mechanism aims to build a causal chain to connect the independent and the dependent variables.

The result of this analysis is displayed in a diagram (figures 4, 5, 6 and 7) for each causal mechanism where the identified causal mechanisms are made as explicit as possible.

3.3.3 Assessing acceptance of policy instruments

This section explains how the information about the acceptance of the different policy instruments is extracted from the interviews. During the interviews, the stakeholders were given some examples of policy interventions that fall into the given categories and were asked how acceptable they found the policies to be (table 8). Secondly, an operational framework is developed to explain how the results are analysed and how the acceptance of these tools is compared. This analysis is performed using a strictly qualitative analysis technique.

During the interviews, interviewees have to classify the different examples of table 8 between (1) acceptable, (2) neutral, or (3) unacceptable. The final output of this research is a table with the answers that stakeholders provided in their responses.

3.3.3.1 Policy instruments

This section explains how the acceptance of the policy instruments from section 2.6 is assessed. For every classification of policy instruments, a set of examples are given to interviewees and they are asked about their opinion. The sections below explain in detail what examples were given to interviewees. As said in section 2.6, the acceptance of de facto and de jure standards best practices is not included in this research due to the fact that this kind of practices do not directly involve roof owners and therefore, they are not familiar with them. A summary of all the policy options is provided in table 8.

3.3.3.1.1 Legislative and regulatory instruments

Interviewees are asked how acceptable they find a rule that aims to promote green roof adoption by means of legal obligation with a system of sanctions. Interviewees are also asked how acceptable they would find the removal of secondary regulations that interfere with the installation of green roofs.

3.3.3.1.2 Economic and fiscal instruments

Interviewees are asked how acceptable they find it that the local government would finance the installation of green roofs of private house owners to promote green roof adoption. Interviewees are also asked about the establishment of a tax differentiation system, where roof owners who adopted a green roof were granted a reduction of their water taxes.

3.3.3.1.3 Agreement-based and incentive-based instruments

Interviewees are asked how acceptable they would find it if the local government would delegate the responsibility to retain and manage rainwater to roof owners. Interviewees are also asked about their opinion if their government would negotiate with insurance companies to make sure that buildings who install a green roof do not have to pay any extra fee and are completely covered in case of any potential damage caused by the green roof as a form of incentive to promote green roof adoption.

3.3.3.1.4 Information-based and communication-based instruments

Interviewees are asked how what they would think if the local government would start a communication campaign to ensure that everybody has sufficient knowledge of the consequences of climate change in cities and the benefits that green roofs can generate to alleviate these consequences.

Table 7: Policy instruments with examples. Source: Lascoumes & Le Gales (2007).

Policy instrument	**Example**	**Result**
Legislative and regulatory	Legal obligation with a system of sanctions.	Acceptable
		Neutral
		Unacceptable
	Removal of regulations that interfere with the installation of green roofs.	Acceptable
		Neutral

		Unacceptable
Economic and fiscal	Finance of the installation of green roofs of private house owners.	Acceptable
		Neutral
		Unacceptable
	Establishment of a tax differentiation system, were roof owners who adopted a green roof were granted with a reduction of their water taxes.	Acceptable
		Neutral
		Unacceptable
Agreement-based and incentive-based	Delegation of the responsibility to retain and manage rainwater to roof owners.	Acceptable
		Neutral
		Unacceptable
	Public negotiation with insurance companies to make sure that buildings who install a green roof do not have to pay any extra fee and are completely covered in case of any potential damage caused by green roofs.	Acceptable
		Neutral
		Unacceptable
Information-based and communication-based	Public communication campaign to ensure that everybody has sufficient knowledge of the consequences of climate change in cities and the benefits that green roofs can generate to alleviate these consequences.	Acceptable
		Neutral
		Unacceptable

4. Identification of barriers

4.1 Introduction

This section aims to identify the barriers that block or delay the process of implementation of green roofs in urban areas. This part particularly focuses on the barriers that are perceived by private roof owners or roof managers. The identification of barriers that affect roof owners is the first step to find out what the causes are that delay or block the implementation of climate change adaptation technologies in urban areas.

4.2 Results

4.2.1 Barriers

The number of barriers identified during the set of interviews are 14. Those barriers are extracted from the interviews with roof owners, where roof owners were asked about the obstacles that they found when they attempted to implement green roofs on their rooftop. The overview of all the identified barriers in the interviews is in Annex 1.

1. *Lack of consideration of green roofs during the process of roof construction/renovation:* The first barrier identified during the interviews is that the option of including a green roof is not considered as an option when a renewing or building a roof. Several roof owners reported that they did not take into consideration the option of building a green roof while they were constructing or renovating a roof. This barrier was reported by a small roof owner and two real estate managers of big organisations.

We should really make a policy for green roofs because now a green roof is never a part of the design unless we explicitly ask for it. Designers would not opt for a green roof because architects have a limited budget and they prefer to spend this money in aesthetics instead of a green roof.

From the interview to an employee of a real estate department of Universiteit Utrecht

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To create a building (as the train station of Utrecht Centraal) takes a lot of time. We had spent ten years building the new station, and ten years ago, solar panels or other measures were a topic, but they were not integrated in the construction plans at that moment. So actually, when they signed

the contract, it was not there. And now the roof is not strong enough to adopt any measure.

From the interview to an employee of a real estate department of Nederlandse Spoorwegen

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I've never thought about installing a green roof. I got some information about solar panels but not about green roofs.

From the interview to private roof owner in Nieuwegein.

2. *Perception of vulnerability*: The installation of new measures such as green roofs induces a feeling of fear for potential damage to the building. Roof owners fear leaks or damages in their buildings due to the potential growth of roots. This barrier was reported by small roof owners and real estate managers of big organisations.

We do not want to assume any extra risk than necessary for our buildings.

From the interview to an employee of a real estate department of the municipality of Amsterdam

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We had a project for the Gemeente of Haarlem. I think that a year ago, we had a design that was solid. We had been struggling with the Gemeente for half a year but not by the department that was responsible for the budget but the department that was responsible for the maintenance. They torpedoed everything we suggested, every design and every technical solution that we proposed was considered bullshit. Even if there is only a blink of a risk, they would kill the plan.

From the interview to an expert from the green roof industry who worked with the real estate department of the municipality of Haarlem (the Netherlands)

I would be scared if I constantly have a layer of water over my head, and those roots could damage my roof.

From the interview to private roof owner in Nieuwegein.

3. *Loss of insurance*: Some mainstream insurances do not want to cover potential damages on buildings that make structural changes as green roofs. That means that roof owners who want to install a green roof have to find an alternative insurance company or they

have to spend more resources on their insurance bill. This barrier was mentioned in one case by a small roof owner.

> *The guarantee that I have is gone if I make a green roof because my company does not have experience.*
>
> *From the interview to private roof owner in Amsterdam.*

4. *Lack of companies that operate with green roofs*: The amount of construction companies that can make green roofs is still limited and that makes the installation of green roofs inaccessible for some roof owners. This barrier was mentioned in one case by a small roof owner.

> *I am a civil servant and I am constantly working with these companies that develop green roofs. I am not allowed to privately give an assignment to those companies because I could be fired and those are the only companies specialised in green roofs.*
>
> *From the interview to private roof owner in Amsterdam.*

5. *Lack problem framing*: The consequences of climate change are not being perceived as a problem by many roof owners. Some roof owners are unfamiliar with the consequences of climate change. This barrier was mentioned in one case by a small roof owner.

> *I have absolutely no idea what is going on in this city. Of course, that there is climate change, but I don't know what is going to happen nor what to do.*
>
> *From the interview to private roof owner in Nieuwegein.*

6. *Problem alienation*: Several roof owners feel that the effects of climate change are not their responsibility. Despite being aware of the consequences of climate change, they feel themselves alienated with the responsibility to cope with these consequences. This barrier was reported among small roof owners, housing corporations and real estate managers of big organisations.

In the Uithof we owe the site as well but in the city centre, the local government has more influence on the way it develops.

From the interview to an employee of a real estate department of Universiteit Utrecht

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This is not the responsibility of the owner, I think that it´s the responsibility of the municipality to cope with it, it is a public problem.

From the interview to an employee of a housing corporation in Enschede

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I don't know if our municipality does anything about climate change, no idea. Maybe there is information but we have our rythm and we do not feel appealed by these things.

From the interview to private roof owner in Nieuwegein.

7. *Lack of knowledge about green roofs*: Roof owners do not know about the existence and the functions of green roofs. Some of the interviewees state that they do not know what a green roof is and the purpose of one. This barrier was mentioned in one case by a small roof owner.

What does a green roof do exactly? What is their function?

From the interview to private roof owner in Nieuwegein.

8. *Competition between climate adaptation and climate mitigation measures*: Roof owners see themselves divided between measures to adapt to climate change and measures to mitigate climate change. Several roof owners reported their willingness to spend resources and to invest in measures to improve their sustainability. However, most of these resources are spent in mitigating climate change instead of adaptation to it. This barrier was reported among small roof owners and real estate managers of big organisations.

We have on our list other topics that are more of a priority, such as investing in solar panels to create more energy and to be energy neutral. That is what we want to reach. Energy neutral for all our train stations in the Netherlands. That is a big subject to get this done and we are looking for new ways to get this done. To isolate the station better, to keep the warmth, applying the warmte

koude opslag...

From the interview to an employee of a real estate department of Nederlandse Spoorwegen

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The main goal that UU have is to be climate neutral, therefore, the most interesting options for our roofs are solar panels.

From the interview to an employee of a real estate department of Universiteit Utrecht

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Solar panels are better because they produce electricity and that has an effect on the energy bill.

From the interview to private roof owner in Rotterdam.

9. *Lack of resources*. The budget of roof owners is divided between several objectives, such as to provide cheap housing, to improve the quality of their households or to spend their resources elsewhere. The need to implement climate adaptation measures competes with all those other options. All roof owners can find other priorities on where to spend their resources and the idea that climate adaptation is not enough of a priority to spend resources is a common situation. This barrier was reported among small roof owners and housing corporations.

Our core goal is not sustainability but to provide cheap housing and to have a good level of maintenance of our buildings.

From the interview to an employee of a housing corporation in Enschede

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Of course, the price of green roofs is an element to consider. I do not want to invest a large amount of money that I could be spending somewhere else.

From the interview to private roof owner in Amsterdam.

Climate adaptation is not our main goal. Sometimes, a few goals can enhance to each other but sometimes it doesn't, so then you have to ask yourself if the money that you have is for climate adaptation or is it meant for housing?

From the interview to an employee of a housing corporation in The Hague

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Everything depends on how much money is on your wallet as well. If your wallet is not so full you have to be more critical with your decisions.

From the interview to private roof owner in Nieuwegein.

10. *Perception that the costs are higher than benefits*: Roof owners perceive that the benefits of installing green roofs are rather limited and it does not compensate the costs of the installation. Roof owners only perceive part of the benefits of green roofs, such as the aesthetic improvement or the water retention, and therefore feel that the investment is not a priority or that the same benefits can be achieved by other means. This barrier was reported by real estate managers of big organisations

Green roofs would not help (to adapt to climate change). The effect over the heat island effect by green roofs is nowadays not measurable. The effects of green roofs in the building are rather limited because is not about the green roof but about the isolation. It is far more effective for fighting the heat stress on a building to isolate it than to invest in a green roof. To increase the amount of plants in the city is not our assignment. For water management, it would be cheaper to collect the water in cellars that are not in use, or in drums in our gardens.

From the interview to an employee of a real estate department of the municipality of Amsterdam

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A green roof is a solution (for heat) but in our opinion it is too much expensive and it is too costly to maintain. We lower the temperature of the building by using our PV panels and an electric air conditioning.

From the interview to an employee of a real estate department of the municipality of Utrecht

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For real estate companies, what we usually meet is a pretty narrow vision, so they have a goal to only retain water or to only in reducing risks.

From the interview to an expert from the green roof industry who worked with real estate companies.

11. *Perception that green roofs are individually an ineffective solution to the consequences of climate change:* Roof owners perceive green roof as an ineffective measure to adapt urban areas to climate change when they are not being implemented on a big scale. The lack of

collective action and the reduced benefits of a single green roof discourage roof owners from adopting green roofs. This barrier is reported with one case of a real estate manager.

I don't think that Vastgoed is relevant to mitigate the effects of climate change. The contribution that I can make is very limited because we own a very limited amount of the total real estate in Amsterdam. I know that there are 400.00 dwellings in Amsterdam and the number of square meters in total is tens of millions, while we own one or two thousand of square meters only. And a fourth of that are roofs, some of them are monuments so the possibilities for us to adapt the city to climate change is limited.

From the interview to an employee of a real estate department of the municipality of Utrecht

12. *Lack of trust with the information about green roofs:* Roof owners perceive that the provided information about green roofs or the effects of climate change is biased. Some roof owners report that they do not always trust the information that they receive about the effects of green roofs to improve the capacity of the city to cope with the effects of climate change. This barrier was reported in a real estate manager and a private roof owner.

A lot of people are highly biased towards green roofs and I see their information as unreliable.

From the interview to an employee of a real estate department of the municipality of Amsterdam

People are not properly informed. So, you have trust issues from some sources. People try to sell you lots of things and I am sceptical.

From the interview to private roof owner in Nieuwegein.

13. *Costs of construction permit*: Roof owners must pay money to obtain a construction permit if they want to install a green roof on their rooftop.

This barrier was reported in the case of an expert from the green roof industry who worked with roof owners and in one roof owner from Rotterdam.

Of course, the costs of a construction permit are an added barrier.

From the interview to an expert from the green roof industry who worked with roof owners.

14. *Conflict with existing regulations*: Existing building regulations do not anticipate the construction of green roofs on rooftops and they can become a barrier to green roof implementation. During the interviews, roof owners say that there are regulations from the national government (The Dutch building code, also called *Bouwbesluit*) or municipal regulations that create obstacles regarding the implementation of green roofs. This barrier was reported in one case of a small roof owner and an expert from the green roof industry.

> *There are situations, especially in Amsterdam, the most ridiculous city, when you need to be one meter from the sides. So instead of 10x5, you then have 7x3. You lose half of the surface of the roof. People have to invest all the money and still have to look at half of their roof being black or with stone.*
>
> *From the interview to an expert from the green roof industry who worked with real estate companies.*

> *Despite having my own house, I live in an association of owners, and if I want to install a green roof I need the permission of my neighbour, and he does not allow me.*
>
> *From the interview to private roof owner in Amsterdam.*

Table 8: Overview of affectation of barriers by typology of roof owner.

	Type of roof owners			
	Members of real estate managers	Experts involved in the installation of big green roofs	Members of housing corporations	Small private roof owners
Total number of interviewees	4	2	3	6
Competition between climate adaptation and climate mitigation measures.	3	0	0	1
Perception than the costs are higher than benefits.	2	0	0	0
Lack of resources.	0	0	3	2
Problem alienation	2	0	1	2
Lack of consideration of green roofs during the process of roof construction/renovation	1	0	0	2
Conflict with existing regulations	0	0	0	1
Perception of vulnerability	1	0	0	1
Lack problem framing.	1	0	0	1

Loss of insurance	0	0	0	1
Lack of companies that operate with green roofs.	0	0	0	1
Perception that green roofs are individually an ineffective solution to the consequences of climate change	1	0	0	1
Lack of trust with the information about green roofs	1	0	0	1
Lack of knowledge about green roofs.	0	0	0	1
Costs of construction permit	0	0	0	1

4.2.1 Classification of the different barriers

Table 9: Classification of the identified barriers based in the classification of Biesbroek (2014).

Cluster	**Barriers**
Conflicting Timescales	-
Substantive, Strategic and Institutional Uncertainty	● Problem alienation. ● Perception of vulnerability.
Institutional Crowdedness and Institutional Void	● Lack of companies that operate with green roofs. ● Conflict with existing regulations. ● Perception that green roofs are individually an ineffective solution to the consequences of climate change.
Institutional Fragmentation	● Competition between climate adaptation and climate mitigation measures. ● Loss of insurance.
Insufficient Awareness and Communication	● Lack problem framing. ● Lack of consideration of green roofs during the process of roof construction/renovation. ● Lack of knowledge about green roofs.
Motives and Willingness to Act	● Perception that the costs are higher than benefits. ● Lack of trust with the information about green roofs.
Insufficient Resources	● Lack of resources. ● Costs of construction permit.

After using the classification from Biesbroek (2014), the first finding is that the barriers are present through all the defined clusters of barriers except for the conflicting timescales. The fact that any of the identified barriers conflict with the cluster of conflicting timescales is unknown. But I speculate that the small size of the sample could explain why I did not identify any barrier from this category.

4.2.2 Impact of the different barriers

Table 10: Weight of the different barriers.

Barrier	**Amount stakeholders (0-2)**	**Perception stakeholders (0-2)**	**Can it be overcome (0-2)**	**Total weight barrier (0-6)**
Competition between climate adaptation and climate mitigation measures.	2	2	2	6
Perception that the costs are higher than benefits.	1	2	2	5
Lack of resources.	2	2	1	5
Problem alienation	2	2	1	5
Lack of consideration of green roofs during the process of roof construction/renovation	1	2	1	4
Conflict with existing regulations	0	2	1	3
Perception of vulnerability	1	2	1	4
Lack problem framing.	1	2	1	4
Loss of insurance	0	2	1	3
Lack of companies that operate with green roofs.	0	2	1	3
Perception that green roofs are	1	2	1	4

individually an ineffective solution to the consequences of climate change				
Lack of trust with the information about green roofs	1	2	1	4
Lack of knowledge about green roofs.	0	1	1	2
Costs of construction permit	0	2	0	2

4.3 Conclusion

In conclusion, as an answer to the first research sub-question formulated in section 1.7, W*hat are the main barriers that stop the implementation of green roofs in urban areas?* the most impactful barrier among the interviewed stakeholders is the competition between climate change mitigation measures and climate change adaptation measures, followed by the perception that the costs are higher than benefits, the lack of resources and the problem alienation (table 9). Those barriers are selected to analyse their causal mechanisms.

The first main finding that can be extracted from this section is the presence of 14 different barriers among 15 roof owners (table 8). The affectation of these barriers varies in different groups of stakeholders. With respect to the four main barriers (section 4.2.2), the competition between climate adaptation and climate mitigation measures affects mostly big real estate organisations (3 out of 4) while only one small roof owner reported to be affected by this barrier (1 out of 6) and none of the housing corporations or big roof owners did report the presence of this barrier. The barrier of lack of resources is visible only among private roof owners, including housing corporations (3 out of 3) and private house owners (2 out of 6). The perception that the costs are higher than the benefits has only been reported among real estate organisations (2 out of 4). Finally, the problem alienation is present among almost all the groups of stakeholders, including real estate organisations (2 out of 4), housing corporations (1 out of 3) and small roof owners (2 out of 6).

These barriers are distributed among all the categories or clusters of barriers proposed by Biesbroek (2014) except for the conflicting timescales (table 9), having all the categories between two (substantive, strategic and institutional uncertainty, institutional fragmentation, motives and willingness to act and insufficient resources) and three (institutional crowdedness and institutional void and insufficient awareness and communication) different barriers each. This distribution indicates that there is not any specific cluster that dominates among the others but that all clusters are equally important.

5. Addressing causality

5.1 Introduction

This section will address the causality of the main barriers identified in section 4 and craft mechanism-based explanations to explain how and why barriers emerge. The expected result is to know what the driving forces are that provoke the emergence of those barriers through the adaptation process.

5.2 Results

5.2.1 The problem dissipation mechanism

This mechanism explains the emergence of the barrier called: Competition between climate adaptation and climate mitigation measures. In this case, interviewees reported to be aware of the necessity to implement measures to address the problem of climate change. However, the complexity and broadness of climate change as a topic (1) makes the decision-making process very complex (2). The excess of options to implement, in combination with a lack of awareness on the specific topic of adaptation to climate change (3) leads to a competition between climate change adaptation measures and climate change mitigation measures (4). These two options compete not only for special resources such as rooftops but also for economic resources or attention.

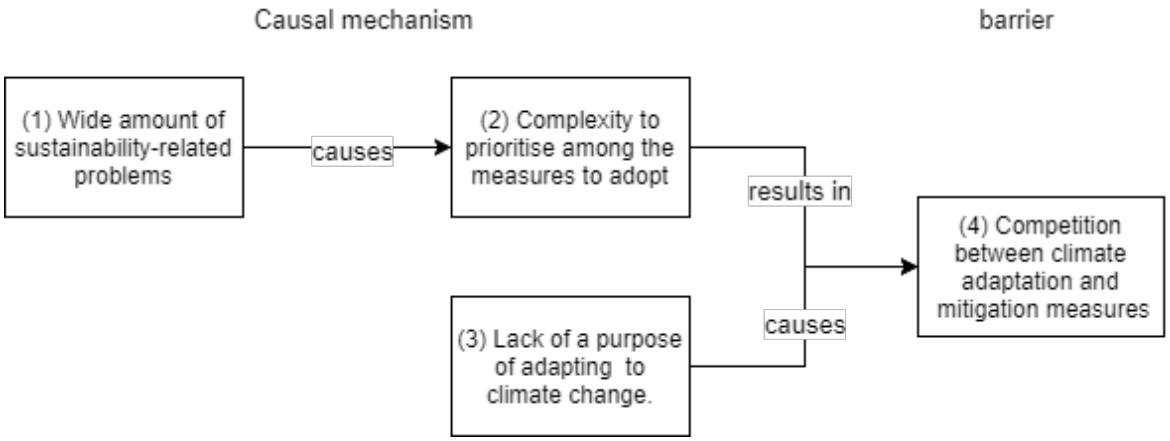

Figure 4: The problem dissipation mechanism.

When roof owners want to invest resources on sustainability measures, they find themselves with a wide set of possible sustainability-related issues that can be targeted (1). This big amount of sustainability-related problems refers to all the problems that target the improvement of the environmental performance, including climate change adaptation measures and climate change mitigation measures. Each of this wide amount of problems comes along with a wide amount of potential measures that can be applied to lessen or overcome the problems.

This wide amount of problems is the cause of the high level of complexity to decide what measure to adopt (2). Roof owners find themselves in a situation where they have to make a complex decision and they have too many options to choose.

All of the interviewed cases, roof owners have a general willingness to improve their environmental performance, but they do not have a specific purpose to adapt to climate change (3). The lack of a specific purpose to adapt to climate change, clearly separated from the purpose to mitigate climate change, leads to a competition between these two purposes (4).

One example of this mechanism can be observed in the organisation that manages the real estate of *Nederlandse Spoorwegen (NS)*, the company that manages the trains in the Netherlands. In front of the complexity of the issue of climate change (2), NS decided to adopt a policy on climate change mitigation focused on making the company climate neutral. This policy is based on the 2015 United Nations Climate Change Conference of Paris (COP 21) and focuses most of the efforts and budget that NS spends on sustainability in reducing the carbon footprint of the company. When asked about their specific measures to adapt to the effects of climate change, the interviewee reported to not to have a separated policy for climate change adaptation and climate change mitigation (3). As a result of this factors, NS invests most of the resources in climate change mitigation measures, leaving climate adaptation measures out of consideration (4).

> *We do not have the assignment to collect water from our roofs. (…) We have on our list other topics that are more of a priority, such as investing in solar panels to create more energy and to be energy neutral. That is what we want to reach. Energy neutral for all our train stations in the Netherlands. That is a big subject to get this done and we are looking for new ways to get this done. To isolate the station better, to keep the warmth, applying the warmte koude opslag...*
>
> *From the interview to an employee of the real estate management of NS*

This mechanism can be partially observed also in the organisation that manages the real estate of Universiteit Utrecht (UU). UU has the objective to be climate neutral by 2030 and it is spending most of its resources in measures that contribute to this objective and it does not have a specific policy for climate change mitigation (3). The topics of climate change adaptation and mitigation are therefore competing between each other for the same attention and resources (4).

> *We should really make a policy on green roofs (…) The main goal that UU has is to be climate neutral, therefore, the most interesting options for our roofs are solar panels.*
>
> *From the interview to an employee of the real estate management of UU*

The real estate department of the municipality of Utrecht is another example of this mechanism. When asked about its policies to adapt to climate change, the interviewee reported that real estate of the municipality of Utrecht opted for making its buildings climate neutral instead (4). When asked about how to prepare their buildings to the effects of climate change, the interviewee reported that they do not have a specific policy for climate change adaptation (3).

> *Panels are more attractive because they reduce electricity costs and help meet the CO_2 neutrality targets for the municipality. (…) we (the real estate department) do not collaborate with the department of environment or the water board to help to solve these problems (effects of climate change).*
>
> *From the interview to an employee of the real estate department of the municipality of Utrecht*

5.2.2 The benefit non-recognition mechanism

This mechanism explains the emergence of the barrier called: Perception that the costs are higher than benefits. In some cases, interviewees recognised the necessity to implement measures to adapt urban areas to the effects of climate changes. However, they expressed that green roofs are not valuable enough or that their cost does not compensate the environmental benefits that they generate. Mostly, interviewees only know or appreciate one or a few of the effects of green roofs, such as the capacity to retain water or the capacity to filter air pollution, but they do not recognise all the benefits that green roofs can generate.

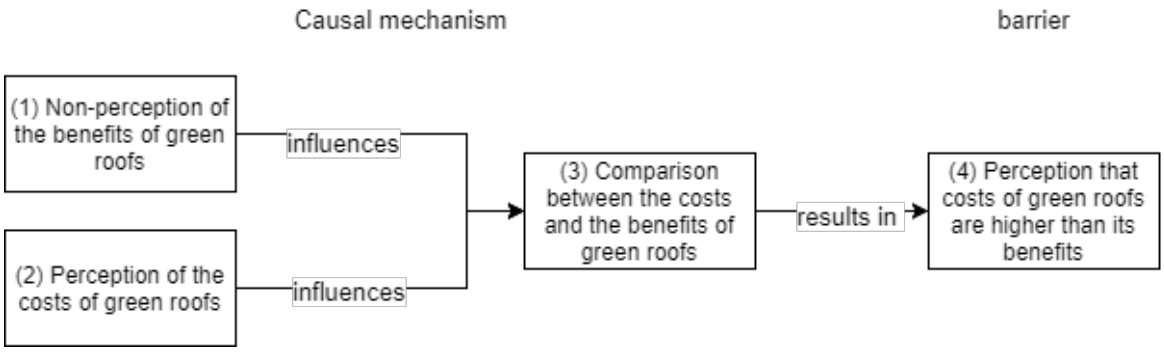

Figure 5: The benefit non-recognition mechanism.

The benefit non-recognition mechanism appears when stakeholders do not perceive the benefits of green roofs (1). This lack of perception is motivated in some cases by the fact that the benefits of

green roofs are not a necessity or a target for the roof owners, or also due to a lack of information about the effects of green roofs.

A second element that motivates the emergence of this mechanism is the full perception of the cost of the different measures that a roof owner can install (2). Roof owners want to use their resources as efficiently as possible, therefore, they compare the different available options to maximise the amount of benefits while keeping the costs as low as possible (3). When roof owners are comparing the different options that are available for them to adopt, if they are not able or willing to consider all the benefits of green roofs, they may underestimate their potential. In this situation, roof owners perceive green roofs as an expensive or inefficient measure (4) and they decide not to implement it.

This mechanism can be observed in the case of a small roof owner in Amsterdam. In that case, the interviewee is aware of the existence of green roofs and knows some of the benefits of it, especially the aesthetic benefits, but he does not mention its benefits to retain water and to mitigate heat stress (1). In that case, the interviewee acknowledges that he would invest his money (2) in a green roof only if the roof is visible for himself. If the roof is not visible, he would find the measure not interesting enough (4).

I know that green roofs are good to have more plants in the city (…) plants are good because they smell good and they filter the air pollution (…) I work in Waterlooplein and we have a green roof there, it smells better than a black roof. (…) to me a green roof is interesting if I can see it from my window and I can smell the flowers, I wouldn't spend money in a green roof on my building if I cannot see it.

From the interview to a small roof owner in Amsterdam

In the case of the interviewee of the real estate of the municipality of Utrecht, he only recognised the benefit of green roofs to lessen the temperature inside of the building during the interview (1). In that context, he reported that the temperature can be lowered in buildings using other measures that can provide that same effect with a lower price (4).

A green roof is a solution (for heat) but in our opinion it is too much expensive and it is too costly to maintain. We lower the temperature of the building by using our PV panels and an electric air conditioning.

From the interview to an employee of the real estate department of the municipality of Utrecht

This same situation can be found in real estate of the municipality of Amsterdam. The interviewee does not recognise the capacity of green roofs to mitigate heat stress and only perceives green roofs as tools to retain water (1), that makes him perceive green roofs as an expensive measure (4). Consequently, the interviewee proposes to invest in cheaper measures that specifically target water retention instead of green roofs.

> *Green roofs would not help (to adapt to climate change). The effect over the heat island effect by green roofs is nowadays not measurable. The effects of green roofs in the building are rather limited because is not about the green roof but about the isolation. It is far more effective for fighting the heat stress on a building to isolate it than to invest in a green roof. To increase the amount of plants in the city is not our assignment. For water management, it would be cheaper to collect the water in cellars that are not in use, or in drums in our gardens.*
>
> *From the interview to an employee of the real estate department of the municipality of Amsterdam*

5.2.3. The resources rivalry mechanism

This mechanism explains the emergence of the barrier called lack of resources. When asked about the necessity to invest in measures to adapt urban areas to climate change, several roof owners find that they have a limited amount of resources available. Roof managers tend to make choices based on their sense of priority, distinguishing between core priorities and secondary goals, and they give priority to the first group.

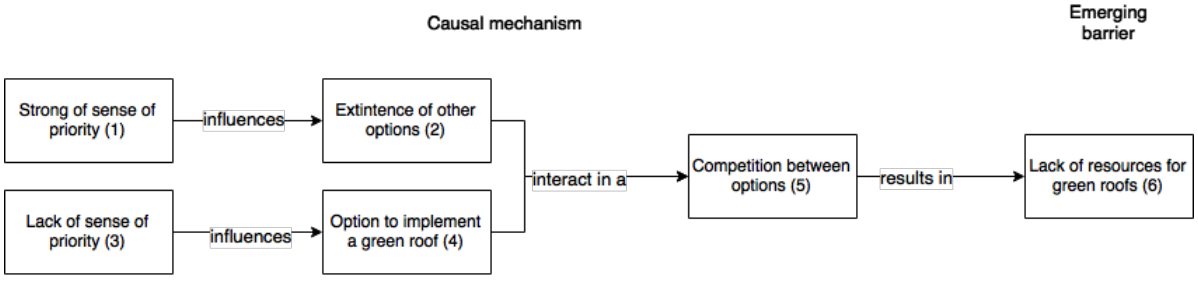

Figure 6: The resources rivalry mechanism.

The first element present in that mechanism is the sense of priority (1 & 2). The sense of priority determines how much attention and resources does certain option receive. The sense of priority has a variable intensity. When an option receives a high level of attention and resources, it has a strong priority (1). If an option does receive a low amount of attention and resources, it has a low sense of priority or it lacks it.

The existence of other options (3) refers to the existence of options alternative to the implementation of green roofs. All roof owners have other options and decision to make that require their resources. Those decisions could be to reduce the price of housing, to improve the maintenance of buildings or even spend the resources in different options such as going for holidays. The option to implement a green roof (4) is the possibility that roof owners have, to implement a green roof in their rooftops.

The competition between options (5) refers to the competition between the option of installing a green roof (4) and investing the resources in other options (3). Those two options compete to obtain resources to be implemented. As a result of this competition, a lack of resources for green roofs (6) can emerge as a barrier.

The resources rivalry mechanism appears in a context where roof owners feel that they have objectives not related to adaptation to climate change (2) that are high priority for them (1), such as cheap housing or the use of better materials (2). At the same time, stakeholders do not have enough elements that pressure them (3) to integrate climate adaptation measures as a relevant issue (4). In this situation, the need to contribute to climate adaptation competes against other issues (5). When the need to adapt to climate change is not considered as a priority, roof owners are unlikely to assign resources to it (6). This mechanism appears to all kind of roof owners without distinction.

A first example of this mechanism can be observed in a housing corporation interviewed in the city of Enschede. This company have a positive attitude to improve its environmental performance and it even invested in a series of pilot projects of green roofs in some houses. However, after investing in these pilots, the company does not plan to continue implementing green roofs in its buildings for the future. The reason that the interviewee provided to stop investing in green roofs was the lack of resources (6). The interviewees said that they are aware of the possibility to invest in green roofs and the benefits of this option (4), but they have other goals to meet such as investing in maintenance or keeping the rents low (3) that are more important for the company (1). Therefore, when green roofs compete for resources (5) within the housing corporation in Enschede, the resources are gone and invested elsewhere (6).

> *We did a pilot, and the if vision of our corporation was only about sustainability, we would have invested more in this (green roofs), but since our core business is to think about our tenants, keep our rents low, and keep the maintenance to a certain level, it is another mission. So eventually we decided to not to invest more in green roofs, because it is not our core mission. Maybe in the future we will invest more in green roofs, but not now.*
>
> *From the interview to a housing association in Enschede*

Another example of this mechanism can be found in the case of a house owner in Nieuwegein. When asked if she would install a green roof, she recognised that she has a limited amount of resources and

that she has to make priorities (5). In the case of green roofs, she indicated that she would prefer to invest these resources in isolating the floor of her house (3) than investing in a green roof (4).

> *I know that this is not a responsible way to think, but I have to recognise that if something costs 100 or 1.000€, that is a big difference. For instance, I would rather prefer to isolate the floor of my floor to have less moist at home before.*
>
> *From the interview to an individual roof owner in Nieuwegein*

During the interviews to green roof experts, interviewees were asked about their experiences with roof owners that they met. During one of the interviews, an expert reported that all kind of organisations struggle to find resources to invest in green roofs. In the case of commercial housing companies, they may consider to invest in green roofs (4), but the level of priority that sustainability-related measures receive is still rather limited (2) and other tasks such as building maintenance (3) tend to receive all the resources of those companies (6).

> *What I have seen in commercial housing, is that they feel that they are obliged to do something to prove themselves to be sustainable, but they have very limited budgets. So they always squeeze their budget to do something inexpensive. They may be interested to invest in green roofs but after they tell me that they first have to do other priorities such as replace their insulations and once they replaced their insulations, their budget is gone.*
>
> *From the interview to a member of a lobby group to promote green roof adoption from Amsterdam*

5.2.4. The problem alienation mechanism

This mechanism explains the emergence of the barrier called: Problem alienation. Some roof owners report that traditionally they had never been involved with any of the environmental problems of their city. Moreover, they report that environmental problems belong to third parties such as local governments. In that situation, roof owners feel alienated towards the environmental problems that their urban areas suffer and do not feel the responsibility to act upon these problems.

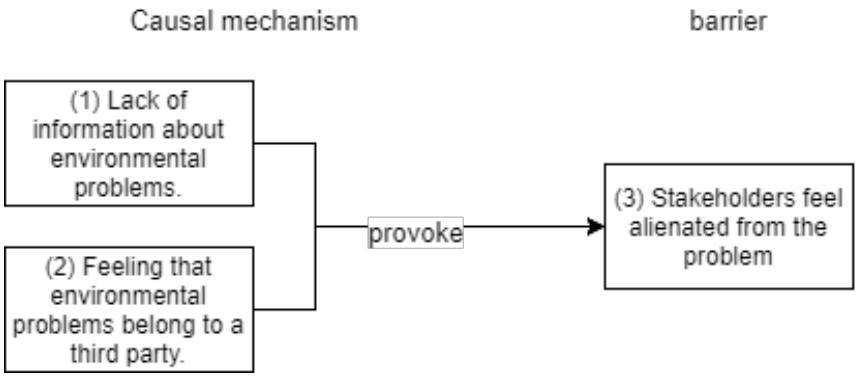

Figure 7: The problem alienation mechanism.

The problem alienation mechanism appears when stakeholders traditionally had never been informed about the environmental problems of their city (1). Roof owners are not just not informed about these problems, they also perceive that the environmental problems that affect their cities do not belong to them (2). This lack of feeling of ownership and information from roof owners leads to a general feeling of alienation about the environmental problems that affect their urban areas (3).

One example of this mechanism can be observed in the organisation that manages the real estate of Utrecht University (UU). UU has a policy to improve its environmental performance as much as possible and allocate resources to measures when it is necessary. However, most of environmental-related policies from UU target the campus, paying less attention to the possible measures that can be applied in the university buildings located in the city centre. The contacted interviewee from UU reported that UU does have a policy to adapt the campus to climate change, but it does not have a strategy to adapt the buildings of the city centre to climate change (3). The interviewee reported that she has a report that details the consequences of climate change in the campus, but this report does not analyse the consequences of climate change in the city of Utrecht, where the real estate department of UU also owns building. Additionally, the interviewee states that the municipal government should adopt the role of leader (2), guiding the climate adaptation measures that must be performed in the city, and that in this sense, UU has always been keen to collaborate.

> *We have a report on what are the consequences of climate change in the campus, but this report did not analyse the effects of climate change in the city centre. (…) In the campus, we own the site as well but in the city centre, the local government has more influence on the way it develops. (…) if the municipal government asks to adopt green roofs in the city centre, we can analyse it, but it has to be the local government who has to make a strategy.*
>
> *From the interview to an employee of the real estate department of Universiteit Utrecht*

In the case of the private roof owner in Nieuwegein, she reported her lack of knowledge and experience about the consequences of climate change in her municipality (1). She also said during the interview that the municipal government of her city should take a stronger role adopting measures such as communication tools (2).

> *I don't know if our municipality does anything about climate change, no idea. Maybe there is information but we have our rhythm and we do not feel appealed by these things. (…) If the municipality does want us to install such measures, first they should inform us about the problem and explain us what to do. (…) but it has to be the local government who gives us instructions, because I don't know these things.*
>
> *From the interview to an individual roof owner in the municipality of Nieuwegein*

During one of the interviews in a housing corporation in Enschede, one of the interviewed employees reported that he is not familiar with the consequences of climate change (1). Moreover, he reported

his perception to adapt the city to climate change is the responsibility of the municipality (2) and he does not feel appealed to adopt climate change adaptation measures to solve a problem of the local government (3).

> *No, I don't know what are the consequences of climate change for the city of Enschede, I know that we are above the sea level and I do not remember floods. (…) This is not the responsibility of the owner, I think that it´s the responsibility of the municipality to cope with it, it is a public problem.*
>
> *From the interview to an employee of a housing corporation in Enschede*

5.3 Conclusion

As an answer to the second research sub-question formulated in section 1.7 *what are the causal mechanisms of the main barriers*? this section identifies and describes four different causal mechanisms: the problem dissipation mechanism (section 5.2.1), the benefit non-recognition mechanism (section 5.2.2), the resources rivalry mechanism (section 5.2.3) and the problem alienation mechanism (section 5.2.4). The following mechanisms are crafted from the information collected during the interviews and their names are originally created in this research.

The first main finding that can be extracted from both section 5 is the complexity of the barriers and the causal mechanisms that prevent private roof owners from implementing green roofs. Section 5.2 shows the complexity of the causes behind the barriers to green roof implementation. All the analysed barriers are not the consequence of a single element but the result of complex processes where diverse elements, actors and conditions interact.

The second main finding from section 5 is the predominant role that information-related elements play in the causal mechanisms of barriers to green roof adoption. In the case of the problem-dissipation mechanism, the willingness of roof owners to implement environmental-related measures is blocked by the complexity of the information received about climate change. A lack of a specific system of priorities delays or blocks the implementation of adaptation-related measures such as green roofs (section 5.2.1). In the case of the benefit non-recognition, the lack of awareness about the benefits of green roofs makes roof owners perceive green roofs as a costly measure with few benefits (section 5.2.2). Information-related elements can be found even in the resources rivalry mechanisms. The sense of priority about climate change plays a predominant role when roof owners decide to invest their resources in green roofs (section 5.2.3). Finally, in the problem alienation mechanism, the information available by roof owners roof owners explains their awareness about the effects of climate change. The information available for them may explain as well their lack of feeling of ownership on the consequences of climate change (section 5.2.4).

The third finding from section 5 is that the resources-related elements play a secondary role in raising barriers to green roof implementation. Resources-related elements can be found in the problem dissipation mechanism, where the availability of resources determines if roof owners can make a specific climate-related policy (section 5.2.1). Resources-related elements also play a relevant role in the resources rivalry mechanism, where the limited amount of resources of roof owners and the presence of other priorities stop roof owners from investing resources in climate adaptation mechanisms (section 5.2.3).

6. Acceptance of policy tools

6.1 Introduction

This research has explored the barriers that prevent roof owners from adopting green roofs as a climate adaptation measure. Those barriers were used to identify the causal mechanisms that provoke its emergence and were scored to classify them according to their magnitude. The last step in this research is to find which are the most appropriate policy instruments to disable the causal mechanisms that block the climate change adaptation process. As explained in section 3.3.3.1.1, to assess the acceptance of policy instruments, interviewees were asked their opinion on an example of an added regulation and an example of a rule that would loosen existing regulations.

The objective of this section is to catalogue the different sort of policy instruments and to measure the acceptance of those instruments among stakeholders. Due to the limited scope of this research, an in-depth survey of roof owners did not take place. The final output of this section is an analysis on how acceptable the different instruments are and a comparison among the different instruments to see what policy tools are perceived as more acceptable and what tools are perceived as less acceptable by stakeholders.

6.2 Results

6.2.1 Legislative and regulatory instruments

To assess the level of acceptance of added regulations, interviewees were asked their opinion on a rule that aims to promote green roof adoption by means of legal obligation with a system of sanctions. This option is seen as the most unfavourable by stakeholders. Only 5 out of 16 interviewed roof managers found this option acceptable and 9 roof managers said that this measure is totally unacceptable. Among the different reasons that roof owners give to qualify such a measure as unacceptable, the most repeated is that it would disrupt their freedom to decide what to install on their own roofs. The fact that roof owners would have to cover the expenses of a green roof by themselves is also a reason for concern. As one roof owner in Nieuwegein said:

> *This is not a dictatorship. I understand that green roofs can be beneficial and even necessary for the environment, but the government cannot obligate me to implement a specific option in my house. I must be able to decide on my house and on my pocket!*
>
> *From the interview to an individual roof owner in the municipality of Nieuwegein*

When interviewees were asked about making existing regulations looser to promote green roofs, they were specifically asked how acceptable they find the removal of secondary regulations that interfere with the installation of green roofs. None of the interviewed stakeholders qualified this measure as unacceptable, but only 5 of 16 stakeholders thought that this measure was acceptable. Most of the opinions were neutral due to their lack of opinion over secondary regulations that interfere in green roof implementation.

6.2.2 Economic and fiscal instruments

Interviewees were asked their opinion on the local government financing the installation of green roofs of private house owners to promote green roof adoption. The response was mostly positive. 11 roof managers considered public allowances an acceptable measure, 5 of the interviewed stakeholders showed a neutral position and nobody considered public allowances as an unacceptable measure. The reasons to consider public allowances as a good policy are focused on the fact that they respect the autonomy for roof owners to make their own choices. Additionally, economic and fiscal instruments make the option of installing a green roof financially accessible. As one of the interviewees said:

> *When you have enough resources, you dare to make more ambitious decisions, but if you are less wealthy you need support.*
>
> *From the interview to an individual roof owner in the municipality of Nieuwegein*

Interviewees were also asked how acceptable they would find the establishment of a tax differentiation system, meaning that roof owners who adopted a green roof would be granted with a reduction of their water taxes. This has been by far the most acceptable policy tool of all. 15 out of 16 interviewees find the idea of a tax differentiation an acceptable measure and only one interviewee is neutral towards this policy. The two most repeated reasons to find tax differentiation as an acceptable measure are that to reduce taxes is fair since green roof owners do contribute to reduce public expenses on sewage. The second reason most commonly said is that tax reduction would make the adoption of green roofs less costly and therefore more attractive.

6.2.3 Agreement-based and incentive-based instruments

Interviewees were asked their opinion on how it would they would find it if the local government would delegate the responsibility to retain and manage rainwater to roof owners. This policy tool, despite being mostly accepted, is the second least accepted tool of the toolkit and it received differing opinions. Two roof owners find this measure unacceptable, six roof owners find this measure

acceptable, and eight roof owners do not have a defined position with regards to this matter. Among the roof owners who find this tool acceptable, the most common argument is the freedom that this tool provides to roof owners to choose the solution to the problem by themselves and the need to involve roof owners directly to the problem of adaptation to climate change. The reasons why two stakeholders find this policy tool as unacceptable is because they find that the distribution of responsibilities derived from this tool is not adequate. During the interviews, those roof managers argued that they feel that collective problems should be addressed collectively.

> *Water storing is a problem for the entire city and not for only roof owners. The responsibility cannot be individual for a collective problem that connects all of us.*
>
> *From the interview to an employee of a housing corporation in Enschede*

Interviewees are also asked about how acceptable would they find if their government would negotiate with insurance companies to make sure that buildings who install a green roof do not have to pay any extra fee and are completely covered in case of any potential damage caused by the green roof as form of incentive to promote green roof adoption. Roof owners are neutral or positive about this measure equally. Most roof owners who adopt a neutral position argue that they are unsure whether this measure is addressing a real problem that roof owners have. Roof owners who find this tool positive argue that it does not represent any inconvenience for them.

6.2.4 Information-based and communication-based instruments

In this research, interviewees are asked how acceptable they would find it if the local government would start a communication campaign to ensure that everybody has sufficient knowledge of the consequences of climate change in cities and the benefits that green roofs can generate to alleviate these consequences. The use of information-based tools is the second most accepted policy tool after the idea of a tax differentiation. 14 roof owners find it acceptable that the government does provide more and better information about climate change adaptation measures and green roofs and only 2 roof owners are neutral in this sense. The most repeated reasons during the interviews was the lack of information and awareness among roof owners and the need to understand the problem. A second argument often repeated is the neutrality of information and the fact that roof owners are the actors who have to be free to make their decisions on their roofs.

I don't even know who is the mayor of Nieuwegein and I don't know what are the policies that our municipality is developing with respect to climate change. This is a commuter town and most of people here are more attached to Utrecht than to Nieuwegein, so we lack of information about what are the problems that are affecting the area where we live. The municipality should target us more intensively if we have to do something for the environment.

From the interview to an individual roof owner in the municipality of Nieuwegein

Table 11: Acceptance of the different policy instruments.

Policy instrument	**Example**	**Stakeholders who find this tool acceptable**	**Stakeholders who are neutral in front of this tool**	**Stakeholders who find this tool unacceptable**
Legislative and regulatory	Legal obligation with a system of sanctions.	5	2	9
	Removal of regulations that interfere with the installation of green roofs.	5	11	0
Economic and fiscal	Finance of the installation of green roofs of private house owners.	11	5	0
	Establishment of a tax differentiation system, were roof owners who adopted a green roof were granted with a reduction of their water taxes.	15	1	0
Agreement-based and incentive-based	Delegation of the responsibility to retain and manage rainwater to roof owners.	6	8	2
	Public negotiation with insurance companies to make sure that buildings who install a green roof do not have to pay any extra fee and are completely covered in case of any potential damage caused by green roofs.	8	8	0

Information-based and communication-based	Public communication campaign to ensure that everybody has sufficient knowledge of the consequences of climate change in cities and the benefits that green roofs can generate to alleviate these consequences.	14	2	0

6.3 Conclusion

This section provides answer to the third research sub-question formulated in section 1.7 *Which policy instruments are being perceived as acceptable by roof owners to overcome those barriers.* In general, roof owners find all the proposed policies acceptable except for the establishment of a legal obligation to adopt green roofs. Roof owners find the policy tools that reduce taxes to the roof owners who do implement green roofs the most acceptable and those policies focused on providing information. Generally, all tools that diminish the freedom of roof owners to make their own decision on their roof is seen negatively, whilst the policies that create incentives and information are more positively perceived by roof owners.

The main finding from section 6, is that most of the policy tools are considered as acceptable by stakeholders except for the use of legislative and regulatory tools. All policy instruments are acceptable if they respect the freedom of roof owners to decide on their own property. Information-based and communication-based instruments are instruments considered as acceptable by roof owners (section 6.2.4). Roof owners do not see these sorts of tools as invasive and they can guide roof owners to make correct decisions and to understand the reasons of the measures that they implement. The use of economic and fiscal instruments can be a good measure to target the resources-related elements that cause barriers in the process of green roof implementation. Agreement based and incentive based instruments received more neutral opinions by the interviewed roof owners. This neutrality is because roof owners are not familiar with the use of these tools, but during the interviews, roof owners did not show opposition to them.

7. Conclusion

This section answers the main research question formulated in section 1.7 *what are the causes to the main barriers that block the adoption of green roofs as climate adaptation measures for roof owners*? The causes of barriers to green roof adoption are complex and diverse mechanisms, mainly integrated by information-related elements, followed by the resources-related elements (section 4.3).

As section 1.5 indicates, the main objective of this research is to draw a policy advice to overcome barriers to green roof adoption. Section 7.2 draws the recommendations to foster the adoption of green roofs among roof owners by addressing barriers to green roof implementation and by finding policy tools that are perceived as acceptable by roof owners.

The structure of this section is as follows: Section 7.1 addresses the main findings of this research. Section 7.2 provides advice on what elements should be addressed by policies that aim to foster climate change adaptation. Finally, section 7.3 discusses the research framework, the contribution of this research in the literature and its methodology.

7.1 Main findings

As said on section 4.3, The main finding extracted from the interviews is the existence of 14 barriers that delay the process of green roof adoption among roof owners. The different profiles of roof owners can be affected by different barriers, being the competition between climate adaptation and climate mitigation measures the barrier that mostly affects big real estate organisations. The lack of resources is the barrier most commonly found among private actors such as housing corporations and small roof owners. When analysing the distribution of barriers among clusters, the results indicate that there is not any specific cluster that dominates among the others but that all clusters are equally important (table 9).

Section 5.3 concludes that the elements that are cost commonly found in the causal mechanisms are the information-related elements, followed by the resources-related elements that play a secondary role in the analysed causal mechanisms.

The first finding from section 6.3 is that most of the policy tools are considered as acceptable by stakeholders except for the use of legislative and regulatory tools. The most commonly reported reason to consider a policy instruments as acceptable is its respect for the freedom of roof owners to decide on their own property. Information-based and communication-based instruments are instruments generally accepted by roof owners, followed by the use of economic and fiscal instruments and finally, the agreement based and incentive based instruments are the last category of instruments to be perceived as acceptable (table 11).

7.2 Recommendations for policy

To prevent the emergence of barriers, climate adaptation policies should interfere in the elements that form the causal mechanisms that cause these barriers. In this sense, a specific policy advice is derived from each of the four main barriers identified in section 4.2.2. These policy recommendations are derived from the causal mechanisms from section 5, but also, they incorporate the findings on acceptance from section 6.

To prevent the problem dissipation mechanism, it is necessary to help roof owners to reduce the complexity to adopt necessary environmental-related measures. In this sense, it is suggested to use information-based or communication-based instruments to provide to roof owners with specific information about city adaption to climate change. It is suggested to local governments to distribute specific information about the risks and environment-related priorities of each zone in urban areas. By drawing specific information, roof owners would be able to identify what measures are the most relevant to apply in their buildings. Climate change mitigation policies and climate change adaptation policies should be designed in a way to minimise their interferences as much as possible. In this sense, it is necessary to develop information that helps roof owners to identify if a measure is relevant for the city and for themselves. The information that is sent to roof owners should also avoid complexity and contradictions to avoid rivalry between climate change mitigation and climate change adaptation measures. Finally, it is necessary to create awareness on adaptation to climate change in areas that are vulnerable to its consequences.

That could be done for instance by creating a centralised tool for each municipality informing about the environmental priorities in each part of the city. A centralised tool would serve as a tool to avoid present contradictions, such as the existence of different policies from different governments targeting rooftops for conflicting purposes, such as the promotion of green roofs and solar panels in rooftops. To avoid rivalry among measures, it is suggested to draw a strategy to integrate all the climate-change related efforts that coordinates the implementation of adaptation measures and mitigation measures and avoids conflicts. This strategy could eventually aim to maximize synergies between climate mitigation measures as solar panels and adaptation measures as green roofs as it is done in other European urban areas as Basel.

To prevent the benefit non-recognition mechanism, it is suggested to prioritise the use of information-based and communication-based instruments as well. In this sense, it is necessary to firstly support roof owners to understand all the benefits of green roofs. It is necessary to inform roof owners with information from sources that are perceived as reliable or recognised. It is also suggested to generate information on the expected costs of not adapting urban areas to climate change.

This information could be created and distributed for example by incentivising municipalities to establish collaborations with research institutions or universities to generate reliable information, but

also to give roof owners the capacity to generate their own information by providing them with tools such as examples of open green roofs that can be visited.

To prevent the resources rivalry mechanism, it is suggested the use of information-based and communication-based instruments to create a bigger sense of priority on the need to adapt to climate change. The use this tools would reduce the cost of gathering and centralising the information about all the measures available to roof owners to adapt to climate change. For this sort of barrier, it would be appropriate the use economic and fiscal instruments to ensure that all roof owners have resources to invest in climate change mitigation measures.

In this sense, it is advised to further analyse the use of tax reduction tools such as a water tax differentiation for roof owners who adopt a green roof since this tool was the most widely accepted of all the tools to promote green roofs. In this sense, there already is a recent study on the possibilities to apply a tax differentiation system over the sewage taxes in the Netherlands that could be considered to overcome this mechanism (see Brackel, 2017).

To prevent the problem alienation mechanism, it is suggested to prioritise the use of information-based and communication-based instruments. In this sense, the use information-based instruments seem the most appropriate to ensure that all the inhabitants of cities know the problems which affect and will affect areas where they live. Secondly, it is suggested to incentivise the engagement of house owners with the management of the environmental problems of the city with information campaigns. To overcome the problem alienation barrier, it is suggested to use additional policy tools, such as the use of agreement-based and incentive-based instruments. It should be encouraged to make agreements with house owners and establishing negotiations and collaborations between public administrations and private house owners to involve them in the process green roof adoption.

For example, next to information campaigns on the effects of climate change in urban areas, local governments could experiment with the delegation of some responsibilities to house owners by making agreements with them. Those agreements could include the delegation of the responsibility to retain water or to expand the amount of green areas in certain areas of the city.

Table 12: Overview of the policy advice

Mechanism to overcome	Policy advice	Example
Problem dissipation mechanism	• Use information-based or communication-based instruments to create distribute specific information about the risks and environment-related priorities of each zone. • Climate change mitigation and adaptation policies should minimise their interferences,	• A centralised tool to coordinate policies and avoid contradictions, such as the competition between green roofs and solar panels in rooftops. • A strategy to coordinate all the

	avoiding complexity and contradictions. • Create specific awareness on the need to climate change adaptation in areas that are vulnerable to the consequences of climate change.	climate-change related efforts, avoid conflicts and maximize synergies between solar panels and green roofs like in Basel.
Benefit non-recognition mechanism	• Support roof owners to understand all the benefits of green roofs. • Use sources that are perceived as reliable or recognised. • Generate information on the expected costs of not adapting urban areas to climate change.	• Establish collaborations between local governments and research institutions or universities to generate reliable information. • Create good examples of green roofs roof that are visible for all owners to allow them to generate their own information.
Resources rivalry mechanism	• Create a bigger sense of priority on the need to adapt to climate change. • Use economic and fiscal instruments to ensure that all roof owners have resources to invest in climate change mitigation measures.	• Implement a tax reduction mechanism such as a sewage tax differentiation for roof owners who adopt a green roof (see Brackel, 2017).
Problem alienation mechanism	• Use information-based instruments seem the most appropriate to ensure that all the inhabitants of cities know the problems that affect and will affect the areas where they live. • Incentivise the engagement of house owners with the management of the environmental problems of the city with information campaigns. • Make agreements between local governments and house owners to collaborate and involve private house owners in the process green roof adoption.	• Information campaign on the effects of climate change. • Experiment with the delegation of some responsibilities to house owners by making agreements with them about topics such as water retention or to green areas expansion.

7.3 Discussion

This research had an explorative aim. The lack of precedents on analysing barriers to private roof owners is a limitation that conditioned this research. As stated in section 1.4.1, only three papers that

analyse barriers on green roof implementation for private roof owners were found and none of them were based in the Netherlands. This condition made this research eminently explorative.

This research contributes to the literature of barriers to climate change adaptation by providing a specific approach to the topic using the mechanistic view (section 2.1), by deepening into the causality of barriers to green roof adoption and by providing specific findings to explain why roof owners in Dutch urban areas are prevented from adopting green roofs.

The approach used in this research was inspired by the approach used by Biesbroek (2014). That research is one of the very few available examples in the literature of Earth system governance where the mechanistic view is applied. The mechanistic view is an approach developed in the field of the political science, but it has not been widely applied in the literature of Earth system governance (Biesbroek, 2017). As described in section 2.1, this approach has a big potential to build theories and to explain complex phenomena. The contribution of this research to the Earth system governance literature is the addition of four more identified causal mechanisms (section 5.2) in the literature of causal mechanisms. The main difference of this research and the research of Biesbroek (2014) is that this research built the causal mechanisms from the analysis of 15 different cases. The research of Biesbroek instead, focused in the analysis of one single case and conducted several interviews with stakeholders related to the same case.

This research contributed in the field of the green roof literature by filling the knowledge gap described in section 1.5. The specific contribution is to identify the specific barriers that affect roof owners in the Netherlands (section 4.2). The previous existing literature on green roof adoption (section 1.4.1) has a descriptive approach and did not focus on the causality of the identified barriers. In this sense, this research contributes in the green roof literature by performing the analysis of the causality of those barriers and providing advice to overcome the described causes.

The selected research approach, described in section 1.6, focuses on the barriers experienced by roof owners. This research analyses the barriers identified among 15 cases of roof owners to interpret what barriers prevented them from adopting green roofs as a climate adaptation measure. However, this focus on a single profile of actors provides a narrow picture of the process of green roof adoption and its impasses. In this sense, further research could draw a bigger picture, incorporating other actors such as members of insurance companies, members of the green roof industry, architects and different members involved in the design of management of roofs in urban areas. This incorporation could provide a wider picture of the barriers to green roof adoption and eventually reveal new barriers that were not detected in this research.

The number of conducted interviews is a clear limitation of this research. The first limitation is the reduced amount of interviewed roof owners. Private organisations and housing companies are not always easily accessible. In this sense, this research counts with two interviews with experts involved in the implementation of two big green roofs and three employees from two housing corporations in The Hague and in Enschede. This is a rather limited number of interviews. However, more companies

that were contacted refused to participate in this research. A second limitation is the diversity of interviewed roof owners. During the process of building the research proposal, it was hypothesised that establishing a comparison between roof owners who did implement green roofs and roof owners who did not implement green roofs would be a valid strategy to identify the causality of barriers to green roof adoption. During the research process, the complexity of the process of green roof adoption and the existence of a wide diversity of opinions among roof owners towards green roofs was realised. Therefore, instead of drawing a plain difference between green roof adopters and non-adopters, the aim was to find roof owners with opinions as diverse as possible. This diversity aims to ensure that the sample of interviewees is as representative as possible and to ensure the maximum number of barriers as possible.

A third limitation of this research is the complexity of the analysed topic. This research unveiled the causal mechanisms of the four most impactful barriers among fourteen barriers. This research demonstrates in section 6.2 that a complex and specific process is causing each barrier. This complexity makes it difficult to establish generalisations or the identification of a common root to the emergence of barriers to the process of green roof adoption.

As explained in section 1.4.2, it is highly relevant to research the level of acceptance to evaluate the capacity of policy tools to involve roof owners in the climate adaptation process. This research focused solely on the variable of acceptance to analyse the capacity of policy tools to be recognised by stakeholders. However, governance literature uses more variables to analyse the perception of stakeholders towards policy tools. This literature is mainly focused on the emergence of legitimacy issues caused by the shift of governance arrangements (Bekkers & Edwards, 2007). Legitimacy however, is a broader term than acceptance. Legitimacy can be divided between input, throughput and output legitimacy (Mees, 2014; Mees, Driessen, & Runhaar, 2012; Papadopoulos, 2011). Input legitimacy comprises issues such as the representation of stakeholders in the process of making decisions (Mees, 2014; Mees et al., 2012). Throughput legitimacy relates to the fairness of the process and the quality of the participation and deliberation (Mees, 2014). Finally, output legitimacy relates to the acceptance of authority, or the effectiveness of the outcomes of the governance process (Bekkers & Edwards, 2007; Mees, 2014). In this sense, further research could incorporate all the dimensions of legitimacy to the analysis of policy tools to foster green roof adoption.

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9.Tables of figures and tables

9.1 Tables

9.2 Figures

10. Appendix

Annex 1: Interview Protocol

The questions of this interview will be asked to stakeholders that manage or are involved in the management of roofs. The objective is to know which are the impasses that affect private roof owners to adopt implement green roofs in their buildings.

The questions will be asked to different type of roof managers, from small owners who only manage their own roof (so with a total decision capacity on their roof but a limited amount of resources to make decisions) to relevant employees of big real estate organisations (actors that have more resources a more limited decision making capacity). That means that these questions will have to be adapted to the different actors and their situation.

While asking, it is very important to ask why after each question of the parts 6b, 6c and 7 to allow the interviewee to fully explain his/her context and his/her full perception. This parts are the most important ones of the interview and the causality of the impasses should be extracted from this part. At the end of the interview, the interviewee should be asked for any relevant thought that he/she has in mind.

<u>Key questions to be asked:</u>

Introduction:

1. Can you introduce yourself and explain your role within your company?
2. What is your opinion about the consequences of climate change in your city?
3. Should your city be adapted to the effects of climate change?

First part: Identifying possible motives and unwillingness to act as a barrier

4. Do you think that you are relevant to contribute to climate change adaptation?

a. Why?

5. Did you adopt/tried to adopt a green roof in the top of your building?
    a. If not:
        i. Would you like to adopt a green roof on your rooftop/ a rooftop managed by you?
    b. If yes:
        i. Can you explain me the process of implementing a green roof that you/your organisation experienced?
    c. Are you aware of the potential benefits of installing a green roof?
        i. Do you perceive as beneficial to reduce the heat stress in your building?
        ii. Do you perceive as beneficial to reduce the heat stress in your neighbourhood?
        iii. Do you perceive as beneficial to have plants on your roof for the environment?
        iv. Do you perceive as beneficial to have plants on your roof for yourself to enjoy?
        v. Do you perceive as beneficial to retain rain water in your rooftop?
        vi. Do you perceive a green roof as an economic opportunity for an economic activity (gardening, having a restaurant/café)?
        vii. Do you perceive green roofs as beneficial in any other sense?

Second part: Identifying barriers

d. Do you face any explicit struggle if you tried to install a green roof on your rooftop?
e. For what reason(s) you did not implement/ you are not implementing green roof(s) on your rooftop(s)?
    i. Please rate this reasons as very influential, lightly influential or insignificant?

With regards to awareness and communication

ii. Do you know/consider that to install a garden in a roof is technologically possible?

With regards to strategic and institutional uncertainty

iii. Do you consider that the benefits of green roofs that I asked before are relevant?
iv. Do you fear leaks or other damages to your building caused by a green roof?
v. Are you discouraged because of other alternatives to green roofs (e.g. solar panels)?

With regards to lack of resources

vi. Are you discouraged for the cost of the installation?
vii. Are you discouraged because of the potential costs of maintaining a green roof?

With regards to institutional void/crowdedness

viii. Does the local/national government requires you to do anything in your roof to adapt to climate change?
ix. Does that affects you to make a decision when renovating your roof?
x. Are you discouraged for additional municipal regulations (i.e. alterations in the front wall)?

With regards to institutional fragmentation

xi. Are you discouraged because the decision to install a green roofs has to be taken by too many actors (e.g. social housing corporations, tenants, architects)?
xii. What do you think about the amount of alternatives (solar panels, other water collection mechanisms) that can receive public support? Does the amount of alternatives makes it easier or more difficult to make a decision on your roof?

Other possible barriers

xiii. Are there other reasons that would stop you to install a green roof?

6. Let's talk about the reasons that you find important.
    a. Reason 1.
        i. What are the causes of that reason?
        ii. Why is that reason important?
        iii. How does that reason affects you?
        iv. What are the actors involved in that reason?

v. How would you solve that reason?

Thind part part: Measuring legitimacy

7. Let's talk about policies. Imagine a scenario where the municipal government wants to build policies for climate change adaptation.
    a. Do you think that taking steps to prepare/adapt your city for climate change is necessary?
    b. If the local government wants to develop a policy to steer up the implementation of green roofs, what policies you find most acceptable between the following options: (distinguish between unacceptable, acceptable and neutral)?

Policy instrument	**Example**
Legislative and regulatory	Legal obligation with a system of sanctions.
	Removal of regulations that interfere with the installation of green roofs.
Economic and fiscal	Finance of the installation of green roofs of private house owners.
	Establishment of a tax differentiation system, were roof owners who adopted a green roof were granted with a reduction of their water taxes.
Agreement-based and incentive-based	Delegation of the responsibility to retain and manage rainwater to roof owners.
	Public negotiation with insurance companies to make sure that buildings who install a green roof do not have to pay any extra fee and are completely covered in case of any potential damage caused by green roofs.
Information-based and communication-based	Public communication campaign to ensure that everybody has sufficient knowledge of the consequences of climate change in cities and the benefits that green roofs can generate to alleviate these consequences.

8. Do you have any other questions, ideas or remarks about the adoption of green roofs that you would like to say?

Annex 2: Overview of barriers among roof owners

		Competition between climate adaptation and climate mitigation measures.	**Perception than the costs are higher than benefits.**	**Lack of resources.**	**Problem alienation**	**Lack of consideration of green roofs during the process of roof construction/renovation**
Employees from real estate departments	Real estate manager of Nederlandse Spoorwegen	**Yes**				Yes
	Real estate manager of Universiteit Utrecht	**Yes**			Yes	
	Real estate manager of the municipality of Amsterdam		Yes			
	Real estate manager of the municipality of Utrecht	**Yes**	Yes		Yes	
Experts involved in the installation of big green roofs	Expert involved in the Miro Watertoets in Enschede					
	Expert involved in the Alexandrium in Rotterdam					
Employees of housing corporations	Employee from a housing corporation in The Hague			Yes		
	Employee			Yes		

	from a housing corporation in Enschede #1					
	Employee from a housing corporation in Enschede #2			Yes	Yes	
Small roof owner	Small roof owner in Amsterdam #1					
	Small roof owner in Amsterdam #2					
	Small roof owner in Amsterdam #3			Yes	Yes	Yes
	Small roof owner in Rotterdam #1	**Yes**				
	Small roof owner in Rotterdam #2					
	Small roof owner in Nieuwegein			Yes	Yes	Yes
		Conflict with existing regulations	Perception of vulnerability	Lack problem framing.	Loss of insurance	Lack of companies that operate with green roofs.
Employees from real estate departments	Real estate manager of Nederlandse Spoorwegen					
	Real estate manager of Universiteit Utrecht					
	Real estate manager of the municipalit		Yes			

	y of Amsterdam					
	Real estate manager of the municipality of Utrecht			Yes		
Experts involved in the installation of big green roofs	Expert involved in the Miro Watertoets in Enschede					
	Expert involved in the Alexandrium in Rotterdam					
Employees of housing corporations	Employee from a housing corporation in The Hague					
	Employee from a housing corporation in Enschede #1					
	Employee from a housing corporation in Enschede #2					
Small roof owner	Small roof owner in Amsterdam #1					
	Small roof owner in Amsterdam #2	Yes			Yes	Yes
	Small roof owner in Amsterdam #3					
	Small roof owner in Rotterdam #1					
	Small roof owner in					

	Rotterdam #2					
	Small roof owner in Nieuwegein		Yes	Yes		
		Perception that green roofs are individually an ineffective solution to the consequences of climate change	Lack of trust with the information about green roofs	Lack of knowledge about green roofs.	Costs of construction permit	
Employees from real estate departments	Real estate manager of Nederlandse Spoorwegen					
	Real estate manager of Universiteit Utrecht					
	Real estate manager of the municipality of Amsterdam	Yes	Yes			
	Real estate manager of the municipality of Utrecht					
Experts involved in the installation of big green roofs	Expert involved in the Miro Watertoets in Enschede					
	Expert involved in the Alexandrium in Rotterdam					

Employees of housing corporations	Employee from a housing corporation in The Hague					
	Employee from a housing corporation in Enschede #1					
	Employee from a housing corporation in Enschede #2					
Small roof owner	Small roof owner in Amsterdam #1					
	Small roof owner in Amsterdam #2					
	Small roof owner in Amsterdam #3	Yes				
	Small roof owner in Rotterdam #1				Yes	
	Small roof owner in Rotterdam #2					
	Small roof owner in Nieuwegein		Yes	Yes		