Master's Thesis

Summer 2024

Topic:

Factors Influencing Dutch Residents' Acceptance of Green Retrofitting Practices in Residential Buildings

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Abstract

The world's energy consumption has increased significantly in recent years, leading to numerous environmental and social challenges. The construction sector is a major contributor, accounting for 30% of final energy consumption and 26% of total greenhouse gas emissions. Researchers and scholars have introduced several paradigms to address these issues, with green retrofitting emerging as a key solution to improve the operational efficiency of residential buildings. To properly answer the main research question of this study, which is what are the key drivers and barriers influencing Dutch residents' adoption of Green Retrofitting (GR) practices in their residential buildings?, this study focuses on analyzing the established policies in the Netherlands, particularly in the city of Utrecht, and examines the drivers and barriers affecting the adoption of GR practices among its citizens. The research involved exploring relevant municipal policies and conducting seven interviews with local residents. The drivers were categorized based on BU2 framework categories and recommendations were made through principles of the Diffusion of Innovations Theory. The findings reveal that financial incentives and environmental benefits are the primary drivers for adopting GR practices. Despite various support schemes such as different subsidies and loans, significant challenges in implementation persist, necessitating local authorities' intervention to enhance adoption rates. The study concludes with practical recommendations to stimulate residents' intentions to apply these practices in their homes based on an expert interview and the author's interpretation of the findings through principles of the Diffusion of Innovations Theory.

Keywords: Green Retrofitting, Drivers and Barriers, Existing Residential Buildings, Green Innovations, Intention and Adoption Analysis, BU2 Framework, Diffusion of Innovations

Acknowledgments

I would like to express my deepest gratitude to my supervisors, Dr. Laura Franco-Garcia, Dr. Athanasios Votsis, and Dr. Sean Vrielink, for their continuous support, guidance, and encouragement throughout the course of this research. Their expertise and insightful feedback were invaluable in shaping this thesis.

I am also thankful to the participants from Utrecht who generously shared their time and experiences, making this study possible.

I extend my appreciation to my classmates and friends for their unwavering support and helpful discussions. Your encouragement has been a great source of motivation.

I would like to express my deepest gratefulness to my dearest girlfriend, Nas Momeni, who has always been there for me through every stage of my life. Her unwavering support and unconditional love have helped me navigate both the highs and lows, and for that, I am eternally thankful.

Finally, I am profoundly grateful to my family for their patience, understanding, and unconditional support during this journey abroad. This accomplishment would not have been possible without them.

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List of Acronyms

AI	Artificial Intelligence
BU2	Build Upon 2
CE	Circular Economy
DG	Degrowth
GBC	Green Building Council
GG	Green Growth
GHG	Green House Gas
GR	Green Retrofitting
GI	Green Infrastructure
SDG	Sustainable Development Goal

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1 Introduction

This chapter introduces the study's aims and scope, beginning with a background of the research topic. It identifies the main research gap, leading to the problem statement. Subsequently, the research objectives are outlined. The main research question is presented next, which will be addressed through four proposed sub-questions. The chapter concludes with a brief section elaborating on the whole document's structure.

1.1 Research Background

The world is witnessing a continuous increase in energy demand and consumption across various sectors, notably in buildings and urban areas, which account for a great portion of global energy consumption and greenhouse gas (GHG) emissions (Rodrigues et al., 2020). A variety of perspectives have been proposed in response to this issue. Some have centered on economic considerations, while others have emphasized social and human factors. Those in the former category have focused on identifying economically feasible and advantageous solutions, while those in the latter have prioritized the livability and well-being aspects of buildings.

Over the past few years, innovative concepts have surfaced from humanity's perspective about how we plan and build our cities. These concepts, such as new urbanism, eco-cities, and green urbanism, break away from traditional models of urban development. They prioritize the social aspects of living and aim to create a future that is both accessible and secure. As Viviers et al. (2017) called it, the ultimate goal of this approach is to construct "something better."

In terms of the economy, various concepts such as Green Growth (GG), Degrowth (DG), and Circular Economy (CE) have been introduced to tackle sustainability issues. These ideas aim to combine different approaches to promote more environmentally-friendly lifestyle models, and the goal is to bridge the gap between these varying perspectives and take action toward a more sustainable future (Calheiros et al., 2021; Tang et al., 2013; Weiss & Cattaneo, 2017). These newly emerged concepts are not only intended to resolve environmental issues but are also committed to addressing the social and economic aspects of living, whether in private spaces like homes or in more public settings like offices.

While DG promotes prioritizing resourcification as a primary solution, focusing on reducing material and energy consumption in economies to address over-resourcification, GG focuses more on improving energy and material usage efficiency while simultaneously addressing social aspects of human life (Corvellec & Paulsson, 2023; Ma et al., 2019). Recently, they have emerged as main attributions in urban (re)development plans and urban planning systems, especially in the building construction sector. Transforming all these concepts to the building and construction sector will lead us to concepts such as green buildings and sustainable construction that could be applied to different kinds of areas and buildings. Diverse studies have been conducted on different aspects of building performance. Karimi et al. (2023) evaluate green buildings based on indoor human health and energy efficiency criteria. On the other hand, some scholars have studied this field from a managerial perspective, such as project management, to cover both practices and processes in associated projects (Wu & Low, 2010). Despite increasing acceptability among households, there are still barriers to implementing such projects and practices across the world (Ho et al., 2017; Kalyana Chakravarthy et al., 2022).

While many studies have concentrated on implementing these practices in the construction of new green buildings, it is equally vital to consider existing buildings and explore strategies for retrofitting[1] them into greener and more sustainable structures (Feng et al., 2020; Lim et al., 2021). This becomes increasingly critical when considering the global housing crisis, particularly in countries like the Netherlands that struggle to construct new buildings due to diverse reasons such as housing shortage, high-interest rates and inflation making borrowing for construction projects costly, lack of available land for development, stringent climate policies, shortage of skilled construction workers, and the pressure of increasing population and immigration driving up demand for housing (Séveno, 2023; Touray, 2021). Retrofitting existing buildings, particularly with Green Retrofitting (GR) techniques, such as rooftop PV panels, green roofs and walls, and insulation materials, has gained traction as a means to enhance sustainability and energy performance (Pedinotti-Castelle et al., 2019). This approach aims to reduce negative environmental impacts and operating costs while simultaneously focusing on different social aspects of living, such as improving indoor environmental quality and residents' health and productivity (Paradis, 2016).

[1] Based on (Cambridge Dictionary, n.d.), it refers to the process of changing a place with equipment that was not initially present during its construction.

1.2 Problem Statement

Efforts to promote GR practices have earned widespread support from various stakeholders, aimed at encouraging residents to enhance efficiency in their living and working environments, thereby mitigating negative impacts across various domains. Alongside the crucial role of reducing negative environmental effects such as GHG emissions and energy consumption, enhancing facility efficiency is also a major concern. Moreover, the social aspects of living and working environments have gained increasing attention in recent years. Governments have implemented a combination of top-down regulations and supportive policies to incentivize residents towards greater efficiency. Despite the mix of supportive tools, numerous challenges hinder residents' successful implementation of these practices, leading to instances of abandonment or frustration. Conversely, while the potential benefits of such practices are promising, the underlying motivations driving residents' intent remain unclear. Clarifying these motivations is crucial for finding effective strategies to facilitate the widespread adoption of GR practices.

1.3 Research Objectives

The objective of this study is to explore the acceptance of Dutch residents regarding the implementation of GR practices in their households, whether they have already adopted them or not. The study's target group comprises residents who are aware of GR practices and have attempted their implementation. This group encompasses two categories: those who have incorporated GR practices into their houses and those who have not. For the former group, both the motivations driving their adoption of GR practices and the challenges encountered during implementation is investigated. The barriers preventing the latter group from implementing GR practices is the other domain of this study.

In addition to identifying motivations and challenges, the study aims to delve deeper into the experiences of both groups regarding GR practices. For those who have already implemented GR practices, a thorough analysis of the factors that stimulated their adoption is conducted. This includes understanding the specific incentives that influence their decision-making process, such as cost savings, environmental concerns, social aspects, or regulatory obligations. Furthermore, the practical challenges they encountered during the implementation phase is explored.

Conversely, the study also investigated the obstacles that have prevented individuals from implementing GR practices. This involves identifying the specific challenges they face, which could include financial constraints, lack of awareness or information, perceived complexity, or skepticism about the benefits of GR practices. By examining these challenges comprehensively, it is aimed to provide insights into the factors that may lead to the widespread adoption of GR practices among Dutch residents.

1.4 Research Question

As discussed in the previous sub-section, this research's objectives aim to explore why Dutch residents adopt GR practices and what challenges they face. By analyzing motivations and barriers, the study seeks to understand residents' decision-making processes. Regarding objectives, the following research question is suggested:

"What are the key drivers and barriers influencing Dutch residents' adoption of Green Retrofitting (GR) practices in their residential buildings?"

In order to effectively address the main research question, a series of sub-questions is proposed to guide the study toward ultimately answering the primary research question.

1. What municipal policies are established to drive residents to adopt GR practices?
2. What main drivers have motivated residents to apply these practices in their houses?
3. What challenges have residents faced during implementing these practices?
4. What barriers prevented residents who considered GR practices from implementing them?

As outlined in the Research Design section (Chapter 3), the study centers around residents in the city of Utrecht in the Netherlands. Therefore, our primary focus is on relevant established policies at the municipal level in Utrecht. This is why the "municipal" term is included in the first sub-question.

1.5 Document Structure

This document is comprised of eight distinct sections that establish an organized flow of information. The document has begun with an introduction, which sets the stage for the research by providing the research background, outlining the problem statement, and detailing the research objectives. It also includes the research question that guides the study and concludes with a brief overview of the document structure, giving readers a clear roadmap of what to expect in the subsequent sections. Following the introduction, the literature review delves into various paradigms and theories related to sustainable urbanism and green practices. It covers topics such as green/sustainable urbanism paradigms, GG, DG, and CE, resourcification, and GR. This section also presents the theoretical/conceptual framework underpinning the study, with a specific focus on the BU2 framework, explaining its relevance and application to the research. The research design section outlines the research methodology employed, including data collection, data requirements, data analysis and management, and ethical considerations.

The document then presents the results and findings, beginning with an introduction to the main findings and detailing the primary results. This includes policy review findings and interview findings, which cover GR practices, planned GR practices, drivers, and barriers. In the discussion section, the primary results are cautiously interpreted, exploring ways to scale up GR adoption through the diffusion of innovations theory and addressing the study's limitations. Finally, the conclusion summarizes the key findings and offers future research recommendations. The document concludes with a list of included references and appendixes providing additional supporting information.

2 Literature Review

This chapter delves into fundamental concepts that are essential to the research. It begins by outlining the significant challenges facing the world in relation to our topic before exploring the societal responses. Throughout these solutions, the resourcification idea was repeatedly encountered, and it manifests in various practices, including GR. These concepts are explained and elaborated in subsequent sections to help fully understand them. Lastly, the conceptual framework that underpins our research is introduced. It aims to go beyond mere description and elucidate the rationale behind selecting this framework.

As stated in the introduction, the world is facing a consistent growth in energy demand and consumption across diverse sectors and industries, leading to a corresponding rise in GHGs worldwide. This surge in energy demand and consumption is particularly pronounced in buildings and urban areas, where the need for power to support daily activities continues to grow (Kammen & Sunter, 2016). The building sector is considered the biggest single contributor to world energy consumption and GHG emissions (Allouhi et al., 2015). Buildings' energy usage constitutes a substantial share of urban energy consumption. Delmastro & Chen's (2023) report on the International Energy Agency (IEA) website claims that building operations contribute to 30% of worldwide final energy consumption and 26% of global energy-related emissions. This encompasses both direct emissions from buildings and indirect emissions stemming from the generation of electricity and heat utilized in buildings. These situations will lead us to the following concepts that emerged as possible solutions to the energy crisis in the context of sustainable urban planning from two different perspectives: Humanity driven and Economic driven .

2.1 Green / Sustainable Urbanism Paradigms

Green or Sustainable Urbanism Paradigms encompass a variety of concepts and strategies aimed at creating urban environments that are environmentally responsible, socially equitable, and economically viable (Jabareen, 2006). These paradigms include some new emerging concepts such as the Eco-City Paradigm, New Urbanism, and the Triple-U Problem. (Bibri, 2020; CNU, n.d.; Roggema, 2016).

The Eco-City Paradigm aims to create cities that operate as closed-loop systems, aiming to minimize waste and maximize resource efficiency. According to Bibri (2020), this approach emphasizes several key elements, including self-sufficient communities with renewable energy sources, local food production systems, and integrated waste management, as elaborated in Table 1.

Table 1. Main focused criteria of Eco-City paradigm (Bibri, 2020)

Eco-City Paradigm	
Sustainable energy systems	High-performance buildings
100% locally renewable energy (sun, wind, and water)	Energy-efficiency technology and renewable energy resources
Bio-fueled CHP system	Improved indoor environment
Passive houses	Pollution prevention, material reduction, and recycling
Sustainable waste management	Sustainable transportation
Smart waste collecting system	Cycling and walking
Vacuum waste chutes system	Public transport (metro, buses, tram, etc.)
Food waste disposers	Car pools (biogas and electric)
Wastewater and sewage treatment system	Mobility management
High-performance infrastructure	Greening and ecological diversity
Component and multifunctional optimization	Multi-functional green structure for ecosystem services
Integrated design	Green factor planning tools

The New Urbanism approach prioritizes the development of walkable, mixed-use neighborhoods, with an emphasis on public transportation, green spaces, and the promotion of a strong sense of community (Howard, 2005; Miller, 2002). Its goal is to reduce reliance on cars and to create dynamic, livable urban environments. In striving for sustainability in cities, there are various uncertainties that could impact the trajectory. Roggema (2016) identifies three types of these uncertainties: Uncertain developments, Enforced uncertainties, and Exposure to uncertainties, which he collectively refers to as the “Triple-U Problem.” Discussing each briefly, he asserts that developments are inherently uncertain and can be easily influenced by factors such as climate change, migration, and technological advancements, making them difficult to predict. Additionally, enforced uncertainties stem from intentional sustainability transitions, such as the shift toward a green economy or low-carbon energy, necessitating systemic urban transformations. Moreover, the ongoing urbanization of the global population, particularly in vulnerable locations, increases the number of people exposed to these uncertainties.

2.2 Green Growth, Degrowth, and Circular Economy

Moving toward more economically-focused concept from previous humanity-focused paradigms , we encountered three significant approaches: Green Growth, Degrowth, and the Circular Economy. These approaches each offer distinct pathways for achieving sustainability, balancing economic development with environmental preservation, and addressing social equity.. Amidst the challenges posed by ecological, economic, and social crises stemming from escalating energy demand, various concepts have emerged to chart deliberate pathways toward sustainability (Belmonte-Ureña et al., 2021). In both public discourse and academia, two prominent narratives under debate are GG and DG (IPCC, 2014). Amongst a challenging debate about selecting pathways for future sustainability, Polewsky et al. (2024) aim to bridge the gap between the contrasting narratives of GG and DG by identifying common ground and potential synergies to advance understanding of transformative economic models. By considering GG, DG, and CE and analyzing their interrelation, countries can further their progress toward achieving sustainable development goals (SDGs) (Belmonte-Ureña et al., 2021). Furthermore, the concepts of A-growth and Post-growth have been explored to address the role of economic growth in achieving environmental sustainability (Lehmann et al., 2022). They concluded that experts who regularly engaged with environmental and ecological subjects tend to favor growth-critical concepts such as a-growth, post-growth, and DG while rejecting GG.

2.3 Resourcification

All three concepts, GG, DG, and CE, emphasize the centrality of the resource concept, underlining its social construction through resourcification theory, and critique unsustainable resourcification practices. For instance, DG advocates prioritize resourcification as the primary solution, emphasizing the shift towards activities with lower material and energy throughputs to address over-resourcification in economies (Corvellec & Paulsson, 2023). Resourcification, as observed in the examination of convivial innovations within sustainable communities, entails utilizing the resources already present within our communities (Bobulescu & Fritscheova, 2021). Emerging forms of interaction and innovative knowledge may reintroduce alternative methods of resource creation, such as retrofitting (Corvellec & Paulsson, 2023; Robra et al., 2020).

2.4 Green Retrofitting

Retrofitting refers to changing the systems or structure of an existing building after its initial construction and occupation. The term "green retrofitting" refers to the change in the existing building to make it more environmentally friendly, reducing negative impacts on society and environment and reducing operating costs by creating a high-performance building by applying the integrated, whole-building design process (Amoah & Smith, 2022; Paradis, 2016). The concept of retrofitting existing buildings with the aim of improving sustainability and energy performance has gained significant attention in recent years. This is primarily because buildings consume a significant amount of energy, particularly for heating and cooling (Amoah & Smith, 2022). This process ensures all key design objectives are met, such as improving indoor environmental quality, decreasing moisture penetration, and reducing mold, all of which result in improved occupant health and productivity (Paradis, 2016).

However, scholars have introduced considerable implementation issues. For instance, Smith (2018) claims that the main obstacles are rooted in (a) the lack of incentives for the owners of existing buildings to retrofit their buildings and (b) the difficulties in adequately communicating the retrofitting "business case" to these owners. Despite these challenges, an increasing number of countries are developing successful retrofitting implementation strategies (Ma'bdeh et al., 2023; Smith, 2018). Studying residents' intentions toward green retrofitting is crucial as it determines the efficacy of transitioning existing buildings from 'energy-saving retrofitting' to 'green retrofitting,' highlighting their pivotal role in advancing sustainable building practices (He et al., 2019).

These circumstances underscore the significance of investigating residents' attitudes toward green retrofitting, emphasizing their pivotal role in promoting sustainable building practices. In the next section, we will discuss the frameworks that is employed in this study.

2.5 Theoretical/Conceptual Framework

BUILD UPON2 (BU2), spearheaded by (GBC, 2021), is a Horizon 2020-funded project designed to equip cities across Europe with the necessary tools to revolutionize building renovation, paving the way towards achieving net zero carbon emissions by 2050. Through collaboration with over 30 European cities from 2019 to 2021, Green Building Council (GBC) members in different countries within the project have tried to align with the European Commission's Renovation Wave, aiming to empower cities to collaborate with national governments and industries in decarbonizing existing building stock. Central to the project's objectives is the development and implementation of the BU2 Framework, a comprehensive tool designed to monitor and report the multifaceted benefits of building renovation, including environmental, social, and economic impacts. Supported by a consortium of eight national GBCs, along with key partners such as the Buildings Performance Institute Europe and Climate Alliance, BU2 aims to drive meaningful progress towards sustainable building practices across Europe.

BU2 framework consists of 3 key factors, i.e., Environmental, Social, and Economic. Each key factor includes specific indicators representing how those beneficial factors could be achieved using measurable variables. Moreover, each indicator can have impacts on both project and city levels that could help policymakers and decision-makers measure those impacts on different scales. This BU2 framework will be used as the baseline of conceptual thinking to identify the main drivers of tenants who have applied GR practices. These factors and indicators are shown in Figure 1.

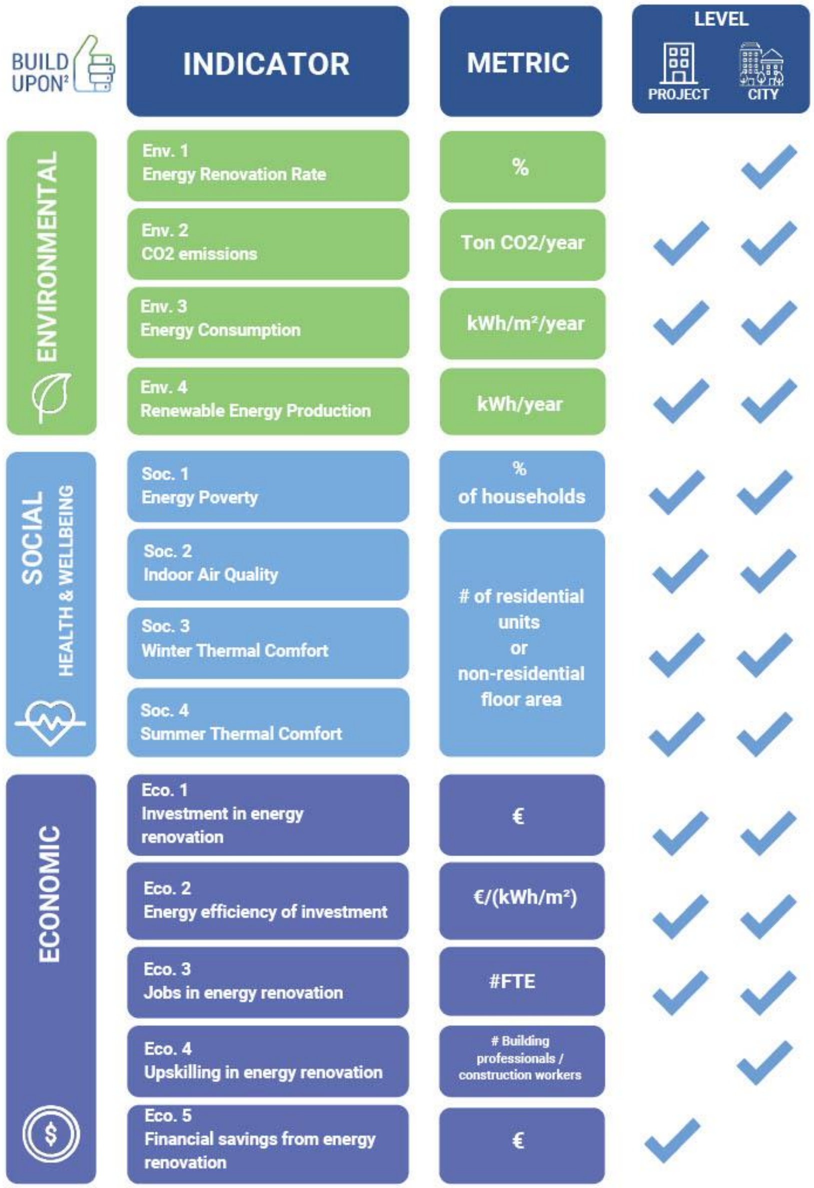

Figure 1. BU² Framework: detailed on its indicators and the level of effect

In addition to the three key factors previously adopted from the BU2 framework, policy and regulation factors will also be investigated as primary criteria. Collectively, these factors are crucial in identifying potential drivers and barriers in the adoption and implementation of green retrofitting practices. Furthermore, considering recent regulatory developments in various countries, particularly within the EU and the Netherlands, policy and regulation factors emerge as significant influences on residents' intentions and can also play a critical role in shaping attitudes towards GR initiatives (He et al., 2019).

2.5.1 Why BU2 Framework?

A thorough scientific literature review was conducted to identify common methods for extracting factors that may impact residents' adoption of GR and Green Infrastructure (GI) practices. To do so, keywords such as "Green Infrastructure," "Green Retrofit," "Energy Efficiency," " Adoption Factor," and "Acceptance Factor" have been used to identify the primary dataset from the Scopus database. Then, they were limited to those focused on "Energy," "Environmental Science," and "Social Science" and were written English. Subsequently, these papers were scanned to identify the most relevant papers to this study's scope and topic. Notably, by reading some of these papers, some relevant papers were also found in their references that have been investigated, too. Finally, the 10 most relevant papers have been extracted. Through this scanning, it was found that the scholars have typically identified and categorized these factors using data collected from either literature reviews or individual interviews. While the number of studied categories and influential factors is diverse, we can generally classify them into Environmental, Economic, and Social aspects, which also align with sustainability criteria. These studies typically focus on the environmental, ecosystem services, and economic benefits of these practices or the social aspects and residents' understanding of these practices. The factors covered in each paper are indicated in Table 2.

Table 2. Overview of sustainability criteria covered by relevant references.

Author(s) of the reference	Sustainability Covered Criteria		
	Env.	Eco.	Soc.
(Achtnicht & Madlener, 2014)	×	✓✓	×
(Lang et al., 2021)	××	✓✓	✓
(Gómez-Baggethun & Barton, 2013)	✓✓	✓✓	×
(Aghimien et al., 2023)	✓	✓✓	×
(Pitman et al., 2015)	✓✓	××	×
(He et al., 2019)	✓	✓	✓
(Liu et al., 2022)	✓	✓	✓✓
(März, 2018)	✓	✓	✓✓
(Pakzad & Osmond, 2016)	✓✓	✓	✓
(Parker & de Baro, 2019)	✓✓	✓	✓✓

××: Not Covered at all ×: Briefly Covered □: Partially Covered □□: (Almost) Entirely Covered

Out of all the references listed in the table, only Pakzad and Osmond (2016) chose a framework prior to conducting their data collection. The framework they selected is very similar to the BU2 framework that will be utilized in this study to identify and categorize drivers. The advantage of using the BU2 framework categorization over other frameworks and categorizations used in prior studies is its high adaptability. This does not necessarily mean the other frameworks are not adaptable, but the BU2 framework is subject to permanent review and revision by more than 30 EU cities that have collaborated to design, promote, and recommend the adoption of this framework. The key factors outlined in the BU2 framework not only cover all sustainable criteria but also can easily be adjusted to fit the specific context. This means the terms and indicators studied through this framework can be modified based on contextual factors. Lastly, compared to evaluating other frameworks in the table above, the BU2 framework covers all comparison criteria. As previously noted, this framework serves to evaluate the effects of GR practices across various levels. For the purposes of this study, the framework will be employed to classify drivers into three distinct factors: Environmental, Social, and Economic. Additionally, the policy and regulation factor will be taken into account, representing the regulatory and legal obligations as another significant factor. Furthermore, the BU2 framework indicators will be utilized to accurately categorize drivers into their respective categories. As a result, these indicators will also serve as a guide for my interview questions.

Eventually, the diffusion of innovations theory is used to suggest comprehensive solutions to scale up the adoption of GR practices. This theory, popularized by Rogers (1962), includes five main attributes: relative advantage, compatibility, complexity, trialability, and observability, indicating how innovations can be spread out in society, as shown in Figure 2. Shortly, relative advantage refers to how much better compared to what it replaces, while compatibility indicates how well the innovation aligns with the values, practices, and needs of potential users. Complexity assesses the difficulty users perceive in understanding and using the innovation, while trialability refers to the extent to which the innovation can be experimented with before full-scale adoption. Observability measures how easily others can witness the results of the innovation in action.

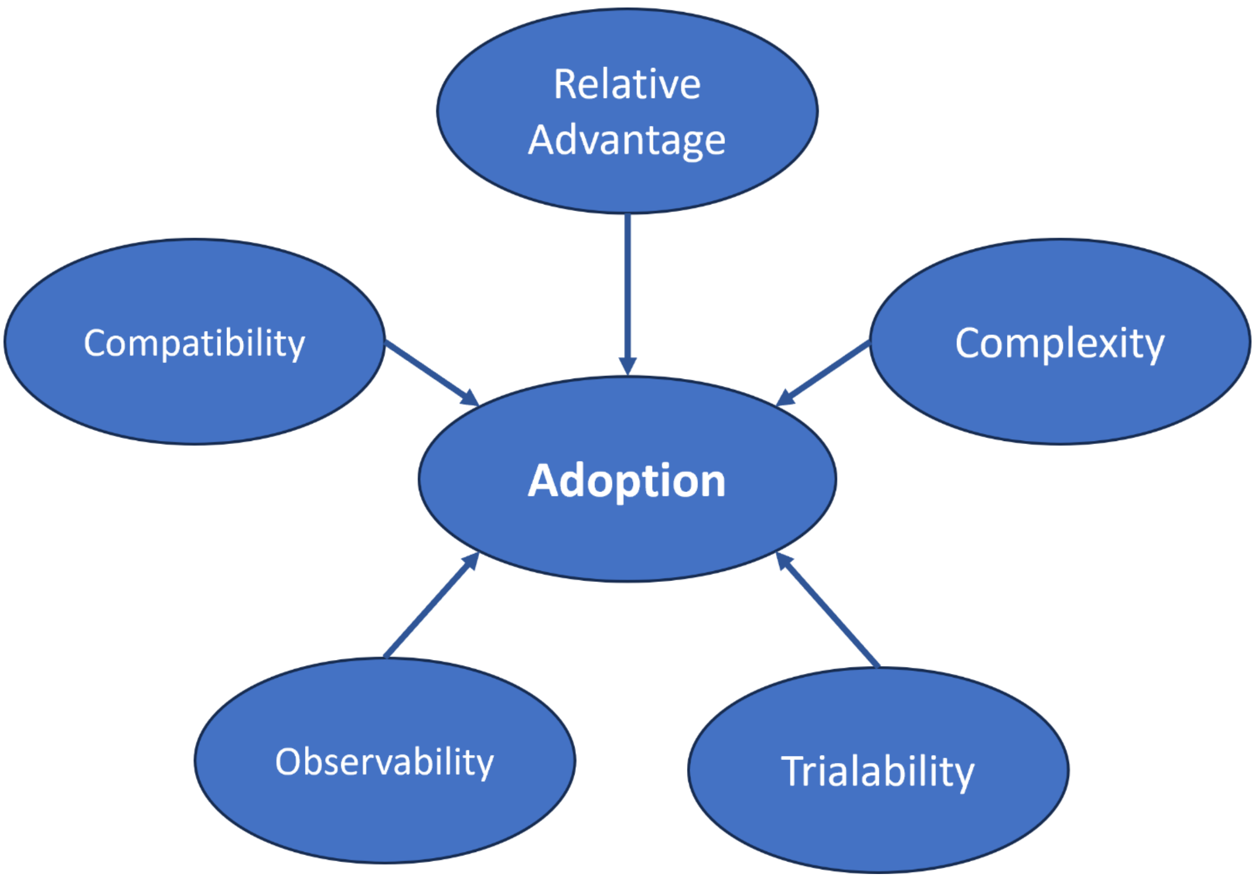

Figure 2. Principles in the Diffusion of Innovation Theory (Rogers, 1962)

This study plans to contribute to the existing knowledge by introducing new factors and indicators to be incorporated into the BU2 framework, which hopefully helps to build up a revised and more comprehensive version of the framework. Moreover, it is planned to enhance current policies by pinpointing the key drivers and barriers that impact the residents' adoption rate of GR practices. Accomplishing this goal may require establishing new policy instruments or revising them and addressing regulatory complexities.

3 Research Design

As mentioned in the first chapter, research objectives and questions have been modified to find key drivers and barriers influencing Dutch residents' adoption of GR practices in their households. In this chapter, the design and execution of this research are described, detailing a series of step-by-step activities aimed at addressing the sub-questions and ultimately resolving the main research question. In order to achieve this, the following sections have been included: Research Methodology, which provides a detailed introduction to the study's target group; Data Collection and Requirements, which delves into the specifics of the data that must be gathered to address each sub-question effectively and outlines the methods of collection; and Data Analysis and Management, which explains the procedures for analyzing the data and answering the research questions. Finally, the chapter concludes with a discussion of Ethical Considerations and Limitations that should be taken into account throughout the research process.

3.1 Research Methodology

In this study, a qualitative research is conducted to identify the drivers and barriers regarding the study's topic. As illustrated in Figure 3, it was necessary to reach out to residents who have thought about GR practices, whether they have applied them or not. In the former group, the main drivers that motivated them to apply such practices and the barriers they faced while implementing them is found. In the latter group, the main obstacles and challenges that have prevented them from applying these practices in their areas of interest is investigated.

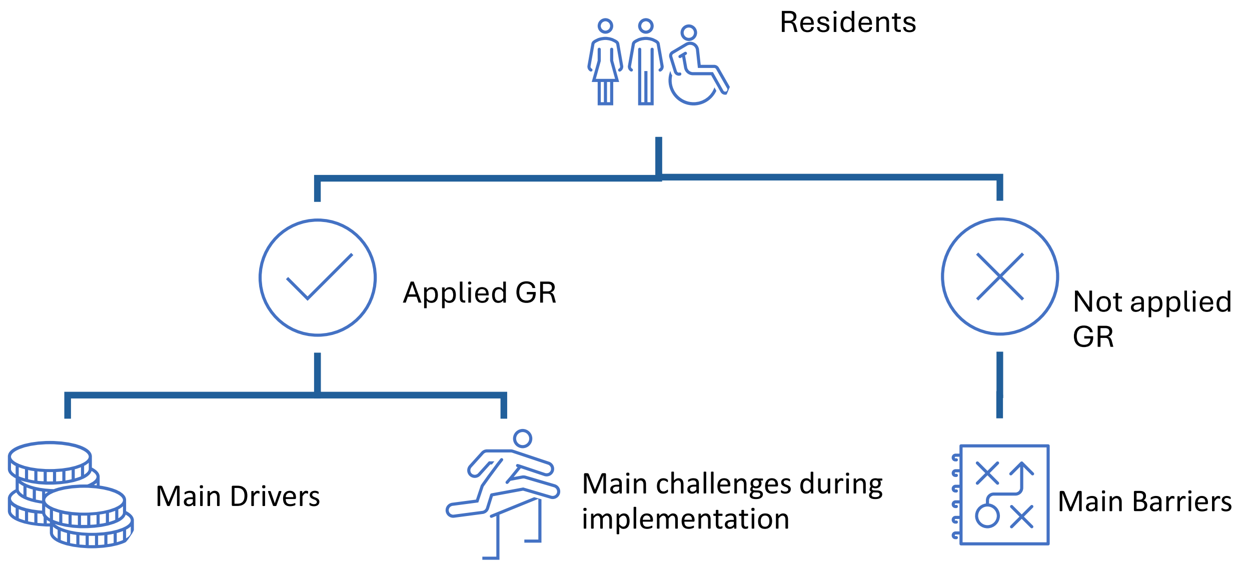

Figure 3. Schematic of the research target group.

After identifying the main drivers and barriers, recommendations are made on how to scale up the adoption of GR practices using the principles of the Diffusion of Innovation Theory.

3.2 Data Requirements

This research integrates primary and secondary data sources to answer the research question and sub-questions. Table 3 provides a summary of each sub-questions and what/how data are collected to answer each properly.

Table 3. Overview of data collection method for each sub-question

Research Question	Data/Information Required	Source of Data	Data Collection Method
What policies are established to drive residents to adopt GR practices?	• Desk Research on Related Policies	• Municipal Documents and webpages	• Secondary Data: Documents and Literature Reviews Content Analysis
What main drivers have motivated residents to apply these practices in their areas of interest?	• Interviews and Meetings	• Suitable Residents	• Primary Data: Semi-structured Interviews
What challenges have residents faced during implementing these practices?	• Interviews and Meetings	• Suitable Residents	• Primary Data: Semi-structured Interviews
What barriers prevented residents who considered GR practices from implementing them?	• Interviews and Meetings	• Suitable Residents	• Primary Data: Semi-structured Interviews

The suitable residents mentioned in the table above primarily refer to those who are currently living in the Utrecht city region, irrespective of specific demographic characteristics such as age, gender, or neighborhood. This inclusive approach was adopted to maximize the response rate and ensure a broad spectrum of perspectives. The decision to include all types of respondents without focusing on particular characteristics such as age, neighborhood, or other personal attributes was driven by several key considerations. By not limiting the sample to specific demographics, we aimed to enhance the likelihood of participation, as this inclusivity was crucial to obtaining a sample size for meaningful analysis. Including residents from diverse backgrounds ensures that the findings reflect a wide range of experiences and viewpoints. This approach helps capture the complexity and heterogeneity of the target population in the Utrecht city region.

For the second and third research questions, the target group is those residents who have applied GR practices in their residential buildings. The other part of the target group represents those residents who have considered applying GR practices at one point but have faced some barriers that have prevented them from implementing such practices, which are used to answer the fourth question. To gain a clearer understanding, consider the following example. Picture a homeowner who has installed solar panels and green walls in their house but has not implemented a green roof. The study looked into the factors that drove them and the obstacles they encountered during the implementation. Furthermore, it also considered the barriers that prevented them from installing a green roof.

The study focuses on the residents of Utrecht, one of the biggest four cities in the Netherlands. Utrecht as the 4^{th} largest city in the Netherlands in the terms of population and 3^{rd} as the area covered, has established various schemes to enhance the sustainability criteria of the city. For instance, they have started a significant push for green roofs with the installation of green roofs on 316 bus stops, completed in April 2019 (Municipality of Utrecht, 2024e).

Subsequently, conducting policy reviews are essential to help identify all pertinent instruments and tools that have been implemented. This thorough recognition and assessment would provide a comprehensive understanding of all potential drivers that could encourage individuals to implement GR practices and the barriers that act as obstacles.

Overall, the primary data required for this study encompassed policy documents, the identification of suitable individuals and interviewing them, and consultations with experts trained in scaling up these practices, drawing upon the principles of the Diffusion of Innovation theory.

3.3 Data Collection

Addressing the initial research sub-question necessitates acquiring a comprehensive understanding of the current policies in place within the selected Dutch city, Utrecht. This required a thorough review of relevant policies and regulations relevant to the subject matter. Such an analysis facilitated the identification of existing supportive frameworks and elucidated any complexities associated with implementing GR practices.

To properly answer the first question, the Utrecht municipality website[1] has been used as the main source of data collection to identify established policies to support residents. Search terms such as "Sustainability," "Green House(s)," and "Subsidy(ies)" are used to explore initial web pages. After scanning these initial pages, more relevant pages for each practice were identified in these initial ones. Although the website is available in English, assistance was provided by a Dutch friend and classmate to explore content in Dutch, as some web pages were exclusively in Dutch. For these pages, Google Translate was used to translate the information into English.

Primary data collection is conducted through semi-structured interviews to answer the next three sub-questions. Accordingly, it was essential to locate suitable residents, requiring the identification of the target group. Firstly, individuals who have implemented GR practices were needed to identify their primary drivers for adoption and the main challenges encountered during implementation. Secondly, efforts were made to engage with residents who have considered adopting such practices but encountered barriers preventing them. Despite this difference, an individual can fall into both categories since they may have implemented GR practice X but not GR practice Y.

To collect data and schedule interviews with residents in the city of Utrecht, a multi-faceted approach was employed to ensure a diverse and comprehensive sample. Over 500 letters were distributed throughout the city, a process that involved physically walking through different neighborhoods and using Google Maps to identify houses with green facilities. This direct approach was complemented by engaging citizens in high-traffic areas, such as supermarkets, churches, and the Central Train Station, to identify and approach suitable residents willing to participate in interviews.

Additionally, the Homeowners Association Community Website was utilized to post an interview request, leveraging this platform to reach a targeted audience of homeowners. Social media also played a significant role in outreach efforts; posts were made on LinkedIn, Instagram, WhatsApp, and Facebook, with requests for friends and followers to share the information further, thereby broadening the reach. Finally, Reddit, specifically the Subreddit of Utrecht, was used to engage with the local online community, inviting residents to participate in the interviews. This combination of traditional, digital, and community-based methods ensured a well-rounded and

[1] www.Utrecht.nl

effective strategy for data collection and interview scheduling, resulting in 7 interviews. The pseudo-anonymized transcripts of these interviews can be accessed. For more details please look at the Appendix I of this study.

Eventually, interviews are arranged with experts within the field to explore strategies for enhancing the adoption rate of GR practices on a larger scale. These discussions aim to gain insights that may lead to actionable recommendations, drawing upon principles outlined in the Diffusion of Innovation theory.

3.4 Data Analysis and Management

As the first sub-question necessitates a review of policy documents, conducting a thorough literature review becomes imperative to analyze the data comprehensively. This process involves categorizing established incentives and regulatory complexities. This stage includes content review, identification of policy instruments, and grouping of these instruments accordingly. Consequently, it is anticipated that a collection of primary incentives and regulatory obstacles or complexities will emerge. Since the study is focused on Utrecht, the municipal policies of this city were reviewed.

Subsequently, interview questions were formulated to identify the drivers based on the BU2 framework and policy and regulatory factors. Following the interviews, a codebook will be developed to categorize motivators into four primary factors: Environmental, Social, Economic (aligned with the BU2 framework), and Policy and Regulation obligations (derived from (He et al., 2019)). Additionally, the interviews were used to yield insights into different kinds of significant barriers. The procedure that resulted in answering all research questions is shown in Figure 4.

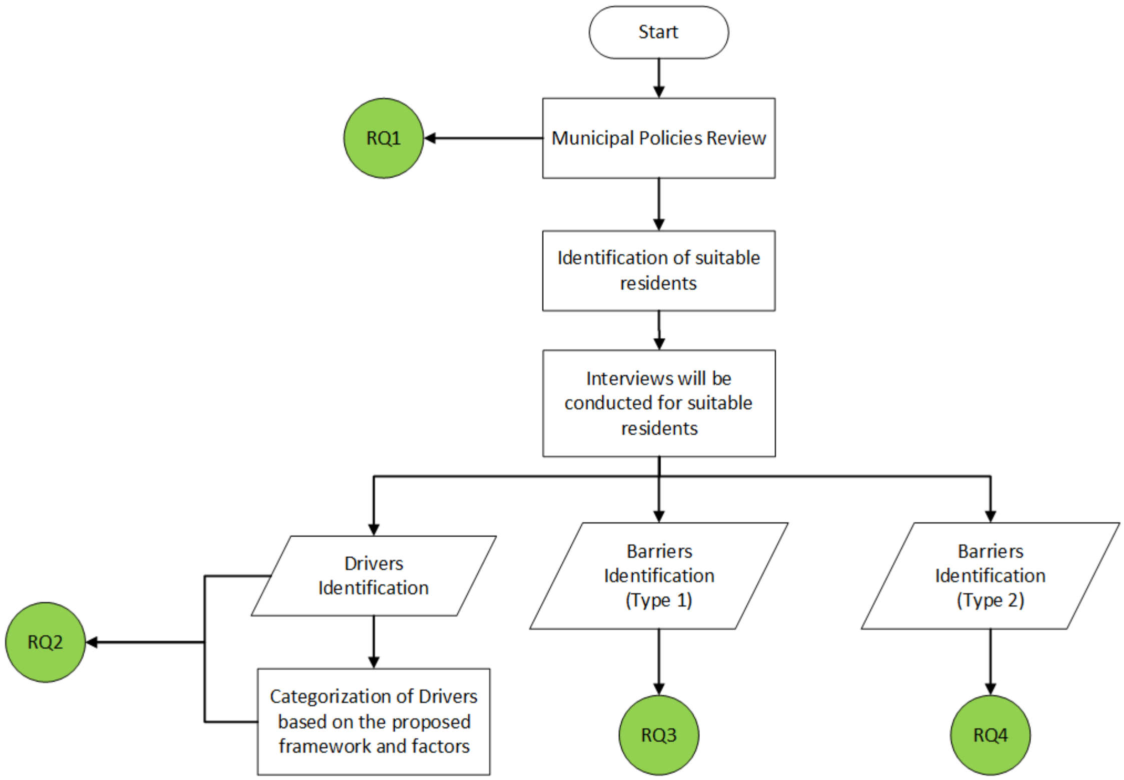

Figure 4. Schematic of data and workflow to answer all questions.

In addressing the initial sub-question, an analysis of the green retrofitting policies for Utrecht's housing was conducted. The Utrecht Municipality Website was utilized to examine the range of available policies, encompassing subsidies and regulations published on the website.

After conducting interviews for three sub-questions, the interview transcripts were used to create a codebook using ATLAS.ti software. ATLAS.ti is a qualitative data analysis software that helps researchers systematically analyze complex phenomena found in textual and multimedia data. It provides tools for coding, annotating, and visualizing data, allowing users to identify patterns, themes, and relationships within their data sets. The software is capable of handling various types of data, including text documents, audio, video, images, and geospatial data. Researchers can also utilize this software for tasks such as literature reviews, content analysis, and grounded theory development. Its comprehensive features has made it a popular choice for academic, market, and social science research.

Furthermore, ensuring consistent, unbiased, and reproducible coding of data is essential for enhancing the overall credibility and trustworthiness of a study's findings. Interrater reliability is utilized to achieve a high level of agreement between multiple raters, allowing researchers to confidently assert that their coding scheme is clear, well-defined, and appropriately applied. This minimizes subjective interpretation and potential biases. This reliability is crucial for validating research outcomes, demonstrating that identified patterns, themes, and insights are robust and generalizable, rather than merely reflecting individual perspectives. In addition, interrater reliability promotes transparency and accountability in the research process, which are indispensable for peer review, replication studies, and the advancement of knowledge within the field. Thereupon, after the interviews were coded, another student from the MEEM program reviewed and confirmed all coding and categories. This step was undertaken to enhance the credibility and trustworthiness of the codes, ensuring interrater reliability.

Ultimately, existing policies and identified drivers and barriers serve as inputs for proposing recommendations through Diffusion and Innovation Theory. These suggestion has been added in the last section of the Discussion chapter.

3.5 Ethical Considerations

Before conducting the interviews, the interview protocol was thoroughly assessed for ethical standards to prevent any ethical wrongdoing. The BMS Ethics Committee also reviewed and approved the ethical standards of the research. Only after obtaining this approval were the interviews conducted.

Interviewees were informed about the research content when invited for an interview and were asked for their consent to audio record the sessions. Each participant's consent was documented in a separate consent form. No interviewee names are mentioned in the thesis.

The interview recordings were stored anonymously on a cloud drive (Google Drive), accessible only to the researcher. These recordings were encrypted to prevent potential misuse, such as training Artificial Intelligence (AI) systems. The recordings will be deleted after the master thesis is accepted and graded. To minimize bias, the research incorporates both documents and interviews, ensuring multiple perspectives are considered.

4 Results and Findings

In this chapter, main results of the study are presented which underly two different parts. First, the analysis of the municipal policies to discover potential supporting schemes and rules and regulations obligatory with the city of Utrecht. This part is presented through a comprehensive secondary data analysis of policy documents to properly answer the first sub-question. As a process to answer sub-questions 2-4, interviews were conducted to identify drivers and barriers that motivated and/or prevented residents from applying GR practices in their houses. The outcome and results of these interviews are presented in the second part of this section. Fortunately, there was no deviation from original plan presented in Table 3. However, more interviews could have resulted in a more statistically significant result regarding research questions two to four.

4.1 Policy Review Findings, RQ 1

The Utrecht municipality provides various subsidy schemes covering different areas such as *art and culture, sustainability, education, sports, welfare, care and health, work and entrepreneurship, and housing and living environment* (Municipality of Utrecht, 2024l). For this study on Green Retrofitting, the relevant schemes fall under sustainability and housing and living environment. Each area offers multiple subsidy options, and we will discuss the most relevant ones shortly in the following text.

4.1.1 Sustainability subsidies

In this series of subsidies, the Municipality of Utrecht (2024m) presents all subsidies regarding sustainability in its region. These subsidies are available to businesses, institutions, and homeowners. The subsidies can be used to make buildings more energy efficient and operate at a more environmentally friendly rate. There are also subsidies available to organizations, companies, associations, and private stakeholders that want to move toward more sustainable pathways. The relevant subsidies to this study’s scope are shortly elaborated below:

4.1.1.1 Energy advice at home and trajectory guidance:

This subsidy supports homeowners in making their homes more sustainable by providing financial assistance for engaging an energy advisor (Municipality of Utrecht, 2024b). Homeowners can receive up to €300 for energy advice and up to €220 for a sustainable long-term plan, as well as up to 75% of the costs for process guidance with a maximum of €450. The subsidy is available to owner-occupiers of ground-level homes and small landlords with up to 10 properties. Eligible measures include insulation, heating, and sustainable energy generation.

4.1.1.2 Green roof (Available until July 1, 2024):

This subsidy requires the total area of the green roof(s) to be at least 10 m², which can be achieved individually or collectively if individual roofs are smaller (Municipality of Utrecht, 2024c). The roofs must be located within the municipality of Utrecht, and applications can be submitted either before or within three months after installation. Applicants can submit joint applications if their roof areas are less than 10 m², provided the total combined area meets the minimum requirement. The amount of the subsidy varies based on the type of green roof: roofs with mosses, sedum, trees, shrubs, and grasses that weigh more than 200 kg/m² when wet and retain at least 70 liters of water per m², roofs with mosses and sedum that retain at least 15 liters of water per m², and roofs with sedum and herbs (with at least 30% herbs and flowers) that retain at least 50 liters of water per m². Each type can receive up to 50% subsidy, with a maximum of €20,000 per application.

4.1.1.3 Green-blue roof (Available from July 1, 2024):

The subsidy for green-blue roofs supports the installation of green-blue roofs, which incorporate plants that also retain water, on houses, sheds, commercial buildings, or other structures (Municipality of Utrecht, 2024d). To qualify, the green-blue roof must cover at least 6 m², and applications can be made individually or collectively. The subsidy can cover up to 50% of the installation costs, with a maximum of €20,000 per application. The amount varies depending on the water retention capacity of the roof, with extensive green roofs retaining 20-29 liters per m² receiving €30 per m², those retaining 30-49 liters per m² receiving €35 per m², and those retaining 50 liters or more per m² receiving €40 per m². Biodiversity and intensive green roofs may have higher subsidy rates.

The main differences between the last two subsidies (Green Roofs and Green-Blue Roofs) lie in their eligibility criteria, water retention requirements, and roof type criteria. The Green Roof subsidy requires a minimum area of 10 m², whereas the Green-Blue Roof subsidy requires only 6 m². Water retention requirements for the Green Roof subsidy vary by roof type, generally starting at 15 liters per m², while the Green-Blue Roof subsidy mandates a minimum retention of 20 liters per m² for extensive roofs, 30 liters per m² for biodiverse roofs, and 70 liters per m² for intensive roofs. The Green Roof subsidy focuses on plant types such as sedum, herbs, and grasses, along with structural weight considerations. In contrast, the Green-Blue Roof subsidy emphasizes water retention capacity, biodiversity, and a mix of plants, including trees and shrubs, for intensive roofs. Both subsidies cover up to 50% of costs, but the Green-Blue Roof subsidy offers tiered financial support based on specific water retention capacities, making its rate structure more detailed than that of the Green Roof subsidy. Key differences between these plans are presented in Table 4.

Table 4. The main differences between the previous subsidy regarding Green Roofs and the new version.

Aspect	Green Roof Subsidy	Green-Blue Roof Subsidy
Minimum Area	10 m²	6 m²
Water Retention Requirements	Varies by roof type, generally starting at 15 liters/m²	Minimum 20 liters/m² for extensive roofs, 30 liters/m² for biodiverse roofs, and 70 liters/m² for intensive roofs
Roof Type Criteria	Focus on plant types (sedum, herbs, grasses) and structural weight	Emphasis on water retention capacity, biodiversity, and mix of plants, including trees and shrubs, for intensive roofs
Subsidy Rates	Up to 50% of costs	Up to 50% of costs, tiered based on specific water retention capacities
Maximum Subsidy	€20,000 per application	€20,000 per application
Collaboration	Allowed for meeting minimum area requirement	Allowed for meeting minimum area requirement
Application Timing	Before or within three months after installation	Up to three months before or after installation

4.1.1.4 Insulate a small association (insulation approach):

This subsidy scheme supports insulation measures for properties in three specific neighborhoods, namely Elinkwijk, Julianapark, and Watervogelbuurt (Municipality of Utrecht, 2024g). This applies to small homeowners' associations with seven or fewer homes. Eligible measures include roof, floor, wall, and window insulation, as well as CO_2-controlled ventilation systems. The subsidy offers up to €1,500 per home for two energy-saving measures (€750 per measure). For those struggling with investment costs or who qualified for energy compensation in 2022 or 2023, the subsidy can go up to €8,000 (€4,000 per measure).

4.1.1.5 Small homeowners' association Loan:

This loan, provided by the SVn (Dutch Municipal Housing Incentive Fund), is designed for 2 to 7 apartments which are defined as a small homeowner's association to support maintenance, renovations, and energy-saving measures such as insulation, hybrid heat pumps, solar panels, and sustainable heating systems (Municipality of Utrecht, 2024i). The loan ranges from €2,500 to €25,000 per apartment with a fixed interest rate of 1.6% and a term of 10, 15, or 20 years. Additionally, loans with the National Mortgage Guarantee (NHG) include a 0.6% guarantee fee. To qualify, the associations must delay the start of their projects until after loan approval, and projects must address common property elements like foundations, floors, facades, roofs, and shared installations. The measures must be recognized by the NHG for energy savings. This initiative aims to facilitate the improvement of collective properties by offering financial support for essential upgrades and sustainable enhancements.

4.1.1.6 Insulate your home – Subsidy:

This subsidy is available to owners of single-family homes or small homeowners' with a WOZ[1] value below €488,000 as of 2022 (Municipality of Utrecht, 2024h). This value will be updated each year. The subsidy supports insulation measures like roof, floor, wall, and window insulation, as well as CO_2-controlled ventilation systems. Homeowners must apply for the subsidy after completing the insulation work. Eligible properties must be poorly insulated with an energy label of D, E, F, or G or lacking an energy label with at least two poorly insulated components. The subsidy provides up to €750 for one measure and a maximum of €1,500 for two measures. For those who qualified for energy compensation in 2022 or 2023 or hold a U-Pas[2], the subsidy can be up to €8,000 for two measures.

4.1.2 Subsidies for housing and living environment

This overarching scheme established by Municipality of Utrecht (2024k) incorporates all subsidies applicable to diverse living environments, encompassing even monuments and yard areas. It

[1] Waardering Onroerende Zaken: It is the annual assessed market value of a property in the Netherlands, determined by the municipality for different purposes such as tax.
[2] U-Pas is a discount card for low-income residents in the Utrecht region, providing access to various discounts and free activities in sports, culture, education, and leisure.

extends to encompass previous sustainability subsidy programs. Furthermore, the municipality is also serving the following subsidy scheme:

4.1.2.1 Initiative Fund, Open Application:

This fund supports ideas or activities that enhance the community by making neighborhoods, districts, or the city more enjoyable, greener, sociable, beautiful, and inclusive (Municipality of Utrecht, 2024f). To qualify, the initiative must have broad support from local residents, and applicants must contribute to its execution through time, money, or resources. The initiative must be carried out within Utrecht. Applications require a budget overview and proof of community support, such as a signature list. There is no minimum amount for requests, but the maximum annual subsidy per initiative is €35,000. Although this subsidy does not implicitly focus on houses, homeowners can use it for their neighborhood or shared area.

4.1.2.2 Sustainable City: Energy – Solar Energy:

The Municipality of Utrecht (2024j) is committed to increasing the use of solar energy, aiming to triple the amount of electricity generated from solar panels on rooftops by 2030 compared to 2020 levels. To achieve this, the municipality provides information and advice to homeowners, particularly targeting homeowners' associations, owners of monumental homes, and those with limited financial means. Although the municipality does not offer direct subsidies for solar installations, it promotes various PV-panels-related financial schemes like the salderingsregeling (Netting/Offsetting in English) and the duurzaamheidslening (Sustainability Loan in English) to make solar panel installation more attractive for homeowners.

The Sustainability Loan has been elaborated on previously. The Netting/Offsetting scheme for solar panels in the Netherlands allows homeowners to offset their electricity consumption by feeding surplus energy generated by their solar panels back into the grid. This scheme effectively uses the electricity grid as a large battery, enabling users to "store" their excess generated electricity and draw from it when needed. To clearly show how it works, the following topics should be considered carefully (Milieu Centraal, 2024):

- **Electricity Generation and Consumption:** Solar panels generate electricity, a portion of which is used directly by household appliances. Any excess electricity is fed back into the grid (this is called "back-feeding").

- **Compensation:** The energy company pays for the electricity fed back into the grid. The rate paid is the same as the rate charged for electricity consumption. For example, if you pay 30 cents per kilowatt-hour (kWh) for electricity, the energy company will also pay you 30 cents per kWh for the electricity you back-fed to the grid.
- **Netting:** The energy company offsets the amount of electricity you consume from the grid against the amount you back-feed. If you consume 2,000 kWh annually and back-feed 2,500 kWh, 2,000 kWh will be offset, and you will be paid for the remaining 500 kWh at a potentially lower rate, such as 10 cents per kWh.
- **Limits:** There is a maximum limit to how much electricity can be offset under this scheme. The excess beyond this limit may be compensated at a very low rate.

To have an overview of how financial investments on the benefits and practicalities of installing solar panels on homes, the webpage Jouw Huis Slimmer (2024) suggested by the municipality website, elaborates on the financial aspects of Solar Panel installation:

- *Initial Costs*

The cost of installing solar panels can vary depending on the system's size, panel quality, and installation fees. For a typical residential setup of around 10 solar panels, the average cost might range between €4,000 and €6,000. This includes the cost of panels, inverters, mounting hardware, and labor.

- *Subsidies and Incentives:*

Dutch homeowners have access to a range of subsidies and financial incentives that can help mitigate their initial investment. Through the netting scheme, homeowners can counterbalance their energy usage with the electricity they generate, leading to substantial reductions in their electricity expenses. Moreover, there are regional subsidies available, along with the potential for a reduced VAT rate on both solar panel purchases and installations.

- *Savings and Return on Investment:*

The return on investment from solar panels can be significant, potentially saving homeowners between €600 to €800 annually on electricity bills, depending on their energy consumption and the size of the solar panel system. Typically, the payback period for the initial investment in solar panels ranges from 6 to 10 years. After this period, the electricity generated by the solar panels effectively becomes free, resulting in long-term savings. Given that Dutch homeowners tend to stay in a house for an average of 11 years (Rabobank, 2024), this payback period is particularly appealing. Additionally, PV solar panels can be relocated to a new home if the owner moves. The investment cost of solar PV panels is often considered a separate value that should be factored into the house price, which would be paid by the new residents.

- *Financing Options:*

For individuals unable to cover the initial expenses, there are several financing options to consider, such as sustainability loans or leases tailored for renewable energy upgrades. These financing choices offer lower interest rates and adaptable repayment terms, aiming to facilitate the switch to solar energy.

The municipality is also exploring additional avenues for solar energy, such as developing solar fields and solar carports. They work closely with companies to find innovative solutions for integrating solar energy, including linking solar energy production with energy consumption on industrial estates, using batteries, and developing digital energy hubs (E-hubs) where multiple businesses can share energy resources. While there is no current mandate for solar panels on buildings, the municipality supports new constructions to meet sustainable energy requirements and anticipates future national regulations that may impose obligations for solar installations on certain new and existing buildings.

Solar panels are not currently mandatory on buildings, but there are plans to require a minimum share of sustainable energy for new constructions, with solar panels playing a significant role. The national government aims to provide municipalities with tools to mandate solar panels in two scenarios: new utility buildings larger than 250 m^2 from 2025 and existing utility buildings during major renovations or replacements expected before 2025. The exact implementation date is still uncertain, and developments are being monitored through various organizations.

4.1.3 Open Application Grant

Despite the variety of supporting schemes available, residents of Utrecht can also apply for a grant for any practice that enhances sustainability criteria and is not covered by previously mentioned schemes (Municipality of Utrecht, 2024a). This grant is accessible through an open application process available on the Utrecht municipality website. This additional grant opportunity ensures that homeowners have the financial support needed to implement a broader range of sustainability practices, further encouraging eco-friendly initiatives within the community.

4.2 Interview Findings, RQ 2-4

The interviews with residents were conducted to identify the potential drivers that have motivated them to apply GR practices in their homes and to understand the barriers they have faced during implementation or that have prevented them from adopting some of these practices. By employing various outreach methods, a total of seven interviews were conducted. These residents were all homeowners in Utrecht, either in the city center or suburbs area, who have implemented a variety of GR practices in their homes.

The following sub-sections provide a detailed discussion of several aspects. First, a short description of the cases that were studied through seven interviews. The next section elaborates on the identified drivers that motivated these residents to adopt GR practices. Finally, the barriers and challenges they experienced during the implementation process are presented in the final sub-section.

4.2.1 Case Description

In this section, the types of GR practices already implemented by these residents are discussed. This is followed by an exploration of the GR practices they would like to add and are planning to implement in the future.

4.2.1.1 GR Practices

In total, seven different practices have been identified as having been implemented in the interviewees' houses. All the interviewees had installed photovoltaic (PV) panels on their roofs, making it the most favored practice among all. Following PV panels, the next most common practices were Green Roofs, Insulated Walls/Roofs, and Rainwater Harvesting, each of which was adopted by 3 out of the 7 interviewees. Additionally, Floor Heating, Heat Pumps, and Window Shields/Covers were also utilized, though less frequently, with only 1 or 2 interviewees having implemented these practices in their homes. Figure 5 shows a graph of these practices displaying the number of instances each practice has been implemented in the interviewees’ houses under their respective names.

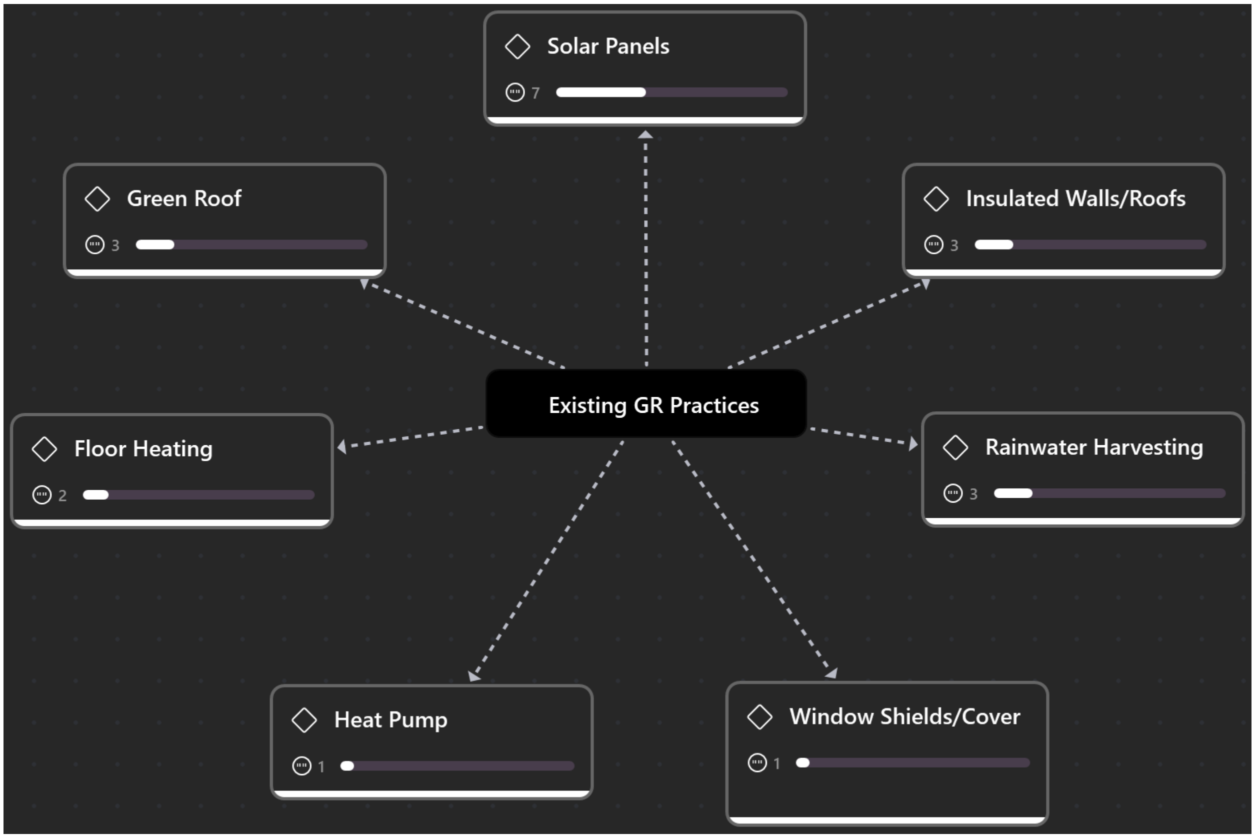

Figure 5. Identified GR practices among the interviewees

Netbeheer Nederland (2024) has reported that the number of houses in the Netherlands with rooftop solar panels has increased by 30% compared to 2022, reaching almost 2.6 million in 2023. It is estimated that this growth will continue in the coming years. While this is an efficient way to increase renewable energy production in the Netherlands, the significant growth has led to grid congestion problems. This highlights the fact that it's not surprising to see solar panels as the most widely adopted GR practice among the population under study.

To get a better understanding of the relationship between implemented GR practices and established policies, please look at Table 5.There is no existing implemented GR practices that is not covered by supporting policies schemes.

Table 5. Established policies and their corresponding existing GR practice

Established Policies	Implemented/Existing GR Practices						
	Solar Panels	Green Roof	Insulated Walls / Roofs	Floor Heating	Rainwater Harvesting	Heat Pumps	Windows Shield / Cover
Energy advice at home and trajectory guidance	✓	✓	✓	✓	✓	✓	✓
Green roof / Green-blue roof	×	✓	×	×	✓	×	×
Insulate a small association: 3 regions in Utrecht	×	×	✓	×	×	×	✓
Small homeowners' association Loan	✓	✓	✓	✓	✓	✓	✓
Insulate your home	×	✓	✓	✓	×	×	✓
Initiative Fund, Open Application	✓	✓	✓	✓	✓	✓	✓
Sustainable City: Solar Energy	✓	×	×	×	×	×	×
Open Application Grant	✓	✓	✓	✓	✓	✓	✓

4.2.1.2 Planned GR Practices

Through seven interviews, it was discovered that five out of the seven interviewees are planning to add additional GR practices to their homes. The specific practices they are considering include Grey/Rainwater Re-Use systems, Green Roofs, and Electrical Storage Systems. Grey/Rainwater Re-Use systems were mentioned by four interviewees, indicating a strong interest in water conservation and sustainable water management. Green Roofs were noted by three interviewees, reflecting a continued commitment to enhancing green spaces and improving insulation. Electrical Storage Systems were mentioned by two interviewees, highlighting an interest in optimizing energy efficiency and storage capabilities. These planned additions signify a growing dedication among homeowners to further enhance the sustainability and environmental friendliness of their residences. Figure 6 illustrates these practices and how many interviewees are planning to implement them in their houses.

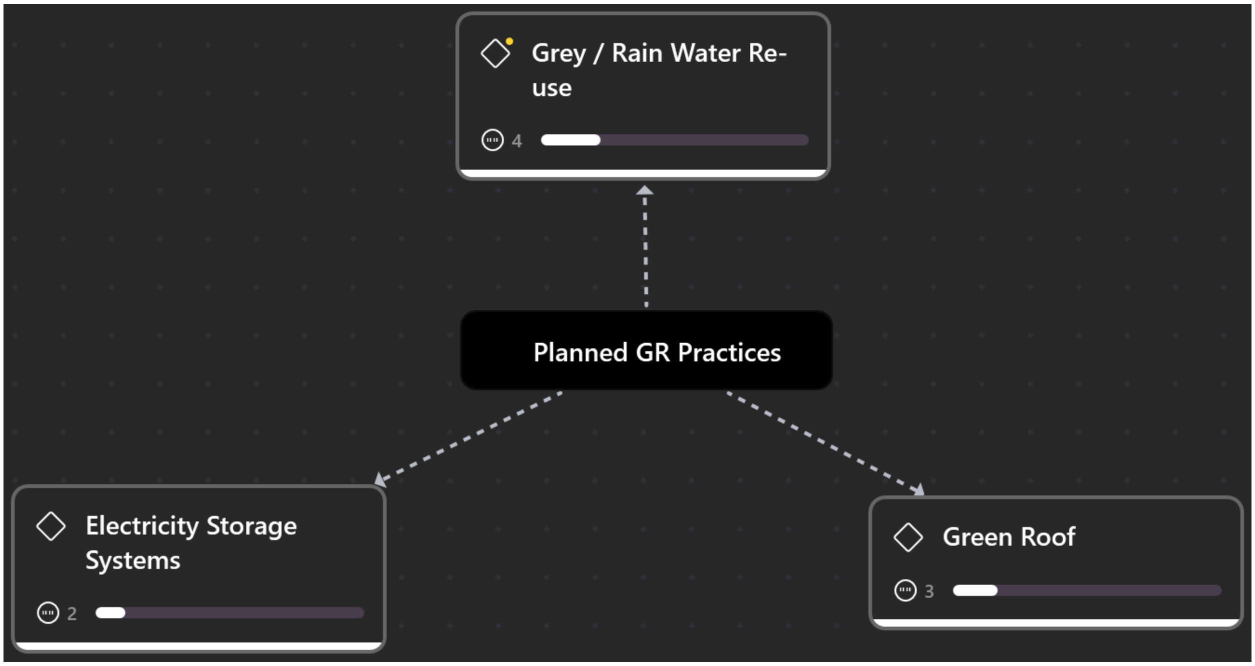

Figure 6. Planned GR Practices by Interviewees.

4.2.2 Drivers

Through the identification of different drivers, the BU2 framework has been used to categorize the reasons behind residents' decisions to adopt and implement GR practices in their homes. These categories, as illustrated in Figure 1, are Environmental, Social, and Economic. The categorization is based on the indicators of the framework and the researcher's interpretation of the interviewees' intentions as expressed during the interviews.

4.2.2.1 Economic Drivers:

This categorization revealed that the most frequently cited reasons fall under the economic benefits of green retrofitting (GR) practices, which were mentioned as a main driver by all interviewees. These motivations encompass energy cost savings, energy efficiency, and the use of potential financial incentives.

- **Financial Decision Making:** One interviewee explicitly mentioned, *"This was really a financial decision"* (Meeting 1). Similarly, another stated, *"It's always been financially a good investment to buy these PV panels"* (Meeting 2). Also in (Meeting 6) it was stated as

“It's mainly financial reasons to implement them”. These quotations highlight the economic motivation centered on financial prudence and investment returns.

- **Cost-Benefit Calculations:** A homeowner described the thorough financial analysis conducted before adopting GR practices: *"I also made a sort of calculation... What is the cost? What is the benefit in financial benefit in time and is that a wise decision also in financial terms"* (Meeting 3).
- **Subsidies and Immediate Action:** The availability of subsidies was a key factor for another resident: "*So I might have done it anyhow, but the subsidy was the reason why I did it at that moment immediately"* (Meeting 4). This indicates how financial incentives can accelerate the decision-making process.
- **Cost Efficiency in Maintenance:** One interviewee combined GR adoption with necessary home maintenance, making it financially efficient to implement changes: *"So we had to do some stuff and then it's easier at that moment to change it and to make the right decisions"* (Meeting 5).
- **Financial Returns:** Another homeowner emphasized the financial returns on energy savings, stating, *"We don't need (consume) much electricity... it is good that we can get some money back"* (Meeting 7).

4.2.2.2 Environmental Drivers:

The second driver was identified as an environmental motivation, focusing mainly on reducing CO2 emissions, lowering energy consumption, and contributing to global environmental challenges.

- **Energy Saving Commitment:** One respondent expressed their motivation to contribute to energy saving beyond financial considerations: *"I'm thinking about that not as a financial thing, but contribute to the whole aspects of energy saving"* (Meeting 1).
- **Environmental Impact:** Another interviewee stated, *"Just personal interest of making sure the save more of the environment than we were currently doing at that point"* (Meeting 2), highlighting a personal commitment to environmental responsibility.
- **Global Responsibility:** A strong sense of global responsibility was mentioned by a homeowner: *"I'm motivated by, let's say, saving the world. To do something, yeah, to save*

energy. Do something good for the environment or do less bad to the environment" (Meeting 3).

- **Environmental Investment:** One respondent mentioned their primary motivation: *"Our main purpose has been because we think it's best to invest in environment"* (Meeting 4).
- **Ecological Concern:** Another expressed their concern for the planet's health: *"World and bees and all kinds of stuff that you feel. Well, we should try to change"* (Meeting 5).
- **Principled Action:** Lastly, an interviewee emphasized the principle of environmental stewardship: "*It's first of all the principle of doing something for the environment"* (Meeting 7).

4.2.2.3 Social Drivers:

Following these two main reasons, social aspects were mentioned four times in the interviews. Social drivers encompass factors like the well-being of in-house residents, thermal comfort, and a sense of global responsibility.

- **Comfort and Well-Being:** two homeowners cited increased comfort as one of key motivations. For instance, one mentioned the improvement in comfort, saying, *" … living in a house with these practices is more comfortable as well"* (Meeting 2), and another emphasized the importance of comfort with specific home features, such as floor heating: *"that (floor heating facility) was just for comfort"* (Meeting 6).
- **Collective Impact:** The idea that small individual actions can collectively make a significant difference was highlighted by a resident who stated, *"they are small things on the small scale, but I think if many people (including me) would do that, that would help"* (Meeting 3). This reflects a social motivation grounded in community and collective action.
- **Global Responsibility:** A sense of duty towards global equity was another social driver, as expressed by an interviewee: *"I think we're incredibly rich in the West, the United States, etcetera, and it's good to all think about other parts of the world (by implementing such practices)"* (Meeting 4). This demonstrates a broader social consciousness and the desire to contribute positively to global challenges.

By detailing these specific motivations, it can be seen how economic, environmental, and social drivers collectively influence the adoption of GR practices among homeowners. This nuanced understanding allows for better-targeted strategies to promote GR practices in urban settings.

Figure 7 provides a summary of all the categories and the frequency of these reasons mentioned during the interviews.

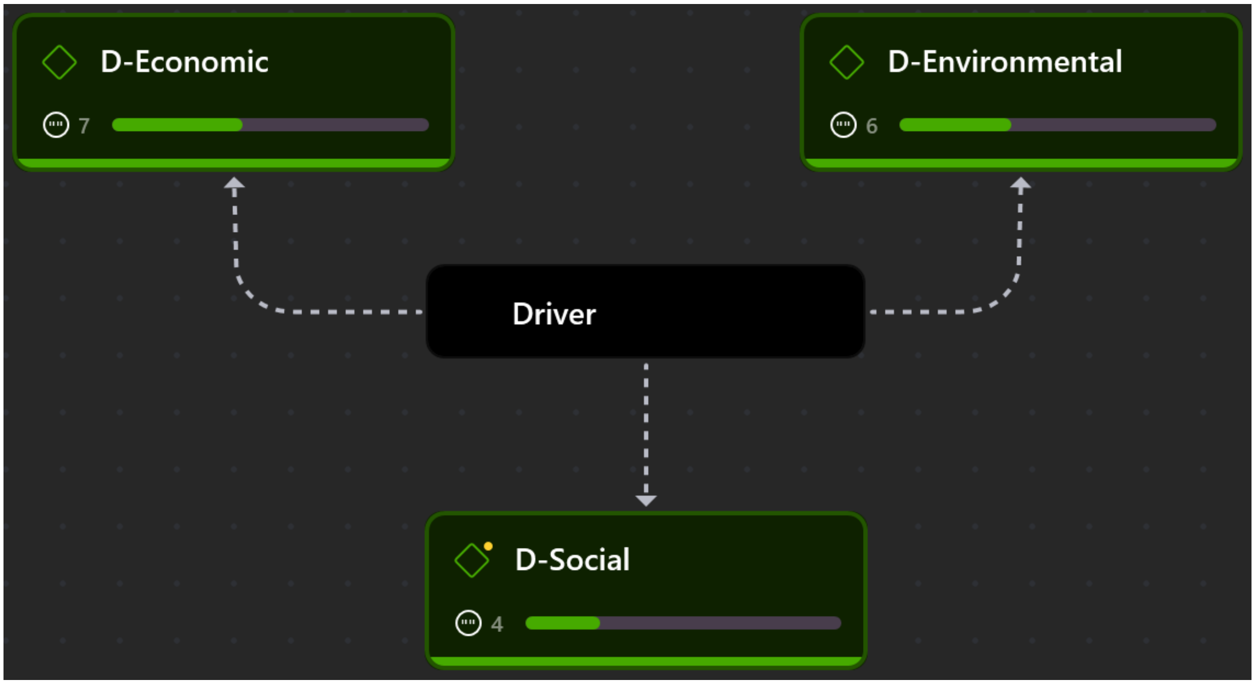

Figure 7. Drivers categories and number of them being repeated during interviews

Although the initial categorization for drivers included a category for policy and regulation factors, this factor was not encountered during the interviews. Based on the findings from the policy reviews in section 4.1.2, it was discovered that these regulations will apply to new houses and major renovations on existing houses starting from 2025. As a result, this factor has not played any role in the Netherlands yet. However, similar regulations have already established in other EU countries, such as Germany that has affected the citizens' decisions in that country (He et al., 2019). This absence of policy-driven obligations among current homeowners underscores the potential impact future regulatory changes could have on the adoption of GR practices. As these regulations come into effect, it is likely that policy and regulation factors will become more significant drivers for sustainable housing practices in the Netherlands, mirroring trends seen in other European nations.

4.2.3 Barriers

Through the identification of barriers, various factors have been discovered that have influenced residents' decisions regarding the implementation of GR practices. These barriers have not only impacted the current adoption of GR practices but also affect their future decisions to adopt more of them. The identified barriers fall into specific initial categories based on the challenges faced by residents:

- Administrative mechanism complexity
- Appearance
- High initial costs
- Lack of expertise/personnel to install
- Lack of incentives
- Resistance against behavioral changes
- Technical complexity
- Unreliability on the impacts/benefits
- VAT (tax) pay back complexity

Figure 8 illustrates these barriers and the frequency with which they were mentioned during the interviews.

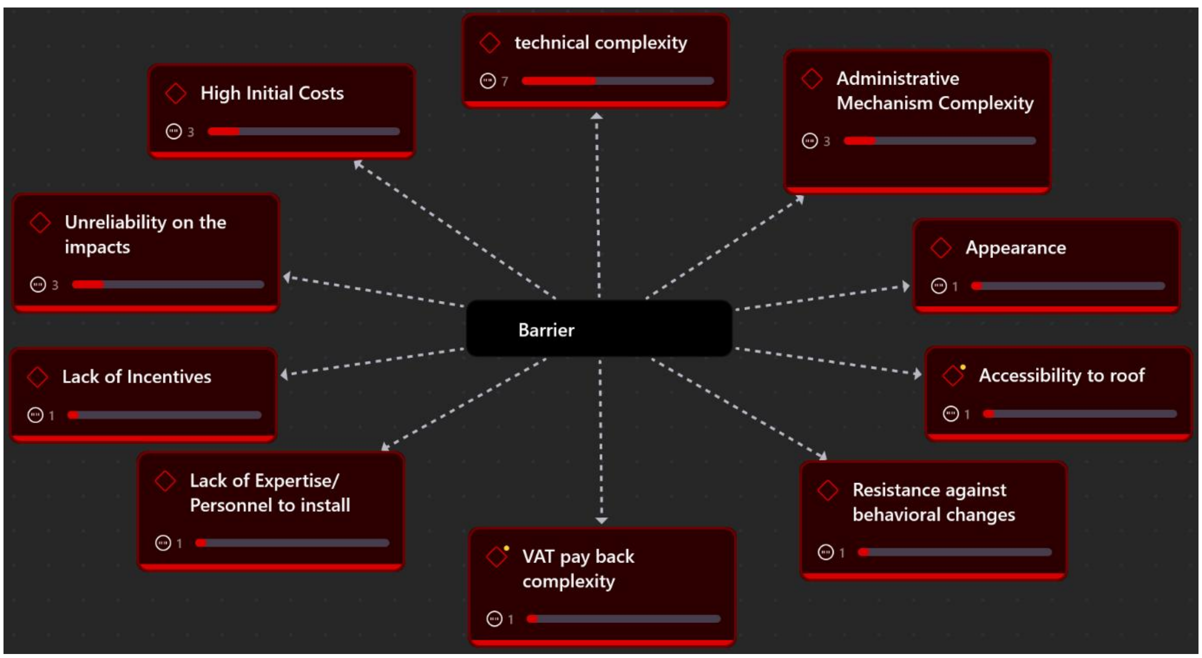

Figure 8. Initial identified barriers.

To better understand the barriers, the initial factors were categorized into five main groups: Financial, Administrative, Technical and Labor, Behavioral and Perceptual, and Other barriers. This categorization was done based on the underlying reasons behind each barrier and how they have affected the residents. The detailed breakdown is shown in Table 6.

Table 6. Categorization of identified initial barriers.

Category	Initial Identified Barrier - Frequency
Financial Barriers	High Initial Costs - 3
	Lack of Incentives - 1
Administrative Barriers	Administrative Mechanism Complexity - 3
	VAT payback complexity - 1
Technical and Labour Barriers	Lack of Expertise/Personnel to install - 1
	Technical complexity - 7
Behavioral and Perceptual Barriers	Appearance - 1
	Resistance against behavioral changes - 1
	Unreliability on the impacts - 3
Other	Accessibility to roof - 1

Following this categorization, the barriers diagram, shown in Figure 9, reveals that Technical and Labor barriers emerged as the most significant, as the interviewees mentioned their covered barriers eight times. Behavioral and Perceptual barriers were the next most frequently cited, mentioned five times by their subset identified barriers. Financial and Administrative barriers each were mentioned four times by their corresponding subset barriers. The least mentioned barrier, cited only once, was Accessibility to the Roof, categorized under Other barriers.

The interviewee who mentioned this specific barrier explained that the design of older Dutch houses often did not prioritize easy access to the roof. As a result, the difficulty in accessing the roof prevented the implementation of a green roof, limiting the benefits they could derive from such a practice. This also applies to the fact that most insulation-related subsidy schemes cannot be adopted by older households. This is primarily because houses must have double (or even triple) walls to qualify for the subsidy, which is not feasible for older Dutch houses that typically have thin, single-layer walls.

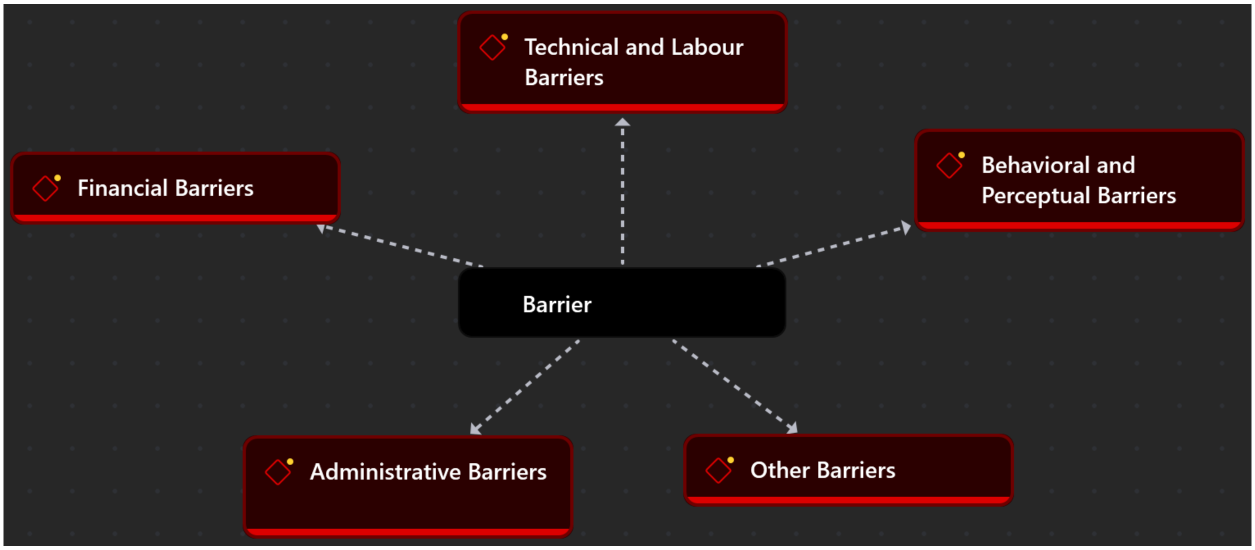

Figure 9. Aggregated barriers categories

5 Discussion

This chapter focuses on the main findings and results of the study presented in the previous chapter. It begins with an in-depth interpretation of the study's primary results, followed by recommendations for increasing the adoption rates of GR practices based on the principles of the Diffusion of Innovations Theory. These recommendations are informed by an interview with an expert in the theory and the author’s insights. The chapter concludes with two sections: one exploring other potential frameworks applicable to studies similar to the current one, and another outlining the study’s limitations.

5.1 Interpretation of Primary Results

While qualitative analysis, based on a limited number of interviews, inherently lacks the ability to represent the entire population and cannot be generalized, this section tries to strengthen the main results and findings by aligning them with pertinent literature. By doing so, it provides a nuanced interpretation of the data, ensuring the results are contextualized and meaningful. This approach not only supports the primary outcomes but also enhances their credibility and relevance within the broader academic discourse.

To properly answer the 1st research sub-question, a comprehensive analysis has been made of Utrecht municipal policies. The Utrecht municipality offers a wide range of subsidy schemes covering diverse areas such as art and culture, sustainability, education, sports, welfare, care and health, work and entrepreneurship, and housing and living environment. For this study on GR practices, the relevant schemes fall under sustainability and housing and living environment. Each of these areas provides multiple subsidy options aimed at promoting various aspects of sustainable living. The municipality of Utrecht has specifically designed these subsidies to encourage businesses, institutions, and homeowners to adopt more environmentally friendly practices and improve the energy efficiency of their buildings. Notable among these are the subsidies for energy advice and trajectory guidance, green-blue roofs, and insulation. These schemes offer substantial financial assistance, making it feasible for a wide range of stakeholders to undertake sustainable initiatives.

The 2nd research sub-question was about identification of main drivers that has affected the adoption of GR practices among Utrecht citizens. Through the identification of these drivers, it was discovered that Dutch citizens possess an financial driven attitude and are keen to gain economic benefits out of these GR investments. Simultaneously, they are also eager to contribute to addressing ecological challenges by adopting various sustainable practices in their homes. For instance, the widespread implementation of solar panels among all interviewees underscores that although their primary motivation was financial advantages of them, they are excited to make their own living more environmentally friendly, too. Some interviewees had installed solar panels over a decade ago, a time when the financial benefits were not as compelling, indicating a strong commitment to environmental sustainability.

Considering the costs of home owning is also crucial in understanding the other economic drivers behind GR practices, as these costs directly affect disposable income and influence real estate dynamics such as property prices, investments, and resident demographics. The financial burden of homeownership—including loans, utilities, and taxes—motivates homeowners to adopt energy-saving measures to reduce expenses and improve financial stability. By lowering energy costs, GR enhances disposable income, making properties more attractive and potentially increasing real estate values, thus influencing market dynamics.

Furthermore, social factors were also another factor that has been considered by more than 50% of interviewees. This suggests that residents are motivated by a sense of social responsibility and a desire to contribute positively to their society. However, many noted that they prefer to address social concerns through other means, such as voting for environmentally conscious parties in elections or participating in community activities.

A comparison between the main driver findings of this study and the results of Ebrahimigharehbaghi et al. (2019) reveals that economic factors remain the primary influence on the adoption rate among Dutch residents. Ebrahimigharehbaghi et al. concluded that 72.4% of their Dutch survey respondents identified financial considerations—specifically, cost savings on energy bills and increasing property value—as their main motivations. Conversely, our study indicates a shift in environmental awareness: while Ebrahimigharehbaghi et al. found that only 24.68% of respondents were motivated by environmental concerns; our findings suggest a growing significance of these factors among citizens. This highlights an evolving awareness and prioritization of environmental issues alongside economic incentives. Social driver comparison also shows slightly similar findings between this study and the mentioned article. These findings also match with similar studies in other EU countries such as Norway (Aune, 2007; Mlecnik & Straub, 2015).

One particularly interesting insight came from an interviewee who discussed an additional driver stemming from their research on the Ukraine-Russia war. They observed that in Ukraine, homes and neighborhoods with their own renewable energy production, such as PV panels, maintained electricity access on most days. This highlighted the role of decentralized energy generation in enhancing energy security. Consequently, the safety and reliability of energy access should be considered as important factors influencing the adoption of GR practices.

Additionally, almost all interviewees agreed that the environmental and social impacts of GR practices cannot be fully realized unless these practices are widely adopted across societies. They acknowledged that while GR practices may have small impacts on individual houses, these small actions can lead to significant environmental and societal effects if adopted on a large scale. Interviewees also suggested that involving large companies and organizations to implement GR practices on their properties could further address existing ecological challenges. They recognized that achieving these advantages would require new policies and regulations established by local or national governments in the future. Simultaneously, scholars agree on the crucial role of governments in increasing the adoption of green innovations, a role that is being neglected for a long time (Driessen & Hillebrand, 2002).

Overall, these insights reveal that economic advantages are key drivers for Dutch citizens in Utrecht when it comes to adopting GR practices, alongside environmental concerns and social impacts. By understanding and addressing these drivers, policymakers and municipalities can better support and encourage the adoption of such sustainable practices among residents; continuing current financial incentives and emphasizing more on their environmental impacts can also help achieve a more sustainable society and higher adoption rates of GR practices.

The 3rd and 4th research sub-questions were about discovering the main barriers residents have faced regarding GR practices adoption. It has been found that, in the context of the Netherlands, and specifically Utrecht various supporting schemes have been established to motivate citizens to adopt GR practices. Despite these comprehensive schemes, most residents were not aware of them. Even among those who were aware, many preferred not to apply due to administrative complexities or a personal preference to implement the practices independently or through specialized companies. These residents also faced a lack of professional experts or companies capable of implementing these practices in their homes. Given that most of these practices require high and specific knowledge, self-implementation proved challenging.

Moreover, despite the availability of schemes to cover initial costs, interviewees mentioned facing financial barriers. This challenge can be addressed through several methods. Municipalities can increase public awareness about these schemes and streamline administrative processes to make subsidies and loans more attractive and accessible. Additionally, municipalities could shift the focus of subsidies and loans from citizens to companies, creating a direct link between companies and municipalities to cover initial costs.

Behavioral and perceptual barriers, mentioned five times in the interviews, also play a significant role in hindering the implementation of GR practices. Some practices require lifestyle changes to achieve maximum efficiency. For instance, installing photovoltaic (PV) panels might necessitate shifting most electricity consumption to daytime hours to maximize environmental, economic, and social benefits. These changes can be gradually achieved through public events and educational systems.

Administrative complexities were another critical barrier identified. These complexities have deterred residents from applying for some desired practices. As one interviewee mentioned, they would prefer to pay all costs themselves rather than navigate the frustration of reading and filling out long forms. Sometimes, the combination of high initial costs and administrative complexities has prevented residents from adopting GR practices, despite both municipalities and residents desiring more of these practices in the city.

These challenges can be resolved in several ways. Municipalities can collaborate with NGOs and third-party companies to assist residents in applying for supporting schemes. Additionally, administrative responsibilities could be shifted to companies which are more capable of handling the paperwork and documentation rather than placing the burden on citizens. By addressing these barriers through targeted strategies, Utrecht can enhance the adoption of GR practices, making the city more sustainable and environmentally friendly.

There are few studies on barriers to the adoption of GR practices and technologies in the Netherlands. These studies have identified both financial and non-financial barriers (Ebrahimigharehbaghi et al., 2019, 2020). Comparing their findings with my research reveals several key similarities. Both studies highlight the significance of financial considerations, with Ebrahimigharehbaghi et al. (2019) emphasizing economic factors as the primary influence on adoption rates, which aligns with my identification of high initial costs and lack of incentives as major financial barriers. Additionally, these studies identified the lack of reliable professionals or contractors, fitting into the technical and labor barriers category of my research. Householders in Ebrahimigharehbaghi et al.'s (2020) study also expressed the need for expert consultation to ensure the impacts and advantages of GR practices, aligning with the behavioral and perceptual barriers category in my study.

5.2 Scale-up GR Adoption Through Diffusion of Innovations Theory

In this section, the steps that should be taken to scale-up the GR practices adoption rates has been presented. These steps are being suggested through "Diffusion of Innovations Theory". Rogers has published a book titled as the theory name about this theory. He claims that innovations vary significantly in their adoption rates due to certain key characteristics. These characteristics include relative advantage, compatibility, complexity, trialability, and observability, which also was mentioned in Figure 2. Relative advantage refers to the perceived superiority of an innovation over the idea it replaces, which can drive faster adoption if the innovation is seen as more beneficial. Compatibility is the degree to which an innovation aligns with the existing values, experiences, and needs of potential adopters, with more compatible innovations being adopted more quickly. Complexity, on the other hand, refers to how difficult an innovation is to understand and use; simpler innovations are adopted more rapidly. Trialability allows innovations to be tested on a small scale, reducing uncertainty and accelerating adoption. Observability is the extent to which the results of an innovation are visible to others, promoting peer discussion and quicker adoption. In a summary, they could define as:

- **Relative Advantage:** Perceived as better than the idea it replaces.
- **Compatibility:** Consistent with existing values, past experiences, and needs.
- **Complexity:** Ease of understanding and use.
- **Trialability:** Ability to experiment on a limited basis.
- **Observability:** Visibility of the innovation's results to others.

Although the adoption and diffusion theory has a long tradition in the social sciences, relatively little research has focused on the adoption and diffusion of green innovations (Driessen & Hillebrand, 2002). Driessen & Hillebrand claimed that suppliers, especially the government, may play a crucial role in adopting and diffusing green innovations, particularly in the early stages. However, the standard adoption model does not adequately address the government's role, treating it as just one of many external factors. Thus, they suggested that there is a need for an adoption model specifically designed for green innovations that assigns a more prominent role to government involvement.

In order to suggest effective recommendations for broadening the implementation and adoption of GR practices in society, an interview was held with Professor Bas Hillebrand, an expert in the field of Diffusion of Innovations Theory; especially on green technologies adoption. As a distinguished professor of Marketing Management and Innovation at the Nijmegen School of Management at Radboud University, Professor Hillebrand is also the founder and co-chair of the research group "Responsible Innovation and Entrepreneurship" at the same university.

After presenting the main findings of the study to Prof. Hillebrand, he confirmed that Rogers' model aligns perfectly with the scope and direction of the study. However, he emphasized that for precise outcomes, each GR practice should be studied separately, as the five principles of the theory might have distinct definitions and interpretations within the context of each GR practice. He mentioned that this model could be instrumental in investigating the reasons behind citizens' intentions to adopt these GR practices.

Regarding the relative advantages principle, it is defined as how a specific innovation relates to other things residents possess by showcasing its own advantages. Since economic and environmental aspects of GR practices are key drivers, residents consider the financial and ecological efficiency of GR practices as relative advantages. Therefore, to promote the adoption of GR practices, future support schemes should focus on these two aspects. While numerous financial supports are provided by the Municipality of Utrecht through various subsidy and loan schemes, this study suggests also disseminating the environmental impact of these practices among residents.

The compatibility principle in this study context refers to how well these practices fit with the structure of the houses. As shown in Figure 5, solar panels are the most implemented practices among others. This indicates that because most houses in the Netherlands have sloping roofs, PV panels can be easily installed and connected to the houses' electricity systems. This is primarily why this practice is widely spread across the city, too. However, green roofs, insulated walls/roofs, and rainwater harvesting systems, used by 3 out of 7 interviewees, demonstrate that despite their environmental impacts, their low compatibility has significantly hindered their adoption in Dutch houses. Therefore, it is recommended to support initiatives and companies that can implement these practices in existing houses with their traditional structures, for instance installing green roofs on sloping roofs. Supporting companies like HERMANO's and S.T. DAKWERKEN, which specialize in these installations, could increase the prevalence of green roofs in the Netherlands.

There are also several residential complexes where houses share roofs, necessitating collaboration among residents, highlighting another aspect of compatibility. This is why many subsidies address both single homeowners and homeowners' associations.

Concerning the complexity principle, the study identifies technical and labor barriers as major obstacles faced by interviewees. Comparing this finding with the principle's definition in the context of GR practices reveals that those which are harder to install have lower adoption rates, such as green roofs, insulated walls/roofs, floor heating, and heat pumps. As also discussed under compatibility, these practices are difficult to integrate with existing Dutch houses, particularly older ones. New technological advancements aimed at increasing the compatibility of these practices with a wider range of house types can help overcome these barriers and challenges, thereby boosting adoption rates.

The trialability and observability principles focus on the validity and visibility of these practices' impacts. While existing financial schemes aim to stimulate adoption, cumulative and snowball effects among residents can further promote these practices. These effects refer to how specific technologies or products gain more attention over time through resident advertising and promotion. One interviewee mentioned that their friends and family became interested in installing solar panels and green roofs after seeing them implemented in resident's house. They also discussed their efficiency and advantages in conversations, underscoring the importance of these two principles.

Overall, to enhance the adoption of GR practices, it is crucial to address each principle of the diffusion of innovations theory tailored to the specific context of each practice. By focusing on financial and ecological advantages, improving compatibility with existing structures, reducing technical and labor barriers as the main complexity principle aspect, and leveraging the trialability and observability effects, municipalities and policymakers can create a more supportive environment for these sustainable innovations.

5.3 Other Possible Frameworks

During the analysis of green technologies management and its effect on citizen adoption, other frameworks have also been utilized. For instance, Ulubeyli et al. (2019) analyzed the factors influencing green buildings through the PESTEL framework. PESTEL stands for Political, Economic, Social, Technological, Environmental, and Legal, which allows for a broader categorization in factor analysis. Additionally, scholars have considered more cognitive-based frameworks, such as the Theory of Planned Behavior, which analyzes residents' adoption intentions from a personal-interest perspective (He et al., 2019). There is also literature that combines different frameworks with their analysis of governmental initiatives and policies to develop a unique categorization of drivers and barriers, which then serves as their main framework (Ebrahimigharehbaghi et al., 2019). These combinations can help tailor each framework to the context and scope of each study.

5.4 Limitations of Study

In this section, the primary limitations encountered during the study are discussed. One significant limitation is that, since interviews rather than surveys were the main method of data collection, the outcomes may not be representative of the entire population. However, the study aimed to conduct an in-depth analysis to identify and understand the factors that promote or impede GR practices through qualitative research based on semi-structured interviews.

Secondly, adequately answering the fourth research question required finding residents who had considered GR practices but had not implemented them. Reaching this target group was challenging. However, during the interviews, it was revealed that those who had implemented some practices also faced obstacles that prevented them from implementing more GR practices.

Thirdly, due to time constraints, data collection was limited to a certain period, resulting in only seven interviewees. With more time, additional interviews could have been conducted. Beyond time constraints, data collection was somewhat frustrating due to the lack of a database or direct connection with targeted residents. This necessitated physically walking through the city to find suitable residents that fit the scope of the study. However, by providing a comprehensive database of houses that have implemented these GR practices, it becomes possible to calculate the number of interviews needed to achieve statistically significant results. To create this database, collaboration between homeowners' associations and the municipality can be extremely helpful and beneficial.

In addition, the specific sample of respondents in this study, primarily and unintendedly consisting of individuals with above-average salaries and good financial standing, may have influenced the results, introducing a potential bias towards more financially secure perspectives. However, it is important to note that the overall financial situation of citizens in Utrecht tends to be above average compared to other cities in the Netherlands, as one of the 4 big cities with most millionaire living in (van Putten, 2023). This means that while my sample might overrepresent financially well-off homeowners, it still reflects a significant portion of the Utrecht population. Moreover, this sample can be seen as representative of urban and suburban homeowners who generally have better financial stability, allowing for relevant connections and implications to be drawn for similar demographic groups in other urban and suburban areas.

Overall, despite the limited number of respondents preventing a comprehensive and fully representative answer to the main research question, the in-depth analysis of the interviews and policy reviews has provided the most probable answers. These insights, drawn from detailed qualitative data, offer valuable understanding and direction. Additionally, in-depth research methods such as interviews can be extremely helpful and beneficial, offering rich, nuanced insights that might not emerge from quantitative data alone.

6 Conclusion

This study aimed to explore the acceptance of GR practices among Dutch residents, whether they have adopted them or not. It targeted residents aware of GR practices, including those which have been implemented or not. The study investigated the residents' motivations and the challenges faced during implementation, such as cost savings, environmental concerns, and practical difficulties. Moreover, the study explored that challenges residents might have faced that prevented them from applying those practices in their houses. By analyzing these factors, the study provided insights into the drivers and barriers influencing the adoption of GR practices among Dutch residents.

For data collection, the study conducted seven interviews with Dutch residents, focusing on citizens of Utrecht as a case study. The drivers for adopting GR practices were categorized using the BU2 framework into environmental, economic, and social categories. Additionally, a fourth category, policy and regulation factors, was also initially included in the main categories. For identifying barriers, all initially identified barriers were categorized based on thematic and semantic similarities. These barriers encompassed both those encountered during implementation and those preventing residents from adopting certain GR practices. Furthermore, the study included a policy review analysis of established policies in the Municipality of Utrecht to gain comprehensive insights into all existing instruments and supporting schemes provided by the municipality.

The study found that the municipality has established various supporting schemes for GR practices in residential buildings. These policies aim to encourage residents to adopt environmentally-friendly activities in their homes to address ecological challenges. The supporting schemes encompass financial assistance through subsidies and loans, as well as consultancy plans that offer valuable advice to residents prior to implementation. In addition to these prepared schemes, the municipality offers open application grants to support and promote initiatives that have not yet been considered.

The study identified financial aspects as the primary driver for Utrecht citizens adopting GR practices, followed by environmental considerations. This finding indicates that while residents have an environmentally-friendly attitude, they require financial incentives from governments and authorities to implement GR practices in their homes. Although policy and regulation were considered another category of drivers, no significant results were found in this regard. Notably, other countries like Germany have implemented regulations on energy efficiency in houses in recent years, and the Netherlands has similar regulations set to take effect from 2025 onwards. While this category of drivers did not play a significant role in the current study, it is anticipated that these regulations will influence residents' intentions in the coming years.

In the barriers identification process, the study identified several obstacles to the adoption of GR practices among Utrecht residents, despite the availability of supporting schemes. Many residents were unaware of these schemes, and even those who were aware often found the administrative complexities daunting or preferred to implement the practices independently. Additionally, a lack of professional experts and companies capable of implementing these practices made self-implementation challenging due to the specific knowledge required. Financial barriers persisted despite schemes to cover initial costs, and behavioral and perceptual barriers, such as the need for lifestyle changes to maximize efficiency, also hindered adoption.

Addressing these barriers could significantly enhance the adoption of GR practices in Utrecht. Simplifying administrative processes and increasing public awareness about available schemes would make subsidies and loans more attractive and accessible. Shifting some responsibilities to companies and NGOs to handle paperwork and implementation could alleviate the burden on residents. Through these targeted strategies, Utrecht can improve the adoption of GR practices, contributing to a more sustainable and environmentally friendly city.

By examining the acceptance and adoption of GR practices among Dutch residents, this study provides valuable insights that bridge the gap between top-down urbanism paradigms and bottom-up behaviors. The Eco-City Paradigm, with its focus on creating closed-loop systems and maximizing resource efficiency, aligns with the observed drivers of Utrecht residents who prioritize financial incentives and environmental benefits. However, the study highlights a crucial discrepancy; while top-down planners may assume that technological and infrastructural solutions alone will drive adoption, residents require clear, accessible information and support to navigate the complexities of implementation. Thus, enhancing public awareness and simplifying administrative processes are essential steps to align residents' actions with the goals of the Eco-City Paradigm, ensuring that top-down initiatives effectively translate into grassroots adoption.

Furthermore, the New Urbanism approach, which emphasizes walkable neighborhoods and strong community engagement, can benefit from understanding the barriers faced by residents in adopting GR practices. The study's findings on the administrative and perceptual challenges suggest that merely providing infrastructure for sustainable living is insufficient without fostering a supportive community framework. This aligns with the Triple-U Problem, which underscores the uncertainties and complexities inherent in urban transformations. By addressing enforced uncertainties through streamlined support schemes and reducing exposure to uncertainties via professional expertise and community involvement, urban planners can better manage the expectations and behaviors of residents. This bottom-up insight enhances the viability of New Urbanism and other sustainable urbanism paradigms by ensuring that the social and behavioral dimensions of sustainability are adequately considered in planning processes.

Additionally to the previous suggestions and to comprehensively overcome these barriers, the Diffusion of Innovations Theory was utilized to analyze all drivers and barriers based on its subset principles: relative advantage, compatibility, complexity, trialability, and observability. Through expert interpretations and the study's findings, it was discovered that the relative advantages principle indicates residents value the financial and ecological efficiency of GR practices, suggesting future support schemes should emphasize these aspects. Despite financial support from the Municipality of Utrecht, promoting the environmental benefits is also crucial. The compatibility principle shows that solar panels are widely adopted due to their fit with Dutch house structures, whereas green roofs and other practices face low compatibility issues. Supporting companies that specialize in adapting these practices to traditional structures can enhance adoption. Technical and labor barriers, identified under the complexity principle, hinder the adoption of harder-to-install practices, such as green roofs and heat pumps, which could be addressed through technological advancements. Lastly, the trialability and observability principles highlight the role of visibility and social influence in adoption, as residents promote practices through their personal networks, underscoring the importance of these principles in encouraging broader acceptance.

Shortly, the study aimed to explore the acceptance of GR practices among Dutch residents, specifically in Utrecht. It found that financial incentives, such as subsidies and loans provided by the municipality, were the primary drivers for adoption, followed by environmental concerns. Despite these incentives, barriers such as lack of awareness about available schemes, administrative complexities, and a shortage of professional expertise hindered widespread adoption. The study concluded that simplifying administrative processes, increasing public awareness, and supporting companies that specialize in GR implementations could significantly enhance adoption rates. Additionally, policy reviews revealed various supporting schemes aimed at encouraging environmentally-friendly practices, though future regulatory measures might further influence adoption.

6.1 Future Research Recommendations

In this section, insights are presented to suggest studies for future research in areas related to the scope of this study. Future research and focus on individual GR practices in separate studies can gain a deeper understanding of the unique drivers and barriers associated with each practice. This approach can provide tailored insights and more effective strategies for promoting specific GR technologies.

Additionally, studies can also be conducted on the adoption of GR practices in commercial buildings such as corporations, hospitals, and train stations. This can help identify unique challenges and opportunities in these environments, differing from those in residential settings.

Conducting quantitative studies that include larger sample sizes could better represent the entire population. This approach would provide more generalizable data and robust statistical analyses, leading to stronger conclusions and recommendations.

Future research could also focus on the supply side of green technologies adoption and diffusion. This includes analyzing the role of manufacturers, suppliers, and installers in promoting GR practices and overcoming barriers related to supply chain and service availability.

Investigating the role of homeowners' associations in motivating residents to apply GR practices is another area of interest that could be studied. Understanding how these associations can influence and support the adoption of green technologies can lead to more effective community-based strategies.

This research primarily focused on understanding the behaviors and perspectives of homeowners who have retrofitted their homes. By including a diverse range of respondents, the study aimed to identify commonalities and differences that could inform broader strategies for promoting GR in urban settings. The decision to include residents from the Utrecht city region, irrespective of specific demographic characteristics, was a deliberate strategy to enhance response rates and ensure a comprehensive understanding of homeowner behaviors. However, future studies should build on these findings by incorporating more detailed demographic analyses. This would involve considering characteristics such as age, gender, neighborhood, and income level to further refine and contextualize the results.

Future research could also apply more cognition-focused frameworks to identify residents' intentions, as suggested by Prof. Hillebrand and based on He et al.'s research. These frameworks can provide insights into the psychological and cognitive factors influencing adoption decisions.

Introducing frameworks based on established policies and initiatives to identify regional or contextual barriers and drivers, as done by Ebrahimigharehbaghi et al., can provide a localized understanding of GR practices adoption. This approach can help in tailoring strategies that consider specific regional policies and conditions.

Finally, future research could extend to other cities in the Netherlands to gain a broader understanding of Dutch residents' adoption intentions. These studies would aid governmental authorities and policymakers in developing more efficient and comprehensive policies in their future planning.

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Appendix I: Access to the Transcripts

Transcripts of all interviews are accessible through following Google Drive link. Also of the contact details such as names, ages, and professions/jobs that could be confidential is also removed. By clicking on the following link, a folder including the word documents of transcripts will be accessible.

Links: Transcripts Folder in Google Drive

For any more information or access, please contact the author through one of the following email addresses:

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Appendix II: Utilized Software Tools

Throughout the course of this thesis, several software tools were utilized. Microsoft Teams served as the primary platform for conducting online interviews and automatically generating transcripts. Amberscript was employed to transcribe two in-person interviews. As detailed in the Data Analysis and Management section, Atlasti was used for analyzing and coding the transcripts. Lastly, Grammarly was used to check for any grammatical and spelling errors in the thesis text.