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INNOVATIVE FINANCING STRATEGIES FOR INVOLVING THE PRIVATE SECTOR IN THE MAINSTREAMING OF NATURE-BASED SOLUTIONS

A CASE STUDY IN BARCELONA

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ABSTRACT

In the era of the Anthropocene, cities face escalating challenges due to climate change. Over the past decade, Urban Nature-Based Solutions (UNBS) have gained increasing interest as a holistic and sustainable way to tackle these challenges. These nature-inspired solutions are cost-effective and provide environmental, social, and economic benefits, helping to build resilience. Despite widespread advocacy for mainstreaming, financing remains a significant challenge. Experts suggest that the private sector should engage in UNBS financing, but this occurs infrequently. Research advocates studying the effectiveness of the innovative approaches that facilitate such engagement.

This thesis investigates the extent to which innovative financing strategies involving the private sector contribute to mainstreaming UNBS, specifically in the context of Barcelona. It focuses on two programs implemented by the municipality: green roofs and green walls. Each program employs a unique innovative financing strategy that leverages a mix of public and private funds to support the installation and maintenance of these solutions.

The way this research studies contribution to mainstreaming is by measuring to what extent they have overcome financing barriers. Both strategies have excelled in addressing barriers to mainstreaming, including information gaps, undervaluing natural capital, reliance on voluntary agreements, policy failures, and institutional inertia. However, other barriers still persist, such as perceived high risks and low economic returns. While the strategies address these issues, they still significantly influence the investor's perspective on the uptake and investment in these solutions, especially when the investor is private. The study identifies that success depends not only on the financing mechanism used, but also on the solution it supports. For instance, green roofs have been more successful in reducing costs compared to green walls, leading to better long-term investment prospects for green roofs. This results in a positive long-term investment outlook for green roofs and a less favorable one for green walls. The research also explores how policy plans continue to incorporate the feedback and counteract these market dynamics.

Through an in-depth analysis, the study scrutinizes these programs, revealing that their success is defined by continuous data collection and collaboration over decades. This positive feedback loop increases interest in UNBS for its benefits, triggering the incorporation of new finance mechanisms and further expanding the solutions.

Finally, the study emphasizes the need for context-specific approaches, highlighting the importance of supportive legal frameworks, political support, comprehensive data, and collaborative networks. Despite existing challenges, the innovative financing strategies developed in Barcelona offer valuable insights for other cities in similar contexts aiming to implement UNBS as part of their urban strategies.

Key words*: Cities, Urban Nature-Based Solutions, Innovative finance, Innovative financing strategies.*

TABLE OF CONTENTS

1. INTRODUCTION

This chapter has five sections. The first introduces the research problem. The second identifies the knowledge gaps. The third presents the research aims, contribution, and relevance. The next displays the research questions. Finally, the last section concludes with the research outline.

1.1. Problem definition

In the era of the Anthropocene, cities face escalating challenges due to climate change and urbanization. Approximately half of the global population resides in urban areas, a proportion expected to rise to 66% by the middle of this century. The most significant effects of climate change are likely to be experienced in cities, manifesting in multiple ways, including rising temperatures, extreme weather events, biodiversity loss, ecosystem degradation, changes in infectious diseases, and food unavailability (Kabisch et al., 2017). Extreme weather and natural disasters are expected to become the top two greatest risks to humanity and the global economy. These challenges not only directly threaten the health and well-being of citizens but also cause major economic losses (Seddon et al., 2020).

To date, urban planners and resource managers have turned to conventional engineering solutions for climate change adaptation and mitigation, such as walls, dikes, or irrigation systems. Yet, these siloed approaches may not always be cost-effective, sufficient, or sustainable (Kabisch et al., 2017; Seddon et al., 2020). The main anthropogenic issues —biodiversity loss, climate change adaptation, and mitigation and citizen well-being— have often been tackled independently. However, there is increasing consensus on the need for integrative approaches that reduce trade-offs and promote synergies (Seddon et al., 2020).

Over the past decade, Nature-based Solutions have gained increasing interest as a set of innovative and sustainable alternatives with holistic benefits (Kabisch et al., 2016; Kabisch et al., 2017; Toxopeus et al., 2017; Dorst 2019; Seddon et al., 2020). The European Union defines them as "solutions inspired and supported by nature, which are cost-effective, simultaneously providing environmental, social, and economic benefits and helping build resilience" (Faivre et al., 2017; European Investment Bank, 2023; Dorst et al., 2019). Although not yet widely applied, these solutions are also described as forms of 'eco-innovations' (Kabisch et al., 2017; Toxopeus et al., 2017).

When applied in cities, these are referred as Urban Nature-Based Solutions (UNBS). Their adaptability to place-based conditions means each ecological domain provides distinct services and benefits for different urban stakeholders, ranging from ecological advantages such as climate adaptation to social and economic benefits like social cohesion and economic development (Toxopeus et al., 2021; Seddon et al., 2020; Kabisch et al., 2016; Frantzeskaki et al., 2023). For example, green roofs and walls can reduce temperatures, increase energy savings, and improve air quality for the building inhabitants. Another example is urban green spaces like parks and street

trees that can mitigate high temperatures while also creating co-benefits such as improved quality of life, mental and physical health, and reinforced cultural identities. These multifunctional benefits make UNBS more efficient and lower-cost solutions to climate change than traditional methods like conventional sewage systems or air conditioning (Kabisch et al., 2016).

Given all their advantages, since 2013, the European Union (EU) Commission has prioritized recognizing UNBS as a cost-effective approach for a greener, more sustainable, and competitive economy, resulting in the development of an R&I agenda and large-scale demonstration projects (Faivre et al., 2017; European Investment Bank, 2023). Building on this momentum of the past decade, there is a clear consensus both in research and policy that mainstreaming UNBS is pivotal for addressing urban challenges and driving transformative change in urban planning and policymaking (Frantzeskaki et al., 2023; Frantzeskaki et al., 2020). However, despite this consensus for widely implementing them and a well-established literature highlighting their benefits, UNBS's extensive adoption is far from taking place at the needed pace (Seddon et al., 2020; Calliari et al., 2022; European Investment Bank, 2023).

Mainstreaming has been widely claimed in literature and policy documents. It has been commonly associated with the upscaling, integration, and institutionalization of solutions into the policymaking and across sectors and scales; and also with broader transformation of the cities and disruption of their current socio-technical systems (Xie et al. 2022; Adams et al., 2023). Mainstreaming Urban Nature-Based Solutions in cities demands major investments concerning both the retrofit of existing structures and the creation of new solutions. Obtaining funding is often the main catalyst for acting, particularly in scenarios with substantial implementation costs (Seddon et al., 2020). However, raising finance for mainstreaming UNBS is not a straightforward process due to the unique nature of these novel solutions.

To understand the finance of Urban Nature-Based Solutions, it is crucial to first comprehend their nature. UNBS can be highly heterogeneous, based on the type of solution they aim to tackle. Ranging from lower to higher human interventionism, these can be divided into three categories: the improved use of natural ecosystems, such as restoring rivers or establishing protected areas; the management or alteration of ecosystems, like expanding green corridors in cities or implementing preservation plans for green spaces to promote biodiversity and enhance residents' well-being; and the design of new ecosystems, such as building green roofs or blue-green infrastructure (Brears, 2022). This heterogeneity necessitates different planning, financing, and mainstreaming approaches (Brears, 2022; Calliari et al., 2021).

Despite their differences, most UNBS share a complex nature: they are simultneously living ecosystems, eco-innovations and local infrastructural solutions. As living entities, they require long-term management and, consequently, long-term financing. As public infrastructures, they possess an illiquid character, and have benefits which are often non-monetary and non-excludable, which cannot be captured by a single entity. As sustainable innovations, they carry risks due to uncertainty regarding their viability. Finally, being locally-based solutions, they require adaptation to their specific contexts. This is why, even if more cost-effective than alternative

traditional gray infrastructure, their complex nature raises several barriers in their uptake, contributing to the finance gap that hinders their mainstreaming (Seddon et al., 2020; Kabisch et al., 2016; Toxopeus et al., 2021; Frantzeskaki 2019).

Today, the financial landscape around UNBS mostly relies on the public sector, which often faces constraints and limitations, leading to major underinvestment (Calliari et al., 2022; Bigger et al., 2023; Brears, 2022; Thompson et al., 2023; Cousins et al., 2021; Toxopeus et al., 2023). Involving the private sector has been widely claimed by experts, however, factors such as high risk and low return on investments are only a few of the several reasons why the private sector has little interest in financing them (Merk et al., 2012; Frantzeskaki et al., 2019; Toxopeus et al., 2021; Brears, 2022; Calliari et al., 2022). This results in finance being one of the main barriers and incognita hindering the mainstreaming process (Toxopeus et al., 2017; Frantzeskaki et al., 2019; Seddon et al., 2020; Calliari et al., 2022) How to resolve this remains an enigma (Hölscher et al., 2017).

1.2. Knowledge Gap

This research focuses on two research gaps that have been identified in the literature regarding the mainstreaming of UNBS.

The first gap is the underdeveloped knowledge on UNBS finance. Despite being recognized as a crucial part of implementation, financing is rarely given consideration in existing frameworks on mainstreaming UNBS (Wickemberg et al., 2020). Researchers have emphasized the urgent need to build knowledge on UNBS financing (Wickemberg et al., 2020; Adams et al., 2023; Fatema, 2022). Recognizing finance and investment as primary barriers to UNBS adoption, experts call for comprehensive research, particularly on developing methods for UNBS financing to involve the private sector to overcome the finance gap, especially through innovative strategies (Toxopeus et al., 2021; Frantzeskaki et al., 2019; Ham and Klimmek, 2017b).

The second gap is the lack of empirical studies on the effectiveness and impact of innovative financing strategies for UNBS finance and mainstreaming (Seddon et al., 2020; Frantzeskaki et al., 2019). The connection in the literature between the financial challenges and proposed solutions is still underdeveloped (Wickemberg et al., 2020; Adams et al., 2023; Fatema, 2022), highlighting the need for a better understanding of how novel financing approaches involving the private sector affect the mainstreaming process of UNBS, considering contextual factors and potential unintended negative effects.

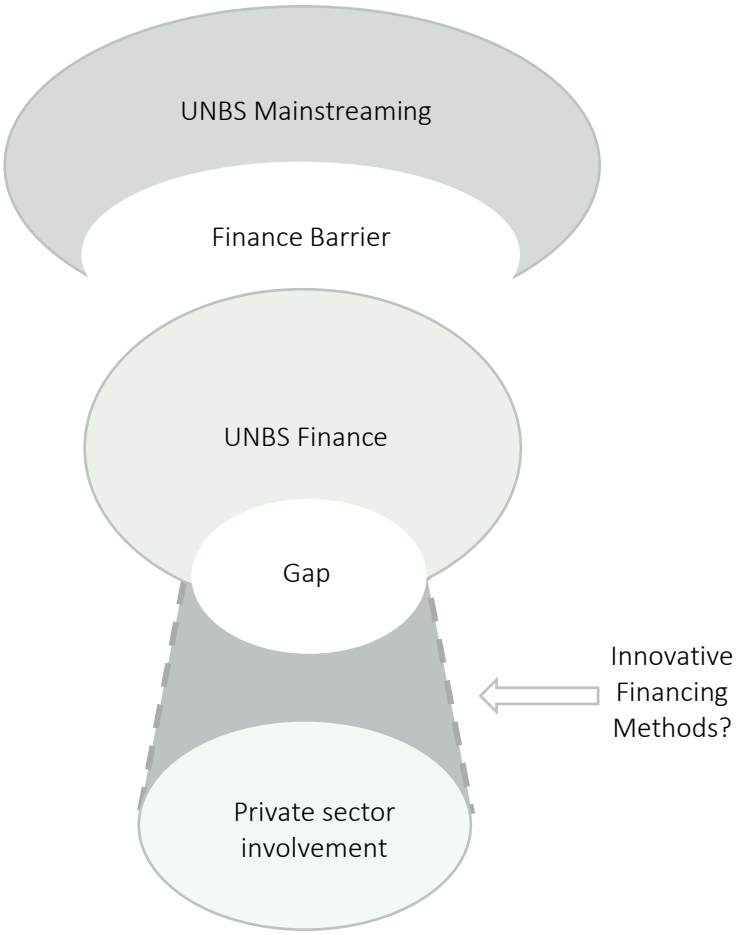


Diagram 2. Research gaps in the literature
Source: Author

1.3. Aim, contribution and relevance

This study aims to understand how and if the use of innovative financing strategies that involve the private sector can help resolve the finance barriers hindering the mainstreaming process of Urban Nature-Based Solutions. The research will contribute to the emerging field of UNBS mainstreaming and finance by offering empirical data on context-specific financing strategies implemented by the pioneer Municipality of Barcelona and testing if these have been able to overcome the finance barriers identified in literature.

The relevance of the study lies in its usefulness for those actors working on or intending to contribute to UNBS mainstreaming in the city of Barcelona, or similar contexts. The inherent variability in UNBS makes one-size-fits-all strategies unviable, thereby necessitating solutions that are responsive to specific local conditions and challenges. Relevant actors from the local administrative bodies might benefit from insights on the innovative financing strategies being used and their consequences. Understanding these strategies may contribute to future optimized decision-making regarding UNBS finance, for the Municipal Institutes studied.

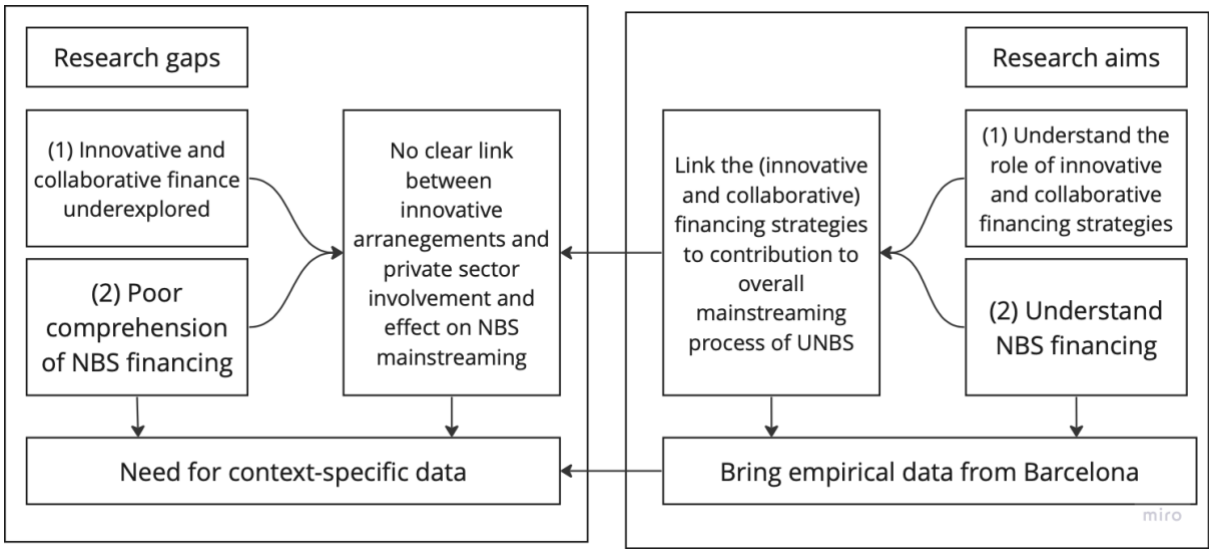


Diagram 1. Link of research gaps with research aims.

Source: Author

1.4. Research Questions

Building on the identified knowledge gaps and the aim of this study, this section introduces the research questions that will guide the investigation. The central research question is:

How do innovative financing strategies that involve the private sector contribute to the mainstreaming of Urban Nature Based Solutions?

To explore this question, three sub-questions have been formulated:

1. What are the finance barriers hindering the mainstreaming process?
2. How is the local government of Barcelona using innovative strategies that involve the private sector in UNBS finance?
3. How do these strategies overcome the finance barriers hindering the mainstreaming process?

The first sub-question helps to build the analytical framework by introducing key concepts necessary to measure mainstreaming. The answer to this sub-question will be introduced in the conceptual research, and later contrasted in the findings. The second sub-question will be addressed in section 4.1., focusing on the object of study, which Is the innovative strategies employed by the government of Barcelona. The third sub-question will provide the initial findings in section 4.3., analyzing how these strategies have overcome financial barriers. Together, these will form the basis for answering the main research question, which will be fully explored in the discussion and conclusion.

1.5. Research outline

The current research aligns with the perspective of Van der Jagt et al., (2020) in that desk studies may uncover relevant strategies for financing Urban Nature-Based Solutions (UNBS), while interviews and fieldwork can enhance understanding of the efficacy of these resources and provide insights into the challenges associated with securing adequate funding (Van der Jagt et al., 2020). The structure of this research will be formulated to contribute in a similar manner.

This research is qualitative and combines a conceptual part with a descriptive part. In the conceptual part (Section 2), a literature review on UNBS mainstreaming and UNBS finance will be presented, explaining the author's view on the relationship between both. This part will help to unravel the key concepts and contextualize the research sub-questions. By the end of this, the hypothesis will be formulated and the framework will be presented and justified. Then, within the same section, the empirical foundations reveal the context of the case study. The next chapter (Section 3) displays the methods. The results will be displayed in the findings chapter (Section 4) and further explored in the discussion (Section 5). Finally, the conclusion (Section 6) will wrap up and summarize the paper, including the limitations.

2. CONCEPTUAL RESEARCH DESIGN

This chapter provides the theoretical background and context from which the research questions and hypotheses are derived. It guides the reader from broader to more specific ideas, elucidating the concepts that underpin the study, clarifying its rationale, and setting the theoretical bases for the analytical framework.

The first section presents the theoretical foundations. It starts with the literature reviews on UNBS mainstreaming and UNBS finance, then narrows down to explain the concepts of finance barriers and innovative financing strategies, elaborating on their relationship. The second section introduces a conceptual model that offers a clearer understanding of the overall conceptual research design.

2.1. Theoretical foundations

This section has three sub-sections. The first, 2.1.1, explains mainstreaming, how it can be achieved, and how it is measured. Then, sub-section 2.1.2 introduces finance in relation to mainstreaming, and presents the finance gap and its related barriers. Next, sub-section 2.1.3 unravels innovative financing strategies, how these are intended to solve the finance barriers, and presents their limitations. The entire section aims to provide an understanding of the theory supporting the research questions, the concepts, and the analytical framework.

2.1.1. UNBS Mainstreaming

This sub-section conceptualizes mainstreaming by presenting the multiple attempts to define the term in literature, in relation to how researchers have planned to achieve mainstreaming in practice. Then, drawing from this information, it presents how the study will measure it, particularly in relation to finance.

What is mainstreaming?

As borrowed from common vernacular, UNBS mainstreaming is a term that has not been clearly and consistently defined (Adams et al., 2021). One of its most common attributions is the idea of “scaling up” or an “increased uptake across a wider and more diverse range of actors” so that UNBS become more extensively used (Fastenrath et al., 2020; Xie et al., 2021). Finding a definition for it is an inquiry often addressed in research. In the literature, UNBS mainstreaming has been associated with upscaling, integration, institutionalization, and more recently, with urban socio-technical transitions approaches.

From an integration perspective, it is defined as the inclusion of UNBS into the decision-making and agenda of policy sectors beyond the environmental one (Wellstead et al., 2015; Adams et al., 2021). The institutionalization lens goes one step further, conceiving mainstreaming as a process of reforming the status quo (Adams et al.,

2021). Both views see mainstreaming as an outcome, whereas the broader lenses from sustainability transitions and urban socio-technical systems understand UNBS mainstreaming as a process. This is the pathway by which UNBS gradually gain power and resources to replace conventional approaches, while disrupting and transforming established dynamics, institutions, and social norms (Markard et al., 2012; Frantzeskaki et al., 2017; Xie et al., 2020; Adams et al., 2023).

Aiming to find a comprehensive definition, Adams et al. (2023) conducted a systematic literature review, proposing to describe mainstreaming NBS as "the process for pursuing, establishing and/or embedding NBS in cities contributing to urban sustainability transitions" (Adams et al., 2023). This complex process involves increasing the use of these solutions across various sectors, scales, and by different actors. Achieving this requires addressing multiple elements such as regulatory frameworks, standards, business and financial models, and societal acceptance of the solutions (Kabisch et al., 2016; Frantzeskaki et al., 2019; Cortinovis et al., 2022).

How to mainstream?

This new understanding of mainstreaming as a process has driven researchers to engage with the question of how to mainstream UNBS. Many efforts have been dedicated to finding strategies to enable these transitions, seeing mainstreaming as an action-oriented concept for the planning and management of cities. Some have focused on creating frameworks on how to upscale the whole process in different contexts (Wamsler et al., 2016; Runhaar et al., 2017; Adams et al., 2023). Others argue that mainstreaming as a proactive process requires the identification and implementation of strategic leverage points of intervention, specific to the context, that can help to facilitate the embeddedness and maintenance of concrete UNBS within their respective urban infrastructure regimes (Van den Jagt, 2020; Xie et al., 2021). However, as pointed out in section 1.2., despite being recognized as a crucial part of implementation, a systematic review revealed that financing is given little consideration in existing frameworks (Wickemberg et al., 2020).

A significant body of literature has focused on identifying the barriers that hinder the process, proposing ways to overcome these (Toxopeus et al., 2017; Frantzeskaki et al., 2019; Toxopeus et al., 2021; Calliari et al., 2022; Hölscher et al., 2023). One of the most recurring barriers is unlocking finance (Frantzeskaki et al., 2019; Toxopeus et al., 2017; Xie et al., 2021; Brears, 2022; Runhaar et al., 2017; Calliari et al, 2022; Kabisch et al., 2017). However, research on how to advance finance to enable mainstreaming is limited. This is partially explained by the fact that most studies focus on evidencing the benefits of UNBS rather than on the policy, planning, and governance implications (Kabisch et al., 2016; Frantzeskaki et al., 2019).

In sum, despite significant research efforts, what mainstreaming entails and how it can be realized have still not been systematically investigated and examined (Hölscher et al., 2023). Consequently, there is no consensus on when mainstreaming is effective, achieved, or how it can be measured (Runhaar et al., 2017). However, the fact that finance is a recurring barrier that limits the process is a well-known issue (Frantzeskaki et al., 2019; Toxopeus

et al., 2017; Xie et al., 2021; Brears, 2022; Runhaar et al., 2017; Calliari et al, 2022; Kabisch et al., 2017), but mainstreaming frameworks pay limited attention to this financial aspect (Wickemberg et al., 2020).

Measuring mainstreaming

All in all, this paper focuses on mainstreaming within the city scale, not merely as a process of integration or institutionalization, but as a multi-sectoral, multi-stakeholder process that requires shifts in all sectors of society. This view enables an understanding of the dimensions of the transition, which adds more weight to the urgency of unlocking the finance gap to achieve it. It also emphasizes the need to integrate a broader range of stakeholders, including private actors, to break established practices such as public and traditional financing of UNBS. It acknowledges the existence of multiple strategies and leverage points as pathways for UNBS mainstreaming. It focuses specifically on a local government's perspective.

In this light, the use of innovative financing strategies that involve the private sector is considered a potential steppingstone to favor the transition towards the widespread adoption of UNBS in the context of Barcelona. This hypothesis is based on research on UNBS finance conducted by Brears (2022) and Frantzeskaki et al. (2019), arguing that innovative financing strategies can help overcome finance barriers in the mainstreaming process, and will be further developed in the next section. Therefore, as identifying all mainstreaming impacts of the strategies is beyond the scope of this research, the contribution to mainstreaming will be measured by the ability to overcome the finance barriers hindering the process itself. These finance barriers and innovative strategies will be explained in the following sections.

2.1.2. UNBS Finance

This sub-section will consider the finance gap of UNBS mainstreaming, exploring the main related financing barriers that constitute it. These will be contrasted with the expected benefits from using innovative financing strategies that involve the private sector. Finally, risks of involving the private sector in UNBS finance will close the sub-section.

What is the Finance Gap and its related barriers?

The following table (Table 1) collects the eleven barriers that constitute what this research calls the finance gap, which hinders the widespread uptake of UNBS. These have been identified by Robert C. Brears (2022) in his research on UNBS finance and are also supported by several sources, detailed in the description that follows the table.

Table 1. Adapted version of Robert C. Brears (2020) Financing Barriers on NBS Mainstreaming

	Barrier	Explanation
1	Low return	Investors perceive insufficient returns from UNBS. Investors may perceive NBS to have a larger management and maintenance cost than conventional technologies.
2	Perceived higher risk	The economic evaluation of UNBS is still in its development, lacking the extensive historical cost-benefit data that traditional gray infrastructure has. This scarcity of data amplifies the risk perception linked to NBS projects.
3	Information gaps	Limited, asymmetrical or even no information on environmental aspects and risks, leading to ill-informed decision making. Negatively reinforced by lack of NBS data, measurements and standards.
4	Undervaluing natural capital	Natural capital is undervalued which leads to the overexploitation of natural resources. GhG emissions, water pollution and other negative externalities remain underpriced
5	Policy failures	Under the status quo, economic incentives generally favour expansion of economic activity, and often environmental harm, over conservation, restoration, and the sustainable use of nature in support of the economic activity. The failure to account for externalities associated with environmental degradation results in the under-pricing of biodiversity risk and misinformed investment and policy decisions.
6	Institutional inertia	It is difficult to change investment patterns due to market's institutional, governance and financial features. As a result, finance favours traditional and known actors and well-understood technological solutions and systems.
7	Lack of institutional capacity	Municipalities don't always have the knowledge and technical skills in facilitating the financing and scaling up of UNBS projects.
8	Undefined financial responsibilities	Not knowing who should pay for UNBS and fund the monitoring or maintenance costs can create a challenge for scaling up. First, those who benefit from existing NBS often receive these benefits for free and therefore may not be inclined to pay for the maintenance of the system. Second, NBS projects often require long-term monitoring and maintenance costs that beneficiaries may not have the ability to finance themselves.
9	Lack of financial resources	Local governments face budget deficits, allocating limited funds to UNBS. Hinders the larger and long-term investment of a sustained management of NBS.
10	Short termism	The preference to maximize short-term profits affects long-term investment decision-making. Short-termism reduces the number of investors that would be able to do long-term investments required by NBS projects – characterised by high upfront capital costs and long-term returns on investment.
11	Reliance on voluntary commitments	There is a reliance on voluntary commitments due to a lack of regulation.

Source: Author

Despite not needing to be groundbreaking interventions, UNBS are innovative within their context. Traditional and current urban planning and financing decision-making has typically favored gray solutions when aiming to solve urban challenges (Kabisch et al., 2016; Dorst et al., 2019; Toxopeus et al., 2021). Intrinsic to this sustainable innovation condition is the challenge of the double externality problem. This is the inability of investors to gain profit from environmental and public benefits (Barrier 1) (Calliari et al., 2022) while still perceiving the risks associated with its innovativeness (Barrier 2) (Merk et al., 2012; Toxopeus et al., 2021; Frantzeskaki et al., 2019). Due to their novelty, economic analyses of UNBS are still not fully developed. As a result, these projects face a disadvantage when competing with the extensive data available for gray infrastructure, which increases their perceived risk (Barrier 2) (Merk et al., 2012; Toxopeus et al., 2021; Brears, 2022; Frantzeskaki et al., 2019; Calliari et al., 2022; Seddon et al., 2020; European Investment Bank, 2023).

A whole range of barriers also stem from this lack of data and information, affecting the position of UNBS in respect to well-established engineered solutions (Droste et al., 2017; Frantzeskaki et al., 2019; Calliari et al., 2022; Zimmerman et al., 2019; Toxopeus et al., 2021). First, standards and measurement mechanisms around environmental aspects and risks are inconsistent or even nonexistent in some cases, failing to account for the complete value of UNBS (Calliari et al., 2022; Frantzeskaki et al., 2019; Seddon et al., 2020; Cousins et al., 2021) (Barrier 3). Second, this lack of data also translates to the inability to account for the negative externalities of the rival traditional solutions, leading to an undervaluation of nature (Barrier 4) (Toxopeus et al., 2021; Calliari et al., 2022; Seddon et al., 2020; ICLEI, 2024), which contributes to ill-informed decision-making that may continue exploiting natural resources and adding up to environmental pressures in support of economic activity (Barrier 5) (Toxopeus et al., 2021; Cousins et al., 2021; Anguelov, 2022; ICLEI, 2024). The incapacity to acknowledge the depreciation of human and ecological assets partly explains the lack of investment in UNBS projects (European Investment Bank, 2023). Additionally, even when the knowledge is there, changing investment patterns faces the resistance of institutional inertia due to market and policy failures that favor the investment of well-known technologies over NBS because of economic-driven policymaking (Seddon et al., 2020; Cousins et al., 2021; Brears, 2022) (Barrier 6). On top of that, even if the willingness is there, local governments might also lack the knowledge, expertise, and technical skills on how to upscale or mainstream UNBS, making it a risky path to take (Calliari et al., 2022; Toxopeus et al., 2021; Brears, 2022; European Investment Bank, 2023) (Barrier 7).

As public infrastructures, these provide multiple benefits and functions that affect and involve a wide variety of actors in society from multiple sectors (Kabisch et al., 2016; Toxopeus et al., 2021; Seddon et al., 2020; Brears, 2022; Frantzeskaki et al., 2023). This often makes it difficult to determine who should pay and how (Barrier 8) (Wickenberg et al., 2020; Seddon et al., 2020; Toxopeus et al., 2021; Brears, 2022; Cousins et al., 2023). At the city level, municipal finance appears to be the logical route for UNBS due to its multiple public benefits. However, this is not as straightforward as it seems. Local governments have limited resources, spending autonomy, and competing budget demands from the departments under their control, leading to relatively low NBS investment levels (Barrier 9) (Calliari et al., 2022; Brears, 2022; Toxopeus et al., 2021; Droste et al., 2017; Zimmerman et al., 2019; Frantzeskaki et al., 2019; Bigger et al., 2023; European Investment Bank, 2023). Even when public funding is available, investment decisions are subject to the need for political support (to win elections) and to citizens' willingness to pay for these solutions. In addition to the struggle of limited resources, municipalities are tied to short-term decision-making cycles. This compromises the crucial securing of funding as mainstreaming requires long-term investment strategies and dedicated budgets for maintenance (Barrier 10) (Toxopeus et al., 2017; Brears, 2022; Kabisch et al., 2016; Seddon et al., 2020; Toxopeus et al., 2021; Frantzeskaki et al., 2019; Calliari et al., 2022; European Investment Bank, 2023). Finally, all these difficulties are reinforced by a landscape of lack of regulation on UNBS implementation and an overreliance on voluntary agreements (Calliari et al., 2022; Brears, 2022) (Barrier 11).

Much is expected from collaboration with private agents such as real estate firms, companies, and citizens with respect to UNBS delivery and financing (Toxopeus et al., 2021). However, today, only 2% of UNBS are being

financed by more than 50% by the private sector (European Investment Bank, 2023). This is largely due to their public and complex nature and their limited potential to generate revenues, making them less appealing to private sector investment (Barrier 1) (Calliari et al., 2022; Toxopeus et al., 2017). These require large upfront investments that may show (usually public) benefits only in the long term and entail risks related to regulatory, economic, and technological uncertainties (Barriers 2 & 10) (Merk et al., 2012; Toxopeus et al., 2017; Frantzeskaki et al., 2019).

2.1.3. Innovative finance for private sector involvement

With all these barriers identified making up the finance gap, we dive now into the literature review presenting solutions that are expected to overcome them, introducing the concept of innovative financing strategies available for a local government. This will help understand how the literature sees these as a potential solution to bridge the finance gap through private sector involvement and innovation.

In higher-income countries, UNBS are often implemented and funded locally. Local public entities often use municipal budgets to directly fund them or use policies that promote or mandate them (Dorst et al., 2019; Thompson et al., 2023; ICLEI 2024). The traditional way to fund these projects is to use municipal revenues which typically come from local taxes, user fees, or intergovernmental transfers (Dorst et al., 2019; Zimmerman et al., 2019; ICLEI 2024). As seen in the previous section, local revenue for funding UNBS faces constraints. In response, new payment strategies and mechanisms have emerged, leveraging economic incentives to attract private investment (Thompson et al., 2023). A fundamental aspect of attracting private actors to finance UNBS is to provide returns on investment and low risk (Merk et al., 2012).

When seeking external funding for UNBS, municipalities can consider various financing options to fit their specific needs and context. As we have seen, the unique nature and heterogeneity of these solutions require a careful consideration of available financing mechanisms to create solid and tailored financing strategies (Zimmerman et al., 2019; Brears, 2022; ICLEI 2024) The list of available instruments is long, but can be divided into direct and indirect methods. A table (Table 6) can be found in section 3.5 giving an explanation for each. Direct methods include the use of public budgets, grants and inter-governmental funding (such as EU or national funding), revenue instruments such as tax, and green finance. Indirect instruments include market-based instruments like user charges, subsidies, environmental taxes, green bonds, payments for ecosystem services, biodiversity offsets, incentives, among others. (Brears, 2022; ICLEI, 2024; European Investment Bank, 2023; Toxopeus et al., 2021). Other indirect methods are Public–Private Partnerships (PPPs), endowments, and Business Improvement Districts. A mix of instruments is often needed to ensure sufficient support throughout the planning, implementation, and long-term operation and mainstream of UNBS (Brears, 2022; Zimmerman et al., 2019).

Recognizing the limitations of overreliance on public funding, many experts emphasize the urgency to develop innovative solutions that engage the private sector for sustained, long-term investment (Toxopeus et al., 2021;

Calliari et al., 2022; Brears, 2022; Ismat Fatema Fathi, 2022; Frantzeskaki et al., 2019; Xie et al. 2022; European Investment Bank, 2023).

What is innovative finance?

Innovative finance has been defined as "a set of financial solutions and mechanisms that create scalable and effective ways of channelling both private money from the financial markets and public resources towards solving pressing global problems" (Brears, 2022).

These innovative financing instruments don't have to be necessarily "new" instruments. Instead, a financial instrument is considered innovative if it can solve challenges that the market alone cannot address (UNFCCC, 2019; ICLEI, 2024). Similar to UNBS themselves, despite not needing to be completely novel solutions, financing methods can become innovative within the context of a UNBS financing strategy. For example, if a traditional tool such as taxation is employed in a new way, to penalize gray infrastructure while promoting green, it can be considered innovative (Calliari et al., 2022). Similarly, PPPs have long been used in the context of infrastructure provision in cities, however, if these mechanisms are able to find ways to finance UNBS projects, restore and conserve ecosystems or protect biodiversity, they can be considered innovative (ICLEI, 2024; Calliari et al., 2022). Much effort has been put into identifying and shedding light on existing practices of "innovative finance for UNBS" (Toxopeus et al., 2021; Calliari et al., 2022; Klimmek et al., 2016; Kabish et al., 2016; Frantzeskaki et al., 2016). Comprehensive EU-wide research showcases a range of innovative economic and financial instruments used by European municipalities to stimulate private sector involvement in financing NBS uptake. These instruments include subsidies for co-funding green roofs and sustainable urban drainage (Naturvation – Building Co-financing agreements, 2024; Calliari et al., 2022); fee deductions for private investment in stormwater management; carbon offset certificates for inner-city afforestation projects; fees to discourage the loss of valuable agricultural land; Public-private partnership (PPP) between hotel chains and local governments for environmental conservation (Calliari et al., 2022). Further examples of such practices are cataloged in the Urban Nature Atlas, which maps over 1000 NBS and their corresponding funding mechanisms (Urban Nature Atlas, 2024). All these display methods in which financial mechanisms have been used by the public to create new ways of involving the private sector in the long-term finance of these solutions.

What are the benefits of involving the private sector through innovative financing strategies?

The following table (Table 2) presents the most recurrent benefits provided by innovative financing strategies and private involvement identified in the literature and links them to the finance barriers these are intended to tackle. Not all the barriers are targeted, leaving some uncertainty about how innovative financing strategies could help resolve them.

Table 2 – Most recurrent expected benefits of private sector involvement and innovative financing strategies

	Barrier	Solution	Expected benefit of solution	Explanation
1	Low return	Private sector involvement	Revenue creation, benefit sharing	Private involvement may be possible if combined with other profitable activities
		Innovative financing strategies	New business models	Innovative models allow investors to capture revenues from UNBS projects with both economic and societal benefits
2	Perceived higher risk	Private sector involvement	Risk reduction	Public-private partnerships have been used in the infrastructure domain to lower the financial risks of projects, through risk redistribution from the public to the private sector, and to enhance efficiency through optimized project structures.
3	Information gaps	Private sector involvement	Resource pooling	Bringing together the public and the private creates syergies accross different sectors of society, which is useful in pooling key resources such as knowledge.
7	Lack of institutional capacity	Private sector involvement	Resource pooling	Collaborative governance studies in the European context have been able to unlock required expertise, capacities and mobilise co-funding to activate UNBS
9	Lack of financial resources	Innovative financing strategies	Generate additional funds	By involving new actors and/or looking beyond conventional mechanisms.
		Private sector involvement	Resource pooling	Bringing together the public and the private makes syergies accross different sectors of society, which is useful in pooling key resources such as funds

Source: Author

Several scholars have focused on displaying the expected advantages of involving the private sector in financing UNBS. The most recurrent benefits are cost reduction, revenue creation, and benefit sharing (Solving Barrier 1), risk and cost reduction (Solving Barrier 2), and resource pooling (Solving Barriers 3, 7, and 9).

Barrier 1 – Low return – has been claimed to be tackled in multiple ways both by innovative financing strategies and private integration in UNBS finance. While it is argued that private investment will only flow towards business models with clear returns on investment, these might or might not be economic (Frantzeskaki et al., 2019). A spectrum of innovative business models has proved to involve the private sector with or without financial benefits (Calliari et al., 2022; Zimmerman et al., 2019; ICLEI, 2024; Toxopeus et al., 2021; Kabisch et al., 2017). Indeed, some investors only engage in UNBS projects that generate clear financial returns. However, others have managed profit from revenue generation or cost savings. Moreover, private actors have also been seen to engage for social and ecological benefits or to meet their environmental and social goals (Calliari et al., 2022; Toxopeus et al., 2021). Innovative models allow investors to capture revenues from UNBS projects with both economic and societal benefits (Calliari et al., 2022). The goal of these mechanisms is to establish a balanced incentive structure and returns on investment to encourage the participation of private financiers (Toxopeus, 2021). In addition, studies from sustainable infrastructure management show that even if projects are unprofitable in economic terms,

private involvement may be possible if combined with other profitable activities (J. F. M. Koppenjan & Enserink, 2009).

Barrier 2 – Perceived high risk – has been addressed by using public-private partnerships (PPPs) in the infrastructure domain to lower the financial risks of projects. This has been done through risk redistribution from the public to the private sector, and to enhance efficiency through optimized project structures (Thompson et al. 2023, Toxopeus et al., 2017). Using PPPs for UNBS is considered an innovative strategy in the context of UNBS (Brears, 2022; ICLEI, 2024; Horizon EU 2020, 2019) and is also expected to provide similar benefits (Frantzeskaki et al., 2019; Toxopeus et al., 2017; Toxopeus et al., 2021; Brears, 2022; ICLEI, 2023; Horizon EU 2020, 2019).
Barriers 3, 7, and 9 – information gaps, lack of institutional capacity, and low financial resources – are expected to be addressed by bringing bringing together the public and the private creates syergies accross different sectors of society, which is useful in pooling key resources such as knowledge (Barrier 3), funds (Barrier 9), skills, and institutional and governance capacities (Barrier 7) (Frantzeskaki et al., 2019; Klimmek et al., 2016; European Investment Bank 2023), creating a strong common focus on timely delivery and bringing results (ICLEI, 2024; C. Brears et al., 2023). Diverse modes of collaborative governance studied in the European context have been able to unlock required expertise, capacities and mobilise co-funding to activate UNBS (Hölscher et al., 2023). Using innovative strategies can also be used to generate additional monetary funds by involving new actors and/or looking beyond conventional mechanisms (Barrier 9) (Brears, 2022; ICLEI, 2024).

These studies show the increasing interest in developing innovative financing mechanisms to involve the private sector. However, despite this interest, no clear link has been drawn in the literature on their effectiveness in solving the finance barriers of the mainstreaming process. This research aims to explore this relationship within the case of the city of Barcelona.

Risks of innovative financing tools involving the private sector

While innovative financing methods that involve the private sector can address financial and governance challenges, some critiques warn against relying too heavily on economic incentives and the private market.

Effective urban greening does rely on financial innovation to create new funding sources for infrastructure improvements. However, market-driven solutions to environmental issues often benefit privileged groups at the expense of the broader public. Scholars have noted that urban greening practices frequently reflect traditional planning and engineering methods, resulting in unequal participation and outcomes in greenspace planning (Cousins et al., 2021).

Furthermore, there are concerns that the rush to financial markets for critical social services may empower financiers, tying urgent issues to their interests, while leaving cities adrift due to austerity and decentralization.

The movement towards financial markets to sustain essential social services should raise concerns about the long-term implications for social and environmental sustainability (Bigger et al., 2023).

This has been demonstrated by the case of green debt, increasingly used by municipalities to address climate change urban challenges. Green bonds became accessible to municipalities and corporations in 2014 in a context of budgetary deficits and austerity pressures. By 2017, the annual issuance of green bonds had nearly surpassed all other forms of climate finance combined. This trend reshaped climate-related funding and investment portfolios, often prioritizing existing projects that provide economic benefits over transformative infrastructure investments. This new market-led focus of climate finance has exacerbated disparities and risks for marginalized communities (Bigger et al., 2023).

Additionally, studies on public-private partnerships reveal significant challenges of involving the private sector in urban sustainable infrastructure. They face constraints such as conflicting interests between private investors short-term interests and government long-term sustainability goals. Inadequate constraints can trigger market failures, leading to low-population coverage, resource inefficiency, and detrimental environmental and societal impacts. There is often misalignment between economic and sustainability objectives, and the need for a supportive integrated institutional framework. Neglecting these issues has led to the failure of PPP initiatives (Koppenjan et al., 2009).

In summary, overreliance on market-based financing strategies or inadequate private sector involvement can limit transformative changes necessary for a just and sustainable transformation, increasing the risk of negative consequences, especially for marginalized communities. Therefore, it is imperative to critically evaluate these innovative financing methods and public-private strategies to ensure they achieve their intended impacts and contribute to equitable urban greening.

2.2. Conceptual model

For a better understanding of the research framework, the following conceptual model illustrates the relationship between the independent and dependent variables, 22ighlighting the indicators that contribute to the mainstreaming process of UNBS. This model serves as a visual representation of the theoretical concepts discussed in the previous sections, linking innovative financing strategies with their potential impact on overcoming financial barriers and facilitating the mainstreaming of UNBS. This model will be used as a basis for further analysis and discussion throughout the study.

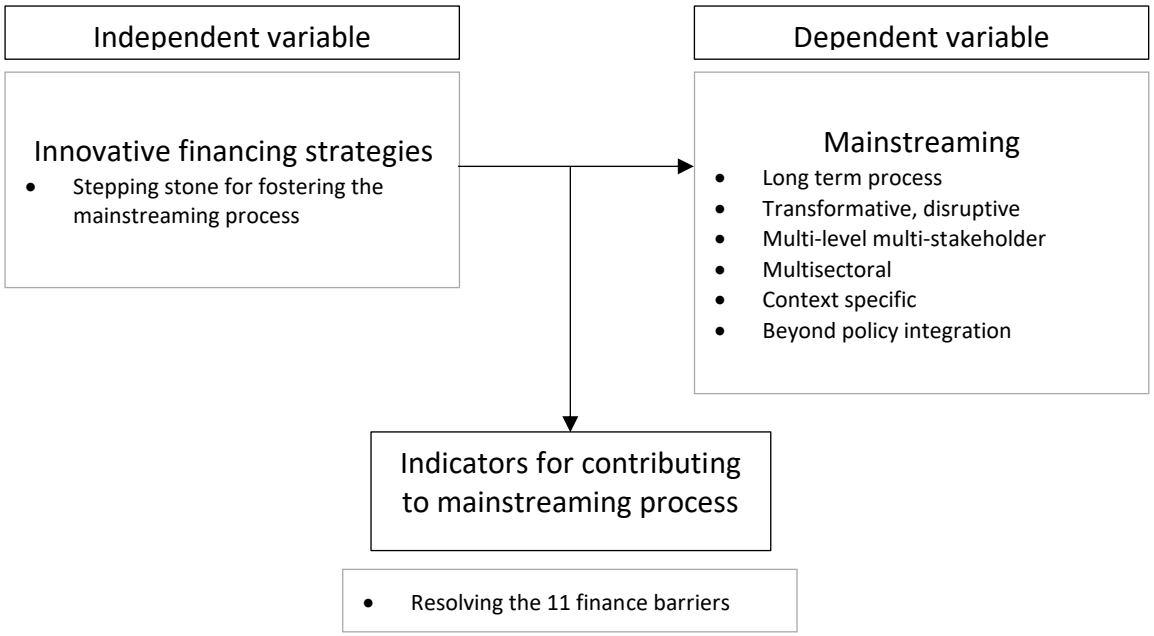


Diagram 3. Conceptual model
Source: Author

3. METHODOLOGY

This chapter is structured into four sections. The first section outlines the overall research strategy. The second provides a justification for the selection of a case study method, and the choice of Barcelona. The third section presents the data collection and data processing methods. The final section addresses the validity of the methods.

3.1. Research Strategy

This research merges conceptual and descriptive methodologies. A qualitative approach is used, as the data collected mostly comes from qualitative sources such as interviews, surveys, documents, and literature reviews. The research process entailed the following phases.

First, a literature review was conducted to clarify concepts stemming from the emerging fields of UNBS mainstreaming and UNBS finance, enriched by sources from other branches. Then, a hypothesis was extracted from the literature review and tested through the empirical case. The goal was not to universally prove the hypothesis but to understand its applicability to the specific context. This phase concluded with the identification of the framework to provide insights for contrasting the hypothesis with the case study. Next, descriptive research was initiated to provide an empirical description of the identified phenomenon. Finally, the analysis of the results and the discussion took place. Overall, the final product is a qualitative conceptual research accompanied by a small-case descriptive empirical research.

3.2. Case study selection

The method of a single case study has been employed, as an intensive analysis of an individual unit that prioritizes depth rather than breadth (B Flyvbjerg, 2011; J Gerring, 2004). This depth has been pursued through several approaches. First, by not only analyzing the variables using an analytical framework but also by providing comprehensive details for each of the variables. Second, by presenting them against a robust contextual background. Finally, by narrowing down to a highly specific context, in order to gather as much detailed information as possible within this narrow case.

A case study was deemed relevant to this study as, within the UNBS context, one-fits-all solutions are not considered as valid. According to UNBS literature and experts on the topic, mainstreaming and finance solutions need to be contextually adapted and account for diverse factors including climatic risks, ecosystems, geographical scale, and socio-economic considerations (Droste et al., 2017; Brears, 2022; Xie et al., 2022; European Investment Bank & European Commission, 2023). Therefore, focusing on a single case enables the study to provide relevant information for stakeholders involved in these processes or operating in similar contexts.

3.3. Barcelona selection

The specific context of Barcelona was selected as the case study for several reasons. First, as the research aimed to explore the relationship between innovative financing strategies and the mainstreaming of Urban Nature Based Solutions. Therefore, the fundamental criterion for selecting the case was the presence of innovative financing strategies around UNBS.

During a pre-research phase, elements regarding public-private collaboration were identified, through news, on-ground evidence. These indicators suggested the potential existence of innovative strategies for UNBS finance in the city. Two key events during this phase were pivotal in confirming the existence of these strategies: an exploratory talk with a municipality agent from Agenda 2030 Commission and attending the World City Expo in Barcelona.

This preliminary investigation was later substantiated through formal research, confirming that some local government departments indeed employ innovative financing strategies for the implementation of UNBS. This led to finally focus on the Municipal Institute of Urban Planning and Quality of Life and its two UNBS projects: the Green Roofs Strategy and the Green Walls Strategy.

Second, a study by the EU-wide project, Naturvation, identified Barcelona as a frontrunner in promoting UNBS within the Spanish context, although these solutions are not yet mainstreamed in the city (Van der Jeght et al., 2020). This double condition of being a frontrunner and lacking of mainstreaming provides an opportunity to focus on the "progress" of the mainstreaming process rather than its outcomes. A deeper description of Barcelona as the unit of study will be presented in the next section. Finally, the researcher resides in Barcelona and is familiar with the local context, which could facilitate interviews and on-ground information gathering in Spanish and Catalan.

In sum, Barcelona was selected for (a) the identification of innovative financing strategies involving the private sector (b) its national leading role in the promotion of UNBS, and (c) the practical advantages of the researcher living there.


Images 1,2,3. World City Congress in Barcelona November 2023

Source: Author

3.4. Identification of the strategies

Barcelona is the second-largest city in Spain (Ajuntament de Barcelona, 2020a). It is one of the densest and most compact cities in Europe. With an area of 10,135 hectares, it is bordered by the coast, two rivers on the sides, and the Collserola Mountain behind, its largest peri-urban forest natural park (Ajuntament de Barcelona, 2020a). Due to its compactness, Barcelona has a low ratio of green spaces per inhabitant compared to other European cities (Fan et al., 2017), with 7 m² of urban green areas per capita. The distribution of the urban green infrastructure is uneven, ranging from 2 m² per inhabitant in the district of Eixample to 17m² per inhabitant in Sants-Montjuïc (Área de Ecología Urbana|Plan Natura, 2021).

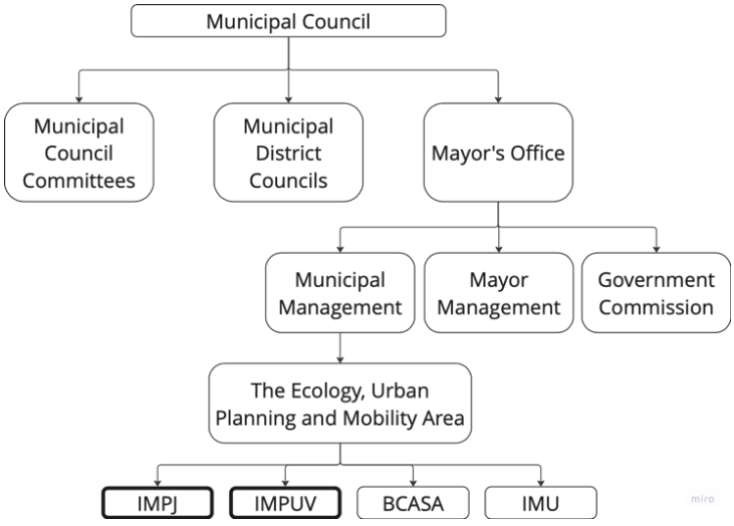
The city faces urgent challenges due to climate change, including the heat island effect, air pollution, drought and water stress, biodiversity loss, and forest fires, all contributing to health deterioration, economic losses, and decreased well-being (Área de Ecología Urbana, 2018 | Plan Clima).

In response, the City Council of Barcelona has developed several policy plans and strategies promoting Urban Nature-Based Solutions and urban greening as key solutions. Despite the city's urban characteristics posing a challenge to increasing green spaces, the municipality aims to add 1 m² of greenery per resident by 2030 (Área de Ecología Urbana| Plan Clima, 2018; Área de Ecología Urbana|Plan Natura, 2021). This goal is embedded in two main overarching plans: the "Climate Plan 2018-2030", the main strategic document for addressing climate change, and the "Nature Plan Barcelona 2021-2030", a roadmap for the city's management of green areas (Àrea

d'Ecologia Urbana Ajuntament de Barcelona, 2021). Of the 3,611 hectares of green space in Barcelona, 50% is the Collserola Park, 30% is public, and 20% is privately owned. The municipality's strategy targets increasing green spaces on both public and private properties (Área de Ecología Urbana|Plan Natura, 2021). To tackle the lack of space, various innovative strategies have been developed by the "Program for Promoting Urban Green Infrastructures".

This research used the "Nature Plan Barcelona 2021-2030" to identify key entities within the municipality that work directly on the promotion and maintenance of UNBS. Four were identified, all falling under the Ecology, Urban Planning and Mobility Area (See Diagram 1). These entities work towards the overarching objectives of the "Climate Plan 2018-2030" and the "Nature Plan Barcelona 2021-2030", and are involved in a lesser or higher degree under the "Programme for Promoting Urban Green Infrastructures" but work independently through their own contributions.

The Municipal Institute of Urban Landscape and Quality of Life (IMPUQV) works with green walls and green roofs; the Municipal Institute of Parks and Gardens (IMPJ) manages trees, parks, and gardens ; the Municipal Institute of Urbanism (IMU) is in charge of macro-urban development projects including the greening of streets; and Barcelona Water Cycle SA (BCASA) runs water management and implements sustainable drainage systems.



IMPJ – Municipal Institute of Parks and Gardens
IMPUQV – Municipal Institute of Urban Landscape and Quality of Life
BCASA –Barcelona Water Cycle SA
IMU - Municipal Institute of Urbanism

Diagram 3. Municipality diagram (very simplified version)

Source: Author

Then, their financing strategies were studied to identify the use of innovative financing strategies involving the private sector.

It was found that financial support for UNBS is primarily provided by the local government, and European and national funds. Most public-private collaborations remain non-economic or publicly financed (Interviewee 1, IMPJ; Interviewee 2, Mans al Verd). For instance, the Municipal Institute of Urbanism (IMU) mainly works on large-scale infrastructural projects such as the "Superilla" or greening of the overall street plan, with funds stemming from National and European budget transfers.

The Municipal Institute of Parks and Gardens (IMPJ) does prioritize collaboration with citizens and the tertiary sector, but strictly rejects any financial agreement or collaborations with profit-making entities. To manage and expand UNBS, IMPJ relies on direct funding from Municipal revenue sources. The only private source of income it uses are traditional tools such as leasing its spaces and charging entrance fees for parks and beaches. The funds are reinvested into the maintenance of such spaces.

However, as each policy area within the City Council has a distinct corporate culture, there are exceptions, leading to differences in financing approaches across departments (Blanco et al., 2020). For instance, the Municipal Institute for Urban Landscape and Quality of Life (IMPUQV) employs a blend of private and public sources to finance its Green Roofs Strategy and Green Walls Strategy. It also engages with for-profit companies, such as advertisement firms, and uses diverse financing methods that make up an innovative financing strategy.

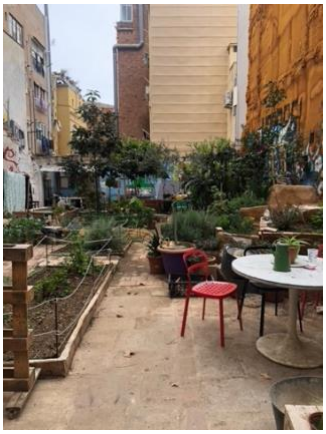
BCASA was unreachable. So, after a first-level analysis, the focus was set on the strategies employed by the Municipal Institute of Urban Landscape and Quality of Life (IMPUQV), and will be further developed and analyzed in the findings.

Images 4 & 5. Sustainable Urban Drainage Systems in Poble Nou (by BCASA and IMU)

Source - Author

Images 6 & 7. Green streets in Eixample; Part of Superilla project (by IMU)

Source - Author

Images 8 & 9. Urban Community Garden in Gràcia (by Mans al Verd)

Source - Author


Images 10 & 11. Green walls in Barceloneta and Poble Nou (by IMPUQV)

Source - Author

3.5. Data collection and data processing methods

The following table (Table 3) explains the data collection and analysis processes for the two complementary parts of the research: the conceptual research and the case study analysis (or descriptive research).

Table 3. Methods for data collection and analysis

Phases of research	Aim of information	Data collection and sources	Data analysis
Developing the conceptual FW	- Unraveling key concepts - Unpack the relationship between them - Unifying information providing a general overview of UNBS finance and UNBS mainstreaming - Presenting theoretical approaches - Identifying a relevant framework to apply to case study	Secondary data sources - Academic literature (UNBS mainstreaming; UNBS finance; urban transition studies; PPPs in urban governance) - Gray literature (Naturvation, EU Horizon 2020 Projects, policy papers and reports from several organizations, Biodiversity and Sustainable finance guides).	The data was processed through a traditional literature review. Conceptualization of variables consisted in manually identifying indicators and adding them into tables with the sources (see section below). Manual coding
Developing the case study analysis	- Data relevant to the framework on mainstreaming - Qualitative information - Subjective information (from the actors involved in using the strategy)	Primary data sources - 4 interviews - 1 survey Secondary data sources - Barcelona's policy documents, legal documents, reports, white papers, and academic articles.	Transcription Coding

Source: Author

Phase 1: Literature review

In the first part of the research, a literature review was conducted. It was mainly divided into literature on UNBS Mainstreaming and Finance, although these often overlap since finance is frequently discussed within the context of mainstreaming. Sources include scientific articles, publications from international organizations, policy reviews, and gray literature. Given that both fields are relatively new and underdeveloped (Wickemberg et al., 2020; Adams et al., 2023; Fatema, 2022), finding information about the expected benefits of finance mechanisms applicable to UNBS entailed using literature and gray documents from other fields. Consequently, papers from Urban Sustainable Transitions, Public-Private Partnerships in urban infrastructure governance, Biodiversity finance, and Sustainable Finance were integrated.

The research strategy for this phase involved using several engines such as Google Scholar and Worldcat. A snowballing technique was employed. The gradual identification of relevant concepts and terms (illustrated in Table 4) was also useful in finding more specific content. These efforts reinforced the research gap and supported identified recommendations and relationships between the concepts.

Table 4. Summary of key concepts for document search strategy

Terms for UNBS	UNBS finance and mainstreaming	Innovative financing strategies
Urban Nature Based Solution, ecosystem services, sustainable infrastructure, ecosystem-based adaptation, green-blue infrastructure, green roofs, green infrastructure	Funding, financing, paying, investing, mainstreaming, upscaling, transition	Private sector, public-private, co-financing, innovative finance, blend finance, business model

Source: Author

For the data analysis and processing of this section, a traditional approach was employed. Information was collected, read, and organized in Excel tables and Notion databases before being summarized for the literature review. Manual coding was performed during the readings, highlighting relevant ideas in different colors for each of the key ideas displayed, with its related concepts in Table 5. This method was useful for building the hypothesis, refining the research gaps, and processing the information in a structured manner.

Table 5. Key coding variables for data processing for descriptive research

Main ideas	Related concepts	Meaning
Research gap	"Gap", "lack of knowledge", "underdveloped in literature", "lack of evidence", "need for further research", etc.	There is not yet enough evidence on effective UNBS finance for mainstreaming.
Financing barriers	"Underinvestment", "finance gap", "finance barrier", "risk", "long-term engagement", "lack of data", etc.	Finance is one of the main barriers to UNBS mainstreaming. Finance for UNBS is still not well developed.
Recommendations for solving the finance barrier OR for mainstreaming UNBS	"PPPs", "collaborative governance", "involving the private sector" "developing innovative finance", "innovative business models", "new finance mechanisms", etc.	A broadly proclaimed way to solve the finance barrier is creating innovative financing mechanisms with their respective business models that involve the private sector in UNBS finance.
Expected contributions of innovative finance	"Solving the double externality problem", "solving risks", "risk-sharing" "benefit sharing" "pooling resources" "generating new funds" "involving new actors" "efficiency", etc.	Expected contributions of innovative finance aligns with solving the finance barrier. Therefore, it could be a good contribution to mainstreaming.

Source: Author

This phase also involved identifying existing innovative financing strategies for UNBS which are listed in Table 6 in the appendix. This identification, together with the literature review, helped define "innovative financing agreements that involve the private sector", and provided an understanding of their characteristics and expected benefits, later used for the analytical framework.

Table 6. Types of financing mechanisms for UNBS finance from local governments perspective

Category	Financing Instrument	Description
Direct implementation	**Public Budgets**	Pooling funds from different departments or using untapped sources like the public health budget.
	Grant Funding and Donations	EU funding, regional and national grants, philanthropic contributions, and crowdfunding.
	Revenue-Generating Instruments	Land sales or leases
		Taxes
		User fees
		Developer contributions
		Betterment levies
		Voluntary contributions
		Sale of development rights
		Offsetting funds
	Green Finance	Loans from financial institutions, green bonds, and the Natural Capital Financing Facility (NCFF).
Indirect implementation	**Market-Based Instruments**	User charges
		Incentive taxes
		Subsidies
		Tax rebates
		Credit-trading systems
		Biodiversity offsets
		Payments for ecosystem services (PES)
	Business Improvement Districts (BID)	Businesses and stakeholders enter an agreement with local government to contribute an additional levy to finance improvements in a specific area. BIDs are free to constitute their own management body, make spending decisions, and seek additional income through various instruments.
	Endowments	Establishment of a fund through i.e. money or property donation, developer contributions, sale of lands, or other sources – and the interest captured from investment of the funds is used to pay for the green infrastructure, leaving the original endowment untouched
	Public-Private Partnerships	PPPs are long-term agreements between a private entity and a government to provide a public asset or service, with the private entity assuming risk and management responsibility. These partnerships have been used for various infrastructure services. The government delegates service provision to the private entity. It can be applied to the delivery and maintenance of green infrastructure. PPPs can take different forms; i.e. operation and maintenance contracts, leases, and concessions.
	Revolving Funds	Is a fund replenished through repayments from loans drawn from the fund or by a constant flow of contributions
	Community Asset Transfers.	Local government can transfer to a community the management or ownership of public land or buildings (usually through long lease). Can be at a lower value than market value to provide societal and ecological benefits.

Source: Horizon 2020 European Union Funding for Research and Innovation – Approaches to financing nature-based solutions in cities 2024

At the beginning of the research process, two initial hypotheses were extracted from the literature: (a) innovative and collaborative financing mechanisms would encourage a greater involvement of the private sector (b) this involvement would help mainstream UNBS in the city. However, the first hypothesis was abandoned during a first-level analysis as it was found to be too simplistic in understanding the process of involving private actors. The decision of private actors to fund UNBS was not found to be uniquely triggered by the type of financing strategies available. The process was found to be neither linear nor direct. Many other factors can impact private actors' decision to finance UNBS. To fully attribute this to the financing strategy would have been an oversimplification; and to contextualize the weight of the available financing strategy among all the other influencing variables would have been too complex. Time constraints and limited contact with the private actors also supported the choice to abandon the hypothesis. The final hypothesis was reformulated to "Innovative financing strategies involving the private sector positively contribute to mainstreaming UNBS".

Subsequently, the conceptualization of the variables was conducted. Mainstreaming was decided to be measured through overcoming finance barriers hindering the process itself. Eleven barriers by Robert C. Brears (2020) were selected for the purpose. The original table was translated into a personalized framework with slight interpretation of each of the indicators.

Overall, these data collection and data processing methods enabled the creation of the conceptual part of the research, which materializes in a literature review and an analytical framework. These compose the foundations for the case study.

Phase 2: Empirical research

The empirical research began with the objective of identifying the innovative financing strategies used by the Municipality of Barcelona which involved the private sector in UNBS projects. Overlapping with the previous phase, all policy plans and strategies of the municipality related to UNBS were scrutinized. This helped to map out the relevant municipal departments and institutes that directly manage and finance these projects. Those departments that did not involve the private sector in UNBS finance were discarded, as well as those that did not respond to outreach efforts. Ultimately, the Institute of Urban Landscape and Quality of Life (IMPUQV) was the only one to meet all criteria.

The research finally focused on the work from this institute and its two UNBS programs – one on green roofs and one on green walls. Each of these uses an innovative financing strategy that involves private actors, using with a mix of traditional and innovative financing tools and direct and indirect implementation. Section 4.2. explains them into detail.

This phase also involved conducting the interviews. Interviewees were selected based on their representativeness and availability, and reached out through a snowball technique. All signed a consent form for recording, except for one. In that case, notes were taken by hand and transcribed immediately after the interview. For privacy reasons, the names are not displayed. Table 7 summarizes the key information on the interviews.

Following a mixed methods approach, the interviews were conducted in a semi-structured manner, gathering qualitative information to capture nuanced insights into the public agent's perspectives of the effects of the innovative financing methods used in their mainstreaming programs.

Table 7. Interviewees and Dates

Interviewees	Date
• Public Agent 0 "Agenda 2030" (exploratory talk) • Public Agent 1 "Parks and Gardens Institute" • Public Agent 2 "Mans al Verd" • Public Agent 3 "Municipal Institute Urban Landscape and Quality of Life (IMPUQV)" • Public Agent 4 "Municipal Institute Urban Landscape and Quality of Life (IMPUQV)" • Public Agent 5 "Municipal Institute Urban Landscape and Quality of Life (IMPUQV)"	• November 2023 • 13 March 2024 • 25 March 2024 • 25 May 2024 • 4 April 2024 • 4 April 2024

Source: Author

To increase accuracy, interviewees were contacted again in May to complete a written survey. They were specifically asked about their perceptions of to what extent each strategy – the Green Roofs Strategy and Green Walls Strategy – was able to overcome financing barriers. Each question was directly linked to the indicators of the analytical framework and required responses on a scale from 1 to 5, with comments also accepted. Emphasis was placed on clarifying that the scale was not an evaluation of the financing strategy itself, but an indication of the extent to which it had been able to overcome each financing barrier. The survey focused on the overall financing strategies rather than the individual financing mechanisms that comprise them.

The following table (Table 8) presents the analytical framework. It includes the indicators for each of the barriers, a conceptualization of what it means to overcome them, and the corresponding survey questions. This conceptualization emphasizes that the research views overcoming a barrier as a process rather than an outcome.

Table 8. Analitical Framework - Adapted version of C. Brears (2020) Financing Barriers on Nature Based Solutions Mainstreaming, operationalisation of the Finance Barriers and questions from the survey

Nº	Barrier	Indicators of overcoming the barrie	Questions survey (the strategy has contributed to...)
1	Low return	Investors shift their perspective on returns from UNBS.	Q 4 - Change investors' perspective on the economic returns or benefits of NBS (positively).
		They don't think management and maintenance costs are higher than the ones from conventional technologies.	Q 6 - Change investors' perception of management and maintenance costs (positively).
2	Perceived higher risk	It helped to build a new economic analysis of NBS, build a historical cost–benefit data available to contrast with the data available for gray infrastructure.	Q 9 - Develop a new economic analysis of NBS.
		This also contributed to lower the perceived risk associated with NBS projects.	Q10 - Reduce the perceived risk associated with UNBS projects (both from private investors and the Institute or City Council).
3	Information gaps	Creates or enables the collection of information regarding UNBS, and environmental aspects.	Q1 - Create or enable the collection of information on relevant Nature-Based Solutions and their environmental aspects.
		Allows the creation of NBS data, measurements and standards.	
4	Undervaluing natural capital	Ghg emissions, water pollution and other negative externalities derived from natural exploitation are accounted for.	Q15 - Better understand how to quantify or value the price of nature
5	Policy failures	Contributed to better account for the cost of environmental impacts, biodiversity, or other environmental measures that are not easily quantifiable to make better informed policy and financial choices.	Q11 - Ensure the Institute or City Council makes more informed investment decisions considering environmental factors.
6	Institutional inertia	The strategy helped in confronting and even changing investment patterns due to market's institutional, governance and financial features.	Q7 - Challenge and potentially change established investment patterns or redirect funds from traditional solutions to innovative ones.
		The strategy allowed finance to shift from flowing to traditional solutions to innovative ones.	
7	Lack of institutional capacity	The municipality was able to gain insights on knowledge and technical skills that facilitated raising finance and upscalling the solutions.	Q8 - Increase the Institute or City Council's knowledge on financing methods for expanding NBS.
		Thanks to this finance mode, knowledge on innovative financing mechanisms was expanded (within the Department or the whole municipality).	
8	Undefined financial responsibilities	There is a clearer idea of who should pay for the UNBS and fund the monitoring and maintenance costs.	Q13 - Clarify who pays for the investment, who covers the management, monitoring, and maintenance costs.
		Actors that benefit from UNBS are more willing to pay for receiving increased public benefits.	Q14 - Encourage actors who could benefit from NBS to be more willing to pay for their benefits.
9	Lack of financial resources	Allows the local government to dedicate new funds towards UNBS.	Q2 - Allocate new funds (both public and private) to NBS.
		Favored the larger and long-term investment of NBS.	Q5 - Reduce instalation, management, maintenance, and/or monitoring costs of NBS.
			Q12 - Cover investment costs and other long-term management, maintenance, and/or monitoring costs.
10	Short termism	The strategy allowed to overcome the barrier of a short-termism view of investors.	Q3 - Facilitate long-term and larger-scale investment in NBS.
		Projects financed were able to cover the high capital costs and maintain a long term investment.	
11	Reliance on voluntary commitments	This strategy carves a way towards regulation, stepping away from voluntay commitments.	Q12 - Cover investment costs and other long-term management, maintenance, and/or monitoring costs.

Source: Author

Phase 3: Analysis of the results

Once the data on the strategies was collected, the second-level analysis began. The interviews and were coded around the themes in Table 9 which were chosen in relation to the research sub-questions.

Table 9. Coding of the interviews

Coding of interviews		
Codes	Subcodes	Related Research Questions
Barriers to mainstreaming	Eleven finance barriers	SQ1- What are the finance barriers hindering the mainstreaming process?
	Other	
Strategies	Green Roofs strategy	SQ2- How is the local government of Barcelona using innovative strategies to involve the private sector in UNBS finance?
	Green Walls Strategy	
	Other	
Mainstreaming enablers	Within the strategies	SQ3- How do these strategies overcome the finance barriers hindering the mainstreaming process?
	Outside the strategies	
Contributions to mainstreaming	Solving the eleven finance barriers	
	Other	

Source: Author

Then, results from the surveys were translated into tables such as the following. These have been included in the appendix, discussed in the findings, and contrasted with the information from the interviews, empirical data collected and insights provided by other municipal departments.

Table 10. Example of displaying table for the results of the survey

B1 – Name of the barrier

Strategy	Score	Question A – From the survey
	Score	Question B – From the survey

Source: Author

1	2	3	4	5

The relation between innovative strategies and mainstreaming was thoroughly examined, resulting in a qualitative comprehensive description of the strategies.

3.6. Validity of the methods

The selection of a mixed method approach lies in the assumption that relying on both kinds of data, the research can provide a more complete understanding of a research problem than either can alone (Creswell, 2014).

Qualitative validity refers to the accuracy of the findings (Creswell, 2014). This has been done by combining multiple sources of data (interviews, survey, policy reviews, and literature review). In addition, in the conceptual phase, the sources themselves draw upon a variety of different literature branches to integrate multiple perspectives and ensure a comprehensive understanding of the subject matter. Additionally, critical lenses were also incorporated to lower the risk of presenting biased or one-sided information.

This research has also tried to guarantee a qualitative validity and research reliability by being transparent on the methods, and on the iterative processes of the research, even openly sharing what didn't succeed or was modified. This goes hand in hand with a self-reflection and further reflectivity approach displayed in the discussion part. As most of the data collected is qualitative, it is also held to subjectivism, however, this subjective information collected from the interviews has been contrasted by numbers and objective information on each of the selected indicators.

4. FINDINGS

This chapter will present the findings. The first section will respond to the second research sub-question by explaining in detail the financing strategies of the IMPUQV; the Green Walls Strategy and the Green Roofs Strategy. The second section will explore the contribution of these strategies to mainstreaming UNBS, giving an answer to the third research sub-question. A first sub-section will present two factors that have enabled both strategies to succeed in mainstreaming UNBS. The second will discuss the primary financial barriers encountered in the mainstreaming process, evaluating the effectiveness of the financing strategies in addressing these challenges.

4.1. Innovative financing strategies for UNBS in Barcelona

This section wil first briefly introduce the work of the Municipal Insitute of Urban Landscape and Quality of Life. Then, it will explain how it developed the Green Walls Strategy and the Green Roofs Strategy, detailing the financing strategies employed by each of them.

The Municipal Institute of Urban Landscape and Quality of Life (IMPUQV)

As explained in section 2.1.3, this research focuses in the work conducted by Municipal Institute of Urban Landscape and Quality of Life (IMPUQV) in mainstreaming Urban Nature Based Solutions in the city.

This institute is an autonomous local entity established in 1997. Its primary objetive is to protect and preserve Barcelona's landscape values through the Municipal Ordinance of Urban Landscape, a regulation for managing the urban environment. The IMPUQV coordinates diverse actions to aimed at building rehabilitation and sustainable urban landscape management, seeking to improve the quality of life of Barcelona's residents. The institute also encourages the participation from both the civil and the private sector in preserving and enhancing urban landscape values.

As a part of the "*Program for Promoting Urban Green Infrastructures*", IMPUQV promotes two types of Urban Nature-Based Solutions: green roofs and green walls. Although both are part of the same program, these are separate strategies made up of differing financing and implementation methods. The institute has the mission to promote, maintain and implement these solutions in public and private spaces. Both party walls and roofs are in the intersection between the public and private domains.

As introduced in 2.1 section, the Municipality of Barcelona is highly committed to increasing UNBS through multiple plans and strategies. The goal of increasing 1m² per inhabitant would result in an increase of 10.67 hectares per year, or 40 per political mandate. The city's topography makes it challenging to add new urban green spaces. This is why roofs are seen as high potential areas to re-naturalize the city. It is estimated that 67% of

Barcelona's rooftops could be converted into gardens (1.764,4 ha) and 20% could become solar energy production centers. Specifically, typical Catalan roofs have optimal conditions to hold green covers, being made of red brick and slightly inclined to facilitate rainwater drainage. In 2017, Barcelona had 3.5 hectares of public green roofs. However, the potential area of intervention for installation in public spaces of these solutions is 65 hectares. This figure can be highly expanded with the integration of private and business initiatives, to achieve the conquer of the total 1.764,4 ha. Only a few isolated and private cases are known. Recognizing this opportunity, the city council has gradually developed a multi-faceted strategy to promotes the adoption of green roofs, both in public and private buildings.

Similarly to roofs, using walls is an effective way for adding nature to dense and compact cities like Barcelona. According to the Municipality of Barcelona, the city holds over 40,000 party walls. A detailed research conducted by the IMPUQV, estimated that from these, 348 are eligible for intervention, meaning they belong to public spaces, are in contact with the ground, and have a minimum surface area of 100m². In a report released in 2023, the institute has set itself the goal of installing 170 green walls over a 10-year-horizon. This would result in annual programs of 8-10 interventions with a budget of €1,500,000 per year. The IMPUQV has focused its efforts on working with those party walls that stay permanent and will not be removed or affected by urban planning. Those that impact the ground, squares and parks are prioritized for their higher visual and societal impact (Institut Municipal del Paisatge Urbà i Qualitat de Vida, 2023).

Table 11 summarizes the key implementation and financing mechanisms for each strategy, which will be explained below. These mechanisms inlcude contests and subsidies for implementation both in public and private spaces. For the Green Walls Strategy, outdoor advertisement tax revenue is used for direct implementation. For the Green Roofs Strategy, direct public funding and regulation is used for own implementation.

Table 11. Strategies used by the IMPUQV with respective implementation mechanisms and sources of funding

Municipal Institute of Urban Landscape and Quality of Life			
Strategy	Implementation	Funding	Mechanisms
Green roofs strategy	Public	Private	Outdoor advertisement tax
	Public	Public	Contest
	Private	Public-Private	Subsidies
Green walls strategy	Private	Public-Private	Contest
			Subsidies
	Public	Public	Direct public funding, regulation

Source: Author

The Green Walls Strategy

Party walls are anonymous walls dividing properties that, due to urban changes, remain exposed to public view in a permanently provisional state. This creates a discontinuity in the urban landscape, leading to construction and habiltability issues for residents and a negative visual impact on public spaces. To resolve these urban discontinuities, the plan for remodeling party walls in Barcelona was created 25 years ago.

Originally, the plan for refurbishing party walls had an aesthetic purpose. Driven to improve the architectural landscape of the city, party walls were intervened to mirror the main façade of buildings. Over time, proposals started including structural improvements and additional openings (e.g., windows and balconies). Later, added features such as caligrams and visual poems were introduced. Often created through participatory processes, these added art to the streets while promoting sociocultural projects (Institut Municipal del Paisatge Urbà i Qualitat de Vida, 2023).

As sustainability regulations evolved, green vegetalisation and thermal insulation of the walls started to gain prominence as solutions to contribute to the green plans of the city. Vegetation and habitats for protected birds were added to the refurbishment projects. Eventually, the plan was refined to incorporate green-gray innovative soutions. In collaboration with Barcelona Energy Agency, plants were combined with photovoltaic energy production, include self-sufficient designs with solar capture and rainwater use for irrigation. This led to increased testing of various methods (Institut Municipal del Paisatge Urbà i Qualitat de Vida, 2023).

Over the years, the plan has shifted towards fostering the implementation of green walls. It has become structured around three approaches to address the remodeling of party walls: First, the own installation of green walls of IMPUQV, financed though the exceptional use of advertising on scaffolding posters. Second, supporting private installation of such solutions, financed through subsidies and incentivied through calls to grants. Third, an international contest for green walls, which is currently taking place for the first time.

Historically, annual intervention programs have been generated based on demands from different districts, both publicly and privately owned. This approach aims to maintain an equitable distribution accross neighbourhoods and adopt tailored solutions for every location (Institut Municipal del Paisatge Urbà i Qualitat de Vida, 2023). In the past, 848 party walls have been remodeled under the IMPUQV direction. This includes 102 under the own public program, 607 interventions under the private support program, and 139 recoveries under the advertising program. However, it is important to remark that not all of these have been green solutions, as this is a recent development (Institut Municipal del Paisatge Urbà i Qualitat de Vida, 2023).

Advertisement funds: Public implementation, Private finance

To finance its own initiative to refurbish abandoned walls, the IMPUQV developed an innovative financing mechanism based on revenue from outdoor advertising. It works as it follows: when any building façade is being renovated, the community of neighbors or property owners can get it partially financed by an advertising company. In exchange, a giant advertisement banner is placed on the building's scaffold as during the renovation period, on which the company can display an advertisement.

The IMPUQV acts as an intermediary, facilitating agreements between the property owners and the advertising companies. These agreements specify the extent of financing (i.e. 80%, 90%, 100%) and the terms for placing the advertisement banner.

For this mediating role, the municipality receives a monthly fee from the company that gets advertised in the banner, which is directly reinvested in the refurbishment of party walls in other places in city. This financing strategy has been used since the early 2000s, and since 2010 with the specific purpose of greening walls.

This model creates a win-win situation: homeowners receive financial support for their façade rehabilitation, advertising companies gain large visible spaces for their ads, and the municipality funds green infrastructure projects to implement UNBS.

Today, the public direct implementation of green walls is almost fully financed by the advertisement revenue (Interviewee 4 – IMPUQV), reducing the financial burden on the institute's funds, while engaging private advertisement companies in the city's greening financing efforts. Currently, it is one of the three financing mechanisms used for the Green Walls Strategy.

Subsidies: Private implementation, Public-Private finance

The second financing method to for the Green Walls Strategy involves providing financial subsidies to incentivize the rehabilitation of party walls in private buildings that are visible from public spaces. This program targets property owners and activity holders in qualifying buildings, excluding new real estate developers. The subsidy covers 35% of costs, up to €120/m². Additional improvements like windows, balconies, or photovoltaic panels can increase the subsidy to 50% (up to €300/m²) for one improvement or 60% (up to €420/m²) for two improvements. Projects located in high-priority urban regeneration areas receive an extra 10% subsidy, as do those using sustainable thermal insulation materials like wood fiber or cork (Bulletí Oficial de la Província de Barcelona, 2024).

Contests: Public implementation, Public finance

Finally, as interest in investing in these solutions continued to grow, a third method was developed. The Municipality is currently launching its first international contest for green walls as part of the initiative to defend

its title as the World Capital of Architecture in 2026. This competition invites young architects from around the world to design green walls for the city (Concurso Internacional Para Jóvenes Arquitectos | Capital Mundial De La Arquitectura | Ajuntament De Barcelona, 2024).

The competition will select proposals for 10 locations, one in each district, focusing on 17 permanent walls. The selection criteria include urban quality, livability, sustainability, and biodiversity. The initiative aims to create meaningful façades that enhance the urban landscape and improve the living conditions of neighbours. A total amount of 52.500 € will be distributed among the three best candidates for their ideas. Additionally, 4,5M € will be used to implement the 10 solutions, fully supported by the municipality, except for new windows and balconies, which will only be partially financed (Concurso Internacional Para Jóvenes Arquitectos | Capital Mundial De La Arquitectura | Ajuntament De Barcelona, 2024).

Image 12. Advertisement on top of a building in the district of Eixample

Stating "PRADA collaborates with the renovation of the wall of the Gardens of Victòrial dels Angels in the UB (University of Barcelona) campus of Raval (district in Barcelona)"

Source: Author

Image 13. Green wall in Barcelona

Source: Newspaper La Razón

Image 14. Advertisement on top of a building in the district of El Gotic

Picturing a collaboration with Martini for the refurbishment of walls in a square in the district of Sant Gervasi

Source: Author

Image 15. Advertisement on top of a building in the district of Eixample

Displaying a collaboration with Cirque du Soleil for the refurbishment of walls in the district of Bon Pastor

Source: Author

Image 16. Advertisement on top of a building in the district Sarrià

Showing a collaboration with Samsung for a wall refurbishment in the district of Les Corts

Source: Author

Image 17. Advertisement on top of a building in the district Eixample

Showing collaboration with Font Vella for the refurbishment of walls in the district of Sant Gervasi

Source: Author

Image 18. Green wall project implemented by the IMPUQV
Before and after the intervention

Source: Institut Municipal de Qualitat de Vida i Paisatje Urbà

The Green Roofs strategy

Currently, the strategy comprises four action lines; two indirect (contests and incentives) and two direct (implementation in new public buildings and in existing public buildings) (Plan verde y de la Biodiversidad de Barcelona 2011-2021, 2017).

Contests: Private implementation, Public-private finance

Promoted by the Barcelona City Council through the Municipal Institute of Urban Landscape, the Green Roofs Strategy started with two contest: the first in 2017, and the second in 2020. A total of 92 proposals participated (45 and 47 proposals respectively), with ten winners per edition. Each winning project received a grant covering 75% of the cost, with a limit of 100,000 euros per roof.

The proposals selected in the first edition were implemented between 2018 and 2019, resulting in an increase of 5,500 m² of green surface. The second edition projects were completed during 2022, adding 2,055 m² of green space and benefiting a total of 262 households (Institut Municipal Del Paisatge Urbà I La Qualitat De Vida & El Globus Vermell, 2022).

Prior to the contests there had been some unsuccessful attempts to promote green roofs through subsidies for private buildings but… "significant effort was needed to gain traction" (Interviewee 4 – IMPUQV).

This first green roof competition was not limited to residential buildings. Private companies, in particular, were enthusiastic participants. The ten winning roofs served a variety of purposes and were installed in a variety of locations: two schoools, three community of neighbours, a refrigerating services company, a nursing home, a hospital, an industrial warehouse, and one social initiative cooperative. This first competition had no specific limitations or use requirements, leading to innovative and creative instalations (Ajuntament de Barcelona, 2024).

Many of the green roofs combined elements of urban farming, biodiversity conservation, and energy generation, demonstrating significant synergies. For instance, one of the schools integrated traditional farming with hydroponics, solar panels, and insect hotels, using all these elements for educational purposes. Another example is a community of neighbors that installed an aquarium with aquaponic technology, powered by a photovoltaic instalation. Taking advantage of the symbiosis between fish and plants, ecological production was achieved with minimal impact. The project also included a garden area designed for butterflies. These combined efforts resulted in an increase of 5.500 square meters of green space in Barcelona (Urbanismo, Transición Ecológica, Servicios Urbanos Y Vivienda, n.d.).

Two years later, in the context of the climate emergency declared by the Climate Plan, a second competition has held. It focused solely on residential buildings and introduced additional evaluation criteria. The projects were

assessed based on factors such as biodiversity enhancement, water cycle efficiency, improvement in energy performance, the use of sustainable materials, cost-effectiveness and social benefits (Área de Urbanismo, Transición Ecológica, Servicios Urbanos y Vivienda, 2021). Working with residential buildings proved to be more complex, leading to half of the projects being postponed (Interviewee 4 – IMPUQV).

Subsidies: Private implementation, Public-private finance

After these two competitions, the IMPUV decided to continue promoting green roofs exclusively in residential buildings through direct subsidies. These subventions, still maintained today, allow any homeowner or community of neighbours to apply for public funding to instal a green roof. The grant covers the 50% of the installation costs up to a maximum of 70.000 euros (Ajuntament de Barcelona, n.d.). Currently, one or two green covers are being installed per year though this system (Interviewees 3 and 4, IMPUQV). Eligible applicants include property owners and communities of property owners of existing buildings that meet general requirements, excluding those with a change of use, real estate developments, and tourist activity roofs. Subsidies can also finance the rehabilitation existing green roofs. Technical requirements include a detailed construction project, automated irrigation, compliance with thermal insulation and waterproofing standards, and a minimum one-year maintenance contract with a four-year commitment (Bulletí Oficial de la Província de Barcelona, 2024).

Own implementation on new buildings: Public implementation, Public finance

All initial projects on private land were created to test the groundwork for future legislation. However, prioritizing public buildings was deemed as the first necessary step. As interviewee 5 recognized, “We realized that we had to lead by example.” (Interviewee 5, IMPUV). Consequently, a municipal directive was issued and approved in 2021, requiring all new municipal buildings or those undergoing major renovations to incorporate green roofs (Gaseta Municipal Ajuntament de Barcelona, 2021). Exceptions are made for heritage-protected buildings and those with sloped roofs. The directive outlines specific environmental criteria to enhance urban sustainability, including thermal insulation, CO2 absorption, creation of microclimates, and heat wave mitigation. It aims to improve biodiversity, water management, social impact, and acoustics (Protocol d’implantació de cobertes verdes en edificis municipals | Institut Municipal del Paisatge Urbà i de la Qualitat de Vida, 2021).

Own implementation on existing buildings: Public implementation, Public finance

Finally, the lastest method for implementing green roofs, which is currently being initiated, involves installing them on existing public buildings, particularly kindergartens. The selection of the buildings is based on three criteria: the vulnerability of the inhabitants, areas with the greatest deficit of green space per inhabitant, and the institution’s willingness to support the project. To date, one green roof per year is being financed through this system through (Interviewee 4 – IMPUQV), with the goal of increasing the rate to 10 green covers in the academic year 2023-2024. This initiative is part of a plan motivated by the climatic emergency declaration, which promotes

climate justice for kindergartens. One of the planned actions of the program is to secure co-financing through European funds (Bressols pel Clima | Institut Municipal d'Educació de l'Ajuntament de Barcelona, 2023).

Image 19. Green roof winning project in Consell de Cent, Eixample– First Contest 2017
School and community of neighbours
Source: Ajuntament de Barcelona

Image 20. Green roof winning project in Horta – First Contest 2017
Hospital
Source: Ajuntament de Barcelona

Image 21. Green roof winning projects in Sants-Montjuïc – First Contest 2017
Nursing home
Source: Ajuntament de Barcelona

Image 22. Green roof winning project in Gràcia – First Contest 2017
Community of Neighbours
Source: Ajuntament de Barcelona

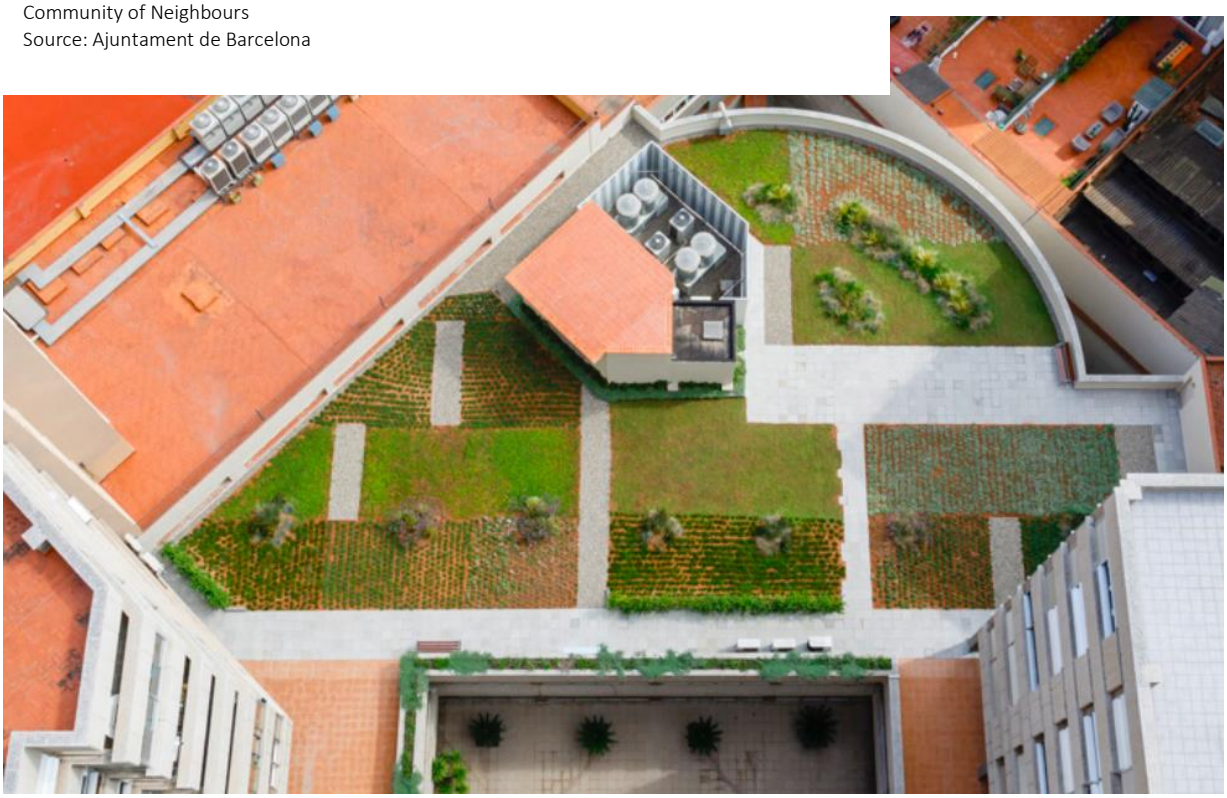


Image 23. Green roof winning project in Aragò, Eixample – First Contest 2017
Community of neighbours
Source: Ajuntament de Barcelona

4.2. Contribution to mainstreaming UNBS in Barcelona

This section explores how the Green Roofs Program and the Green Walls Strategy contribute to mainstreaming UNBS, addressing the thir sub-question. It will describe how each of the two strategies addressed the eleven financing barriers identified by the analytical framework. The analysis is based on responses from the questionnaire, where public agents from the IMPUQV rated the perceived effectiveness of the innovative financing strategies in overcoming each of the eleven barriers to mainstreaming. The ratings, which can be found in the Appendix, will be contrasted with insights from the interviews and policy documents. The Green Roofs Strategy and the Green Walls Strategy were rated separately and will be considered accordingly.

B1 – Low return

According to the survey, both strategies contributed to the development of new economic analysis for UNBS, with a higher impact for green roofs, and more moderate impact for green walls. A concise summary of the economic analysis on green roofs is available to the public in the document "Guía de cubiertas vivas y tejados verdes", accessible on the municipality's website. It includes general estimated prices for each of the eight types of green cover, intending to help investors, such as private and public building owners, evaluate the costs of installation and maintenance. Economic analysis on green walls are not publicly available.

However, according to the interviews, prices have increased significantly over the past few years, and the guide does not reflect this. In addition, the IMPUQV continues to study the economic gains from energy savings through small-scale experiments, aiming to optimize the current analyses and provide a clearer picture of the long-term economic benefits (Interviewee 3, IMPUQV). One of the action points in the "Nature Plan 2021-2030", is the development of an integrative cost analysis for green and biodiversity maintenance. This analysis will encompass both existing and future solutions, including new infrastructure such as green roofs and walls (Área de Ecología Urbana|Plan Natura, 2021).

The Green Walls financing strategy has not improved investors' perspectives on the economic results or benefits of UNBS at all. In contrast, the Green Roofs Strategy has had a slight positive impact. Despite the economic analyses and innovative financing strategies, the economic returns of green walls and green roofs remain low. These solutions provide moderate energy savings which, in the case of green roofs, only benefit the apartments on the top floors of the buildings. As a result, low return on investment is one of the main barriers that hinder the private sector's spontaneous uptake of UNBS. The main economic value lies in the increased property value. However, if residents do not intend to sell, it may be perceived as an unnecessary expense (Interviewees 3 & 4, IMPUQV).

“In residential buildings, it is challenging (…). The expense is carried by the community, and the benefits, such as being in contact with nature, reducing stress levels, and having a safe space, are less economic. The energy-saving benefits primarily impact the upper floors rather than the entire building.” (Interviewee 3, IMPUQV).

Ultimately, what drives the greater uptake of these solutions is the property owner’s criteria. For public spaces, the IMPUQV is the primary decision-maker, and economic return is not the main criterion for implementing these solutions. In contrast, for private properties, economic returns are highly valued by the residents, causing a significant barrier mainstreaming these green infrastructures.

“The first hurdle is convincing property owners to install a green roof. Many times, repairs are kept to a minimum; they do only the necessary repairs, pass technical inspections, but no one forces them to install a green roof." (Interviewee 5, IMPUQV).

Contests and incentives have been able to partially address this barrier, stimulating the private demand for green roofs, but not in the case of green walls (Pla de remodelació de parets mitgeres| Institut Municipal del Paisatge Urbà i la Qualitat de Vida, 2023). According to the survey, investors' perspective on the economic returns or benefits of NBS has only been changed partially.

“Currently, what residents perceive as the main economic benefit is the subsidy (…) Without incentives, more actions are taken in commercial, tertiary, or office buildings. These sectors perceive a quicker and higher cost-benefit. For example, if a buidling with coworking spaces installs a green roof, the rental value of each co-working space unit increases. This leads to a quicker return on investment. The same applies to hotels; many hotels install green roofs to create a new, pleasant space that enhances the hotel's amenities, thus offering greater value.” (Interviewee3, IMPUQV).

B2 - Perceived Risk

Risks associated with both green roofs and green walls have been reduced. Prior to the implementation of these programs, there was no data available on the effectiveness and maintenance of these solutions in Barcelona’s climate. Through innovative experimentation and continuous monitoring, studies and guides have been released, reducing the overall risk of the projects.

The support document for citizens “Guia de cubiertas vivas y tejados verdes” released by the municipality also enable investors to be better informed about the maintenance and finance of green roofs. Similarly, the Green Walls Strategy, despite initial setbacks, has benefited from ongoing trial and error adjustments, contributing to a moderate reduction in risk. For example, initial experiments with vertical gardens failed because substrate would burn and the plants would die. Through these trials, the municipality has identified what works and what doesn’t,

allowing for the abandonement of ineffective practices. Utilizing low-maintenance solutions and understanding the local climate conditions has further mitigated the risk (Interviewee 5 – IMPUQV).

However, risks still persist and continue to affect the mainstreaming of UNBS. Water scarcity remains a primary concern. Specifically, at the time of the research, one of the most pressing issues is the major drought that Barcelona is experiencing, unseen since 2007. The City Council has established a Drought Risk Action Protocol which sets preventive measures such as water restrictions that heavily impact the greenery of the city. Watering of green areas and gardens, both public and private, is currently prohibited, except for the survival of trees and public botanical gardens if done with reclaimed groundwater (Ayuntamiento de Barcelona, 2024).

Forecasts suggest droughts may persist, posing an ongoing challenge. Large-scale planting initiatives face the problem of requiring consistent maintenance. Increasing the green infrastructure strategies without ensuring their long-term functionality would be highly risky (Interviewees 4,5 & 6 – IMPUQV).

"Accurately calculating the water needs of the area is crucial. We are experiencing losses due to frequent droughts, among other factors. Large-scale planting of this type faces the problem of requiring consistent maintenance. It makes no sense to mandate green roofs if, after a year, none of them are functioning properly. Ensuring the maintenance of these green roofs is essential to their success." (Interviewee 3 - IMPUQV).

The municipality is actively addressing this issue in several ways. First, criteria for contests now prioritize water-saving technologies, and subsidies also reward these kind of solutions with extra funds (Institut Municipal del Paisatge Urbà i Qualitat de Vida). Second, partnerships also help to explore potential water mitigation strategies. The IMPUQV is currently collaborating with BCASA (Institute for Water Management) for the development of such technologies. Third, current monitoring effors are directed towards measuring the effects of green roof water collection.

"There are already implementations that recirculate water from the roof's irrigation system because this (water scarcity) has been a recognized issue from the project's inception." (Interviewee 3 - IMPUQV).

B3 – Information gaps

One of the main advantages of the strategies were their ability to generate new knowledge. A whole section will be dedicated to the contribution of building new knowledge for its strong impact on the advancement in the mainstreaming process. This significantly contributed to collecting relevant information on the UNBS, helping to bridge information gaps. Most data on biodiversity, ecosystem services, and benefits from greening infrastructure were initially collected in the "Plan verde y de la Biodiversidad" document and later expanded in the "Nature Plan 2021-2030". Yet, green roofs offer a unique advantage in terms of local knowledge as the institute possesses studies on their own green roofs, and an additional citizen-friendly guide.

Moreover, “The data allowed for two factors. A better account for the value of its benefits (Contributing to solve Barrier 4 – Undervaluing natural capital) and an optimized decision-making (Contributing to solve Barrier 5 – Policy failure).” (Interviewee 5, IMPUQV).

B4 – Undervaluing natural capital

As previously mentioned, the contest has served as the entry point for the IMPUQV to study mutiple soluttions, proving their benefits in the local climate through empirical monitoring. This has enabled the accurate accounting of their benefits, thereby accrediting the institute’s commitment to green infrastructure solutions. As a result, several reports have demonstrated the thermal improvements, water drainage advantages, acoustic impacts and social benefits achieved by these real solutions.

One of the published results is a study released in 2022 that measured the social impact of the three of the contest-winning green roofs implemented. This study, based on a comprehensive survey, gathered qualitative data on the neighbours perception of the implementations. The results succesfully proved health, mobility, aesthetic and community benefits, with added ecological values. Execution issues were minor and awareness and motivation was high despite inicial resistance. Once experienced, residents are likely to recommend green roofs to other buildings (Estudi sobre els beneficis socials derivats de la implantació de les cobertes verdes a Barcelona | Institut Municipal Del Paisatge Urbà I La Qualitat De Vida & El Globus Vermell, 2022).

In the same year, acoustic impacts were also measured in three other winning green roof projects, revealing a moderate to good improvement on impact noise levels (Informe de mesures d’aïllament acústic a soroll aeri i nivell de soroll d’impactes de 3 cobertes de Barcelona abans i després d’enjardinar | Institut Municipal Del Paisatge Urbà I La Qualitat De Vida et al., 2022).

In 2023, a water cycle analysis research was conducted on one of the green covers. The primary objective was to accredit green roofs as a sustainable water drainage system. The perceived benefits included potable water savings from the network and the water retention capacity of the substrate. This retention reduced the water flow into the sewer system during intense rainfall episodes, extending evacuation times, and helping to reduce flooding in the city (Institut Municipal Del Paisatge Urbà I La Qualitat De Vida, 2023).

Another study includes a thermal and energy analysis on three green roofs in Barcelona, published in 2024. This study calculates the time required to recover the embedded emissions of the covers by measuring the environmental footprint of the construction materials against their improvements in thermal insultation, CO2 absorbtion, microclimates creation, and heat waves mitigation (Estudi tèrmic i energètic de tres cobertes verdes a Barcelona | Institut Municipal Del Paisatge Urbà I La Qualitat De Vida & Arqbag, 2024).

These are examples of how the IMPUQV has improved its own valuation of nature, in addition to the economic analyses mentioned previously (B1).

B5 – Policy failures

Survey responses show that the strategies have significantly enabled the IMPUQV to make more informed decisions considering environmental factors. A clear indicator is the integration of environmental criteria into the incentives program for green walls and green roofs, such as requiring the use of local plant species, with minimal hydric demands. Additional funds are now offered for environmental features such as adding photovoltaic panels, or termal insulation. The program also provides an extra 10% subsidy for using eco-friendly materials like wood fiber, cork, or rock wool. Similarly, the green roof incentive includes an additional 3% subsidy for incorporating such sustainable materials (Bulletí Oficial de la Província de Barcelona, 2024). Another example is the integration of biodiversity and sustainability-related criteria for the two upcoming green walls and green roofs international contests (Adjudicadas Las Diez Cubiertas Ganadoras Del Segundo Concurso De Cubiertas Verdes, 2024; Arqa, 2024).

B6 – Institutional inertia

One of the challenges that has been most successfully targetted by both the green roof and green wall financing strategies is the ability to overcome institutional inertia. This means that established patters have been challenged or even changed, redirecting funds from traditional to innovative solutions.

This can be clearly constated in the transition from the original purpose of the institute being urban lanscape protection, primarily through aesthetic improvements, to the shift in priorities towards biodiversity conservation, and sustainability. Particularly, in the case of green walls strategies, there has been a shift from using traditonal refurbishing methods for party walls to utilizing vegetative strategies. Starting from addressesing aesthetic improvements to integrate environmental benefits showcases a strategic move towards sustainability in the overall mission of the institute. This shift is also witnessed in the new international competition launched to defend its World Architecture Capital title, in which the city is investing 4,5M € for the implementation of 10 walls to become Barcelona's new architectural landmarks (Concurso Internacional Para Jóvenes Arquitectos | Capital Mundial De La Arquitectura | Ajuntament De Barcelona, 2024). Moreover, the new "*Strategy for green walls*" released in 2023, plans to dedicate a 15M € budget to the refurbishment of the targetted party walls in a 10-years time scale, meaning 1.5M€ per year (Institut Municipal del Paisatge Urbà i la Qualitat de Vida, 2023).

In the case of green roofs strategy, this shift can be perceived in the increasing number of methods employed to finance these solutions. Starting with the contests, moving to the subsidies, and finally towards direct implementation in new and existing public buildings. Additionally, the Program for Green Infrastructure predicts the creation of 22.000 m² of green roofs and 12.100 m² of green walls from 2020 to 2030, especially targetting public municipal buildings (Ajuntament de Barcelona, 2017).

B7 – Lack of institutional capacity

The pace of interventions by the IMPUQV is limited by its institutional capacity. The institute recognizes it has a small team, working on lengthy procedures, with high intervention costs, and limited resources. Additionally, the maintenance of green walls is still perceived by the IMPUQV as an challenge due to technical specificities (Institut Municipal del Paisatge Urbà i la Qualitat de Vida | Plà de remodelació de Parets Mijeres, 2023).

Nevertheless, one of the institute's strengths is its 25 years of experience in testing a diverse range of typological and compositional green infrastructures. This extensive journey allows for a well-developed knowledge base on the competent development of tailored local solutions, and a well-equiped team in managing and evaluating the solutions (Institut Municipal del Paisatge Urbà i la Qualitat de Vida | Plà de remodelació de Parets Mijeres, 2023).

Moreover, collaboration and the development of a network of experts have been instrumental in this process. Working with BCASA and the Municipal Institute of Parks and Gardens within the municipality has helped to expand and delegate part of the technical knowledge and skills beyond the institute's realm. Additionally, the citizen's guide on green roof provides a list of collaborating firms and technicians qualified to conduct the installation and maintenance, increasing institutional capacity to expand UNBS (Guia de azoteas vivas y cubiertas verdes | Institut Municipal del Paisatje Urbà i la Qualitat de Vida, 2024).

One hindering aspect in the development of institutional capacity recognized by the survey is the moderate knowledge on financing methods for expanding UNBS, both for green roofs and green walls.

B8 – Undefined financial responsibilities

The survey results indicate that the Green Walls Strategy hasn't been clarified who should pay for the management, monitoring and maintenance costs. One of the threats perceived by the SWOT analysis is that green walls always need to be developed by the public administration, as they entail the use of public space, even when constructed on private buildings (Institut Municipal del Paisatge Urbà i la Qualitat de Vida | Plà de remodelació de Parets Mijeres, 2023). Moreover, once implemented, the maintenance of the walls becomes part of the green maintenance budget of the municipality. Interviewees consider public maintenance of these solutions more effective to ensure their long term upkeep; however, these solutions create increasing economic burdens that are difficult to bear (Interviewee 4 – IMPUQV).

The survey also reveals that the strategy has enabled actors to be more willing to pay for the benefits of green walls. In contrast, a SWOT analysis conducted by the IMPUQV highlights one of their main threats the fact that many actors that could benefit from a green wall don't know they can. Moreover, despite offering generous subsidy percentages linked to the subventions program, few private properties take the advantage of it. Green walls are only considered when there is a construction need, and rarely from the perspective of landscape,

sustainability or habitability improvements. To address this issue, the institute sees a future opportunity in creating a specific and direct difussion campaign to communicate the transformative capacity of walls (Institut Municipal del Paisatge Urbà i la Qualitat de Vida | Plà de remodelació de Parets Mijeres, 2023).

In the case of the Green Roofs Strategy, is slightly clearer who should pay for the investment, management, monitoring and maintenance of these solutions. Plus, actors who can benefit from green roofs are more willing to pay for their benefits.

However, one of IMPUQV's case studies revealed that the primary difficulty affecting all projects has been securing finance for the development of the solution, despite the subsidy. Satisfation rates regarding the investment varied among the buildings but received one of the lower scores. Despite this, once implemented, 100%, 84% and 82% of the residents from the three buildings would recommend green covers to others (Estudi sobre els beneficis socials derivats de la implantació de les cobertes verdes a Barcelona | Institut Municipal i Qualitat de Vida & El Globus Vermell, 2022).

B9 – Lack of Financial Resources

The IMPUQV considers one of its main barriers to be the limited funds hindering its speed and capacity of green walls implementation. The economic impact per m² of investment is considerably high. Overall, all the revenue collected from the advertisement banners is reinvested in the Green Walls Strategy, supplemented partially with contributions from the municipality. The financial viability of the advertising program's interventions depends on very specific banner locations that can generate the required income for the operation (Institut Municipal del Paisatge Urbà i la Qualitat de Vida | Plà de remodelació de Parets Mitgeres, 2023).

"The implementation pace of green walls depends on the revenue generated from advertising. All generated income is reinvested. There are not many." - (Interviewee 4 – IMPUQV).

While the current budget allows for steady progress, additional private sector collaboration could further expedite the implementation of green roofs, especially if considering mainstreaming of these solutions (Interviewee 4 – IMPUQV).

One of the main gains in terms of overcoming lack of finance for green walls has been cost reduction. This has been enabled through experimentation and familiarization with cost-effective solutions. Starting simple, the techniques became more complex and innovative with time, to then go back to basics.

"We have tried all kinds of systems. We started planting in the ground, then tried planting at height, then tried vertical gardens, from hydroponic to natural substrates. Now we are returning to ground planting whenever possible. This reduces maintenance costs and facilitates care tasks. However, the program has costs This reduces maintenance costs and facilitates care tasks." – (Interviewee 5 – IMPUQV).

Drawing external sources of investment allowed continued experimentation with different solutions despite the first ones not being optimal. This shift has allowed costs to be drastically reduced.

"The maintenance is public and handled by the City Council. However, we have opted for low-maintenance solutions. We have tried various systems: we started planting on the ground, then tried planting at height, and later experimented with vertical gardens, ranging from hydroponic to natural substrates. Now, we are returning to ground planting whenever possible because it reduces maintenance costs and facilitates care tasks (S10). Additionally, in vertical gardens, the substrate would burn, causing the plants to die, so it needed to be replaced annually." - (Interviewee 5 – IMPUQV).

Despite the cost reduction, according to the survey, the Green Walls Strategy is not able to draw enough funds to sustain the long-term management, mainstainance and monitoring costs. This supports the SWOT analysis argument that interventions with elements complementary to the architectural refurbishment, such as greenery, solar and water capture, among others, create ongoing and increasing maintenance burdens for the public administration.

Both strategies highly differ in their ability to overcome the scarcity of financial resources. For instance, the Green Roofs Strategy has been successful in allocating new funds (both public and private) to UNBS, reducing costs, covering the long term management and monitoring costs. In contrast, while the Green Walls Strategy has managed to reduce costs, it has not been able to allocate new funds, or cover investment, management, maintenance and monitoring costs.

B10 – Short termism

Securing long-term and large-scale investment in NBS is still unresolved. As previously explained, there are over 40,000 party walls in Barcelona, with around 6,000 having a significant presence in public space. According to the IMPUQV, following the current development lines, the methodology, investment pace, and human capacity would take approximately 80 years to address these party walls. This prompted the reconsideration and urge to strengthen the intervention strategies (Institut Municipal del Paisatge Urbà i la Qualitat de Vida | Plà de remodelació de Parets Mijeres, 2023).

Despite the successful cost reduction achieved by the strategy, investor's perception on management and maintenance costs have not shifted positively. In fact, the high costs of horizontal green upkeep is one of the main difficulties perceived by the IMPUQV (Institut Municipal del Paisatge Urbà i la Qualitat de Vida | Plà de remodelació de Parets Mijeres, 2023).

IMPUQV interviewees feel more positive about the long-term and large-scale investment capacity of the Green Roofs Strategy. This is reflected in the municipality's goal of increasing 1m² per inhabitant for 2030 (Área de Ecología Urbana|Plan Natura, 2021).

The strategy has also moderately helped to improve investors' perspective on management and maintenance cots. However, maintenance and its related costs are still perceived as one of the main barriers when trying to promote the installation of a green roof.

"The greater challenges are: maintenance, costs and water requirements." (Interviewee 3 – IMPUQV).

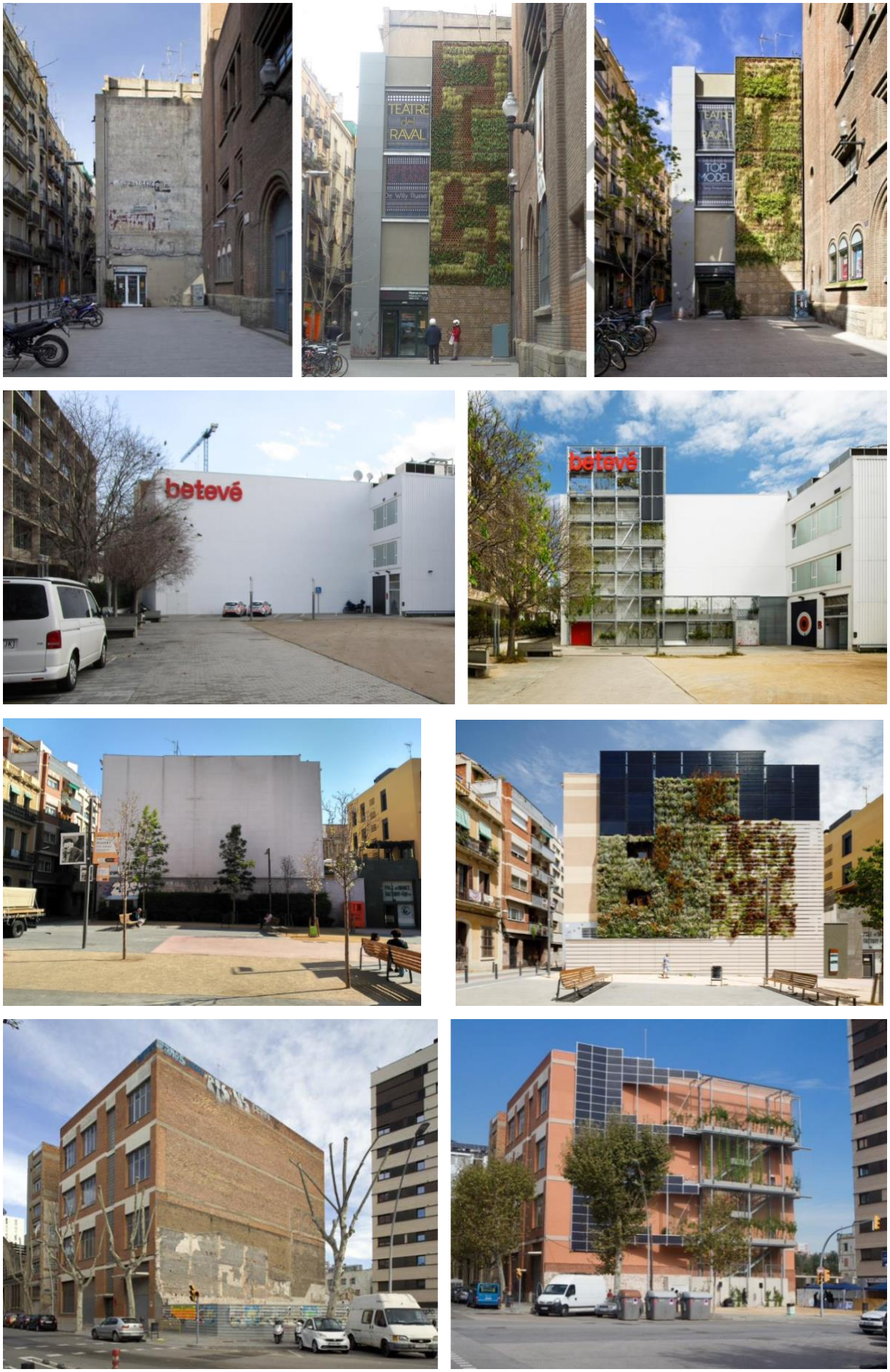
Even when the green roof installation is directly offered to public buildings, resistance has been encountered. The two main concerns revolve around maintenance of the solutions; specifically how to maintain it and how much it costs. To address the "how" question, comprehensive technical documentation has been prepared in collaboration with the Parks and Gardens Institute. Financing has also been estimated based on the insights gained from the and years of experience (Interviewee 4 – IMPUQV).

"The question of "how will we do it?" is being addressed with technical documentation. We have prepared comprehensive specifications for both construction and maintenance contracts, in collaboration with Parks and Gardens. The question of "how will we pay for it?" is also covered. We have calculations, and the costs are not excessive. The annual maintenance cost for a green roof of 200-250 square meters is less than €4000." (Interviewee 4 – IMPUQV).

B11 – Reliance on Voluntary Agreements

Finally, both strategies have highly contributed to create a path towards legistlation. Since the inception of the project, legislation was considered. However, the lack of information inhibited this possibility. By implementing green roofs on a variety of private and residential buildings, the municipality tested a wide range of solutions, collecting data that reduced risk and allowed for the first local green roof legislation. In 2021 municipal released a directive requiring green roofs on all new or renovated municipal buildings, except for heritage-protected and sloped-roof structures (Gaseta Municipal Ajuntament de Barcelona, 2021).

Taking a further step and mandating green roof instalations for every new public and private building constructed is still envisioned as a possiblity (Interviewee 3 – IMPUQV).



Images 24, 25, 26, 27. Green walls interventions by the IMPUQV

Before and after

Source: Institut Municipal de Qualitat de Vida i Paisatje Urbà

5. DISCUSSION

This chapter further enriches the findings by exploring other the key factors identified in the research that enabled the effective advancement of both strategies in the mainstreaming of UNBS. These are collaboration, data collection and a supportive institutional stance for private sector collaboration. Explaining these factors gives us a clearer understanding of how the IMPUQV has been able to make progress in addressing the financing barriers and what other factors influence progress towards mainstreaming.

5.1. Enabling factors for mainstreaming

Data collection

One of the key contributions to mainstreaming green infrastructure, and supporting the innovative financing strategies, has been the extensive data collection process. This data gathering has been crucial in overcoming several barriers and adriving the continuous development and expansion of the mainstreaming strategy itself.

As previously explained, the green wall initiative began primarily as an aesthetic project aimed at enhancing the urban landscape. Over time, as relevant documents on Barcelona's nature were published within the municipality, the IMPUQV began considering the environmental benefits of these infrastructural solutions. The "Plan verde y de la Biodiversidad de Barcelona 2011-2020" (Green and Biodiversity Plan of Barcelona 2011-2020) considered the environmental, social and biodiversity benefits of green walls and green roofs. Based on this, the IMPUQV started the Green Walls Strategy, and later expanded through the Green Roofs Strategy.

"We mainly started this promotion as it improved the landscape. Additionally, we saw there was a wide range of benefits that we could explore within the field. Then we identified there was a greater territory where we could expand (roofs)". (Interviewee 4 - IMPUQV)

Green walls were seen to contribute to biodiversity by providing habitats for various species in urban areas, promoting ecological health alongside their visual appeal. Having this information shifted the project's focus from a visual improvement for the city to recognizing other values that UNBS could add to it. Today both programs are embedded within the "Nature Plan", increasing urban green and promoting biodiversity, and in the Climate Plan, contributing to energy efficiency and energy creation targets (Interviewee 4, IMPUQV).

Moreover, in 2015, based on books, articles, international policy documents and university studies, the municipality published a technical guide for citizens compiling information green roof intalations to support the uptake of the Green Roofs Strategy. Information was summarized for eight different types of green roof covers, specifying cost, maintenance requirements, type of vegetation, substrates, weight and construction systems (Área

de Ecología Urbana | Guia de azoteas vivas y cubiertas verdes, 2015). This comprehensive information allows investors to consider all technical aspects before deciding which type of green roof to install. The guide, available on the IMPUQV website, reduces risk for homeowners and communities considering to adopt green roof instalations (Contributing to solving Barrier 2 – Perceived High Risk) .

As a result from the contests, the municipality was started gathering comprehensive information from the various green roofs pilot experiments in Barcelona's climate. This initiative was crucial to move forward with the expansion of the strategy, as prior to this, there were no studies on green roofs in the climate of southern European cities (Interviewee 5, IMPUQV).

"The second competition was particularly useful for monitoring all the results of these green roofs. (…) While we were all very committed to the project, we lacked scientific data for arid climates. Not just us, but globally, no one had studied the benefits of green roofs at the city level. Now we have results, and they are published (Contributing to solving Barrier 3 – Information gaps) (Interviewee 5, IMPUQV).

According to the interviewees, collecting scientific data was particularly beneficial in determining the effectiveness of the green roofs in providing certain benefits. In view of developing further legislation, the institute has been conducting a series of studies on various aspects of green covers, focusing on biodiversity, water, social impact, acoustics and energy. Reports include an acoustic study, a thermal impact analysis, a water cycle research and a social study of the perceived benefits of green roofs (Estudi tèrmic i energètic de tres cobertes verdes a Barcelona | Institut Municipal Del Paisatge Urbà I La Qualitat De Vida & Arqbag, 2024; Estudi sobre els beneficis socials derivats de la implantació de les cobertes verdes a Barcelona | Institut Municipal Del Paisatge Urbà I La Qualitat De Vida & El Globus Vermell, 2022; Informe de mesures d'aïllament acústic a soroll aeri i nivell de soroll d'impactes de 3 cobertes de Barcelona abans i després d'enjardinar | Institut Municipal Del Paisatge Urbà I La Qualitat De Vida et al., 2022; (Institut Municipal Del Paisatge Urbà I La Qualitat De Vida, 2023).

Moreover, as the contests attracted a variety innovative ideas, experiments could be held in different kinds of mixed solutions. For instance, the thermal impact analysis study was conducted in a project on top of an industrial warehouse with large refrigerated containers. The green roof included photovoltaic panels that generated energy, and the vegetation was used to recirculate excess water from the refrigeration units, creating significant economic benefits. The results were contrasted with two residential buildings, one with five different greening zones and soils, and the other with four, and solar panels (1r Concurs De Cobertes Verdes 2017 | Urbanisme, Transició Ecològica, Serveis Urbans I Habitatge, n.d.).

"We used both simulations and in situ measurements to assess temperature changes by comparing interior and exterior temperatures. It is measurable, and we are actively working on this." (Interviewee 3, IMPUQV).

The municipality was able to test green roofs in a variety of private and residential buildings, getting insights from new types of infrastructure. This diversity of information may not have been possible if the initiative had relied solely on green roof instalations in only public buildings, which would have provided a limited sample of examples. This extensive data gathering led to the creation of legislation mandating the implementation of green roofs on municipal buildings (Contributing to solve Barrier 12 – Reliance on voluntary agreements). This had its own advantages in terms of data collection, such as enabling long-term data monitoring and generating continuous insights on maintenance (Contributing to solve Barrier 11 – Short termism).

"We are also very interested in having our own green roof on municipal buildings. Besides the inherent benefits, it allows us to monitor and collect reliable data. This data can then be extrapolated to the entire city. The more green roofs we study, the better we understand the different construction types, substrate thicknesses, and installation methods. Having concrete information enables us to make well-informed decisions and obtain credible, city-wide results" (Interviewee 5, IMPUQV) (Contributing to solve Barrier 5 – Policy failures).

Collaboration

Another key enabling factor for the optimal development of the strategy in overcoming barriers within the mainstreaming process has been collaboration.

When first considering the implementation of the Green Roofs Program, the agents from the IMPUQV reached out to a variety of stakeholders within the municipality.

"When first monitoring data, and developing plans, we sought partners within the City Council, such as biodiversity and sustainability staff, who were enthusiastic about this initiative. Both individuals directly related to the promotion of Nature-Based Solutions and experts within the city council that could help. Including people from BCASA, Environmental department, and especially Parks and Gardens, crucial as they are the green experts (Interviewee 4 – IMPUQV).

The synergy was successful as both institutes could benefit from each other. The Institute of Parks and Gardens had the environmental and biodiversity knowledge and interest in developing green spaces but was limited to working in the public sphere. The IMPUQV needed the knowledge, but had the advantage of working at the intersection between private and public sectors. Within the strategy, a monitoring group was established with the partners mentioned earlier. By collaborating with biodiversity and sustainability staff, as well as experts from various city departments and universities, the implementation could be enhanced more effectively (Interviewees 4 & 5 – IMPUQV).

Additionally, research and policy documents have been conducted both with external and internal municipal actors. For instance, the Guide for green roofs was developed with a variety of Barcelona and Catalan universities (schools of architecture, biology, environmental sciences, engineers, etc) and AESCUVE, the Spanish Association for Green Roofs. Moreover, the green roof case studies exposed in the previous section were conducted in partnership with private entities (Ajuntament de Barcelona, 2015). The research on acoustic impact was done in collaboration with two acoustic engineering firms (Institut Municipal Del Paisatge Urbà I La Qualitat De Vida et al., 2022). The water cycle study was carried out with MataAlta, a regenerative architecture studio (Institut Municipal Del Paisatge Urbà I La Qualitat De Vida, 2023). The thermal impact analysis was conducted with Arqbag, an architecture cooperative (Institut Municipal Del Paisatge Urbà I La Qualitat De Vida & Arqbag, 2024). Finally, the research on societal impacts was undertaken with El Globus Vermell, an architectural socio-cultural association (Institut Municipal Del Paisatge Urbà I La Qualitat De Vida & El Globus Vermell, 2022). All this external collaboration facilitied the enrichment of knowledge on the solutions.

Moreover, a new research group has been created in 2022 to develop a single monitoring and evaluation plan to measure the performance of integrating vegetation into green roofs, walls, and façades in Barcelona. The project, Verd de Proximitat BCN, aims take monitoring efforts one step further and integrate them into one framework to ensure long-term measuring of multiple ecologic, technical, social and economic variables of the Barcelona's solutions. This multi-stakeholder team is composed of research groups from two universities, two NBS greening companies and one gardening cooperative. It is partially supported by Fundación la Caixa (one of the most prominent Spanish and Catalan banks) and the Municipality of Barcelona. Additionally, it aims to be integrative and participatory, so users of the rooftops will contribute to collecting and assessing data from their buildings (VerdBCN, 2022).

Furthermore, currently, the municipality supports two architectural international contests, in collaboration with the Mies van der Rohe Foundation, the public body for architecture in Barcelona. The "Reusing Rooftops Barcelona 2024" is organized by Archstorming, an international platform for humanitarian, sustainable and innovative architecture. It invites contestants to design green roofs for the city, focusing on sustainability, innovation, technical feasibility and scalability. It offers 5.500 euros in several prizes and the publication of the winning solutions in well claimed architecture magazines and social media (reusingrooftops.com, 2024). The second is the ongoing Green walls contest (see section 4.1), which in this case, is co-organized by the IMPUQV, with the support of UNESCO and the International Union of Architects. Partnering with these other institutions allows a greater visibility in the local and international (ARQA, 2024).

Finally, what has also contributed to strengthening the strategy the fluid contact with the Spanish Association of Green Covers (AESCUBE) and attending national and international knowlege-sharing congresses to share experiences (Interviewee 4 – IMPUQV). Plus, national an international collaboration has longly been one of the key priorities in the Municipality of Barcelona's policy plans. It actively participates in city networks and works in hand with the most relevant organizations committed to biodiversity conservation (ICLEI-LAB, IUCN, Local

Governments for Sustainability + Biodiversity 2010), exchanging experiences, and thus demonstrating the city's commitment to a global issue (Plan Verde y de la Biodiversidad Barcelona 2011-2020; 2013). As a result, the IMPUQV recognizes as one of its strengths its positionement as an international reference in the development of opportunities on party walls, transferring experiences to other cities (Institut Municipal del Paisatge Urbà i la Qualitat de Vida, 2023).

Image 28. Poster for international contest for green walls 2024

Source – Municipality of Barcelona

Supportive institutional framework

Finally, the last main key factor that supported the strategies in their development and contribution to mainstreaming was the favorable institutional framework of the IMPUQV. This part will present how other departments from the Municipality of Barcelona, also working on UNBS mainstreaming, collaborate differently with the private sector. These collaborations are usually more limited, and non-financial. Contrasting these to the IMPUQV's work can help understand how the strategies were supported by the IMPUQV's institutional framework, corporate culture, and past experience on public-private collaboration.

Two interviews with biodiversity experts from the Parks and Gardens Municipal Institute (IMPJ), and the "Mans al verd" project highlighted their perceptions, willingness, and limitations in developing new forms of financial collaboration with the private sector. "Mans al Verd" is the public project that encompasses all initiatives to involve citizens and the economic and social agents in Barcelona in the care of the urban green spaces. Its goals are to empower citizens to take initiative in public and private spaces and to create more green spaces within a

collaborative management framework. Collaboration with the private sector is core to its mission; however, it has long been restricted to non-financial partnerships. The only type of involvement with for-profit companies is the authorization to use green spaces.

"In everything we work on, there is no economic exchange. If we work with a company, it can't have a profit motive. The private entities we work with are typically purely social or non-profit companies that work on aspects of social vulnerability. (…) Whenever we collaborate with for-profit private companies, we always work with agreements, (…) mostly with authorizations for the use of spaces." (Interviewee 2 – Mans al Verd)

The Municipal Institute for Parks and Gardens is the institution in charge of managing and promoting the city's urban greenery and environment. It is responsible for remodeling, constructing, conserving and maintaining Barcelona's urban parks, gardens, beaches and forests (Municipal Institute of Parks and Gardens | Urban Planning, Ecological Transition, Urban Services and Housing, n.d.). The IMPJ also only engages in with private entities in a very restricted way. The types of financial collaboration it employs are limited to the leasing of spaces and entrance fees, reinvested in the maintenance of the solutions. Now, they are also gradually opening up towards new types of public-private collaboration (Interviewee 1 - IMPJ).

"An example is the possibility of collaborating with companies. Sternalia, a company specializing in special events organization, recently contacted the City Council to rent public spaces where it could carry out its activities. A few years ago, they wouldn't even have been received. But now, they are." (Interviewee 1 - IMPJ).

The interviewees pointed out that this restriction is highly determined by the political party in power. Since 2015, the Municipality of Barcelona has been governed by the party "Barcelona en Comú", a left-wing participatory coalition. This year, the "Socialist Political Party" came to power, a center-left party. Two of the agents of the municipality noticed that with the change in government, there is a tendency to expand the types of collaboration with private entities, including those involving private finance.

"Many years ago, small and simple sponsorships were carried out. For example, private concert sessions were organized in parks, and private companies were asked to sponsor events such as the "Annual rose competition" or thematic journeys such as "Kids reforestation and environmental education days". With the administration of the "Commons" party, collaboration with private companies ceased as private sector involvement was strongly rejected. Even these small forms of event subsidies were halted. If the company profits and there are benefits involved, the possibility is not even considered." (Interviewee 2 – Mans al Verd).

According to the same interviewee, these small-scale opportunities of financial public-private collaboration began to be reconsidered with the creation of the "Nature Plan 2021-2030". Action point nº93 of the plan states: "Study the possibilities of green taxation and alternative management and financing methods for the creation and

maintenance of green spaces, such as private sponsorship, custodial actions, temporary leases, permits, discounts, etc."

"When I started (in Mans al Verd, during the Commons legislation), the directive was that there couldn't be any sponsors. Now this is something (new forms of financial collaboration) that is starting to be considered as the government has changed, but it is not resolved either." (Interviewee 2 – Mans al Verd).

This opennes to new forms of financial collaboration is also partially driven by government budgetary constraints.

"The current economic situation regarding the implementation, maintenance, and management of parks and green areas is primarily funded through the Municipal budget, which is experiencing a shortage. Additionally, all departments of the City Council are constantly competing to have their budgets increased. Therefore, new forms of income are needed." (Interviewee 1 - IMPJ).

The interviewee added, even if the shift is allowed, it remains hindered at legal framework level. The ways the IMPJ gets involved with private companies are studied and controlled in detail (Barrier 6 – Institutional inertia). The institute has strict norms in regarding how the partnership can be and what counter-services the private actors receive. Additionally, the opening up approach is still very incipient.

The public agents interviewed recognized that the Municipal Institute of Parks and Gardens is passive in taking up these initiatives. The real catalyzer for new collaborations is usually companies reaching out to them. This has also been a trigger to consider new types of (financial and innovative) collaborations.

"Sometimes you have to be a good salesperson. If the company has an idea, presents it, and is persistent, there's a greater chance of being heard. Other times, you have to approach the right person at the right time. Whether it materializes depends on the management and therefore the manager in charge, but if there's an enthusiastic technician with the idea and persists, they may convince the manager." (Interviewee 1 - IMPJ).

In comparison to these two other institutions, the IMPUQV is less restricted and has a longer collaboration history with private entities.

"We have always worked in the intersection between the private and the public. Walls are private property but the green is from the public domain." (Interviewee 4, IMPUQV).

However, there is also a strict regulation on which kind of collaborations cannot be held. For instance, as previously pointed out, contests are only directed now towards residential and not corporate buildings. This has been shaped throughout the development of the strategies. However, the agents intervieweed do see an advantage in collaboration, and are open to increase the agreements to foster the mainstreaming process.

"In my opinion, any type of collaboration is positive. We move at the pace it allows us. It's important to have the freedom to carry out initiatives that come to us from outside." (Interviewee 4 – IMPUQV)

In summary, the data gathering process and the development of the mainstreaming strategy of green infrastructure in Barcelona have reinforced each other, creating a beneficial cycle. Innovative financing strategies facilitated the initial collection of valuable data, which in turn have sparked interest in expanding these green infrastructure solutions. This increased interest led to the development of new strategies to enhance mainstreaming and data collection efforts. In addition, collaboration with private actors has allowed for the exploration of innovative strategies, which have created a richer database. Simultaneously, this private iniciative to innovate has been enabled by the public funds. This cyclical process between public innovative financing strategies, allowing private innovation and richer data collection has been crucial in advancing the implementation and effectiveness of Urban Nature-Based Solutions in the city. Finally, the supportive institutional framework of the IMPUQV, characterized by its openness to private sector financial collaboration and its experience in public-private partnerships, has been crucial in advancing the mainstreaming of UNBS and supporting the expansion of the strategies. In contrast to other municipal departments with more restrictiver collaboration practices, the IMPUQV's approach has allowed for innovative financing strategies and a broader engagement with diverse stakeholders. Altogether, these factors have his enabled more effective scalling up of green infrastructure projects.

6. CONCLUSION

The conclusion chapter is composed of three sections. The first section will summarize the responses from the three research sub-questions. The second will discuss the limitations of the research, and how these have shaped the findings. Finally, the main research question will be addressed, adding considerations for further research.

6.1. Addressing the Research Sub-Questions

This section will provide concise answers to the research sub-questions addressed throughout the study.

What are the finance barriers hindering the mainstreaming process?

The financial barriers hindering the mainstreaming process identified in literature that form the analytical framework are eleven. These include low returns, high perceived risks, knowledge gaps, undervaluing natural capital, policy failures, institutional inertia, lack of institutional capacity, underfined financial responsibilities, lack of financial resources, short termism and reliance on voluntary agreements. All of these barriers had been encountered by the agents working in the IMPUQV and tackled to a larger or lesser degree by the strategies.

How is the local government of Barcelona using innovative strategies that involve the private sector in UNBS finance?

The local government of Barcelona employs a multifaceted approach to involving the private sector in financing Urban Nature-Based Solutions (UNBS). This strategy is characterized by a combination of innovative financing mechanisms, including contests, subsidies, and direct implementation projects, which together form a robust framework for promoting green infrastructure.

In the Green Roofs Strategy, Barcelona has implemented a series of contests aimed at stimulating private sector investment in green roofs. These contests, held biennially, provide substantial grants covering up to 75% of the installation costs, capped at €100,000 per project. This initiative added 7,555 m² of green space.

Moreover, the government extends its support through a subsidy program targeting residential buildings. These subsidies cover 50% of installation costs, up to €70,000, facilitating the adoption of green roofs by reducing financial barriers for homeowners and communities. This approach leverages public funds to catalyze private investment, ensuring sustained growth in green roof instalations.

The Green Walls Strategy employs a similar innovative approach, comingning diffferent financing methods. The IMPUQV's use of revenue from outdoor advertising to finance green wall instalations is particularly noteworthy. This method transforms urban advertising spaces into financial resources for greening projects. By acting as an intermediary, the IMPUQV facilitates agreements between property owners and advertising companies, ensuring a steady flow of funds for public green wall projects. This strategy not only supports the implementation of green walls but also integrates private sector finance into urban sustainability efforts.

Additionally, the Green Walls Strategy includes a subsidy program for private building owners, covering 35% of the costs with the potential for increased support for additional improvements. This mechanism promotes the adoption of green walls by mitigating financial risks for private investors, thus enhancing the city's overall green infrastructure.

In conclusion, Barcelona's approach to involving the private sector in UNBS finance is a well-rounded blend of public and private funding mechanisms, strategic use of incentives, and innovative partnerships. This multifaceted strategy allows the municipal institute to promote the installation of green roofs on private gound and to secure private funds for the installation of green walls.

How do these strategies overcome the finance barriers hindering the mainstreaming process?

Both strategies have effectively addressed several significant barriers. They have excelled in addressing information gaps, and the information gathered has been crucial in overcoming the undervaluation of natural capital. By providing comprehensive data and insights, the original aesthetic-driven purpose of the mission was shifted to focus on biodiversity and environmental objectives. This shift has also highly contributed in reducing policy failures stemming from ill-informed-decision making, incorporating biodiversity, energy targets and water-saving criteria into valuation schemes, which are now rewarded and even required for the incentives and contest programs.

Institutional inertia has also been successfully targeted. The strategies have challenged established investment patterns, redirecting funds towards innovative solutions, as seen in the increase uptake of financing methods. This momentum reduced reliance on voluntary agreements, evidenced by the emergence of new regulations supporting green infrastructure implementation.

The perception of low returns has been moderately shifted through the development of new economic analyses. Additionally, studying cases of instalations that have accredited the expected benefits of instalations has helped lower risk perceptions. However, pressing challenges such as drought remain unresolved and continue to increase risk. Furthermore, the years of experience and collaboration have partially enhanced institutional capacity. Technical implementation and management skills have increased due to support networks created though collaboration with other institutions, but knowledge on financing methods for these solutions is still limited.

Undefined financial responsibilities also remain a challenge. However, the strategies incentivizing private uptake continue addressing this issue. Despite finance being a barrier, once overcome, satisfaction rates among beneficiaries are very high.

Some disparities in addressing barriers have been encountered among strategies, despite sharing most of the finance mechanisms. Effectiveness in resolving some barriers has varied depending on the type of solution targetted (green roofs vs green walls). For instance, while both have been highly successful in reducing costs, securing long-term management costs has been achieved for green roofs, but not for green walls. This disparity has led to short-termism still hindering the uptake of green walls, but not of green roofs. Differing investor's perspective on economic returns and management costs might explain this phenomenon. Green roofs are perceived to offer moderate economic returns, and manageable management costs, whereas green walls are viewed less favorably in both aspects. This explains why lack of financial resources is perceived a barrier for green walls but not green roofs. Nonetheless, current policy plans reflect a growing emphasis on Green Roofs Strategy. The Green Walls Remodelation Plan, released last year, outlines ambitious goals, including the installation of 170 new green walls over the next decade, supported by a budget allocation of 24M€.

6.2. Limitations of the research

This thesis has limitations due to the time, capacity and scope of the research. These include that the number of interviewees, although representative within the institute, could be limited to draw conclusions, as all are from within the municipality. Although most of their assessments provided by the surveys were contrasted as carefully as possible with studies, policy documents and interviews, interpretations can be subject to the author's interpretation, as the interviews took place before the survey.

A second limitation is that the strategies were evaluated a whole, which did not allow for a detailed differenctiation beteen the various financing mechanisms, such as incentives, contests, and others. This holistic approach may have blurred the specific effectiveness and challenges associated with each individual financing program. Further research could target this gap.

Furthermore, the assessment relied on a limited number of indicators, with a maximum of two per barrier, to evaluate the strategies' effectiveness in overcoming each barrier. This constraint was primarily due to the need to keep the survey and interviews manageable for interviewees.

Finally, the study only focused on two type of solutions. Further research could also benefit from a macro study on the overall mainstreaming process within the city, including strategies from other departments working for

UNBS and measuring the impacts in a city-scale. For instance, the IMPUQV's work could be compared to the one from BCASA, IMPJ and IMU.

Addressing these limitations in future research could provide more detailed picture of the strategies' impact and effectiveness, and research questions would be addressed more accurately. However, displaying the main insights on the potential and capacity of mainstreaming of the strategies has been achieved despite these limitations.

6.3. Contribution to mainstreaming and further research

Finally, the main research question will be replied and the further research recommendations will be presented.

How do innovative financing strategies that involve the private sector contribute to the mainstreaming of Urban Nature Based Solutions?

Understanding how to finance UNBS mainstreaming has been widely advocated by experts. According to the literature, on one side, public sector seems the most logical financing actor, but its conomic capacities are limited. On the other side, involving private actors has widely been claimed. However, UNBS' intrinsic characteristics make them less attractive as investment opportunities for profit-making entitities. As a result, there is a large finance gap in UNBS mainstreaming. There are increasing claims to use innovative financing strategies that enable the involvement of the private sector in UNBS finance. Researchers suggest studying these solutions and their effects on mainstreaming. This thesis has aimed to provide insights from one real case. It explored the role of innovative financing strategies employed by the pioneer city of Barcelona for involving the private sector in green walls and green roofs financing.

An analytical framework was selected to identify the 11 most recurrent barriers in UNBS finance. All of these were found in the case study.

The strategies employed by the local government of Barcelona to mainstream Urban Nature-Based Solutions have been able to overcome some financial barriers successfully, contributing to an advancement in mainstreaming UNBS. However, it is crucial to consider some key contextual factors which have been crucial for supporting the strategies in the mainstreaming process. These include an extensive data collection process, collaboration networks, and a favorable openness and supportive institutional framework for private sector collaboration.

Extensive data collection was crucial in addressing several barriers. For instance the whole aesthetic purpose of the Green Walls Strategy was shifted once recognized the biodiversity and environmental effects. This shift was driven by understanding the additional values that UNBS could add to urban spaces, and was the catalyst for initiating the Green Roofs Strategy. This development of the strategy led into various pilot experiments from which valuable insights into their effectiveness in Barcelona's climate were captured, creating a whole new

database for green roof implementation in Southern European city contexts. This empirical evidence has supported tackling some barriers such as the perceived risk and bridged information gaps, facilitating better decision-making. The publication of technical guidelines for green roofs installation helped investors understand the technical and financial aspects of green roofs, thereby reducing the perceived risk and encouraging the uptake.

Collaboration with various stakeholders within the municipality and external experts and researchers was another key factor. The IMPUQV engaged with biodiversity and sustainability staff, as well as experts from institutions like the Municipal Institute of Parks and Gardens. These synergies allowed the IMPUQV to leverage expertise and resources, increasing institutional capacity. This also facilitated implementation and monitoring. By forming partnerships with universities, private entities and other city departments, the municipality was able to conduct detailed studies and gather robust data, reinforcing the benefits of the extensive data collection process. This collaborative approach ensured that the strategies were well informed, and widely supported, facilitating mainstreaming.

All in all, innovative financing strategies present a promising avenue for overcoming financial barriers to mainstreaming UNBS. However, their success and adoption rate could be further expanded by unlocking some of the key barriers that still limit their growth. The insights gained from the experience of the Municipal Institute of Landscape and Quality of Life may provide a valuable foundation for other departments within the municipality working on UNBS in a context of opening up to new forms of private sector collaboration.

Future research could focus on expanding this empirical study by considering other Urban-Nature Based Solutions in Barcelona, also beyond the political sphere, exploring other innovative financing models. Additionally, this research could delve into the barriers which have not been able to be addressed, and explore the integration of other tools within the strategy. Finally, it can hopefully be useful both for the other institutes in the Municipality of Barcelona and for other local governments in Spanish and Southern European cities to learn from these successes and lessons, expanding on them.

Image 29. Green wall intervention by the IMPUQV in Poble Nou

Source: Author

APPENDIX

Responses from survey sent to the Public Agents working in the IMPUQV

These had to rank from 1 to 5 the Green Roofs Strategy and the Green Walls Strategy in their contribution to solve each of the 11 barriers.

1	2	3	4	5

B1 – Low return

Green Walls	4	Question 9 - Develop a new economic analysis of NBS.
	1	Question 4 - Change investors' perspective on the economic returns or benefits of NBS (positively).

Green Roofs	3	Question 9 - Develop a new economic analysis of NBS.
	3	Question 4 - Change investors' perspective on the economic returns or benefits of NBS (positively).

B2 - Perceived Risk

Green Walls	3	Q10 - Reduce the perceived risk associated with UNBS projects (both from private investors and the Institute or City Council).

Green Roofs	4	Q10 - Reduce the perceived risk associated with UNBS projects (both from private investors and the Institute or City Council).

B3 – Information gaps

Green Walls	4	Question 1 - Create or enable the collection of information on relevant Nature-Based Solutions and their environmental aspects.

Green Roofs	5	Question 1 - Create or enable the collection of information on relevant Nature-Based Solutions and their environmental aspects.

B4 – Undervaluing natural capital

Green Walls	5	Q15 - Better understand how to quantify or value the price of nature

Green Roofs	5	Q15 - Better understand how to quantify or value the price of nature

B5 – Policy failures

Green Walls	5	Q11 - Ensure the Institute or City Council makes more informed investment decisions considering environmental factors.

Green Roofs	5	Q11 - Ensure the Institute or City Council makes more informed investment decisions considering environmental factors.

B6 – Institutional inertia

Green Walls	5	Q7 - Challenge and potentially change established investment patterns or redirect funds from traditional solutions to innovative ones.

Green Roofs	5	Q7 - Challenge and potentially change established investment patterns or redirect funds from traditional solutions to innovative ones.

B7 – Lack of institutional capacity

Green Walls	3	Q8 - Increase the Institute or City Council's knowledge on financing methods for expanding NBS.

Green Roofs	3	Q8 - Increase the Institute or City Council's knowledge on financing methods for expanding NBS.

B8 – Undefined financial responsibilities

Green Walls	2	Q13 - Clarify who pays for the investment, who covers the management, monitoring, and maintenance costs.
	4	Q14 - Encourage actors who could benefit from NBS to be more willing to pay for their benefits.

Green Roofs	3	Q13 - Clarify who pays for the investment, who covers the management, monitoring, and maintenance costs.
	4	Q14 - Encourage actors who could benefit from NBS to be more willing to pay for their benefits.

B9 – Lack of Financial Resources

Green Walls	1	Q2 - Allocate new funds (both public and private) to NBS.
	5	Q5 - Reduce instalation, management, maintenance, and/or monitoring costs of NBS.
	1	Q12 - Cover investment costs and other long-term management, maintenance, and/or monitoring costs.

	5	Q2 - Allocate new funds (both public and private) to NBS

Green Roofs	5	Q5 - Reduce instalation, management, maintenance, and/or monitoring costs of NBS.
	4	Q12 - Cover investment costs and other long-term management, maintenance, and/or monitoring costs.

B10 – Short termism

Green Walls	1	Question 3 - Facilitate long-term and larger-scale investment in NBS.
	1	Question 6 - Change investors' perception of management and maintenance costs (positively).

Green Roofs	4	Question 3 - Facilitate long-term and larger-scale investment in NBS
	3	Question 6 - Change investors' perception of management and maintenance costs (positively).

B11 – Reliance on Voluntary Agreements

Green Walls	4	Q16 - Pave the way for possible regulation or legislation.

Green Roofs	5	Q16 - Pave the way for possible regulation or legislation.

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