Strategies for increasing adoption of green roofs in the Netherlands

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ABSTRACT

In the Netherlands, green roof technology is not yet widespread adopted. It is well-established that green roof technology not only contributes to mitigation of the increasing climate change impacts such as increased peak precipitation and heat waves, but also have an abundance of other benefits. This study aims to determine how potential adopters can be better targeted to increase green roof technology adoption. Specifically, it investigates what institutional strategies can facilitate an increase in adoption of green roofs.

To study the green roof adoption process, a mixed-method approach was applied. This comprised of expert interviews with frontrunners on green roof adoption in the Netherlands and content analysis of relevant documents. The results showed a misalignment in the costs and benefits for the potential adopter, complexity in applicating for subsidies and the need for a change in incentives.

These results suggest that, for the increase of green roof technology adoption, the potential adopters should be compensated for the benefits they provide others. Furthermore, they should be assisted in the adoption process by specialist. Additionally, there is a need for integration of adaptation and mitigation policy.

Keywords: green roof technology, diffusion of innovation, adoption rate, institutional strategy, ecosystem services

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LIST OF ABBREVIATIONS

BAG	Basisregistratie Adressen en Gebouwen
DPRA	Delta Plan Ruimtelijke Adaptatie (Delta Plan Spatial Adaptation)
ES	Ecosystem services
EPA	Environmental Protection Agency
GI	Green infrastructure
GRs	Green roofs
IPCC	Intergovernmental Panel on Climate Change
NAS	Nationale klimaatadaptatiestrategie (National Adaptation Strategy)
NBS	Nature-based solutions
MA	Millennium Ecosystem Assessment
UHI	Urban Heat Island

1 INTRODUCTION

1.1 INCREASING CLIMATE CHANGE IMPACTS

Climate change, also referred to as global warming, has an increasingly negative impact on earth. It is anticipated that over the following decades, weather becomes more severe, ensuing in longer durations of warmth and drought, and excessive precipitation (IPCC, 2014). Due to the materials used in urban areas, the density of buildings and anthropogenic dynamics, some effects are felt more severely in urban areas opposed to rural areas (Langemeyer et al., 2018). For instance, the excessive peak precipitation can cause pluvial flooding as the materials used in urban areas have a low permeability and the discharge speed can not facilitate the amount of stormwater, resulting in damages and mental health impacts. The warmth and drought will be amplified in urban areas due to the material composition. Heat strokes, decreased sleep quality, increased mortality rates, lower work productivity and increased power usage for air conditioning are only a few illustrations of the negative effects of increased temperatures (Solcerova et al., 2017).

Currently, over half the world's population lives in cities. For, among others, economic opportunities and armed conflicts, people have been migrating to urban areas. According to the projection by the UN (2018), approximately 68% of the world population will live in urban areas in 2050. Together with the amplified climate change impacts in urban areas this results in a massive amount of people at risk. There are two strategies for reducing the risk: mitigation and adaptation (Biesbroek et al., 2009). Climate change mitigation is the reduction of the severity of climate change. Mitigation is, for example, found in the Paris Agreement, where many countries commit to mitigate the cause of climate change, greenhouse gasses. In doing so, the goal is to have a maximum increase of 2 degrees Celsius. Climate change adaptation is the process of minimizing the consequences by adapting to future scenarios.

1.2 A NEED FOR SPATIAL ADAPTATION

Climate change adaptation is high on the urban agenda in the Netherlands, embedded in the Deltaplan Spatial Adaptation (DPRA) and National Climate Adaptation Strategy (Nationale Klimaatadaptatie Strategie, hereinafter referred to as NAS). The DPRA set the goal to become climate-proof in 2050 (Rijksoverheid, 2019). The NAS is the overarching strategy for climate adaptation and aim to supplement the DPRA where it is lacking. Overall, these programs aim for a national approach to tackle the climate change induced risks for our economy, health, and safety throughout the levels of the government. To do so, the national budget of climate adaptation impulse regulation is divided over the municipalities, provinces, and water authorities. Together, these governmental bodies can locally invest in the spatial adaptation that will mitigate the negative effects of climate change. This is in line with the findings of Biesbroek et al (2009) that both politicians and academics agree that climate change adaptation needs to be achieved locally.

One attempt to reduce the heat problem and accommodate the peak precipitation is the increase of green infrastructure (GI). This increase of vegetation cools through evaporating water and can reduce stormwater runoff. However, there is a lack of available space in urban areas. Consequently, people have started looking at the potential that can be found on the roof: green roof technology.

According to the latest data from the national register, the Netherlands has 400.000.000

m2 flat roofs, to which approximately 10-15.000.000 m2 is added each year (RIVM, 2019). The often-unused rooftop area has high potential. Hence, scholars from various disciplines have started studying green roofs (Shafique et al., 2018). Most academic literature is focused on the environmental and macro-economic effects of green roofs (Berardi et al., 2014). Among others, the benefits of green roofs include thermal protection (Moonen et al., 2012), sound absorption (H. S. Yang et al., 2012), urban heat island mitigation (Kleerekoper et al., 2012) and reduction of rainwater runoff (Gill et al., 2007).

Studies in the Netherland on green roofs as a strategy for mitigating climate change effects focused on governance arrangements (e.g. Mees et al., 2013) or the role of residents (e.g. Hegger et al., 2017). The study of Mees and Roosmalen (2014) compared the policies of the cities with the highest percentage of green roof implementation. They found that the best practice examples Basel and Stuttgart were already involved in green roof policy decades earlier than Dutch cities. Furthermore, these policies made it obligatory for new buildings to have green roofs. The policies in the Netherlands have not proven to be successful, as currently only 0.5% of the potential buildings in the Netherlands have green roofs (Readar, 2021).

From the governance perspective, the responsibilities should be shared between state, market and civil society, according to Mees et al. (2013). The awareness of these shared responsibilities in the civil society is unknown. Therefore, it is important to understand what can entice the civil society to take responsibility in climate adaptation.

1.3 RESEARCH PROBLEM

Although the benefits of green roofs are abundant, it is not yet in large scale adopted in the Netherlands. The research question that follows is:

What strategies can facilitate the increase in green roof technology adoption?

Supportive questions that aim for a broader expertise of the subject and for answering the studies question:

1. What factors influence the adoption of product innovations?

The analysis and evaluation of the current body of literature on the theory of adoption of product innovations and of the innovation i.e. green roof technology itself, creates an analytical framework. This analytical framework forms the basis of the research and will be built upon by the following sub-questions.

In the diffusion of innovations throughout a bigger public, frontrunners are deemed important (Huitema et al., 2011). Their importance within green roof technology adaptation, however, has not been studied. Subsequently, the supportive question that follows is:

2. How do frontrunners influence potential adopters?

Following the analytical framework of the first supportive question, enriched by the information from the frontrunners, the following question can be answered.

3. What institutional design can facilitate city-wide adoption of green roofs in the Netherlands?

1.4 SOCIETAL AND SCIENTIFIC RELEVANCE

For society it is important to mitigate as much of the consequences of climate change as possible. Hoyios and colleagues (2007) found that in 2006 at least a thousand heat-related deaths took place in the Netherlands. Heat waves, out of all other natural hazards, have been found to kill most people (Gasparrini & Armstrong, 2011). The heat wave of 2003 in Europe resulted in 70,000 excess deaths (Robine et al., 2008), which is expected to be amplified by the urban heat island effect.

While green roof technology has clear environmental benefits, consisting of reduction of stormwater runoff, increased biodiversity, and urban heat island mitigation, many building owners are unaware of these benefits or are unable to value these advantages (Hendricks & Calkins, 2006). To support the state and market in achieving climate-proof living, civil society must take part. The perspective of spatial planners can be of importance for understanding the lack of adoption and, subsequently, for creating possible strategies to facilitate the adoption of green roof technology. The perspective of the spatial planner is holistic, i.e. it perceives the system and its interconnected parts as a whole, not merely as a collection of parts. This perspective is necessary for integrated plan making, where the various aims, needs and wants are considered from different parties. Efforts so far have been made in a fragmented way, which prevents available resources being used in the most effective manner.

The scientific relevance of this study lies in bridging the academic and professional world. The meta-analysis of Shafique et al. (2018) found that there is a gap between the academic and professional world in the expression of green roofs' benefits. Furthermore, it explores the role of frontrunners in the persuasion of potential adopters. Finally, this study takes the position of the civil society as adopter and argues from that position, in contrast to current studies.

1.5 READER'S GUIDE

With the essential factors of this study introduced, chapter two begins with the theory of diffusion of innovation. After that, it addresses ecosystem thinking and describes the ecosystem costs and benefits related to green roofs. Chapter three evaluates potential methodologies and elaborates on the chosen mixed-method methodology regarding the data collection and analysis. Chapter four presents the findings from the interviews and the content analysis. Chapter five translates this knowledge into an institutional design that can increase the implementation by resolving the barriers and making it enticing. Chapter six wraps up the study, emphasizes the contribution of this study and reflects on the process.

2 THEORETICAL FRAMEWORK

This chapter evaluates the current body of literature on the adoption of product innovations. Subsequently, it explains the multifunctionality and versatility of green roofs and its place within the theories of the adoption of innovations. By doing so, the first secondary question *what factors influence the adoption of innovations* can be answered and put into the conceptual model (see Chapter 2.3). Moreover, this conceptual model forms the input for the methodology and will be a tool throughout the entire research.

2.1 RATE OF ADOPTION/CITY-WIDE IMPLEMENTATION

The adoption rate of green roofs can be explained through the lens of innovation theory. Although green roofs have existed for centuries, green roof technology may be taken into consideration as an innovation in the roofing domain, as it differs considerably from conventional roofing technologies. There are many theories on the adoption of innovations and diffusion in social systems of the innovations. Such as the conceptual model of Feitelson and Salomon (2004), that expresses the technical feasibility, social feasibility, and political feasibility. These theories and conceptual models, however, discuss social innovations and examines the political stance in this domain. Furthermore, most theories describe the prerequisites that are necessary for innovation to even be considered or slightly adopted. Currently, there are green roofs and incentives for green roofs in the Netherlands. The difference between incentives and subsidies is that the first encompasses all nudging methods that stimulate or discourage behaviour. Whereas subsidies are only financial incentives to influence the market. This research follows the study of Hendricks and Calkins (2006) and takes one of the oldest theories in social sciences, the *Diffusion of innovation* theory by Rogers (1995) as a framework.

Rogers (1995) defines innovation as "An *innovation* is an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12). It looks at the factors that contribute to the adoption of innovations, and the types of users of these innovations. The influential theory by Rogers (1962; 1995; 2003) is based on the meta-analysis of a wide range of innovations and the corresponding adoption or rejection, i.e. from keyboard layouts to hybrid corn and kindergarten to electric cars.

This study will look at green roofs as product innovation, as the replacement for conventional bitumen flat roofs. Although the diffusion of an idea and a product goes through the same stages of adoption, the rate of the latter is generally faster.

The literature on variables that influence the rate of adoption of innovations tends to fall into five areas:

1) **the perceived attributes of innovations** i.e. the characteristics that are perceived by the potential adopter, such as the relative advantage;

2) **type of innovation-decision** i.e. the size and role of the adopter, such as individual or authoritative decision-making;

3) **the characteristics of the adopter** i.e. what kind of person the adopter is and, as a result, how willing to adopt or reject an innovation;

4) **communication channels** i.e. the type of communication and

5) **the extent of change agents' promotion efforts.**

These variables tend to affect the decision-making in different parts of the process. The different variables affecting the adoption of the product innovation at different moments in the decision-making process is shown in Figure 1. Understanding the theoretical variables that influence the decision-making in the adoption of green roofs is necessary for developing strategies that will contribute to increased adoption.

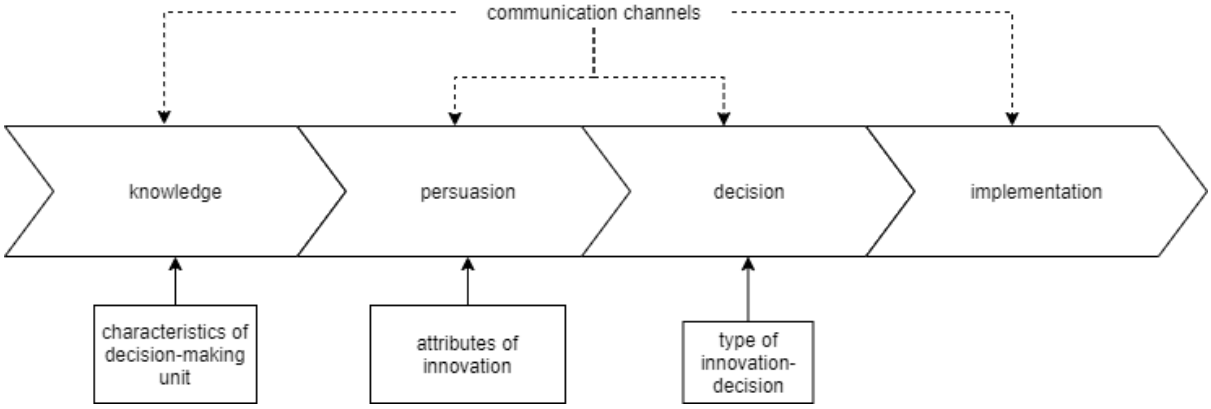

Figure 1. Variables affecting the adoption of innovations (based on Rogers, 1995). The characteristics of the decision-making unit determine the willingness to adopt an innovation and what kind of communication channel has the most effect in changing this, the perceived attributes of the innovation determine the extent to which a potential adopter is persuaded, the type of innovation-decision influences the decision-making process before the implementation.

2.1.1 Characteristics of the adopter

The willingness of the decision-making unit, i.e. the potential adopter, to adopt an innovation is determined by the characteristics of the adopter. The theory of Rogers, (1995) distinguishes five types of groups of people that adopt an innovation: innovators (2.5%); early adopters (13.5%); the early majority (34%); the late majority (34%); and laggards (16%) (See Figure 2).

To these groups of people, the most efficient marketing differs. The distinct communication channels and messages should be tailored accordingly. The first group, the innovators, is a small though important group, as they are always the first to learn about and adopt an innovation. They are risk-taking, adventurous and like being on the cutting edge (Kaminski, 2011). The innovators introduce innovations to the larger population by sharing their experiences with their friends and communities. The early adopters or visionaries are also a small forward-thinking group and are often highly respected as opinion leaders. Their endorsement of innovation plays a key role in what is called crossing the chasm: bridging the gap between the trendsetters and the majority. About two thirds (68%) of the population fall into either the early or late majority groups. The early majority or pragmatists, take time to make decisions. They will observe others' experiences and will only adopt a product once they are convinced it has benefits and it is the status quo. The late majority or conservatists are more resistant to change, but they are very responsive to peer pressure. They want innovations to be very well tested and widely used before they will risk trying them. Finally, the last group to adopt a product or innovation, is called the laggards. Laggards or sceptics are highly resistant to change and they can be hard to reach with marketing campaigns, because they often have minimal exposure to media. They wait until the innovation is completely mainstream before they adopt it and in some cases they never do. Understanding this division in the public, is necessary to tailor communication channels and messages as this will improve the chance of catalyzing widespread adoption.

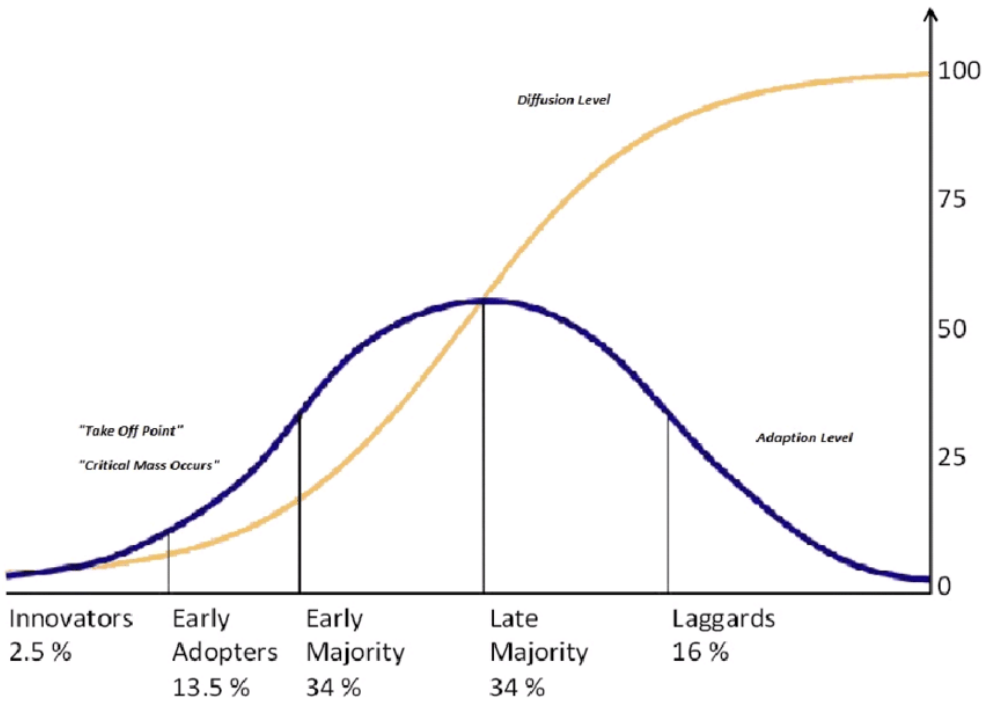

Figure 1. Adoption and diffusion level of innovations with the corresponding characteristic types of adopters. On the x-axis the type of adopters and the corresponding amount is shown. The y-axis shows the diffusion level in percentages (source: Martinaro & Liu, 2015, adopted from Rogers, 1995).

2.1.2 Perceived attributes of innovations

The characteristics of the innovation, the attributes, determine to what extent the decision-making unit is persuaded into adopting the innovation. Some attributes, such as relative advantage, have shown to be a more important predictor of the rate of adoption than others (Rogers, 2003). The five perceived attributes of innovations are relative advantage, trialability, observability, compatibility, and complexity.

First of all, relative advantage. Rogers (1995) states that the likelihood of the adoption of the innovation increases if it is appeared to have a relative advantage over the current technology. Other scholars emphasize that the relative advantage is one of the most prominent indicators of the innovations' adoption rate (Huitema et al., 2011; Moore & Benbasat, 1991). The relative advantage is determined by "the degree of economic profitability, low initial cost, decrease in discomfort, social prestige, savings in time and effort and the immediacy of the reward" (Rogers, 1995 p. 216). The perceived relative advantage depends on the marketing and understanding of the costs and benefits. Adopter incentives of direct or indirect payment can increase the relative advantage in the degree of economic profitability, initial cost and immediacy of the reward and, subsequently, speed up the rate of adoption (Moore & Benbasat, 1991). Green roofs, have a relative advantage over conventional roofs in performance, aesthetic, environmental and economic domains but have high initial costs and no immediate rewards. The perceived relative advantage is, therefore, debatable and depends on the knowledge of the adopter and incentives. Important to note is that the relative advantage is deemed the most important predictor of the rate of adoption. One limiting factor in the relative advantage is the perceived time lapse before the beneficial consequences can be seen or felt. Therefore, incremental innovations diffuse with less effort than preventative innovations.

Secondly, ease of trial or trialability has been observed to increase the adoption of an innovation. In software, this would be a trial that shows a part of the product, which is limited

in use but shows how the product functions. Green roof components, such as a sedum mat, can easily be tried on a small scale before applying to the entire roof system.

Thirdly, the observability of innovations contributes to the rate of adoption. A side-by-side comparison of green roofs and conventional roofs, show the potential adopters the visible benefits and adds to the adoption rate. Furthermore, the visibility of innovation shows the potential adopter, that others have adopted the innovation which can result in a conversation. Another option for increasing the visibility, in line with the trialability, is the displaying of the various green roof components to potential adopters in e.g. neighbourhoods. To influence the observability and thus stimulate the adoption rate, diffuser incentives can add to the observability of innovations. A diffuser incentive is rewarding for the earlier adopter to convince another to adopt the innovation.

Fourthly, compatibility is the degree an innovation is congruent with current practices and needs of potential adopters. Green roofs share the same basic functions as conventional roofs (e.g. safety, dry indoor), with additional benefits, but are limited to roofs with a slope of 35 degrees and lower. Additionally, the building construction should be strong enough to hold the addition of a green roof. The weight depends on the design of the green roof. However, in general, for extensive green roofs the construction strength should hold an extra maximum of 190 kg/m^2 (Shafique et al., 2018). For intensive green roofs, this can be up to 300 kg/m^2 (Bianchini & Hewage, 2012). Moreover, innovations may be perceived as an interrelated bundle of new ideas. For example, green, blue, green-blue and solar roofs are all innovations in the same domain, that might be perceived as interrelated. Under such circumstances, a change agent can also additionally find it beneficial to sell a cluster or bundle of innovations to clients, instead of dealing with every new concept separately. Solar roofs might be a competition for green roofs, as the energy transition is taking place to renewable sources and as it reduces the costs of living for those that own a solar roof. Finally, complexity is the relative difficulty to understand, implement and use innovation. The complexity of an innovation is the only attribute that inhibits the rate of adoption. Implementing green roofs, when the basic conditions are fulfilled, is not considered complex (Kabisch et al., 2016). However, the way to approval and subsidy for green roofs process could be considered complex and should be studied.

2.1.3 Type of innovation-decision

The type of innovation decision influences the rate of adoption of innovations. There are three types of decision-making units: optional-individual, collective or authoritative. The first two decision-making units, consist of persons of equal decision-making power whereas the latter concerns a few individuals with power, high social status or technical expertise that decide for a larger population (Rogers, 2003). In general, individual-optional decisions adopt innovations faster than collective or authoritative. The more people involved in the decision-making process, the slower the adoption rate. To tailor a strategy it is, therefore, important to understand who and how many persons are involved in the decision-making process.

2.1.4 Communication channels

The awareness and perception of the attributes, is crucial as it directly influences the decision-making process (Hendricks & Calkins, 2006). The communication channels are, therefore, of immense importance for the distribution of knowledge, the persuasion by the attributes of the innovation, and the decision-making. The literature distinguishes two types of communication channels through which the information can be distributed: interpersonal and mass media

(Rogers and Kincaid, 1981). These two channels encompass a wide array of sources, such as neighbours, friends or frontrunners and newspapers, television or the internet respectively. Some sources (e.g. frontrunners), can use both interpersonal communication (e.g. information meetings) as a channel, as well as mass media (e.g. newspaper) to convey their message. This study will look at both the different channels used for spreading knowledge and/or influencing the decision-making of potential adopters and the types of sources that are used for this message. The various types of groups of people are informed through different channels, as shown in Table 1.

Table 1. Innovation adopter types and their communication channels (source: Rogers, 1995, 2003; Hendricks and Calkins, 2006)

Innovation adopter types	*Communication channels*	*Strategies*
Innovators	Very little effort to appeal	
Early adopters	Interpersonal, mass media	Manuals and information sheets
Early majority	Interpersonal, mass media	Success stories and evidence of effectiveness
Late majority	Mass media	Information on successful implementation
Laggards	Mass media	Peer pressure and statistics

The communication channels through which the information can be distributed and, thus, a strategy to appeal to the correct type of potential adopter will catalyze widespread adoption (Rogers and Kincaid, 1981). Therefore, it is important to know the current diffusion level and the corresponding type of adopters that should be targeted to tailor a suitable strategy.

2.1.5 The extent of change agents' promotion efforts

In the theory of diffusion of innovation, the fifth component is the promotion efforts of change agents. A change agent is a person or agency who impacts others' innovation decisions, positively or negatively. In the domain of spatial planning, change agents are often referred to as policy entrepreneurs, advocates or frontrunners (Huitema et al., 2011). Policy entrepreneurs/advocates are change agents that influence the agenda-setting of (local) governmental bodies. They are, thus, concerned with impacting the innovation-decision of authorities, whereas frontrunners are involved in impacting innovation-decisions of individuals or collectives. Change agents, albeit policy entrepreneurs or frontrunners, are important for increasing local institutional capacity and contributing to community resourcefulness. This study is interested in the frontrunners function and thus change agents are hereinafter referred to as frontrunners.

Frontrunners have expert knowledge on innovation and can function as a communication channel (i.e. interpersonal). Not only is their function important in sharing knowledge about the innovation, but they can also persuade the potential adopter by increasing the perceived relative advantage (e.g. contracts with suppliers for mass adoption), observability (e.g. green roof walking tours), trialability (e.g. bringing sedum mats to display), and decreasing complexity (e.g. information sheets on implementation and subsidies). The role of the frontrunners, in the early adopters and early majority phase, is thus important and should be studied in-depth.

To conclude and reflect on Rogers' theory of diffusion of innovation has limitations amongst which the social support to adopt the innovation (Mintrom, 1997), which applies to an idea as innovation, not a product. Furthermore, according to Mintrom (1997), the importance of change agents is not emphasized sufficiently. Change agents, often referred to as policy entrepreneurs in the spatial planning domain, influence the agenda-setting of (local) governmental bodies. By pushing innovations on the agenda of governmental bodies, the exposure of the innovation is expanded, increasing the diffusion of the innovations. Additionally, when innovations are incorporated in policies, the momentum of adoption will strengthen.

2.2 ECOSYSTEM SERVICES OF GREEN ROOFS

In theory, the most influential attribute of innovations is the relative advantage. This chapter elaborates on the costs and benefits of green roofs. Most research that investigates the benefits of green roofs, looks at the economic benefits (Niu et al., 2010), environmental benefits (Berardi et al., 2014) or social benefits (Langemeyer et al., 2020; Sanchez & Reames, 2019). This research takes a holistic perspective and places green roofs as a product in the domain of ecosystem services. Ecosystem services are referred to as the benefits the human population derive from ecosystems (Bolund & Hunhammar, 1999). It is important to take this holistic perspective as it allows for insights into the segregation of benefits. And potentially how processes might be streamlined to integrate the segregated perspectives from other domains. Ecosystem services also include the benefits that people derive from green roofs, that can't be quantified or expressed financially, irrespective of the value it has.

The term and definition of ecosystem services gained momentum after 2005. In 2001, the United Nations Secretary-General Kofi Annan initiated the Millennium Ecosystem Assessment (MA, 2005), which was published after the collective effort of 1300 scientists from 2001 onwards and subsequently stimulated the ecological turn in the planning paradigm (Fisher et al., 2009). The report assessed multiple facets of ecosystems such as freshwater, climate regulation and nutrient cycling, and noticed that 15 of the 24 ecosystem services were degrading, making the world even more aware of the necessity to change behaviour.

The quality and quantity of ecosystem services (i.e. benefits) that can be derived from green roofs are bound by the size of the implementation and the used materials. For instance, precipitation runoff can, to an extent, be mitigated and thus prevent pluvial flooding with the city-wide implementation of intensive green roofs. However, a single green roof will not be enough to sufficiently alleviate the pressure of the sewer system. Additionally, the investors in and owners of the green roofs are not directly rewarded by all the benefits. Alleviating the pressure of the sewer systems won't directly be a benefit for the investor but for the owners and maintainers of the sewer systems, and the insurance agencies that would cover the damage due to pluvial flooding. Therefore, it is vital to understand what the benefits of green roofs are and to whom and, subsequently, and why it is of benefit.

2.2.1 (Thermal) protection of the building

In the summer, solar radiation on buildings and outdoor temperature increases indoor temperature. Raising energy consumption for the maintenance of a pleasant temperature by cooling. In the winter, the outdoor temperature decreases the indoor temperature of buildings, increasing the need for heating. Adding another layer of insulation on a traditional roof will decrease the energy consumption of buildings. Green roofs are an extra insulation layer,

making buildings more “energy-efficient and eco responsive” (Kumar & Kaushik, 2005 p.1510). The energy needed for heating in colder periods and cooling in warmer periods relies on the insulation of the building. The case study of Niachou and colleagues (2001) in Greece found that for non-insulation, moderate insulation and well insulation respectively 48%, 7% and 2% energy saving consumption can be found annually. Currently, in the Netherlands, cooling indoors is not as necessary as in Greece for the average temperature in the summer. However, thermal protection of the building and the energy consumption that accompanies it, will gain increasing importance in the coming decades, as heat intensity increases due to climate change (Moonen et al., 2012). The study of Santamouris and colleagues (2001) found that the cooling load of urban buildings may be doubled at an increase of 10 °C and even more at higher temperatures. Next to the energy-saving, which could be seen on both individual (i.e. financial) and collective (i.e. lower pressure on energy grid) benefits, reduction of heat indoors is seen as an important factor contributing to health, thermal comfort and subsequently well-being (Kleerekoper et al., 2012). Being healthier is beneficial for an employer in terms of sick leave and health insurance agencies in terms of healthcare costs.

Thermal comfort, the human sensory perception of temperature, is a benefit that can be derived from the insulation properties of green roofs, both indoors and outdoors (van Hove et al., 2015). The combination of the weather parameters radiation, temperature, airflow and humidity, determine the perceived thermal comfort that correlates with physiological stress and thus, subsequently, with health (Peng & Jim, 2013). Although thermal comfort is subjective and personal, the combined weather parameters give an estimation of the perceived thermal comforts and as such can be modelled and predicted (e.g. Peng & Jim, 2013; Moonen et al., 2012). The case study of Peng and Jim (2013) in Hong Kong finds – in line with the findings of Susca and colleagues (2011) – that vegetation in urban areas increases thermal comfort. The contribution of wide-spread green roofs in a neighbourhood to thermal comfort is the highest at the rooftop level itself, where extensive green roofs cool between 0.1 and 1.6 °C and intensive green roofs cool between 0.2 and 2.1 °C (Peng & Jim, 2013). At the pedestrian level, the cooling effects are between 0.0 and 0.7 °C for extensive green roofs and 0.0-1.7 °C for intensive green roofs. It is important to mention, two additional findings from this study, 1). The intensive green roofs have a higher increase of thermal comfort than extensive green roofs, and 2) the improvements of thermal comfort are limited to the podium-level of the green roofs and hardly improves thermal comfort at ground level. Thermal comfort is not only important for the individual but also for (if applicable) their employer. Work productivity is correlated with room temperature, and although personal preferences apply to thermal comfort, the study of Zander and colleagues (2015) found that the work productivity decreased significantly with temperature increase and estimated that the heat stress-related issues amount to 0.33 to 0.47% of the national GDP in Australia.

2.2.2 Sound absorption/noise regulation

Quietness and lower levels of noise are beneficial for the health and well-being of people (WHO, 2011). Urban areas are full of materials that are acoustically rigid, such as streets, bricks and concrete, leading to a reflection of the emitted sound waves and that results into large sound pressures (Van Renterghem et al., 2013). Green roofs can, as consisting of physically flexible material, reduce sound pressures. It mitigates noise in two ways, sound insulation and noise absorption. Sound insulation is the reduction of sound at the top of the roof, where the sound penetration is reduced by the extra layer on top of the traditional roof (Van Renterghem et al., 2013; Van Renterghem & Botteldooren, 2009, 2011). It creates an extra barrier for the sound

and thus reduces the noise from outside indoors, whereas noise absorption reduces the further spread and reflectance of sound waves. Noise absorption occurs at both the vegetation and the soil layer (H. S. Yang et al., 2012). The soil's absorption is the strongest when there are many open pores, which is the case with green roofs. Furthermore, the vegetation layer scatters the sound waves by the different vegetation elements, further absorbing the noise (H. S. Yang et al., 2012). Noise induces interruption of sleep which increases stress and, subsequently, has negative health effects (Muzet, 2007). Therefore, the reduction of noise is an important ecosystem service that can be derived from green roofs, as it improves quality of life for the individual.

2.2.3 Aesthetics, spiritual and psychological services

Aside from the regulating ecosystem services that green roofs provide, there are "nonmaterial benefits people obtain from ecosystems" which are called cultural ecosystem services, or CES in short (MA, 2005, p.29). CES has, until recently, not been researched thoroughly despite their importance for urban quality of life, as it is hard to quantify compared to the material benefits of ES. For example, CES contributes to reducing stress (Ward Thompson et al., 2012), improving concentration and cognitive ability (Gidlow et al., 2016), and improving social health and providing inspiration (Jennings et al., 2016). These benefits correlate with broader studies on the effect of greenery on cognitive functions (Keniger et al., 2013). The aesthetic value not only adds to the spiritual and psychological well-being, but also increases property value as well (Bockarjova et al., 2020). In this sense, a green roof is an investment that rewards not only in ecological but also in economic value, making it more attractive for the adopter. It is, however, important to note that the rise of property value might induce gentrification (Bockarjova et al., 2020).

2.2.4 Fighting urban heat island effects

Urban areas have a higher air temperature than the surrounding rural areas, this is called the urban heat island (UHI) phenomenon (Kleerekoper et al., 2012). Kleerekoper and colleagues (2012) state that "the extent of the temperature differences vary in time and place as a result of meteorological, locational and urban characteristics" (Kleerekoper et al., 2012, page 30). The intensity of the UHI depends on the energy balance in urban areas that are affected by a decrease in urban albedo (Sanchez & Reames, 2019; Santamouris, 2014), thermal properties of building materials (Gobakis et al., 2011), air pollution (Kleerekoper et al., 2012), urban canyon (Landsberg, 1981), anthropogenic heat such as traffic or industries (Hart & Sailor, 2009) and a decrease in evaporation rate (Susca et al., 2011). Vegetation, such as green roofs and urban green spaces, reduces the urban heat island effects through evapotranspiration, storage of water, increase of albedo and shade (Susca et al., 2011). Although the decrease in urban heat island effect improves the well-being and health of the individuals, there is a collective effort and city-wide implementation needed to reduce the urban heat island.

"According to the Environmental Protection Agency, the most important negative impacts of the UHI are increased energy use for cooling, higher emissions of air pollutants, human health risks and discomfort, and lower water quality" (Estrada et al., 2017, p. 1). The UHI effect can exacerbate heat waves, which, among other impacts, have been shown to cause economic losses because of reduced labour productivity (Zander et al., 2015). There is an abundance of people that benefit from the reduction of urban heat islands, these include health care institutions, individuals, employers, and governments.

2.2.5 Reduction of rainwater runoff

The ecosystem service reduction of rainwater runoff refers to stormwater management. One of the many effects of climate change is the increase in peak precipitation. Urban areas are mostly made of impervious materials such as concrete, tarmac and stone, which increases surface water run-off and limited rainwater storage. The lack of storage capacity and increased runoff results in sewage overflows and, subsequently, pluvial flooding. Green roofs decrease the pressure on the sewerage systems in two ways: reducing the volume of runoff and delaying the stormwater (Getter & Rowe, 2006). The total amount of reduction of pressure on the sewerage system depends on the design configuration of the green roof and the size. The study of Zhang *et al.* (2015) found that on average 77.2% of the rainfall-runoff was reduced by green roofs in 19 events. The reduction of rainwater runoff is beneficial for water authorities in decreasing pressure on the sewerage system and insurance agencies, as it mitigates the risk of pluvial flooding damage.

2.2.6 Improved water and air quality

Although there has not been a long term monitoring of green roofs, in respect to water and air quality improvements (Czemiel Berndtsson, 2010; Shafique et al., 2016), green roofs provide short term improvements in both water (Berardi et al., 2014) and air quality (Niu et al., 2010) by phytoremediation. The improvement of water quality is especially relevant in developing areas where water treatment facilities are limited or non-existent. In developed areas, the benefits of improved water quality rely on the reduction of the burden of the water treatment facilities. The air quality improvements, however, are both in developed and developing areas relevant. The study of Yang, Yu and Gong (2008) found that green roofs clean large amounts of pollutants (e.g. NO_2, SO_2, O_3 and PM_{10}) from the air. The removal rate of green roofs of 97 kg ha^{-1} yr^{-1} is comparable with the removal rates of urban forests which is a cheaper alternative if there is space available (J. Yang et al., 2008).

In line with the improvement of air quality are carbon capture and storage. The reduction of CO_2 out of the atmosphere, is not only beneficial for the health of people but also helps to reduce the pressure on the environment. Reducing carbon footprints is a high priority, and can be done by reducing the CO_2 released in the air (e.g. filters) or by increasing the uptake of CO_2, by plants. The study of Li *et al.* (2010) found that, on a sunny day, green roofs lower the CO_2 concentration by 2% in the adjacent region. Additionally, particulate matter (PM_{10} and $PM_{2.5}$) are increasingly correlated with adverse respiratory and cardiovascular health effects (Kim et al., 2015). As an effect, the particulate matter should be reduced to increase the air quality. Vegetation cleans particulate matter out of the air. A single green roof does not make a significant difference.

2.2.7 Ecological preservation

Green roofs, as a part of green infrastructure, has an important function in ecological preservation, providing habitat and supporting biodiversity. Francis and Lorimer (2011) argued that for ecological preservation and optimizing green roofs for supporting biodiversity, the design of green roofs needs to be heterogeneous and city-wide. The choice in vegetation (e.g. sedum, mosses, grasses, wildflowers, etc.) determines the potential biodiversity in such areas. Many small insects, such as beetles or butterflies, make use of the vegetation as a habitat (Getter & Rowe, 2006). As organism need to adapt to new habitats, the biodiversity on green roofs increases in time (Getter & Rowe, 2006). Furthermore, within ecological preservation and inherently linked to biodiversity, is pollination. Pollination, the transfer of pollen to vegetation

to allow fertilization, is necessary for the reproduction of vegetation. Insects, and particularly bees, are necessary for the pollination process and are of increasing importance in our ecosystem. There is not a single individual that benefits from ecological preservation, however, the collective does.

2.2.8 Urban agriculture

The last potential ES that can be attributed to GRs is urban agriculture. Urban agriculture, growing food in cities, has been gaining popularity for improving food security in the global south and bringing the same multifunctional benefits as green roofs (Steenkamp et al., 2021). However, concerns are raised about the quality of the food. The pollutants that vegetation filters out of the air and water that gets stored in the plants, which with consumption would enter the human body. Although most of the pollutants are stored in the roots (phytostabilization) of the plants, and the production on rooftops often does not include growing root vegetables, the long-term effects of urban agriculture have not been studied extensively (Specht et al., 2014). The benefits of urban agriculture lie with the users or owners of the buildings, the product can be either sold or consumed. The main reason for urban agriculture to take place is for food security, with which the Netherlands has no problem.

2.2.9 Costs of green roofs

Concluding from the previous paragraphs, the benefits are abundant. However, the innovation – that is green roofs – is not (yet) adopted in high volume in the Netherlands. To investigate the possible reason for the lacking implementation of green roofs, the costs and constraints need to be considered. Costs are considered in the broadest sense of the word: what are the (financial) requirements for green roofs. The literature states that the largest challenge within the green roof implementation is the initial large construction expense. Green roof prices depend upon the numerous elements which include location, labour costs, green roof type and material. However, the fact that almost all the financial costs are at the implementation of the green roofs makes it a barrier. Bianchini and Hewage (2012) stated that the installation costs including material of the extensive green roof in British Columbia range between 12 CAD/ft^2 and 15 CAD/ft^2, which at the time of writing converts to €87,58/m^2 and €109,30/m^2 respectively. The recent Dutch prices and incentives need to be studied to make a relevant case. Installation prices and price advantage evaluation of various research (Carter & Keeler, 2008; Whatley, 2011) confirmed that green roof is much less expensive than the conventional roof. These studies investigated the increased lifespan of green roofs compared to traditional roofs, which increased by up to 20 years, making the green roofs more cost-effective in the long run.

To increase the adoption of innovations in general and green roofs in particular, financial incentives are given from various sources, including the national government, local government, water authority. Incentives, according to Rogers (1995), can be subdivided into two categories: adoption incentives and diffuser incentives. Adoption incentives are aimed at individual adopters, whereas diffuser incentives are aimed at influencing the persons that already have adopted the innovation to diffuse it. In the sense of green roofs, the adoption incentives are targeted at individuals and diffuser incentives target a larger population. For example, a diffuser incentive for green roofs can be the collective adoption of green roofs by an entire neighbourhood. Linking in with economies of scale, the individual costs should be lower.

2.3 CONCEPTUAL MODEL

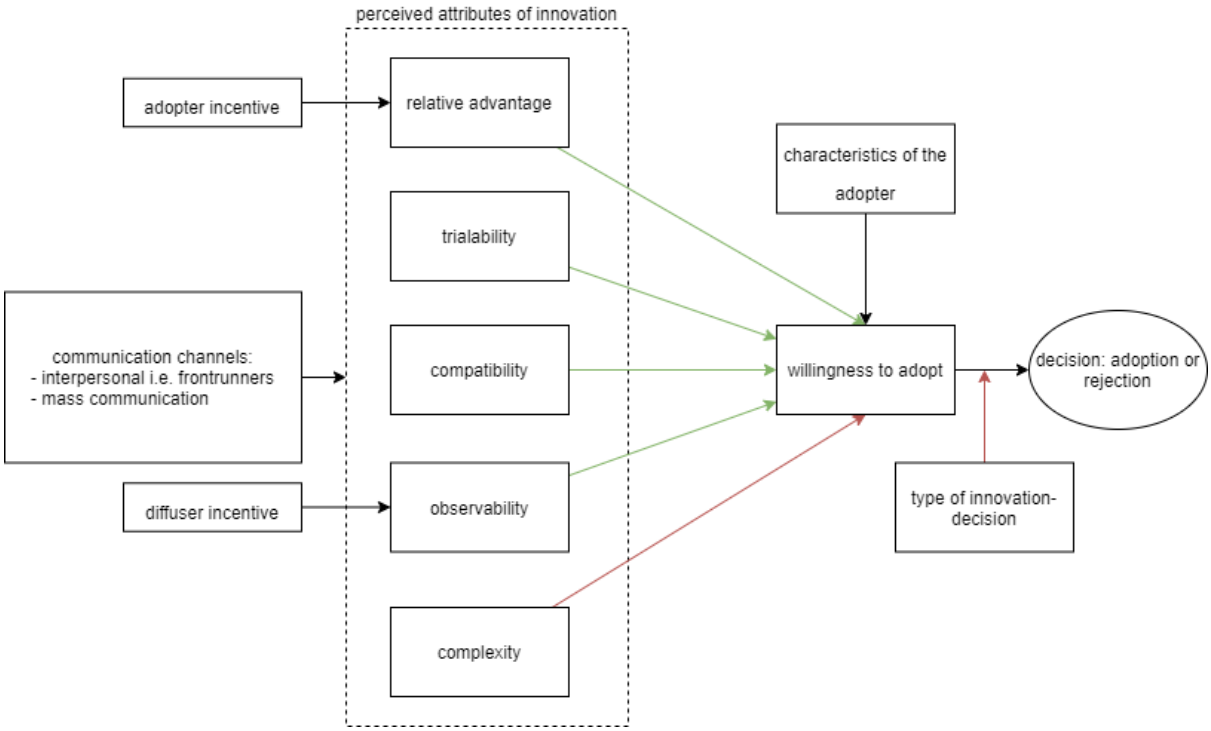

Figure 2. This conceptual model shows the variables that contribute to the decision-making of the potential adopter with relationships both positive (green) and negative (red).

3 METHODOLOGY

The conceptual model that is the product of the theoretical framework is used as the basis of this research. Therefore, the various communication channels (i.e. interpersonal and mass media), the attributes of innovation (i.e. complexity, relative advantage, compatibility, observability and trialability), the incentives and the decision-making units within the Dutch context need to be explored to create an institutional design. A good research design is the backbone of every research and helps to achieve valid, reproducible, and generalizable outcomes.

3.1 RESEARCH METHODOLOGY

As stated in the theoretical framework, this research is written from the perspective of a spatial planner. This perspective is holistic and integrated; it looks at all the possible perspectives and aims to bring the perspectives together. In this case, it looks at the potential adopters' view on green roofs and how it is affected by various communication channels in the decision-making process. In doing so, it does not take a sociology or psychology worldview that aims to understand the social construct that determines the decision process, nor does it take the biological worldview to test the magnitude of all the benefits and which design variables alter this magnitude.

This study takes the communicative spatial planning worldview, in which spatial adaptation can be achieved through communication between stakeholders. The data on the communication channels and their effect on potential adopters is acquired by the following strategy.

The strategy for this research consists of three phases of data collection: (1) secondary data collection through content analysis, (2) primary data collection through interviews, and (3) secondary data collection through content analysis. By collecting secondary data, such as documents before the interview, depth can be added. Subsequently, information that was not collected the first time, of secondary data collection, that comes up in the interviews can be studied afterwards. To understand the role of frontrunners, in the adoption rate of green roofs, the persuasion techniques that are used by frontrunners are studied. Finally, to explore the type of groups that adopt green roofs, in-depth semi-structured interviews are conducted with six frontrunners of green roofs.

The participants of the interview are frontrunners. Frontrunners both inform potential adopters of the possibilities and in return, the potential adopters, raise the challenges to the frontrunners. Frontrunners are experts in convincing or helping others, to adopt green roofs, by sharing their knowledge. This study assumes that, through trial and error, the frontrunners have learnt what type of information sharing has the highest probability to persuade a potential adopter. Additionally, they are within a network of other green roof advocates and aware of the projects in their region, that might be complicated to access through the internet. In this sense, the frontrunners can explicitly state their role, the activities they perform, and give insight into how they influence the potential adopters. At last, frontrunners and other stakeholders are underrepresented in the current body of literature.

3.2 DATA COLLECTION

For this study, both primary and secondary data was collected, to get a comprehensive understanding of the adoption of green roofs in the Netherlands. The primary data is collected

through interviews and the secondary data through content analysis. The interviews represented the interpersonal communication channel, whereas the content analysis represented the mass media communication channel. A mixed-method approach increases the understanding of the subject, whilst enhancing the validity of the results (Morse, 2016).

The premise of this methodology is that the integration allows a more complete and synergistic utilization of data, than single quantitative or qualitative data collection and analysis. Although a mixed-method approach most often refers to a combination of both qualitative and quantitative methods, the combination of multiple qualitative data sources and methods, is likewise considered a mixed-method approach (Hennink et al., 2020). This research combines two qualitative data collection methods, interviews and content analysis. Hennink and colleagues (2020) consider qualitative methods most suitable for understanding social processes.

3.2.1 Interviews

The primary data was collected through semi-structured interviews. Semi-structured interviews have the benefit of being both rigid and flexible; a predetermined structure, of which can be deviated to address other issues, if necessary. The interviews are semi-structured through the use of an interview guide (for more information, see Appendix 1).

The interview guide is inspired by the communication channels' influence on the decision-making process of potential adopters, as per the conceptual model. It includes background information of the interviewee, the motivations for and challenges of implementing green roofs, the persuasion of others and the type of adopters. Questions were asked, how they have convinced or persuaded others in the adoption of green roofs and whether that would be a standard procedure, or that it would be tailored to the potential adopter. The interview technique was based on "the active interview" written by Holstein and Gubrium (1995). In this book, the emphasis lies on making the interviewee feel at home, by creating a pleasant and good atmosphere in which the interviewee can speak freely without interruption. Additionally, by staying silent and friendly smiling, the interviewee will answer more elaborately than without this technique.

Purposive sampling was applied to select potential participants. According to Heslinga (2012), purposive sampling is effective, only if a restricted number of participants from a population serves as a legitimate source. Potential participants were contacted through e-mail, phone, LinkedIn and contact pages, on websites from various urban areas in the Netherlands. Through the process of interviewing the first selection of participants, others were suggested by the participants, also referred to as snowball sampling (Goodman, 1961). Snowball sampling can introduce potential participants that are not in the foreground, or that are easier accessed through others. Table 2 shows the six participants, the area in the Netherlands that they work in and their relation to being a frontrunner (i.e. paid or voluntary). All interviews were, due to the COVID-19 pandemic, conducted online through Google Meet and executed in Dutch. Recording the interviews, after having both verbal and written informed consent, enabled transcribing of the interviews. The interviews took between 30 and 40 minutes, depending on the length of the answers given by the participants. From half an hour to an hour is considered a good length for a semi-structured interview (Crabtree and DiCicco-Bloom, 2006). The dates of the interviews are included in Table 2.

Table 2: Description of interview participants, their corresponding area they are involved in and their financial involvement

Interviewee	*Urban area*	*Paid/voluntary*	*Date*
A	Amsterdam	Paid	22/06/2021
B	Rosmalen	Voluntary	23/06/2021
C	Rotterdam	Voluntary	25/06/2021
D	Rotterdam	Voluntary	27/06/2021
E	Herveld	Paid	28/06/2021
F	Groningen	Paid	28/06/2021

3.2.2 Content analysis of documents

Additional to the interviews, documents were analysed through content analysis. Content analysis is at first defined by Berelson (1952) as "a research technique for objective, systematic and quantitative description of the manifest content of communication" (Berelson, 1952, p. 18). However, content analysis is more than merely a quantitative description, as it can produce objective, systematic and generalizable results from qualitative data (Prasad, 2008).

The secondary data is both collected before the interviews and after the interviews. On the one hand, this allowed for more depth in the interviews, as the information before the interview generated insight that could trigger the interviewee. On the other hand, the information that the participants delivered directed the researcher to documents that weren't studied before the interview. This three-step plan, therefore, creates both depth in the research as width. The data consists of written documents, i.e. policies, newspapers and websites, and transcriptions of verbal documentation such as podcasts and television. The content analysis aimed to give depth to the interviews, and to understand the costs and subsidies in the Netherlands. Subsidies for green roofs in the Netherlands are often local and depend on the context. Therefore, the three largest Dutch cities The Hague, Amsterdam and Rotterdam were chosen for studying local subsidies, as larger cities have greater consequences that need to be mitigated and should thus be better prepared. These cities will, therefore, need to be more proactive to mitigate greater risk.

The search terms 'green roofs' and 'subsidy green roofs' for respectively the Netherlands, the Hague, Amsterdam and Rotterdam were used. As the regular Google interface uses tracking and personalizes the order of the website suggestions, the incognito version of Google was utilized, increasing the replicability of the study. Furthermore, the digital versions of the three Dutch newspapers NRC, Volkskrant and de Telegraaf were scanned, on June 19th, for articles on green roofs. This resulted in a total of three articles. Using the Google News function, more regional or local newspapers gave results on the search query, however, it can be debated whether that is mass media. Table 3 displays the documents that were used for the content analysis.

Table 3: List of analyzed websites, podcasts, television interviews, news articles and policy documents that are used for the content analysis

Document type	*Title*	*Source/author*	*Accessed on*
Website	Groendak. Implementation and supply of green roofs	Groendak.nl	June 20, 2021
Website	Groenedaken.net the green roof webshop	Groenedaken.net	June 20, 2021
Website	Green roof Milieucentraal	Milieucentraal.nl/huis-en-tuin/klussen/groen-dak	June 20, 2021

Website	Rooftoprevolution. More green roofs in the Netherlands	Rooftoprevolution.nl	June 20, 2021
Website	Dakdokters we make the city healthy	Dakdokters.nl	June 20, 2021
Website	Green deal green roofs	Greendealgroenedaken.nl	June 20, 2021
Website	The green counter	hetgroeneloket.nl	June 20, 2021
Podcast	S02E09 – the chances are on the roof	Data Studio, soundcloud	June 21, 2021
Podcast	Rooftop revolution – ASN bank – Let's talk business Duurzaamheidsspecial	New Business Radio, soundcloud	June 21, 2021
Television interview	Tijd voor Max	Omroep Max	June 14, 2021
Television interview	Taking resilience to a higher level	TEDxGorinchem	June 15, 2021
News article	Mastering the rainstorms and creating a greener garden	https://www.telegraaf.nl/lifestyle/1327269498/zo-word-je-regenbuien-de-baas-en-creeer-je-een-groenere-tuin	June 19, 2021
News article	The benefits of a green roof	https://www.telegraaf.nl/lifestyle/1293629707/de-voordelen-van-een-groen-dak	June 19, 2021
News article	the leaden expectations of green roofs	https://www.nrc.nl/nieuws/2021/06/18/de-loodzware-verwachtingen-van-groene-daken-a4047851	June 19, 2021
Policy document	Subsidy regulation green in Amsterdam	Municipality of Amsterdam	June 28, 2021
Policy document	Stimulating regulation tailor-made climate adaptation Delfland	Hoogheemraadschap van Delfland	June 28, 2021
Policy document	Subsidy climate adaptation until €1.500	Municipality of Rotterdam	June 28, 2021
Policy document	Stimulating regulation climate active built area *Aa en Maas*	Water authority Aa en Maas	June 28, 2021
Policy document	Subsidy green roofs 2021	Municipality of the Hague	June 28, 2021

3.3 DATA ANALYSIS

To create solid, reproducible, transparent, and useful results, a systematic evaluation of the data is necessary. First, the recordings from the semi-structured interviews were transcribed manually, verbatim. Although there is an abundance of software that can automatically transcribe video or audio files, the accuracy of the software in recognizing Dutch sentences is not sufficiently good. Subsequently, the transcripts of the interviews and the documents from the content analysis, were analysed with the software Atlas.ti by coding the data. The coding of the data helps to extract information by organizing the data and attaching values to the data

(Auerbach & Silverstein, 2003). This coding was on implicit statements (i.e. statements that suggest though not directly express) and explicit statements (e.g. animals are coded with biodiversity).

To be transparent and leave little room for ambiguity, examples and definitions from the literature are used in the coding scheme. The analysis of the data was executed in a hybrid manner i.e. deductive and inductive coding. The first, deductive coding, is the testing of expected theoretical concepts on the data. These codes are hierarchical with a category, code and sub-code, and include the categories persuasion technique, benefits and challenges as per the concepts from chapter 2. The inductive coding covers elements, that had not been taken into account before the interviews. To state this differently, deductive coding is applying. And testing theoretical concepts and inductive coding adds to the theoretical concepts and thus enriches the results. The inductive codes include PV panels, property value, applying for a subsidy, timing, and uncertainty. Inductive codes were grouped into categories, after which a connection has been sought between the categories. The complete overview of the codes, both deductive and inductive, are shown in Appendix 2.

The organization of the codes was executed by the code group manager, and the different kinds of documents were managed by the tool document group manager. Next to in-depth analysis of the roles of frontrunners and their effects on potential adopters, conceptual content analysis of both the documents and the interviews are executed. Conceptual content analysis helps to quantify the presence or absence of phrases or words in qualitative data (Krippendorff, 1989). The frequency of the mentioned subjects gives insight into the focus of both communication channels. Finally, these results were written down, summarized into hierarchies or figures.

3.4 ETHICAL CONSIDERATIONS

The data that is acquired for this study is handled with ethical considerations throughout all the steps in the research design. Before conducting the interviews, the participants have been sent an information letter through e-mail or LinkedIn. This information letter explained the purpose of the study, and closed off with a declaration of informed consent, that had to be signed off to participate (see Appendix 1). Additionally, the process of informed consent was repeated, before starting the recording. It explains the aim of the study, what will be asked of the participants, and that the participant can stop at any time without consequences. Furthermore, the data will be anonymized, and only referred to as Interviewee A, B, C, D or E, to reduce the likelihood of tracing back the interviewees. After the collection of the data, it is stored on the computer offline, to reduce the probability of data leakage. This computer can only be accessed by the researcher, with two-factor authentication. Moreover, the raw data can only be viewed with the written permission of the corresponding participant. The processed data will be visible in this thesis. For this reason, the participants were asked for approval of using the quotes, in the results section. After conducting this research, the raw data (i.e. recordings and transcript) will be permanently removed. The content analysis, analyzing only publicly open sources, does not harm any copyrights as it only analyzes, and not copies the information. Through the transparency and ethical considerations in all the steps, legitimacy will be acquired, and validity increased.

4 RESULTS

This chapter describes the findings of the collected primary and secondary data, about the influence that frontrunners have on potential adopters of green roofs in the Netherlands. Furthermore, the factors that influence the adoption of product innovations and how other channels are utilized for the adoption of green roofs. First, it is important to understand the way the frontrunners conveyed their message, to the potential adopters. This, therefore, discusses the innovation attributes relative advantage, complexity, compatibility, observability and trialability. Subsequently, the difference between interpersonal (e.g. frontrunners) and mass communication channels, is shown in the conceptual content analysis of the pros and cons of green roofs. Finally, the costs and incentives are evaluated.

Together, it studies the diffusion of innovation theory applied to green roofs in the Netherlands, after which an institutional strategy can be formed. The results are discussed according to the conceptual framework. As the interviews were conducted in Dutch, the quotes in this result section are the translated quotes. The original Dutch quotes can be found in Appendix 3, numbered.

4.1 ROLE OF FRONTRUNNERS

The conducted interviews gave contradicting views of the roles of frontrunners. The six frontrunners, of which three fulfil the role on voluntary basis and the other three are paid. There is a difference in terminology, "role is a part played by someone in a particular situation whereas function is the duty of someone" (Hasa, 2017). Hereinafter, will be referred to as the role of frontrunners instead of the function. Both types are considered frontrunners and share the same goal of increasing the implementation around them. However, the time they invest in increasing the adoption of green roofs, and the communication method they use varies. Furthermore, the way they engage in convincing others to adopt a green roof is either active (i.e. engaging with people that were not yet interested) or passive (i.e. engaging with people that were already interested). The participants, their corresponding relation to being a frontrunner and the effort they make is presented in Table 4.

Table 4: List of the interviewed frontrunners, their background, effort and function

Participant	*Professional background*	*Financial interest*	*Time investment*	*Perceived role*	*Communication method*	*Engagement*
A (female)	Student socio-spatial planning	Paid	Fulltime	Facilitator	Information meeting, *dakfiets*, interpersonal communication, opportunity map, website, flyers	Active
B (female)	Project officer healthcare	Voluntary	Parttime	Facilitator	Presentation (interpersonal), prototype	Semi-active
C (male)	Industrial designer	Paid	Parttime	Convincing, intermediary	Interpersonal communication, group meetings, website	Passive
D (female)	Store owner	Voluntary	Parttime	Facilitator, connector	Interpersonal communication, website	Passive

E (male)	Construction worker	Paid	Fulltime	Implementer	Newspaper, interpersonal communication, website	Passive
F (male)	Human resource manager	Voluntary	Parttime	Facilitator, advocate	Flyers, interpersonal communication, website	Active

Within this group of participants, only one (C) is paid for part-time effort, whereas the rest are paid for full-time functions or fulfil an unpaid part-time role, as frontrunners. The paid frontrunners have experience in the construction or planning domain and, subsequently, created their job in the domain of green roofs. The voluntary frontrunners were brought in contact with the subject, by either wanting to implement it for themselves and convinced others into adopting green roofs simultaneously (B and F), or through their partner (D).

After explaining the purpose of the study in the introduction of the interview, all participants agreed that they can be seen as frontrunners of green roofs. Within the interview, participant E referred to his role as an implementer, whereas the rest referred to themselves as facilitator or connectors. Participant C even downplayed his role "because you are really only an intermediary between gardener and the person that wants to install a green roof" (Appendix 3, 1). Participant F explained his role as more than just a facilitator, in the sense that he also is an advocate of green roofs. In this small sample, there seems no direct correlation between the financial relation, time investment and/or engagement.

4.1.1 Communication method

Collectively, the frontrunners use a broad array of methods for conveying their message. All frontrunners were involved in interpersonal communication i.e. conversating with potential adopters about green roofs. Oftentimes, these conversations were initiated by a potential adopter. Hence, these frontrunners were classified as passive.

Participant A utilizes the most communication methods, namely: information meeting, *dakfiets*, interpersonal communication, opportunity map, flyers and a website. The *dakfiets* is a cargo bike of which the cargo chassis is made of a prototype of green roofs. It displays the various layers of a green roof, linking to the observability and trialability of the attributes of innovation. Because she undertakes these activities, in which she actively engages, with potential adopters that were not yet interested, she is classified as active. Her active engagement is visible in the following quote: "That is visiting people or talking to people in the street. For example, we give roof advice and they report via the website and they report their roofs. They fill in some general information: roof area, construction, construction material, etc." (Appendix 3, 2). In this example, she combines multiple methods – interpersonal communication, written roof advice and website – that results in repetition in information but also gives the person the chance to read through the information and discuss before making the decision.

Participant B is classified as semi-active. As she was convinced to implement a green roof herself, she became enthusiastic and eventually made the effort to collectively implement green roofs with sixty of the hundred dwellings in the neighbourhood. The effort of participant B consisted of giving a presentation, handling the subsidy for the collective implementation (i.e. diffuser incentive) and facilitating the process, by keeping in contact with the adopters and the implementing parties. Though this part of the process is active, after the implementation in

her neighbourhood, she has not actively engaged with others outside the neighbourhood. Additionally, the participant was recruited through LinkedIn after finding a news article about this process. She is the only participant without a website, through which information could be found.

Participant F is the last actively engaged interviewee. The human resource manager is involved in convincing others into the adoption of green roofs, by going through neighbourhoods and talking to people. “Yes, then I will visit people with flat roofs in a neighbourhood. I will talk to them to see how much they already know about green roofs and whether they would be interested in hearing more about it” (Appendix 3, 3). Additionally to the door-to-door method, participant F hands out flyers to interested potential adopters. Only participant F referred to himself as an advocate of green roofs, of the three actively engaged frontrunners.

The participants that were engaged passively included two paid participants (C and E) of which one worked full-time as a frontrunner of green roofs (E). The other passively engaged participant (D) is a part-time volunteer. Remarkable is that participant C calls himself a “wijkaanjager”, which loosely translates as a neighbourhood catalyst or booster, without active engagement. Although all three work in different organizations, the method is the same: their website is their business card and the starting point of the process. As they don’t actively engage with new potential adopters, the people that visit their website and get in contact with them, have heard through other channels about the potential of green roofs and are interested. The response on how to get in contact was generally the same: through others, their neighbours, friends, or family. This strengthens the position of the interpersonal communication channel, in this stage of the diffusion process.

4.1.2 Influence on the attributes of innovation

Before going deeper into the costs and benefits that are mentioned in the interviews, an analysis of the implicitly mentioned attributes of innovation is necessary. This gives us insight into how the persuasion of the frontrunners links to the theory of diffusion of innovation. Table 5 describes the attributes from the theory (i.e. complexity, compatibility, relative advantage, trialability and observability), the pros or cons towards the innovation and the frequency. This follows the conceptual framework, that is used as an analytical framework. The table will be explained and elaborated on in this paragraph, per attribute. The questions in the interview were constructed, in such a way, that the attributes could be mentioned throughout.

Table 5: attributes of innovation, the perceived value and frequency of mentioning, sorted on the total mentioning frequency

Attribute	*Pro*	*Frequency*	*Con*	*Frequency*	*Total frequency*
Trialability	Trialability	2			2
Compatibility	Cluster	7	Construction weight	2	
			Flat roof	1	10
Observability	Visibility	8			
	Diffuser incentive	3			11
Complexity			Implementation	4	
			Knowledge	4	
			Paperwork	14	26
Relative advantage	Benefits	49	Costs	12	
	Adopter incentives	23			
	Comparison with the current system	2			86

4.1.2.1 Trialability

The trialability of a green roof is the least mentioned attribute of the five. This is an outcome that could be expected, as the frontrunners are not involved at moments, in time, when potential adopters try out a part of a green roof. Participant A mentioned that it is possible to go for cheap options, which would be "DIY mats" that you roll out over your roof. This will, however, not give a representation of the benefits that can be derived, from green roofs. A possible trial could be a demonstration for a neighbourhood of people that are not yet interested.

4.1.2.2 Compatibility

The theory on green roofs already discussed the two requirements for the implementation of green roofs on existing buildings: rooftop with a smaller angle than 35 degrees and strong construction to support both the additional weight of the green roof layers and the possible weight from precipitation. No specific question was asked to address how the compatibility of flat roofs with current systems was perceived. The two requirements are easily understood, although the construction oftentimes needs a calculation on the possible weight before implementation. As this is one of the requirements that need to be filled in on forms in the process of applying, it had a low mentioning frequency. In four of the six interviews, the participants mentioned the combination with other functions, coded as "cluster". One interviewee (D) mentioned the combination with recreation on the roof, which would be appreciated by the renters within a housing corporation. However, not by the housing corporation itself. As an explanation, she mentioned, that housing corporations are risk-averse and recreation on rooftops are risk inducing. D and three other interviewees (C, B and F) referred to the combination with photovoltaic panels. Participant D mentioned that the increased yield of photo-voltaic (PV) panels in combination with green roofs is approximately 8% due to the reduced heat of the solar panels on the roof. This is a figure that multiple internet sources, from green roof providers, also estimated. Not including the PV panels, as an ecosystem service of green roofs, is not seen as a flaw in the research, as it only displays the link between the potential of compatibility (i.e. clusters) and the heat-reducing ecosystem service of green roofs. Furthermore, the PV panels are, by the interviewees, not seen as a competitor for green roofs but rather as an additional function. Participant F mentioned that the payback period of PV panels, is a driver for people to adopt the panels and he thinks that the lack of a clear payback time of green roofs is limiting the further adoption of green roofs. This links in with a part of the theory of Rogers (1995) that incremental innovations diffuse with less effort than preventative innovations, as the time-lapse before beneficial consequences, is perceived as long.

4.1.2.3 Observability

Observability, by theory, is referred to by visibility. The theory also states the link between diffuser incentives and observability, where the diffuser incentives consist of a reward for the diffuser (i.e. the person that convinces others to join the adoption of green roofs). The diffuser incentive is mentioned by participant B. Next to the individual adopter incentive, from the municipality, the neighbourhood applied for a group incentive. This incentive was only given under the circumstances that it was a joint venture of a minimal of two parties, e.g. neighbours, municipality, company etc. These and other incentives are elaborated on in Chapter 4.3. The visibility factor is inevitably linked with the aesthetic appearance and pleasure, that can be

derived from it. To minimize double coding, visibility was only coded, when it did not contain the aesthetic benefit. For example, participant A stated that "normally, together with *resilio*, we would go with our dakfiets that includes a blue-green roof prototype to a neighbourhood. There we would not only speak with the interested residents but also with people from the neighbourhood to raise awareness" (Appendix 3, 4). To clarify, *resilio* is a company, in Amsterdam, that implements green blue roofs.

Showing the prototype is, in theory, considered an important method of persuading potential adopters in adopting an innovation. Oftentimes, green roofs are on top of a building, reducing the visibility of the innovation. This potential limiting effect of the visibility is expressed by participant C: "[…] but if there is a green roof above you, you can't see it. It is important to have lower roofs greened to increase the visibility. The visibility is quite important for something like this" (Appendix 3, 5). The final question of the interview – in which the participant could answer broadly – was an exploration of what the frontrunners deemed necessary to increase the implementation, in the Netherlands. Participant C "[…], but such an example roof must be placed somewhere in every neighbourhood. Something that other residents can emulate, that if you want that, then you should more or less replace your roof and you will be assured of sustainability, cooler locations and more birds and bees for the future" (Appendix 3, 6). This is in line with the theory of Rogers (1995), on the importance of observability on the diffusion of an innovation.

4.1.2.4 Complexity

The question "what are the challenges you encounter" supplemented by the follow-up question "what challenges did the people you met encounter" was aimed at the complexity attribute and the innovation-decision. These two variables were the only inhibiting factors on the adoption rate. The challenges that arise, in the process of adopting a green roof, were inductively coded into the categories of implementation, knowledge and paperwork. Knowledge has overlap with implementation and paperwork, as a person can have knowledge on how the implementation needs to be handled, or the knowledge of how the paperwork needs to be handled. However, the knowledge, that is referred to here, is about the what and the who. What needs to be done or, what are my options, and who can help me with this. For the implementation, participant A mentioned this as "Not everyone can get on their roof and do it themselves" (Appendix 3, 7). The implementation, according to participant D is not complex: "Yes, exactly, because it is the complexity of it, the implementation, although it is not difficult to do it yourself, then it is not done well. You can do it yourself, but it requires you to be handy" (Appendix 3, 8). As the implementation was not mentioned that frequently, and one of the participants indicates that it is possible to do it yourself, this element of complexity is not considered that high and should not limit the adoption rate. The paperwork was the most frequently mentioned challenge for the potential adopters, from the perspective of the frontrunners. This inductively coded factor distinguishes itself from adopter incentive and diffuser incentive as it represents the negative aspect of the subsidies, the bureaucratic process of applying for a subsidy. Whereas the adopter incentive and diffuser incentive have a positive relation to the adoption of innovations. Moreover, the paperwork is not only related to the application for subsidies, as explained in this quote of participant A:

> *"However, it is also the steps you have to take from application to construction. For example, when applying to landscapers, people may find that difficult. What do I need to send? Sometimes they ask for certain information about the roof:*

> *the year of construction and the construction of the roof, and then people get stressed because they have no idea. Then you need quite a few documents for a subsidy application and it can take quite a long time. If there is a mistake in a document that is then submitted again, it takes another 8 weeks."* (Appendix 3, 9)

This is strengthened by participant D who stated that, in her experience, quite some private individuals decide not to bother about the subsidy "[…] because before I get through the municipality, I've already built a green roof ten times" (Appendix 3, 10).

4.1.2.5 Relative advantage

As expected, the most frequently mentioned attribute of the innovation was the relative advantage. The question "what benefits of green roofs do you list and explain to potential adopters" was aimed at understanding the benefits, that green roofs provide, that would be mentioned in the persuading process of potential adopters, as will be discussed elaborately below. Important to note is that not all the benefits fall into the category of relative advantages, such as PV panels. Furthermore, the cons or barriers only apply to relative advantage when they can be considered a cost. The comparison with the current system (i.e. conventional roofs), has a low frequency of being mentioned, as only one participant discussed this practice. Furthermore, if and only if green roofs were compared with the current roofing system without discussing the compatibility of mounting it on top, it was coded as "comparison with the current system". The benefits that are mentioned by the frontrunners are expressed in Figure 4. The cons or barriers that are mentioned by the frontrunners are expressed in Figure 5. The items that were not mentioned by the frontrunners but are mentioned in the literature are visible in Table 6.

From the benefits that can be derived from green roofs, only the recreation was not explicitly included in the theoretical framework. Not including the recreation as an ecosystem service of green roofs is not seen as a flaw in the research, as it only displays the link between the potential of compatibility (i.e. clusters) and the other benefits of green roofs. The most frequently mentioned benefits by the frontrunners, in persuading potential adopters, are the aesthetic value, biodiversity and indoor temperature. The aesthetic value of green roofs contributes to the observability aspect of the theory, and can be linked to increased property value, psychological benefits, and spirituality. In this study, these three factors are considered separately. Participant B claims that the aesthetic value comes from the flourishing sedum. Participant D compared the aesthetics of green roofs with conventional roofs, making a case

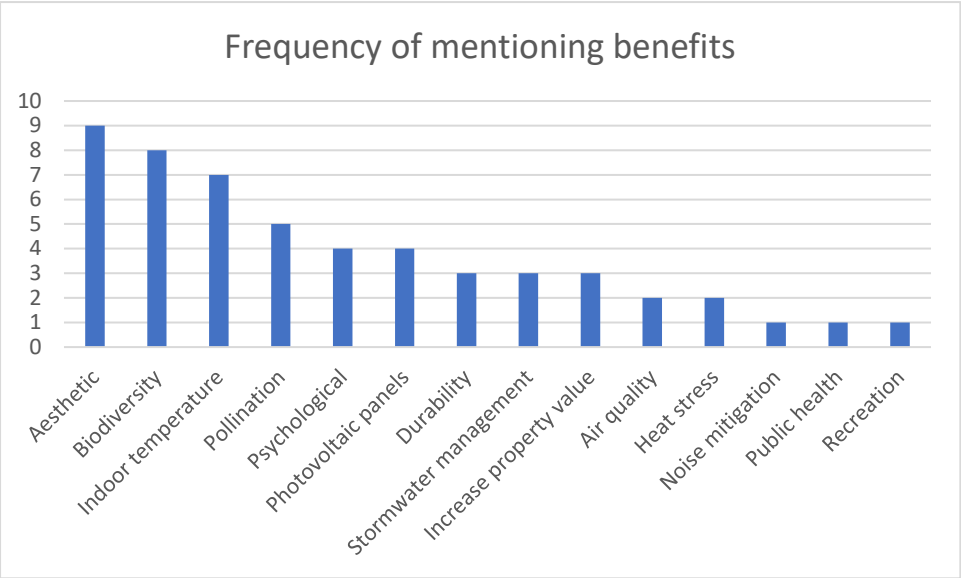

Figure 3. Frequency of mentioning types of benefits by frontrunners

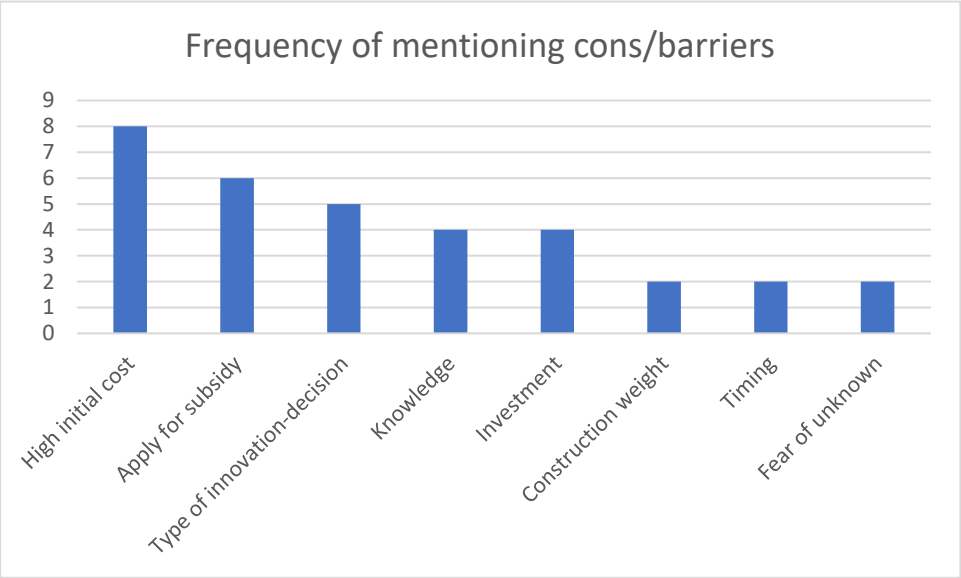

Figure 5. Frequency of mentioning types of cons/barriers by frontrunners

that green roofs are prettier than conventional roofs and that people "are more cheerful when they look at green than at black" (Appendix 3, 11). Biodiversity was high on the agenda of mentioning, to the potential adopters, implicitly and explicitly. Implicitly, the birds, insects, and butterflies, in specific, were mentioned. Although, bees are technically part of biodiversity, the main advantage of bees is pollination. The indoor temperature of buildings with green roofs, was almost as frequently mentioned as biodiversity or aesthetic value. Explained by participant A: "Well, the first thing we always mention is the cooling effect, which is the subject of the most research with the most quantified evidence. That's also something that is close to people, if they have a flat roof, and experience heat in the summer." (Appendix 3, 12). It shows the nuisance that the adopters have experienced before installing a green roof, making the implementation a reactive measure.

The items that were mentioned four or three times are coded with medium: psychological, PV panels, durability, stormwater management and increased property value. The psychological value of green roofs, as explained above, was mentioned by participant E

twice, as the happiness that can be derived from green, in general. Participant A explained that the strengthening of social cohesion is a factor that she knows of but hardly ever mentions, as it is abstract and difficult to explain. It is important to consider that it is a benefit, but that it hardly gets mentioned for this reason. The PV panels are discussed in the compatibility paragraph above. The durability, i.e. increased life cycle of roofs, is mentioned three times. Two of the three times it was mentioned, it was correlated with the inductively coded timing. The increased life span of traditional roofs, by mounting green roofs on top, is dependent on the current state of the traditional roof. As participant F stated, "you have to pick your moment, it makes more sense when you are replacing your bitumen roof. At that moment in time, the benefits for the life span is the largest" (Appendix 3, 13). Stormwater management, in the case of Participant B's experience, was only a relevant benefit to mention for the adopters after a shock event. One and a half years before the implementation of green roofs in the neighbourhood of Rosmalen, the neighbourhood had flooding. And although it is calculated to only happen once in 25 years, it was a motivator for the adopters. In this study, stormwater management and indoor temperature both are benefits that mitigate a negative effect, making it a reactive decision.

The benefits of green roofs with a low mentioning frequency are air quality, heat stress, noise mitigation, public health, and recreation. The air quality that is increased by the purifying function of green roofs is only mentioned twice, by both participant B and E. Participant B mentioned that it was not a significant driver for her neighbourhood, as that location was already good in terms of air quality, according to the municipality. Participant E only slightly touched upon the subject when listing the benefits. The ability of green roofs to mitigate heat stress, the by-product of the urban heat island, is not frequently mentioned just as noise mitigation, public health, and recreation.

Of the nine cons or barriers, only two have not been discussed in previous attributes: type of innovation-decision and fear of unknown. First, the type of innovation decision is not within the attributes of the innovation, as it does not say anything about the attribute itself, but rather about the potential adopter and the diffusion rate. Secondly, fear of the unknown or uncertainty is linked to the characteristics of the adopter. Or more specifically, the willingness to accept risk. As participant B stated: "Those people said, that they would first see how things went with the neighbours. They also said, that they did not want to take the risk." (Appendix 3, 14). Risk aversiveness, being hesitant and needing more (scientific) proof link in with the theory of types of adopters. This example from participant B is probably the late majority or laggards.

Before discussing how the mass media differs from interpersonal communication (i.e. frontrunners), some pros and cons are mentioned in the literature and not by the interviewees (see Table 6). These are spiritual and urban agriculture benefits, and the disadvantage of runoff quality. First, the earlier mentioned psychology and the spiritual benefits are hard to distinguish, as both concern the self, the mind and the body. However, psychology is about how behaviour is affected, whereas spirituality is being concerned with the human spirit. There was no implicit or explicit mentioning of spirituality in the interviews. Secondly, urban agriculture, in the sense of growing food on the rooftops, has not been discussed by frontrunners as one of the potential benefits of green roofs. As with the PV panels or the recreational aspect, it is a design configuration that determines the possible other benefits. Urban agriculture is most promising for food security reasons which are not a problem in the Netherlands.

Table 6: pros and cons in academic literature, not mentioned in the conducted interviews with the frontrunners in this report

Pro	*Source*	*Con*	*Source*
Spiritual	(Jennings et al., 2016)	Runoff quality	(Berardi et al., 2014; Shafique et al., 2018)
Urban Agriculture	(Specht et al., 2014; Steenkamp et al., 2021)		

4.2 MASS COMMUNICATION CHANNELS

Additionally to the interviews, mass media channels were studied to understand the other source of information for potential adopters.

4.2.1 Role of mass communication channels

Table 7 shows the mass communication channel sources, their role, communication method and engagement. These sources comprise two podcasts, two television interviews, seven websites and three newspapers. Below the table, it is analysed.

Table 7: The analysed (types of) documents, the role they fulfil and their engagement

	Title	*Financial interest in implementation*	*Role*	*Communication method*	*Engagement*
Website	Groendak. Implementation and supply of green roofs	Yes	Implement and sell	Webshop, website	Passive
	Groenedaken.net the green roof webshop	Yes	Sell	Webshop, website	Passive
	Green roof Milieucentraal	No	Inform	website	Passive
	Rooftoprevolution More green roofs in the Netherlands	Yes	Inform, implement and sell	Website, flyers, frontrunners	Active
	Dakdokters we make the city healthy	Yes	Inform, implement and sell	Website, webshop	Passive
	Green deal green roofs	No	Inform	Website	Passive
	The green counter	Yes	Implement and sell	Website, webshop, information meetings	Active
News article	Mastering the rainstorms and creating a greener garden	No	Inform	Written	Passive
	The benefits of a green roof	No	Inform	Written	Passive
	The leaden expectations of green roofs	No	Inform	Written	Passive

Podcast	The chances are on the roof	No	Inform	Verbal	Passive
	Let's talk business*	No	Inform	Verbal	Active
Television	Tijd voor Max	No	Inform	Verbal and visual	Active
	Taking resilience to a higher level	No	Inform	Verbal and visual	Active

* The podcast Let's talk business is part of a radio show and thus classified as active in engagement; people that are not engaged with green roofs themselves can be targeted.

Of the seven websites, only *rooftoprevolution* and *the green counter* actively provide help in the steps to undertake. In the rest of the websites, four passively provide help by addressing the steps to undertake whereas, one only, stated the benefits. Surprisingly, only five of the fourteen sources potentially reach a public that was not yet intrinsically engaged with green roofs: the television sources, one podcast and two websites. These television sources and the podcast reach the viewing or listening public and might be able to trigger them into looking for green roofs. These websites or the agencies behind the websites, however, have information meetings and frontrunners that reach neighbourhoods with potential adopters.

4.2.2 The difference in the content of mass and interpersonal communication

After discussing the process and the role of these sources, the content is discussed. The following section compares, the pros and cons, between the mass communication channels and interpersonal communication, as visible in Table 8.

Table 8: frequency of pros and cons of green roofs from both interpersonal and mass communication sources

Pro	*Frequency*		*Con or barrier*	*Frequency*	
	Interpersonal	Mass media		Interpersonal	Mass media
Aesthetic	High (9)	High (9)	High initial cost	High (8)	Medium (3)
Biodiversity	High (8)	High (13)	Apply for subsidy	High (6)	High (7)*
Indoor temperature	High (7)	High (10)	Type of innovation-decision	Medium (5)	Low (2)
Pollination	High (5)	Low (4)	Knowledge	Medium (4)	Low (2)
Psychological	Medium (4)	Low (4)	Investment	Medium (4)	Medium (3)
Photovoltaic panels	Medium (4)	High (8)	Construction weight	Low (2)	Low (1)
Durability	Medium (3)	Low (4)	Timing	Low (2)	(0)
Stormwater management	Medium (3)	Medium (7)	Fear of unknown	Low (2)	(0)
Increase property value	Medium (3)	Low (4)	Leakage	Low (1)	(0)
Air quality	Low (2)	Medium (6)			
Heat stress	Low (2)	Low (4)			

Noise mitigation	Low (1)	Low (3)		
Public health	Low (1)	(0)		
Recreation	Low (1)	(0)		
	Total 53	Total 76	Total 34	Total 18

* In mass media, the struggle of applying for a subsidy is not discussed as a barrier. It only mentions that there are subsidies that are dependent on your location. In the cases of local sources, the applicable subsidies are mentioned.

To start with the difference in the frequency of mentioning benefits between mass media and interpersonal communication. Biodiversity and pollination are inherently linked, where pollination is a necessity for biodiversity to thrive as plants are needed for animals to live from. Within the interviews with frontrunners, biodiversity, and pollination both were in the foreground of the benefits. In the mass media, biodiversity was the most frequently addressed benefit from green roofs whereas pollination was only mentioned in three documents. The combination with PV panels is mentioned relatively more frequently in mass media communication than in interpersonal communication. However, mass communication – in line with interpersonal communication – does not discuss PV panels as a competitor to green roofs but as an addition or synergy. In general, the analysed documents showed an emphasis on the benefits of green roofs, neglecting the cons or barriers that can be expected.

4.3 ADOPTER AND DIFFUSER INCENTIVES IN THE NETHERLANDS

Next to the benefits that can be derived from green roofs, there are costs and barriers. As discussed in the theory, there are adopter incentives and diffuser incentives that improve the relative advantage and the observability respectively. This chapter first discusses the incentives in the Netherlands by studying the subsidies of The Hague, Rotterdam, and Amsterdam. Shown in Table 9 are the subsidies that are available in The Hague, Rotterdam, and Amsterdam, as examples. The subsidies that are available from the municipalities of these cities come from the national budget of *Impulsregeling Klimaatadaptatie*, (translated: climate adaptation impulse regulation). This budget of 200 million for 2021 is part of the DPRA and aims to accelerate adaptation measures in provinces, water authorities and municipalities. The division of the budget over these overlapping authorities is to not exclude any urban area. Amsterdam's water authority is AGV (Amstel Gooi Vecht), which does not grant a subsidy for green roofs. Rotterdam has three water authorities of which only Hoogheemraadschap van Delfland grants a subsidy. This is also the water authority in The Hague. Furthermore, in the interview of participant B, a diffusion subsidy was mentioned and thus included: Waterschap Aa en Maas. What we can derive from Table 9 is that:

- All local authorities have their terms and conditions, in their written regulations;
- The municipalities require a minimum storage capacity of water for green roofs to get subsidized;
- The timing of the subsidy (i.e. before or after the implementation) is not nationally regulated;
- There is no uniformity on the target group, the height of the subsidy, the conditions that need to be adhered to and the timing of the subsidy.

Table 9: Incentives for implementing green roofs in The Hague, Rotterdam and Amsterdam

	Title and organization	*Diffuser/ adopter*	*Finance*	*Before/after*	*Conditions*	*Target group*	*Source*
Municipality	Subsidy green in Amsterdam	Adopter	• Maximum of €30/m2, • Unless water storage capacity > 50L, then €50/m2	Before (until €5000), otherwise max 75% before	• Minimum of 30 m2, • Water storage capacity > 30L/m2 • Maximum: €50.000 • No maximum subsidy budget	Not specified	(Gemeente Amsterdam, 2021)
	Subsidy green roofs the Hague	Adopter	• €25/m2 until a maximum of 50% of the implementation costs	After	• Minimum 6 m2, • Water storage capacity > 18L/m2, • Budget: €175.000	All, except for governmental bodies in the Hague	(Gemeente den Haag, 2021)
	Subsidy climate adaptation Rotterdam	Adopter	• €10/m2 • Additionally, above 1m3 water, cubic meters * €500	After	• Minimum 20 m2, • Water storage capacity > 30L/m2 • Budget: €500.000	Residents, owners associations, businesses and organizations in Rotterdam	(Gemeente Rotterdam, 2021)
Water	Hoogheemraadschap van Delfland (The Hague, Rotterdam)	Adopter	• 30% of the costs • Less than €500/m3	Before (max of 50%), after	• Budget: €260.000 • Cost minimum of €3.333	Residents, businesses and organizations	(Hoogheem-raadschap van Delfland, 2021)

		• Less than €50.000 total				
Waterschap Aa en Maas (Rosmalen)	Diffuser	• 30% of the costs • Maximum €5.000 • In Oss, Meijerijstad, Uden, Bernheze, Landerd of Boekel the maximum is 45% and €7.500	Before	• Minimum of two parties participating • Budget: €140.000 • No minimum storage capacity	Not specified	(Waterschap Aa en Maas, 2021)

4.3.1 Costs of green roofs

The cons or barriers that were mentioned by the frontrunners from their experience with potential adopters are generally financially oriented; the high initial cost, applying for a subsidy, investment and construction weight are all financially oriented factors. The initial cost, as elaborated on in the literature, depends on location, labour costs, green roof type and material. Although this study concerns the Netherlands as the study area, two example calculations on the location of the Hague and Amsterdam are done, as the incentives and costs differ per location.

Shown in Table 10 is the an example of the costs for various roof technologies. The costs are from the website the green counter, as analysed for the frequency of mentioning of pros and cons. The energy saving per year is based on the findings of Niachou et al. (2001) on good insulated housing, a saving of 2% a year. The energy price is the current average. After 11 years, the green and PV panel synergy is paid back and yields almost 92 euros per year.

Table 10: Cost example of various roof technologies in the Hague

Inputs		*Bitumen*	*Green*	*Green+PV*
Installation cost	[€/m2]	-15,00	-62,00	-62,00
Installation PV	[€/m2]			-120,00
Subsidy the Hague	[€/m2]		25,00	25,00
Subsidy water authority	[€/m2]		18,60	18,60
Property value increase	[€/m2]		75,00	75,00
Maintenance	[€/m2/year]		-5,00	-5,00
Energy-saving	[/year]		2,00	2,00
Energy	[kWh/m2/year]			135
Energy price	[€/kWh]			0,08
Projected lifetime	[years]	40	60	60
For a roof of 20 m2, this would be:	[€/year]	-7,50	+18,86	+91,87
Payback period	[years]	-	0	11

4.3.2 Type of innovation-decision

Finally, to form a suitable strategy, the type of innovation decision is important to understand i.e. who the owners are of the roofs. In the Netherlands, the roofs are owned by private individual house owners (57%), housing corporations (29%) and others (14%) (See Figure 6).

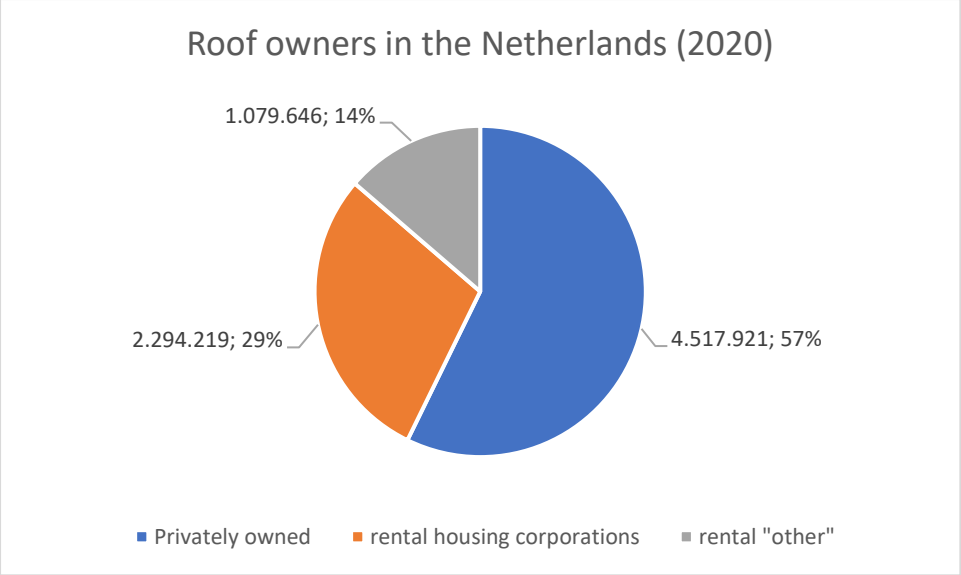

Figure 4. Roof owners in the Netherlands. (Source: CBS, 2020)

There is no data in the Netherlands that can accurately state the amount of owners associations, as it can comprise of individual house owners and renters. The type of innovation-decision is therefore difficult to state. The specific strategy will have to be considered per city.

5 DISCUSSION

This section provides an interpretation and generalization of the results. It proposes four strategies, based on the results and the conceptual model. Within these strategies it will discuss 1) whether the data is consistent with previous studies, 2) whether it supports or challenges an existing theory, 3) why the results matter and 4) whether there are any practical implications.

5.1 STRATEGIES FOR INCREASING IMPLEMENTATION IN THE NETHERLANDS

The national objective of the Netherlands, as stated in the DPRA, is to become climate resilient and water robust in 2050. As argued by Mees et al. (2013) and other environmental governance theorists, the responsibility for reaching such goals is not anymore merely the responsibility of the state, but rather should be shared by state, market and civil society. The following four strategies are, therefore, not only focused on policymaking of governmental bodies. Following the theoretical conceptual model and the results of this study, several potential explanations can be given why the adoption of green roofs in the Netherlands has not taken off. First of all, the relative advantage of green roofs over conventional roofs is limited for the adopters, as the costs and the benefits are not sufficiently aligned, and the beneficial consequences are distant in time. Secondly, the emphasis of the national government and, subsequently, the municipalities have been on the energy transition separately from climate resilience. Or to state it differently, the focus of municipalities has been on either the energy transition or climate resilience although these two subjects are not mutually exclusive and could be in symbiosis to create a synergy. That brings us to the last potential explanation, there are unresolved challenges in the adoption process of green roofs. The first three strategies are an answer to these potential explanations. A last strategy is an additional approach for increasing green roof implementation in the Netherlands, based on outcomes of the interviews and the strategy of best practice examples Stuttgart and Basel, as per Mees and Roosmalen (2014). Deriving from the amount of implemented green roofs can be stated that the target group for the implementation is early adopters, the eager and easily convinced group. The message, both through interpersonal and mass communication channels, does not to be adjusted to serve the more difficult convinced at this stage in time.

5.1.1 Increasing relative advantage: aligning costs and benefits to the adopter

This paragraph will elaborate on the costs and benefits of green roofs, to strengthen the argument that the perceived relative advantage of green roofs over conventional roofs is limited for the adopters and create a strategy to overcome this limiting factor. The theory of diffusion of innovation by Rogers (1995) dictates that the perceived relative advantage is the most important indicator for the rate of adoption of innovations. In the interviews with the frontrunners, the relative advantage was the most frequently addressed attribute. The frontrunners in their role of experts on convincing others to implement green roofs emphasize this attribute over the others. This does not conclude that it is the most important indicator, however, it shows that, within the strategy of the frontrunners, it has priority.

The perceived relative advantage of green roofs over conventional roofs can be perceived as low since there is no immediacy of the reward: the beneficial consequences are distant in time. Additionally, there is uncertainty in the magnitude of the climate change impacts and thus of the magnitude of the beneficial consequences. The most frequently

mentioned benefits of green roofs are those that can be experienced from the implementation of a single green roof and within a two-year period: aesthetics, biodiversity, and indoor temperature. The least frequently mentioned benefits are the benefits that are distant in time, difficult to experience and can only be obtained through neighbourhood-wide implementation: stormwater management, increased property value, air quality, heat stress, noise mitigation and public health. The potential beneficial consequences of stormwater management could be perceived by the neighbourhood after the recent flooding, as per the experience of participant B. Waiting for an increased urgency to implement green roofs as a preventative measure reactively, is counterintuitive. Therefore, to increase the relative advantage, the distance in time of the beneficial consequences should be compensated for the lack of expression of the benefit by those that benefit from the neighbourhood-wide implementation. This compensation should be a diffuser incentive, i.e. have a collective implementation in a neighbourhood as a condition, that is paid in advance. From both the interviews and the literature (e.g. Hendricks and Calkins, 2006; Shafique, Kim and Rafiq, 2018; McClymont *et al.*, 2020) is the high initial cost stated as a barrier for the implementation. Of the total costs, only a small amount is maintenance cost whereas the largest share is at the start of the project, limiting the implementation. The parties that (partially) benefit from the city-wide implementation should be those that collaboratively incentivize the adoption, through diffusion subsidies.

As stated by Shafique, Kim and Rafiq (2018), cooperation and collaboration between different fields interested in increasing the implementation of green roofs requires attention. They list architectural, civil, environmental engineers and residents that need to collaborate, to which I would add the parties that (indirectly) benefit from the ecosystem services: the collective, sewerage agencies, healthcare and insurance agencies. The collective might need explaining. We all benefit from reduced heat stress and reduced pollution in our quality of life and as we collectively pay taxes, the incentive could be paid from tax. In line with the recently accepted Dutch 'Preventieakkoord' that wants to prevent the damages of obesity, smoking and excessive drinking, the prevention of the damages that negative aspects of living in a concrete jungle does to health and well-being should be considered equally. The strategy is visible in Table 11.

Table 11: Strategy 1: aligning costs and benefits to the adopter

Benefit	*For whom?*	*Description*	*Strategy*
Urban heat island red.	Collective	Heat stress, amplified pollution	Diffusion incentive by municipality paid from tax
Reduction stormwater runoff	Insurance agencies; municipality	Less pluvial flooding; risk reduction Less pressure on sewerage systems	Diffusion incentive by insurance agencies, or a reduction in price of insurance Diffusion incentive from Rioolheffing (sewerage tax) to support implementation
Water and air quality	Collective; health agencies (red cross)	Reduction of PM_{10}, $PM_{2,5}$ and CO_2 (2%)	Incentive by government paid from tax, in line with 'Preventieakkoord'

5.1.2 Increasing compatibility: synergy with solar panels

The second strategy – as a reaction of segregated focus of municipalities on climate resilience and the energy transition – is to increase the rate of adoption through compatibility. Within the green roof literature, the compatibility with PV panels is mentioned but not emphasized as it is not a benefit of the green roof itself but merely a potential function that depends on the design configuration. Within the compatibility attribute of diffusion of innovation theory is discussed that bundling similar innovations can be beneficial for the adoption rate. For roofing technology this would imply the bundling of solar roofs, blue-green roofs, green roofs etc. From both the interviews and the content analysis of the mass media, the compatibility of PV panels with green roofs comes forward not as a competitor but as an addition to green roofs. The recommendation, therefore, was to create a synergy between green and solar roofs. The acclaimed increased yield of 8% of solar panels with green roofs will improve the performance and thus relative advantage of solar panels. Simultaneously, the adoption rate of green roofs will increase, albeit with the solar roofs together, starting the take-off phase and critical mass of the innovation.

The increase of a collaboration between solar and green roof companies, where both companies advice the adopter of either product to implement a synergetic product, will improve the energy transition and the climate resilience objective of municipalities, and increase the adoption rate. This synergy is especially interesting for larger decision-making units such as owners associations. This entices the co-adopters within a collective that don't directly benefit from the green roof aspect of the synergy, with a return on investment.

5.1.3 Reducing complexity: dedicated actively engaged specialists

Most cons/barriers that were mentioned by the frontrunners are consistent with previous meta-studies (e.g. Berardi et al., 2014; Shafique et al., 2018). The financial components (i.e. high initial cost, investment, construction weight) and the knowledge components (i.e. knowledge and fear of unknown) are consistent with previous studies. However, the complexity of applying for a subsidy was mentioned frequently in the interviews and not in the literature. Additionally, the type of innovation decision was inductively coded from the information of the interviews, regarding the struggle of a collective decision in, for example, owners associations. Although this is not discussed thoroughly in previous studies on green roofs, it can be explained. Both the innovation decision and the complexity of applying for a subsidy are depending on the (institutional) context that the study is conducted in. The easier it is to get a subsidy, the higher the number of payouts. The allocated budget of municipalities for green roof subsidies is in some major cities already overrun in June (for example, Groningen in the Netherlands). Decreasing the complexity of subsidies might only be feasible in combination with changing from adoption to diffusion incentives. In the long run, the allocated budget for green roof subsidies repays in the reduction of the costs for, for example, water authorities or insurance agencies. This means that a transition from reactive to proactive policy and budget allocation has to be made.

Decreasing the complexity of applying for a subsidy without reducing the regulations a roof has to adhere to can be done through appointing dedicated individuals or collectives that help with the entire process. Throughout the process of adopting a green roof, several applications with different people or agencies is needed. Additionally to the simplification of this process, these appointed individuals or collectives can actively advocate green roofs in, for example, areas where the urban heat island intensity or the risk of pluvial flooding is highest. Thus, the strategy is to create dedicated actively engaged specialists that help throughout the process in bottom-up initiatives and can actively engage those in an area with a high need of neighbourhood wide implementation.

5.1.4 Obligated green roofs for (re-)construction

The last strategy is a strategy that does not fit the conceptual model. From the interviews the element of timing came up. As green roofs require a good construction to be implemented on for it to give the abundance of benefits with the increased life span on the forefront, timing is of essence. Building green roofs on conventional roofs that are not in a good state, will not be the most suitable thing to do. As not every roof of a municipality is monitored for the state of it, nor will it be monitored in the future, a different plan than mass communication through, for example, flyers is needed. Making it mandatory for people to be informed on the possibility of green roofs at the time of inquiring roof maintenance/replacement can yield in potential buyers for the reason of the long-life span. This obligatory information can increase the adoption rate.

The introduction of this thesis stated the research of Mees and Roosmalen (2014) that compared policy between the three most successful cities in implementing green roofs in Germany, Switzerland and the United States of America: Stuttgart, Basel and Chicago respectively. Next to the earlier start in green roof policy, the cities made the implementation of green roofs mandatory. The three cities had adopted a policy that required a minimum percentage of newly built areas to have green roofs. Consequently, a competitive market was created for green roofs, lowering the prices. Considering the current housing shortage of 331.000 at the time of writing in the Netherlands, an amendment in the building regulations that require new buildings to have green roofs can be the catalyst.

6 CONCLUSION

This research aimed to identify potential institutional strategies that can facilitate the increase in green roof technology adoption. Based on the qualitative analysis of semi-structured interviews with frontrunners on their role in the adoption of green roof technology and the content analysis of documents from the perspective of mass communication, it can be concluded that the perceived relative advantage, compatibility, and complexity are important factors to consider when designing and targeting campaigns. The results indicate that the experts convince potential adopters most through these attributes as the potential adopters are most recipient for them. The four strategies are therefore 1) Increasing relative advantage through aligning the costs and benefits to the adopter; 2) Emphasizing the synergetic compatibility of green roofs with solar panels through increased collaboration of both solar and green roof domains; 3) Reducing the complexity by creating a function of actively engaged specialists that facilitate the whole process; and 4) Increasing the market engagement by obliging new or re-construction to include a green roof.

The strategies are a product of the secondary questions. The diffusion of innovation theory by Rogers (1995) provided insight in the factors that influence the adoption of product innovations: characteristics of the adopter, attributes of the innovation, type of innovation decision, communication channels and the extent of the change agents' promotion efforts. The role of the frontrunners on the potential adopters is that of a facilitator, connecter, implementer or intermediary. In this role they influence the potential adopters by reducing most of the challenges, informing on the possibilities of green roofs. Furthermore, some frontrunners have an active role in diffusing the innovation through various methods such as flyers, showing prototypes and give presentations. The strategies, as elaborated on in the discussion, were formed on improving the three most important attributes by institutional changes. There is a difference in the communication method between the mass communication and interpersonal communication; the frontrunners were actively engaged, tailored their message of the benefits to the adopter and decreased the complexity whereas the mass communication passively informs on all the benefits with limited assistance in guiding the process.

6.1 RECOMMENDATIONS

Based on these conclusions, policymakers in the local policy field should consider incorporating roof design in (local) building regulations. Increasing the adoption of green roofs in the Netherlands on existing buildings has been discussed thoroughly. However, at the time of writing, there is a backlog of 331.000 dwellings. Incorporating the obligation of green, solar or a combination on buildings that still need to build in the (local) building regulations will support the city-wide implementation. Furthermore, incorporating green roofs and other climate adaptive measures in a new neighbourhood not only increases the resilience to the increasing climate change effects but also adds to the improvement of health. For these practitioners in the policy field, making it obligatory for replacers of roofs to mention the option of green roofs with the corresponding benefits will have the same increasing effect. Furthermore, the ecosystem services that are distant in time, difficult to experience and can only be obtained through neighbourhood-wide implementation should be promoted through diffusion incentives. Integrating subsidies from the multiple benefitting parties, as elaborated in strategy 1 of the discussion, will reduce the segregated perspective. It will lower the cost for all the involved parties and thus increase the adoption of green roofs. In summary, there is a need for policy integration at various locations.

Building on the conclusions of this research, three further research suggestions are interesting. First, further research is needed to determine the best way for integrating climate policy from the various segregated sectors, even within organizations. In specific, it would be the integration of subsidies on multifunctional adaptation and mitigation measures such as green roofs. Secondly, the current financial construction for green roofs is limiting the implementation. The high initial cost is seen as a challenge. Further research is needed to determine other financial structures in which, for example, leasing green roofs is possible. This could entice other investors than private individuals. Finally, the true value of green roofs should be calculated. This includes the financial expression of pluvial flooding damage control, extended life span, increased health, heat mitigation.

6.2 CONTRIBUTIONS

For understanding the contributions of this research, it is useful to position it in the current theoretical and practical planning debate. The paradigm shift from technical rationale to communicative rationale increased the awareness that not everything can be calculated, quantified or predicted. Some attributes of green roofs, such as the aesthetic value, are subjective and other attributes such as heat stress reduction are harder to quantify, increasing the importance for clear communication.

This research contributes to the planning debate by taking the position of the adopter. It shows what type of communication is promising for increasing the adoption of an adaptation measure by the civil society. This research positions itself in the communicative rationale rather than the technical rationale, as it tries to collectively come to a possible solution. By taking an ecosystem services lens, more stakeholders can be identified than the parties that are usually involved. For example, insurance agencies will benefit in the long term from reducing the likelihood of having to pay out insurance money for the water damage due to pluvial flooding. The risk-averse nature of such a group will make a likely subsidiser. Moreover, the research shows the problems that are found in having segregated policy domains, that call for policy integration. Multifunctional measures such as green roofs are viewed from policies as only a stormwater management option, rather than including the other benefits such as insulation or the combination with solar panels. In that way, municipalities can have an integrated vision that includes both climate resilience and the energy transition. To summarize, for multifunctional measures that contribute to several domains, policy integration is needed.

At last, this research shows the importance of active engagement with potential adopters by frontrunners/change agents. And, for planning practice, the shift from segregated adoption incentives to integrated diffusion incentives is promising.

The green you take away below, you have to bring back at the top.

6.3 REFLECTIONS

First, I will reflect on the research design, then on the outcomes and finally on the process. In the research design, the sample size of the interviews might give a limitation in the generalizability of the data. Although the data set was diverse in backgrounds and the way the frontrunners fulfilled their roles, there is a possibility that there are frontrunners that are not as accessible as this sample that have other preferences in how to approach potential adopters. Increasing the sample size, therefore, would have increased the validity of the results. This is the same for the content analysis, increasing the number of documents to compare with, representing the mass communication channel. Overall, the research strategy was effective in

answering my research question and the secondary questions. The research did give any unexpected insights; many of the current policies in domains are the product of high specialization. Having a network of all highly specialized people that, to the best of their knowledge, make decisions on small parts does not constitute into a good decision when all taken together. In this sense, the whole is bigger than the sum of its parts. This also states the need for generalists in a highly specialized world, such as spatial planners.

The outcomes of the research were in line with my expectance, based on the theory. That the relative advantage would be mentioned most of the attributes did not surprise, nor did the fact that complexity was the second most frequently mentioned by the interviewees. From the standpoint of homo economicus, basing every decision on costs and benefits to make a rational decision, these would be the most influential attributes. What I thought was striking, is how good the theory of diffusion of innovation fitted in this research. The theory had many resemblances with transition theory, but then from a different perspective.

The process of the thesis could have gone better. The delineation of the research was a struggle at the beginning. I was unable to find a suitable lens and know what I was exactly studying. This resulted in rewriting the proposal, rewriting the theoretical framework multiple times and rewriting the background. When I, eventually, had delineated my research framework and knew what the actual question was that I was wondering, the execution of my research went quite fast. After getting in contact with the first few frontrunners, the interviews were nice and easy. I had studied the subject of green roofs for several months, constituting in confidence for interviewing the experts. As time management and organization is my skill, I'd created a schedule for taking the interviews, transcribing, coding, getting secondary data, and working that into a logical machine. I am happy with the end result and, at the end, I could enjoy the process.

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APPENDIX 1: INTERVIEW GUIDE

This is the interview guide for the semi-structured interviews. These questions gave direction to the interview, but were not exclusive. Furthermore, the order of the questions could be diverted off.

Introduction

Thank you for taking the time to meet with me to talk about strategies for increasing adoption of green roofs in the Netherlands. Your answers will contribute to my research, which tries to entangle how frontrunners influence potential adopters of green roofs.

Consent

I would like to remind you that this interview will be recorded to examine further after the interview is done. Before we begin, do I have your voluntary permission to document our conversation? [READ FORM]

[START RECORDING]

This is the interview (x) on (x) and he/she understands that this interview is being recorded. Is this correct?

Warming up (getting to know)

Q1: What is your professional background?

Q2: In what area of the Netherlands are you living

→ How much do you perceive the city in need for (climate) adaptation

Q3: Do you see yourself as a leader of a group (in the realm of green roofs)

Q4: What is the reason/what motivated you in adopting a green roof yourself?

→ What benefits do you experience from your green roof

Q5: What are the challenges you encounter?

→ what was easy to do

→ What was not easy to do?

→ What challenges did the people you met encounter?

Exploration of frontrunners role

Q6: In what way did you persuade others in the adoption of green roofs?

→ what type of techniques did you use to persuade them? E.g. inform them (knowledge), show them, discuss the benefits over conventional roofs? Display try-outs, show what is needed for it to implement, how hard it is to implement?

Q7: What role do you play as frontrunner?

→ can you describe the activities you undertook

→ how do you see yourself?

Q8: What benefits of green roofs do you list and explain to potential adopters?

Exploration of types of adopters

Q9: What types of people are you approaching for adopting green roofs? And who are adopting green roofs?

→ can you describe the type of person
→ how did these persons get in contact with you?
→ can you describe their living situation
→ are they individuals that owns houses, or collectives such as owners associations, or businesses? Or governmental buildings?

Q10: Do you know the main reason for the adoption of green roofs of the people you persuaded?

Closing

The end of the interview is near, I just have a final question.

Q11: What could help increasing the implementation of green roofs more? How?

Before ending this interview, is there anything you would like to add or discuss?

Repeat protocol:

- Anonymity
- Transcript on factual incorrectness.

[Thank the respondent]

[END RECORDING]

Form of informed consent

(name participant)

……..

Hereby consents to be a participant in the current research performed by [insert name interviewer].

I have agreed to take part in the study entitled Strategies for increasing adoption of green roofs in the Netherlands and I understand that my participation is entirely voluntary. I understand that my responses will be kept strictly confidential and anonymous. I have the option to withdraw from this study at any time, without penalty, and I also have the right to request that my responses will not be used.

The following points have been explained to me:

1. The goals of this study is

   To understand 1) the role of frontrunners in adoption rate of green roofs, 2) what persuasion techniques are used by frontrunners and 3) the type of groups that adopt green roofs

2. Participation in this study should help advance our understanding of

   Information distribution and persuasion of potential adopters by frontrunners

3. I shall be asked to

   Explain my role in facilitating the adoption rate of green roofs and the experiences that I have in persuading people in adopting green roofs.

4. My responses will be treated confidentially and my anonymity will be ensured. Hence, my responses cannot be identifiable and linked back to me as an individual

5. The researcher will answer any questions I might have regarding this research, now or later in the course of the study

Date: Signature researcher:

Date: Signature participant:

APPENDIX 2: CODING SCHEME

The coding scheme that is used for the semi-structured interviews and the content analysis

Category	*Code (subcode)*	*Definition*	*Inductive/ deductive*
Attribute of innovation	Observability (visibility)	Whether the green roof is visible	Deductive
	Observability (diffuser incentive)	Incentive for implementation with at least two parties	Deductive
	Compatibility (construction weight)	The construction strength needs to hold the weight of green roofs	Deductive
	Compatibility (cluster)	Combination with other roof related innovations such as solar panels, blue-green roofs etc.	Deductive
	Compatibility (flat roof)	whether green roofs are compatible with the current system	Deductive
	Complexity (implementation)	Difficulty of getting on the roof or implementing the green roof yourself	Deductive
	Complexity (knowledge)	Difficulty of knowing what needs to be done, what the options are and who could assist. This subcode is also in the challenge category	Deductive
	Complexity (paperwork)	Difficulty of handling paperwork (e.g. incentives, building regulations). It includes the "apply for a subsidy" code	Deductive
	Trialability	Trying out a version of the product	Deductive
	Relative advantage (benefits)	Collection of the category "benefits"	-
	Relative advantage (costs)	Collection of the financial challenges, marked by (*)	-
	Relative advantage (adopter incentives)	Subsidies or nudging from benefitting parties	Deductive
	Relative advantage (comparison with the current system)	Directly comparing green roof technology with the current technology	Deductive
Benefits	Thermal protection (durability of the roof)	The extended life span of roofs through application of green roof	Deductive
	Thermal protection (indoor temperature)	Thermal comfort and cooling effect from insulation	Deductive
	Sound absorption (noise mitigation)	Reduction of noise levels through vegetation	Deductive
	Cultural ecosystem services (aesthetic)	The aesthetic value that can be derived from the green roof	Deductive
	Cultural ecosystem services (spiritual)	Inner centered spiritual value from green. For example, human nature connection	Deductive
	Cultural ecosystem services (psychological)	The positive psychological effect green roofs have on humans	Deductive
	Urban heat island	Higher temperature that stays within the urban area	Deductive
	Stormwater management	The reduction of stormwater runoff through vegetation	Deductive
	Improved water and air quality (air quality)	PM2.5, PM10 or CO2 concentrations that are lowered	Deductive

	Improved water and air quality (water quality)	Water is filtered through the plants, improving the precipitation quality.	Deductive
	Improved water and air quality (health)	The improvement of water and air quality and subsequently, the beneficial effect on public health	Deductive
	Ecological preservation (biodiversity)	The variety and variability of life on earth. For the sake of the animals and vegetation, excluding insects.	Deductive
	Ecological preservation (pollination)	The fertilization of plants, by insects such as bees.	Deductive
	Urban agriculture	Growing produce for consumption on a rooftop	Deductive
	PV panels	Energy production through solar panels on rooftops	Inductive
	Property value	The increase of property value through the installment of green roofs	Inductive
Challenges	High initial cost (*)	The costs until and including the installment of green roofs	Deductive
	Apply for a subsidy	Application process at an agency or governmental body that grants a subsidy	Inductive
	Type of innovation-decision	By whom the decision to adopt a green roof has to be made; authoritive, collective or individual	Deductive
	Knowledge	Difficulty of knowing what needs to be done, what the options are and who could assist	Deductive
	Investment (*)	Allocating money with the expectation to have return on that investment	Inductive
	Timing	The judgement whether the implementation of green roofs is the best at that time	Inductive
	Fear of unknown/uncertainty	Future oriented uncertainty of the severity of the climate change effects	Inductive
Target group	Housing corporations	“woningcorporatie”, social housing	Deductive
	Private	Non-public residence	Deductive
	Owners association	An organization comprised of owners in a planned community	Deductive
Communication channels	Methods	The ways in which the frontrunners persuaded the potential adopters. For example, flyers.	Deductive
	Role	The (perceived) role of the frontrunners	Deductive

APPENDIX 3: ORIGINAL QUOTES

1. Dat is met dit soort dingen natuurlijk lastig, omdat je eigenlijk alleen maar een intermediair bent tussen tuinman en degene die een groen dak aan wil leggen.
2. Dat is bij mensen langs gaan of mensen op straat aanspreken, bijvoorbeeld: wij geven dakadviezen en mensen melden zich aan via de website en die geven dan hun dak op. Ze vullen wat algemene informatie in: dakoppervlak, constructie, constructiemateriaal etcetera.
3. Ja dan ga ik in een buurt langs mensen met een plat dak. Daar ga ik dan een gesprek met hun aan om te kijken hoeveel ze al weten over groene daken en of ze eventueel geïnteresseerd zijn om daar meer over te horen.
4. Normaal gesproken zouden we dus met resilio met een DAKFIETS, een omgebouwde bakfiets met een prototype van een blauwgroen dak. Met resilio gingen we dan de wijk in waar de daken komen om dan in de buurt niet alleen de bewoners te spreken maar ook de mensen uit de buurt om naamsbekendheid te verwerven
5. Maar als er een dak boven je zit, heb je er weinig aan. Dus het is ook belangrijk om beneden wat daken te vergroenen, omdat het dan zichtbaar is. De zichtbaarheid is wel belangrijk voor zoiets
6. [dat kun je natuurlijk niet altijd doen bij particulieren of bij VVE's, maar] het is wel heel belangrijk dat er ergens in iedere wijk zo'n voorbeeld dak komt. Waar ook de andere bewoners zich aan kunnen spiegelen, dat als je dat wilt, dan moet je je dak ook min of meer vervangen en dan ga je voor de toekomst verzekerd zijn van duurzaamheid, koelere locatie en meer vogels en bijtjes.
7. Niet iedereen kan op zijn eigen dak komen en is in staat om dat zelf te doen.
8. Ja, precies, want het is de moeilijkheid ervan, de uitvoering, hoewel het niet moeilijk is om het zelf te doen, maar dan wordt het niet goed gedaan. Je kunt het zelf doen, maar het vereist wel dat je handig bent.
9. Toch zijn het verder ook wel de stappen die je moet zetten van aanvraag tot aanleg. Bijvoorbeeld bij de aanvraag bij hoveniers, dat kunnen mensen wel lastig vinden. Wat moet ik dan opsturen, soms wordt er gevraagd naar bepaalde gegevens van het dak. Bijvoorbeeld het bouwjaar en de constructie van het dak en dan raken mensen in de stress omdat ze geen idee hebben. Vervolgens heb je voor een subsidieaanvraag toch best veel documenten nodig en kan het best lang duren. Als er dan wat fout is in een document wat dan vervolgens weer opnieuw ingediend wordt, gaat er weer 8 weken overheen.
10. Want voordat ik door die gemeenten molen ben, heb ik al tien keer maar gewoon groen dak aangelegd
11. Zijn wat vrolijker als ze op groen uit kijken dan op zwart
12. Nouja, het eerste wat we altijd noemen is het verkoelende effect, daar is het meest onderzoek over bekend met de meeste cijfers. Dat is ook iets wat dicht bij mensen staat, als ze een plat dak hebben en in de zomer hitte ervaren.
13. Je moet je moment kiezen, het is zinvoller wanneer je je bitumen dak gaat vervangen. Op dat moment zijn de voordelen voor de levensduur het grootst
14. Die mensen zeiden dat ze eerst kijken hoe het bij de buren gaat. Die zeiden ook wel dat ze het risico niet wilden lopen.