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Exploring the Social Impacts of Nature-based Solutions (NbS) for more Inclusive Climate Actions (ICAs) in Brussels, Belgium

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Abstract- English

The urgent need for climate action has driven a growing number of Nature-based Solutions (NbS) projects. However, as cities develop innovative strategies to integrate nature into the urban fabric, knowledge about the effectiveness of these implemented solutions remains limited. Additionally, existing assessment frameworks primarily focus on environmental impacts while overlooking NBS' implications for social issues such as inclusion, well-being, and place attachment. This thesis highlights the social impacts of NbS by evaluating a selected set of Key Performance Indicators (KPIs) to assess the alignment of NbS initiatives with societal needs. Specifically, the research examines the effects of implemented NbS on four indicators: citizen involvement in environmental education activities, the proportion of citizens engaged in participatory processes, estimated mortality and morbidity, and the perceived quality of urban spaces. These indicators are analyzed using a questionnaire distributed to citizens and stakeholders at the local level. This inclusive and participatory approach is applied to data collection in Brussels, Belgium. The questionnaire results are analyzed using descriptive statistics, with findings for each indicator discussed and compared across different contexts. The study highlights the multifunctional benefits of NbS, emphasizing their potential to enhance inclusivity, foster community engagement, and strengthen residents' connection to nature. Ultimately, this work underscores the critical need for a comprehensive framework to assess the broader societal implications of climate action. By integrating diverse stakeholder perspectives, the results not only provide actionable insights for policymakers and practitioners, but also include residents in the analysis of NbS strategies. This marks a starting point to make NbS pivotal strategies for fostering sustainable and inclusive cities. The results presented are an integral part of the European project GREEN-INC: growing effective and equitable nature-based solutions through inclusive climate actions.

Keywords: Nature-based Solutions (NbS), Inclusive Climate Actions, Key Performance Indicators (KPIs), Social assessment.

Abstract- Italian

L'urgente necessità di intraprendere azioni per il clima ha portato a un crescente sviluppo di progetti basati su Soluzioni Basate sulla Natura (Nature-based Solutions, NbS). Tuttavia, mentre le città elaborano strategie innovative per integrare la natura nel tessuto urbano, le conoscenze sull'efficacia delle soluzioni implementate rimangono ancora limitate. Inoltre, i quadri di valutazione esistenti si concentrano principalmente sugli impatti ambientali, trascurando le implicazioni delle NbS su questioni sociali quali l'inclusione, il benessere e il senso di appartenenza ai luoghi.

Il presente studio pone l'accento sugli impatti sociali delle NbS attraverso la valutazione di un insieme selezionato di Indicatori Chiave di Prestazione (Key Performance Indicators, KPIs) sociali e indicatori di supporto, al fine di analizzare l'allineamento delle iniziative NbS con i bisogni della società. In particolare, la ricerca esamina gli effetti delle NbS implementate su quattro indicatori: il coinvolgimento dei cittadini in attività di educazione ambientale, la proporzione di cittadini partecipanti a processi partecipativi, la stima della mortalità e morbilità, e la qualità percepita degli spazi urbani. Tali indicatori sono analizzati attraverso un questionario distribuito a cittadini e stakeholder a livello locale.

Questo approccio inclusivo e partecipativo è stato applicato alla raccolta dati nella città di Bruxelles, in Belgio. I risultati del questionario sono analizzati tramite statistiche descrittive, e i risultati per ciascun indicatore vengono discussi e confrontati tra diversi contesti. Lo studio evidenzia i benefici multifunzionali delle NbS, sottolineandone il potenziale nel promuovere l'inclusione, rafforzare l'impegno comunitario e consolidare il legame dei residenti con la natura.

In definitiva, questo lavoro mette in luce la necessità di un quadro di valutazione completo per analizzare le più ampie implicazioni sociali delle azioni climatiche. Integrando prospettive diverse degli stakeholder, i risultati offrono non solo indicazioni concrete per decisori politici e operatori del settore, ma coinvolgono anche i cittadini nell'analisi delle strategie NbS. Ciò rappresenta un punto di partenza per rendere le NbS strategie fondamentali per la costruzione di città sostenibili e inclusive. I risultati presentati fanno parte integrante del progetto europeo GREEN-INC: sviluppo di soluzioni basate sulla natura efficaci ed eque attraverso azioni climatiche inclusive.

Parole chiave: Soluzioni Basate sulla Natura (NbS), Azioni Climatiche Inclusive, Indicatori Chiave di Prestazione (KPIs), Valutazione Sociale.

List of Abbreviation

KPIs- Key Performance Indicators

ICAs- Inclusive Climate Actions

NBS- Nature-based solutions

IPBES- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

EC- European Commission

WWF-World Wide Fund for Nature

SDGs- Sustainable Development Goals

UN- United Nations

CC- Climate Change

CR- Climate Resilience

SIA- Social Impact Assessment

1. Introduction

In the face of accelerating climate change and growing urbanization, Nature-based Solutions (NbS) have emerged as a pivotal strategy to address a wide array of environmental and social challenges. NbS are increasingly recognized for their potential to enhance urban resilience, mitigate climate risks, and foster social well-being. According to Raymond et al. (2017), these solutions offer a promising pathway to sustainable urban development by leveraging the inherent benefits of natural ecosystems.

The most recent and widely accepted definition by the International Union for Conservation of Nature (IUCN, 2024) describes NbS as "actions to protect, sustainably manage, and restore natural and modified ecosystems to address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits." This definition underscores the multifunctionality of NbS, highlighting their capacity to generate synergies between ecological sustainability and social inclusivity. By integrating ecological and social objectives, NbS can create more resilient and adaptive urban environments.

Despite the growing interest in NbS, much of the existing research and policy focus has been predominantly on their environmental benefits. These benefits include carbon sequestration, air quality improvement, and temperature regulation, as noted by Kabisch et al. (2017). While these environmental outcomes are crucial, the social dimensions of NbS remain underexplored, particularly in urban contexts where their impacts on inclusivity, well-being, and community cohesion are critical. Frantzeskaki et al. (2019) emphasize the need to assess the social outcomes of NbS to ensure that these interventions are not only ecologically effective but also equitable and responsive to diverse societal needs.

Although several studies have attempted to evaluate the social impacts of NbS, they are not sufficient to fully capture the breadth and depth of these outcomes in urban contexts. For instance, research by Walker et al. (2024) on flood buyout programs highlights the complex equity implications of NbS, revealing gaps in addressing community well-being and decision-making power. Similarly, studies like those by Vicarelli et al. (2023) have developed databases to analyze the economic and social impacts of NbS, yet comprehensive methodologies that integrate diverse stakeholder perspectives are still lacking. These examples underscore the necessity for more holistic approaches to NbS impact assessment, ensuring that these solutions are both ecologically effective and socially inclusive.

In this study, the effectiveness of NbS is assessed through the evaluation of four key social indicators: Citizen Involvement in Participatory Activities, Citizen Involvement in Environmental Education Activities, Perceived Quality of Urban Spaces, and Estimated Morbidity and Mortality in local level. These indicators are part of a broader framework developed under the GREEN-INC project; a European initiative aimed at enhancing the effectiveness of NbS in promoting more

Inclusive Climate Actions (ICAs). By applying this framework to selected case studies in Brussels, the research aims to provide a more nuanced understanding of how NbS contribute to socially inclusive and resilient urban environments.

In overall, this study not only provides actionable insights for policymakers and practitioners but also includes residents in the analysis of NbS strategies. This inclusive approach ensures that NbS are designed and implemented in a manner that reflects the needs and aspirations of the community. The findings of this research mark a significant starting point for making NbS pivotal strategies in fostering sustainable and inclusive cities. By highlighting the social dimensions of NbS, this study underscores their potential to enhance urban resilience, promote social equity, and contribute to the overall well-being of urban populations.

1.1. Background and Problem Statement

Climate change is a long-term shift in global and regional climate patterns, largely driven by human activities such as the burning of fossil fuels, deforestation, and industrial operations. These actions release large amounts of greenhouse gases into the atmosphere, leading to a gradual increase in the Earth's average temperature, commonly known as global warming. This warming is the root cause of many environmental changes, including rising sea levels, more frequent and severe extreme weather events, and disruptions to ecosystems—changes that have far-reaching consequences for human societies, affecting public health, food security, water availability, and economic stability (United Nations, 2023).

The IPCC's 2022 report further underscores that human-induced climate change, including more frequent and intense extreme events like heatwaves, heavy rainfall, and floods, has already caused widespread adverse impacts that exceed natural climate variability. These events are becoming more severe and frequent, leading to irreversible consequences for both natural and human systems. Without substantial and immediate action, the long-term effects—especially after 2040—are expected to intensify, disproportionately affecting vulnerable communities and compounding existing global challenges (IPCC, 2022).

The social impacts of climate change are particularly devastating for vulnerable populations, such as low-income communities, women, children, and Indigenous groups, who are disproportionately affected by climate risks. These groups often face pre-existing social, economic, and political marginalization, making them more susceptible to the consequences of climate-related hazards. For instance, individuals in low-lying coastal areas are at greater risk of flooding and displacement due to sea-level rise, while agricultural communities face heightened threats from droughts, floods, and unpredictable weather patterns. These disruptions can lead to long-term challenges such as loss of income, reduced access to education and healthcare, and the breakdown of community structures (Tomatis, 2023).

As climate change continues to intensify, its broader social consequences are becoming increasingly evident. Social development—which includes education, healthcare, economic growth, and general well-being—is under growing threat. Climate-related hazards can destabilize societies by damaging infrastructure, disrupting essential services, and displacing populations, particularly in communities that lack the resources to recover or adapt effectively. These impacts hinder progress toward development goals and deepen existing inequalities (World Bank, 2023; IPCC, 2022).

Thus, integrating social assessments into climate policies is crucial to ensuring that adaptation measures do not inadvertently exacerbate existing inequalities. If adaptation strategies do not account for social equities, they may end up benefiting wealthier sectors of society while leaving poorer, more marginalized groups even more exposed to climate risks. For example, large-scale infrastructure projects designed to protect cities from flooding may be inaccessible to rural populations or those in informal settlements, further deepening social inequalities. By considering social equity and involving justice in community decision-making, climate adaptation strategies can become more sustainable and effective in building long-term urban resilience (IPCC, 2022).

Recent studies highlight the importance of social dimensions in climate resilience. For instance, O'Brien et al. (2023) argue that the social resilience of communities depends on their ability to maintain essential social functions—such as education, healthcare, and social support systems—during times of crisis. Climate events, however, often disrupt these functions, leaving communities without the resources they need to recover. The authors advocate for social impact assessments that look not only at physical exposure to climate risks but also at the capacity of communities to maintain their social fabric.

In addition, recent work by Klein et al. (2022) emphasizes that social vulnerability must be considered in the design of climate policies. Communities with limited access to resources and social safety nets are more likely to suffer from the impacts of climate change. Adger et al. (2021) similarly stress the importance of integrating social factors into climate adaptation planning to ensure that no group is left behind. This is especially critical in regions where climate change is expected to have the most devastating effects, such as low-income countries and areas that are already experiencing high levels of social inequality.

The need for comprehensive social assessments is further highlighted by the World Bank (2023) report on climate resilience, which stresses the importance of improving social protection systems, investing in education, and ensuring equitable access to resources. These measures are critical for building long-term resilience in vulnerable communities. Similarly, Fankhauser et al. (2023) argue that incorporating social assessments into climate policies ensures that adaptation measures are not only effective but also just, addressing the needs of the most vulnerable populations.

In conclusion, the social impacts of climate change are deeply intertwined with the environmental challenges posed by global warming. Effective climate change policies must consider both the

environmental and social dimensions of resilience. By integrating social assessments into climate planning, decision-makers can design more equitable and sustainable solutions that address the needs of vulnerable communities and build resilience for the future.

1.1.1. Climate Change: Urban Adaptation and Mitigation

To effectively mitigate climate change, cities must undergo significant structural transformations across various sectors, including transportation, building infrastructure, and energy systems. With projections estimating that by 2050, nearly 70% of the global population will reside in urban areas, the urgency for sustainable urban planning strategies has never been greater (UN-Habitat, 2022). Rapid urbanization intensifies climate risks and environmental degradation, making it imperative to adopt solutions that enhance urban resilience while ensuring sustainability. In response, NbS have gained prominence as an integrated approach to addressing climate challenges, supporting biodiversity, and improving the quality of urban life. However, while the ecological and economic benefits of NbS are well-documented, their social implications remain underexplored (Kabisch et al., 2021).

At the European level, policy frameworks increasingly emphasize air pollution reduction, climate adaptation, and sustainable resource management, recognizing the role of NbS in achieving these objectives (European Commission, 2023). NbS provide multifunctional solutions by enhancing green infrastructure, reducing urban heat islands, and promoting biodiversity while simultaneously influencing social dynamics such as community cohesion, accessibility, and inclusivity (Raymond et al., 2023). However, their implementation can also create unintended social challenges, such as gentrification, unequal access to green spaces, and governance conflicts. Given the complexity of urban environments, a comprehensive assessment of NbS impacts on social structures is necessary to ensure their equitable and sustainable integration into city planning.

A key approach to addressing these concerns is conducting Social Impact Assessments (SIA), which provide a structured framework for evaluating how NbS interventions affect communities. SIA helps identify potential risks, assess inclusivity and governance structures, and ensure that NbS projects contribute positively to social sustainability (Albert et al., 2021). By integrating SIA into NbS planning, policymakers and urban developers can design interventions that align with local needs, minimize unintended consequences, and enhance overall urban resilience. This approach ensures that NbS not only contribute to climate adaptation and environmental goals but also promote socially inclusive and sustainable urban development.

1.2. Overview of Research Project

GREEN-INC, which stands for *GRowing Effective & Equitable Nature-based Solutions through INClusive Climate Actions*, is a European research initiative involving six universities and five partner cities. The universities include the University of Amsterdam, DIST (Politecnico di Torino), Vrije Universiteit Brussel, Université libre de Bruxelles, CCMESI (University of Bucharest), and Lulea University of Technology. The partner organizations include Informart Association, Les Etats Généraux de l'eau à Bruxelles, Waternet Amsterdam, the City of Torino, and Skellefteå Municipality.

The project focuses on investigating how *Inclusive Climate Actions* can enhance the effectiveness and equity of *Nature-based Solutions* (NbS) for both human communities and natural ecosystems. By prioritizing inclusion, GREEN-INC seeks to support European cities in designing and implementing climate actions that ensure fairer distribution of the benefits and impacts of NbS, thereby promoting social justice while addressing environmental challenges. (GREEN-INC website)

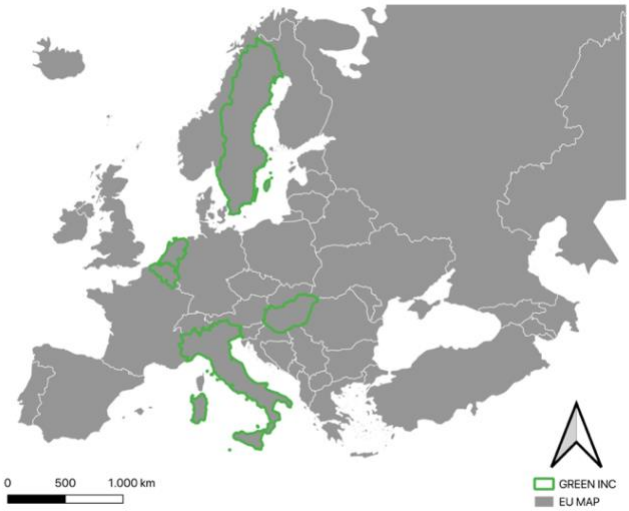

Figure 1 GREEN-INC consortium

This research was carried out as part of my master's thesis at the DIST Department of Politecnico di Torino. Over a six-month period, I contributed to the project by analyzing selected case studies in Brussels. The study was conducted in collaboration with the Water and Climate Department (HYDR) at Vrije Universiteit Brussel, with a particular focus on evaluating the social impact of NbS through the assessment of specific social indicators, aiming to promote more ICAs in the city.

1.3. Case Studies

This study focuses on NbS projects implemented between 2019 and 2022 in Brussels, Belgium. These projects were selected for their diverse approaches to enhancing urban sustainability and social well-being, making them suitable case studies for the GREEN-INC project observatory. The social impact assessment conducted on these projects provides valuable insights into their effectiveness and inclusivity.

As follows in Figure 2, the exact locations and boundaries of the case studies in the city of Brussels are indicated, along with a description and explanation of each one.

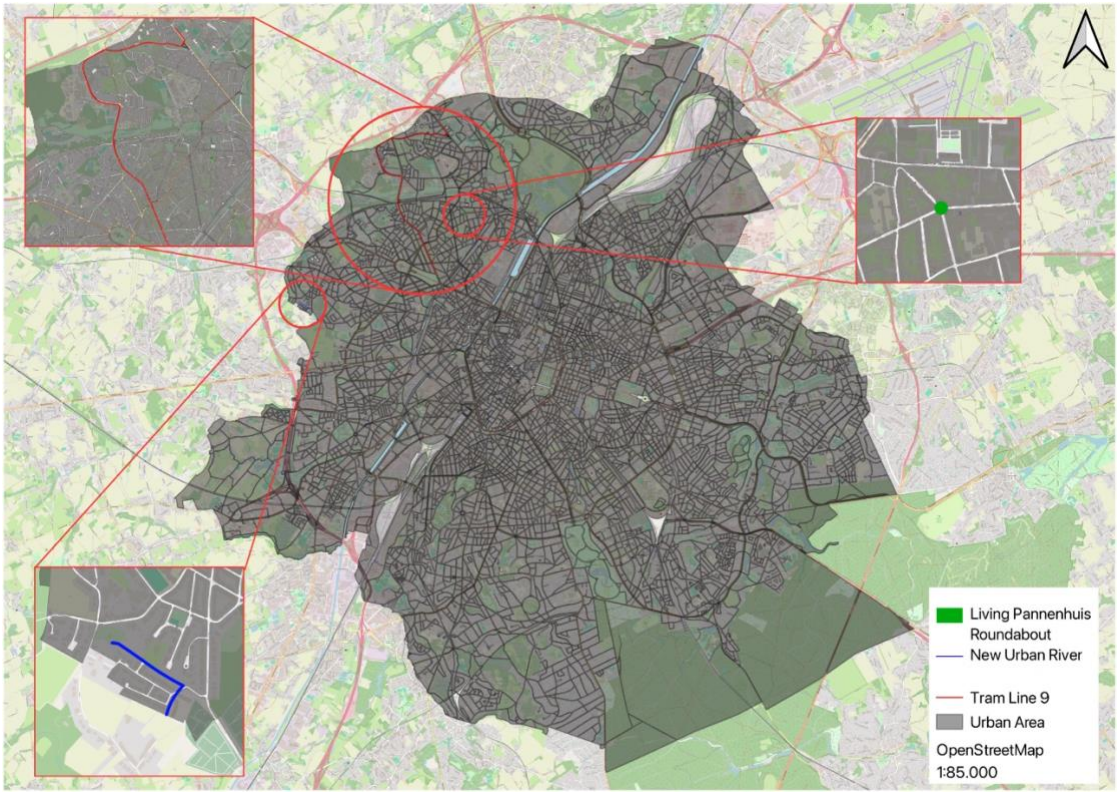

Figure 2 Case Studies' Locations and Boundaries

i. Living Pannenhuis Roundabout:

The Living Pannenhuis Roundabout project aimed to transform a busy roundabout in Brussels into a sustainable neighborhood space. The primary objectives were to improve pedestrian safety, add green spaces, and manage surface water for environmental sustainability. By redesigning the roundabout, the project created a safer and more accessible environment for pedestrians, while also enhancing the aesthetic appeal of the area with new green spaces. Additionally, the implementation of surface water management techniques helped mitigate flooding risks and promote environmental sustainability. The social impact assessment revealed positive outcomes

in terms of community engagement, increased pedestrian activity, and improved perceptions of safety and well-being among residents (Urban Brussels, 2024).

Figure 3 Living Pannenhuis Roundabout

ii. New Urban River (NRU):

The New Urban River (NRU) project, led by Egeb in Berchem-Sainte-Agathe, Brussels, focused on creating a swale to sustainably manage rainwater and prevent flooding. It is a water path in the Cognassier neighborhood that aims at the construction of a natural waterway designed to capture and filter rainwater, reducing the risk of urban flooding. The project not only addressed environmental challenges but also provided recreational and educational opportunities for the local community. The social impact assessment highlighted the project's success in fostering community cohesion, enhancing local biodiversity, and improving residents' awareness of sustainable water management practices. The NRU project demonstrated the multifunctionality of NbS by combining ecological benefits with social inclusivity (Egeb, 2024).

Figure 4 New Urban River (NRU)

iii. Tram Line 9:

The Tram Line 9 project aimed to improve public spaces, green areas, and connectivity in Brussels. By integrating NbS into the urban infrastructure, the project enhanced the quality of public spaces

and increased green areas along the tram line. This initiative not only improved the aesthetic and environmental quality of the area but also promoted sustainable transportation options. The social impact assessment indicated positive effects on community well-being, increased use of public spaces, and improved connectivity between neighborhoods. Residents reported higher levels of satisfaction with the urban environment and greater opportunities for social interaction and physical activity (Urban Brussels, 2024).

Figure 5 Tram Line 9

1.3.1. Brussels' Urban NbS: Governance and Society

Brussels, as a dense, multicultural, and politically complex urban region, offers a compelling case study for examining the social impacts of NbS in practice. The city faces a range of environmental and social challenges, including air pollution, urban heat islands, socio-spatial inequality, and fragmented governance. In response, Brussels has increasingly turned to NbS—such as green corridors, urban wetlands, and community gardens—as part of its broader climate adaptation and urban regeneration strategies.

The implementation of NbS in Brussels is shaped by both top-down policy frameworks and bottom-up community initiatives. Projects like the "Parc de la Senne" and the "Green Network Plan" aim to restore ecological connectivity while enhancing public access to green space, particularly in underserved neighborhoods. These interventions are designed not only to mitigate climate risks but also to promote social inclusion, public health, and neighborhood revitalization. However, the outcomes of these projects are not uniformly distributed, and their social impacts vary across different demographic and spatial contexts.

Recent research highlights both the opportunities and tensions inherent in Brussels' NbS agenda. On one hand, NbS have contributed to improved environmental quality, increased biodiversity, and enhanced recreational opportunities in areas previously lacking green infrastructure. On the other hand, concerns have been raised about green gentrification, where environmental improvements lead to rising property values and the displacement of low-income residents. These dynamics underscore the importance of integrating equity considerations into the planning, implementation, and evaluation of NbS.

Moreover, the governance of NbS in Brussels reflects the city's complex institutional landscape, which includes multiple layers of authority (regional, municipal, and community-level) and a diverse array of stakeholders. This fragmentation can hinder coordination and limit the effectiveness of NbS, particularly when social objectives are not clearly prioritized. Nonetheless, there are promising examples of participatory governance, such as co-designed green spaces and citizen-led greening initiatives, which demonstrate the potential for inclusive and context-sensitive NbS implementation.

The Brussels case illustrates the broader themes discussed throughout this review: the multifunctionality of NbS and the importance of social impact assessment. As cities across Europe and beyond seek to scale up NbS, the experiences of Brussels offer valuable lessons on how to balance ecological goals with social justice, and how to design interventions that are both resilient and equitable.

1.4. Research Objective

The primary objective of this study is to assess the social impacts of NbS in urban contexts, with a specific focus on projects implemented at the district level in Brussels. By evaluating the social dimensions of these NbS projects, the study aims to provide a comprehensive understanding of effectivess of NbS to urban sustainability, social equity, and community well-being to support more ICAs.

To achieve this, the study will:

I. Investigate the social impact assessment of NbS projects to support more effective ICAs in Brussels, Belgium.

II. To derive actionable recommendations for enhancing the social effectiveness of future NbS projects.

By addressing these objectives, the study aims to provide actionable insights for policymakers, urban planners, and community stakeholders, enabling them to design and implement NbS that are both environmentally sustainable and socially inclusive.

1.5. Research Questions

In order to fulfill the objectives of this project, the study addresses the following research questions:

I. How do specific NbS projects in Brussels, such as the Living Pannenhuis Roundabout, New Urban River (NRU), and Tram Line 9, impact social dimensions at the district level?

   - What are the specific social outcomes of these projects in terms of safety, engagement, and connectivity?
   - How do these projects influence residents' satisfaction with their urban environment and overall well-being?

II. How can the findings of this study inform the social effectiveness of NbS projects and inform the planning of future initiatives?

   - How can NbS projects be designed and implemented to maximize their social benefits?
   - What recommendations can be made to policymakers and urban planners based on the social impact assessments?
   - What strategies can be employed to ensure that NbS are both environmentally sustainable and socially inclusive?

2. Literature review

The second chapter of this thesis focuses on the literature review, presenting a thorough examination of existing research relevant to the topic. It synthesizes key studies, theories, and frameworks related to climate action, NbS, sustainable development, and the crucial role of social assessment in achieving sustainable and secure development, recognizing society as the primary stakeholder. By critically evaluating prior research, this chapter identifies gaps in knowledge and highlights areas that require further exploration. Serving as the foundation for the research questions and methodology, it provides the theoretical framework necessary to support the subsequent chapters. Through this review, the chapter establishes the groundwork for a more in-depth investigation of the subject.

2.1. Nature Based Solutions

NbS have emerged as a critical framework for addressing the dual crises of climate change and biodiversity loss while promoting sustainable development. Defined by the International Union for Conservation of Nature (IUCN) as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively," NbS offer a holistic approach that integrates ecological integrity with human well-being (IUCN, 2016).

For instance, a common issue is flooding in coastal areas that happens due to storms and coastal erosion. This issue, which was usually tackled with manmade or grey infrastructure, e.g., dikes, can also be tackled by solutions that also provide ecosystem services such as tree planting.

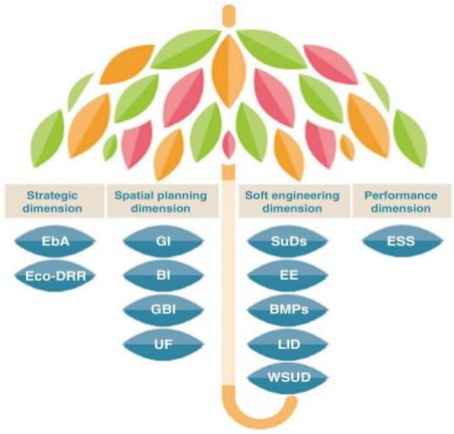

Figure 6 The NbS umbrella concept (European Commission. et al. 2021)

Recent scholarship emphasizes the growing relevance of NbS in climate policy and urban planning. Yang et al. (2024) conducted a comprehensive analysis of over 2,600 peer-reviewed studies and found that NbS research has increasingly focused on urban governance, green

infrastructure, flood mitigation, and carbon sequestration. This trend reflects a shift from purely ecological applications toward integrated urban and climate resilience strategies.

NbS are particularly valuable in urban contexts, where they can mitigate the urban heat island effect, manage stormwater, and enhance air quality. Fu (2023) highlights that NbS not only improve environmental performance but also contribute to social equity and public health by providing accessible green spaces and ecosystem services 2. These co-benefits make NbS a compelling alternative to conventional grey infrastructure, especially in rapidly urbanizing regions.

Despite their promise, the implementation of NbS faces several challenges, including institutional fragmentation, lack of standardized evaluation metrics, and limited financial mechanisms. A global review by PNAS Nexus (2024) identified governance, land tenure, and policy alignment as key non-biophysical constraints to the scalability of natural climate solutions 3. Addressing these barriers is essential for mainstreaming NbS into national adaptation and mitigation strategies.

In summary, nature-based solutions represent a transformative approach to climate resilience and sustainable development. Their integration into urban systems and climate policy not only supports environmental goals but also advances multiple Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land). As the climate crisis intensifies, NbS offer a scientifically grounded and socially inclusive pathway toward a more resilient and equitable future.

2.2. NbS in Urban Climate Action

Urban areas are increasingly recognized as pivotal in the global response to climate change due to their dense populations, extensive infrastructure, and high emissions. According to the IPCC (2021), cities are responsible for over 70% of global carbon dioxide emissions and are highly vulnerable to climate-related risks such as heatwaves, flooding, and air pollution. In this context, NbS present a promising approach to strengthening urban climate resilience while delivering ecological, social, and economic co-benefits.

Urban NbS encompass a range of interventions including green roofs, urban forests, permeable pavements, bioswales, and restored wetlands. These strategies regulate urban microclimates, reduce stormwater runoff, improve air quality, and support biodiversity. For instance, green infrastructure can alleviate the urban heat island effect by reducing surface temperatures, while constructed wetlands help absorb stormwater and mitigate flood risk (Kabisch et al., 2016). The multifunctionality of these solutions makes them especially appealing for cities seeking cost-effective and adaptive measures to address climate challenges.

Empirical evidence supports the effectiveness of NbS in urban climate governance. A meta-analysis by Frantzeskaki et al. (2022) revealed that cities implementing NbS reported tangible improvements in climate adaptation, including reduced exposure to extreme weather and enhanced delivery of ecosystem services. However, the study also emphasized that outcomes are contingent on robust governance, stakeholder participation, and the integration of NbS within broader urban planning strategies.

Despite their advantages, several barriers hinder the widespread adoption of NbS in cities. These include institutional fragmentation, limited technical expertise, and difficulties in securing long-term financial support. Additionally, NbS are often undervalued in traditional cost-benefit frameworks, which tend to favor grey infrastructure, overlooking the long-term sustainability and broader co-benefits of ecosystem-based approaches (Waite et al., 2023). Overcoming these challenges requires a paradigm shift in urban planning—from reactive, engineering-driven solutions to proactive, systems-based approaches that prioritize ecological resilience and human well-being.

NbS also offer an opportunity to foster inclusive and participatory urban governance. Involving local communities in the planning, implementation, and stewardship of green spaces not only enhances social cohesion but also ensures that interventions are culturally relevant and locally supported. This participatory aspect is essential for securing public buy-in and sustaining NbS initiatives over time (Bussu et al., 2022).

As cities continue to expand and climate risks escalate, the strategic integration of NbS into urban policy will be essential. Their capacity to deliver adaptive, low-carbon, and socially inclusive solutions makes them critical tools for building sustainable urban futures. The following section examines how NbS contribute to the United Nations Sustainable Development Goals (SDGs), reinforcing their significance within global sustainability agendas.

2.3. NbS at the SDGs

NbS are increasingly recognized as vital tools for achieving the United Nations SDGs, particularly in the face of accelerating climate change, urbanization, and biodiversity loss. While NbS align most directly with SDG 13 (Climate Action), their multifunctional benefits enable them to contribute meaningfully to several other goals, including SDG 11 (Sustainable Cities and Communities), SDG 15 (Life on Land), SDG 6 (Clean Water and Sanitation), and SDG 3 (Good Health and Well-being) (Seddon et al., 2021).

The integration of NbS into the SDG framework reflects growing awareness of the interdependence between ecological health and human development. For example, urban green infrastructure can reduce climate-related risks while simultaneously improving air quality, lowering noise pollution, and enhancing mental health—contributing to both environmental

sustainability and public well-being. Likewise, reforestation and wetland restoration initiatives support biodiversity (SDG 15), improve water regulation (SDG 6), and generate green employment opportunities (SDG 8), demonstrating the cross-sectoral potential of NbS.

Despite their promise, the integration of NbS into SDG implementation remains constrained by fragmented institutions, inconsistent evaluation metrics, and limited coordination across sectors. A global review by Chausson et al. (2020) found that although NbS are increasingly featured in national climate strategies, their deployment often lacks the systemic integration required to fully realize benefits across multiple SDGs. Addressing this gap calls for coherent policy frameworks that embed NbS within national development agendas, urban planning processes, and climate adaptation pathways.

In addition, the SDGs offer a valuable lens through which to assess the equity and inclusiveness of NbS. Goals such as SDG 10 (Reduced Inequalities) and SDG 5 (Gender Equality) emphasize the need to ensure fair distribution of benefits and inclusive participation in decision-making. This aligns with emerging research advocating for a transition from technocratic approaches to more socially embedded models of NbS—where local knowledge, cultural values, and community agency play central roles in shaping interventions (Frantzeskaki et al., 2022).

In this way, NbS function not only as environmental strategies but also as catalysts for integrated and inclusive development. Their alignment with the SDGs enhances their relevance within global policy agendas and underscores the importance of cross-sectoral collaboration. The following section will delve deeper into the social dimensions of NbS, examining how these interventions influence community well-being, equity, and participatory governance.

2.4. Inclusivity In Climate Actions

Inclusivity has become a central principle in contemporary climate governance, reflecting a growing recognition that effective and equitable climate action must involve all segments of society. This is particularly relevant in the context of NbS, which intersect with diverse social, cultural, and economic realities. Inclusive climate action ensures that marginalized and vulnerable groups—often the most affected by climate change—are not only protected but also empowered to shape the policies and interventions that impact their lives (Schlosberg et al., 2017).

The rationale for inclusivity is both ethical and practical. From an ethical standpoint, climate justice demands that those who have contributed least to climate change are not disproportionately burdened by its effects. From a practical perspective, inclusive processes enhance the legitimacy, relevance, and effectiveness of climate interventions. Research shows that participatory approaches in NbS planning lead to more context-sensitive designs, stronger community ownership, and improved long-term outcomes (Frantzeskaki et al., 2022).

Inclusivity in climate action involves more than just consultation; it requires meaningful participation, power-sharing, and the recognition of diverse knowledge systems. This includes Indigenous and local knowledge, which often offer valuable insights into ecosystem management and resilience. However, institutional barriers—such as technocratic planning cultures, limited access to decision-making forums, and socio-economic inequalities—frequently hinder inclusive engagement. Overcoming these barriers requires deliberate efforts to build capacity, foster trust, and institutionalize participatory governance mechanisms (Corgo et al., 2024).

In urban contexts, inclusivity is particularly critical. Cities are socially heterogeneous spaces where climate risks and adaptive capacities are unevenly distributed. Low-income and minority communities often reside in areas most vulnerable to flooding, heat stress, and pollution, yet they are frequently excluded from urban planning processes. NbS offer an opportunity to redress these imbalances by integrating equity goals into environmental interventions. For example, co-designed green spaces can serve as platforms for community engagement, cultural expression, and social cohesion, while also delivering ecological benefits (Kabisch et al., 2017).

Moreover, inclusivity must be embedded in the evaluation and monitoring of NbS. This includes developing indicators that capture social equity, procedural justice, and distributional outcomes. Tools such as SIA, discussed in the previous section, can support this process by providing structured methodologies for assessing who benefits from NbS and who may be left behind.

As the next section will illustrate, the principles of inclusivity and social equity are not only theoretical ideals but are being actively tested in real-world contexts. The case of Brussels provides a compelling example of how NbS are being implemented in a dense, multicultural urban environment, and how their social impacts are being negotiated in practice.

2.5. Social Dimensions of NbS

While NbS are often promoted for their ecological and climate-related benefits, their social dimensions are equally critical to their success and sustainability. NbS interventions—such as urban parks, green corridors, and restored wetlands—are embedded in complex socio-political contexts and can significantly influence community well-being, social equity, and public participation. As such, understanding and addressing the social implications of NbS is essential for ensuring that these interventions are not only environmentally effective but also socially just.

NbS can generate a wide range of positive social outcomes. These include improved mental and physical health through access to green spaces, enhanced social cohesion via community-based stewardship, and increased environmental awareness through participatory planning processes (Raymond et al., 2017). In urban contexts, green infrastructure can also contribute to safer, more inclusive public spaces, particularly in underserved neighborhoods. These benefits align with

broader goals of environmental justice and urban equity, reinforcing the role of NbS as tools for inclusive development.

However, the social impacts of NbS are not uniformly positive. Without careful planning and inclusive governance, NbS can exacerbate existing inequalities. One prominent example is the phenomenon of "green gentrification," where the introduction of high-quality green spaces leads to rising property values and the displacement of low-income residents (Anguelovski et al., 2019). This underscores the importance of integrating equity considerations into the design, implementation, and evaluation of NbS.

Moreover, the success of NbS often hinges on the degree of community engagement and local ownership. Participatory approaches that involve residents in decision-making processes can enhance the legitimacy, relevance, and long-term sustainability of NbS projects. Yet, such engagement is frequently limited by institutional constraints, lack of capacity, or tokenistic consultation practices. Addressing these challenges requires a shift toward more inclusive and deliberative governance models that recognize diverse knowledge systems and empower marginalized voices (Frantzeskaki et al., 2022).

The social dimensions of NbS also intersect with broader issues of governance, power, and access to resources. Who decides where and how NbS are implemented? Who benefits, and who bears the costs? These questions highlight the need for critical, context-sensitive analyses that go beyond ecological metrics to consider the lived experiences of affected communities (Reed et al., 2022). As the next section will explore, SIA offers a valuable framework for systematically evaluating these social outcomes and ensuring that NbS contribute to equitable and inclusive climate action.

2.6. Social Impact Assessment

As NbS become increasingly central to climate adaptation and urban sustainability strategies, there is a growing need for robust frameworks to evaluate their social outcomes. social impact assessment offers a systematic approach to identifying, analyzing, and managing the social consequences of planned interventions, including changes in community well-being, equity, access to resources, and social cohesion (Esteves et al., 2012). While SIA has traditionally been applied in the context of infrastructure and extractive industries, its relevance to NbS is gaining recognition, particularly as the social dimensions of environmental interventions come under greater scrutiny.

SIA provides a structured methodology for anticipating both positive and negative social impacts. In the context of NbS, this includes assessing how interventions affect different demographic groups, whether they promote or hinder social inclusion, and how they influence perceptions of safety, belonging, and environmental justice. For example, the introduction of green infrastructure in urban neighborhoods may improve quality of life for some residents while contributing to

displacement pressures for others—a dynamic that SIA can help illuminate and address (Vanclay, 2020).

Integrating SIA into NbS planning and evaluation processes can enhance transparency, accountability, and responsiveness. It enables planners and policymakers to engage with affected communities early in the design phase, identify potential risks, and co-develop mitigation strategies. Moreover, SIA can support the development of context-specific indicators that reflect local values and priorities, moving beyond generic metrics to capture the lived experiences of diverse populations (Frantzeskaki et al., 2022).

Despite its potential, the application of SIA to NbS remains limited and under-theorized. One challenge is the lack of standardized tools and guidelines tailored to the unique characteristics of NbS, which often span ecological, spatial, and temporal scales. Another is the tendency to prioritize ecological performance over social outcomes in NbS evaluations, leading to a gap in understanding how these interventions affect human systems. Addressing these limitations requires interdisciplinary collaboration and the development of integrated assessment frameworks that combine ecological, economic, and social dimensions (Nalumu et al., 2025).

Importantly, SIA aligns with broader calls for inclusive and just climate action. By foregrounding issues of equity, participation, and distributional justice, SIA can help ensure that NbS do not inadvertently reproduce or exacerbate existing social inequalities. As the next section will explore, inclusivity is not only a normative goal but also a practical necessity for the legitimacy and effectiveness of climate interventions.

2.7. Social indicators

Social indicators play a crucial role in SIA by providing measurable evidence of social change resulting from projects, policies, or interventions. The careful selection of appropriate indicators is fundamental to ensuring that the assessment accurately captures the diverse and complex social dynamics affected by an intervention (Esteves, Franks, & Vanclay, 2012). Well-chosen indicators allow for the identification of both intended and unintended social impacts, contributing to more informed decision-making and fostering more equitable and sustainable outcomes. Conversely, poorly selected indicators may overlook significant effects or misrepresent the realities of affected communities. Therefore, it is essential to adopt a context-specific and stakeholder-informed approach to indicator selection, aligning them with the goals and scope of the assessment while maintaining sensitivity to cultural, social, and environmental factors.

Thus, the social indicators for SIA have been chosen from the article "A place-based framework for assessing the effectiveness of inclusive climate actions for nature-based solutions in cities" by Virginia Pellerey and Sara Torabi Moghadam. This article provides a comprehensive framework

for evaluating and monitoring the effectiveness of inclusive climate actions for NbS, offering valuable insights into the environmental, social, and economic trade-offs and synergies associated with NbS (Pellerey & Moghadam, 2024).

The selected social indicators and their definitions, drawn from relevant literature and adapted to the specific aims of this study, are presented below:

- Citizens involved in participatory process

Citizen involvement in participatory processes is a crucial social indicator for assessing the effectiveness of NbS. This indicator measures the extent to which citizens are engaged in the planning, implementation, and monitoring of NbS projects. Active participation from local communities ensures that NbS initiatives are inclusive, equitable, and reflective of the needs and preferences of the people they are designed to benefit.

Citizen participation is essential for the success of NbS projects. It fosters a sense of ownership and responsibility among community members, leading to more sustainable and resilient outcomes. When citizens are actively involved, they are more likely to support and maintain NbS initiatives, ensuring their long-term viability. Moreover, participatory processes can enhance social cohesion and trust within communities, as individuals work together towards common goals (OECD, 2023).

There are various methods for involving citizens in NbS projects, including public consultations, participatory budgeting, citizen science, and civic monitoring. These methods provide platforms for community members to voice their opinions, contribute their knowledge, and collaborate with stakeholders. For example, participatory budgeting allows citizens to decide how to allocate funds for NbS projects, ensuring that resources are directed towards initiatives that have broad community support (OECD, 2023).

Participatory processes offer numerous benefits for NbS projects. They can improve the quality and relevance of NbS initiatives by incorporating diverse perspectives and local knowledge. This leads to more effective and context-specific solutions that address the unique challenges faced by communities. Additionally, participatory processes can empower marginalized groups by giving them a voice in decision-making, promoting social equity and inclusion (Morrissey, 2000).

Despite the benefits, there are challenges associated with citizen participation in NbS projects. Ensuring equitable participation can be difficult, as some community members may face barriers to involvement, such as lack of time, resources, or access to information. It is important to address these barriers and create inclusive participatory processes that engage all segments of the community. Additionally, maintaining sustained participation over the long term requires ongoing efforts to build trust and provide meaningful opportunities for engagement (OECD, 2023).

The importance of engagement in participatory processes cannot be overstated. Engaging citizens in NbS projects ensures that these initiatives are more likely to succeed and be sustainable. It helps build a sense of community and shared responsibility, making it easier to address environmental challenges collectively. Furthermore, engagement fosters innovation and creativity, as diverse perspectives contribute to the development of more effective solutions (Nunes et al., 2021).

- Citizen involvement in environmental education activities

Citizen involvement in environmental education activities is a crucial social indicator for assessing the effectiveness of NbS. This indicator measures the extent to which citizens participate in educational programs and initiatives aimed at raising awareness about environmental issues and promoting sustainable practices. Active engagement in environmental education empowers individuals to make informed decisions and take meaningful actions to protect and preserve the environment.

Environmental education plays a vital role in building awareness and knowledge about the impact of human activities on the environment. It equips individuals with the skills and understanding needed to address environmental challenges and adopt sustainable practices. By fostering a sense of responsibility and stewardship, environmental education encourages citizens to become proactive in conserving natural resources and reducing their ecological footprint (Steps4Kids, 2025).

There are various methods for involving citizens in environmental education activities, including workshops, community events, school programs, and citizen science projects. These activities provide opportunities for individuals to learn about environmental issues, engage in hands-on experiences, and contribute to scientific research. For example, citizen science initiatives allow participants to collect data on air quality, biodiversity, and water pollution, enhancing their understanding of environmental processes and impacts (ATMOTUBE, 2025).

Citizen involvement in environmental education activities offers numerous benefits. It enhances the effectiveness of NbS by ensuring that community members are informed and engaged in environmental stewardship. Educated citizens are more likely to support and participate in NbS projects, leading to more successful and sustainable outcomes. Additionally, environmental education fosters a sense of community and collaboration, as individuals work together to address common environmental challenges (Steps4Kids, 2025).

Despite the benefits, there are challenges associated with citizen involvement in environmental education activities. Ensuring equitable access to educational opportunities can be difficult, as some individuals may face barriers such as lack of time, resources, or access to information. It is important to address these barriers and create inclusive educational programs that engage all segments of the community. Additionally, maintaining sustained participation requires ongoing efforts to provide engaging and relevant content (ATMOTUBE, 2025).

In conclusion, citizen involvement in environmental education activities is a vital social indicator for assessing the effectiveness of NbS. By fostering environmental awareness and stewardship, these activities empower individuals to take meaningful actions to protect the environment, ultimately contributing to the success and sustainability of NbS projects.

- Perceived quality of urban spaces

Perceived quality of urban spaces is a crucial social indicator for assessing the effectiveness of NbS. This indicator measures how residents perceive the quality of their urban environment, including green spaces, public areas, and infrastructure. The perceived quality of urban spaces significantly influences neighborhood satisfaction, well-being, and overall quality of life.

The perceived quality of urban spaces is essential for understanding how environmental features impact residents' well-being. High-quality urban spaces can enhance physical and mental health, promote social interactions, and provide aesthetic and recreational benefits. Conversely, poorly perceived urban spaces can lead to dissatisfaction, stress, and reduced quality of life (Zhang et al., 2017).

Several factors influence the perceived quality of urban spaces, including accessibility, usability, safety, cleanliness, and aesthetic appeal. Accessible and usable green spaces, for example, are more likely to be perceived positively by residents. Safety and cleanliness also play a significant role, as well-maintained and secure areas are more inviting and enjoyable for community members (Adams, 2014).

High-quality urban spaces offer numerous benefits. They can improve physical health by providing areas for exercise and recreation, enhance mental health by offering peaceful and aesthetically pleasing environments, and foster social cohesion by creating spaces for community gatherings and interactions. Additionally, high-quality urban spaces can increase property values and attract businesses, contributing to economic development (Zhang et al., 2017).

Despite the benefits, there are challenges associated with maintaining high-quality urban spaces. Ensuring equitable access to these spaces can be difficult, as some neighborhoods may lack sufficient green areas or face barriers to accessibility. It is important to address these disparities and create inclusive urban environments that cater to the needs of all residents. Additionally, ongoing maintenance and investment are required to preserve the quality of urban spaces over time (Adams, 2014).

In conclusion, the perceived quality of urban spaces is a vital social indicator for assessing the effectiveness of NbS. By understanding and enhancing the factors that contribute to positive perceptions, urban planners and policymakers can create environments that improve residents' well-being and quality of life.

- Estimated morbidity and mortality

Estimated morbidity and mortality is a critical health-related indicator for assessing the broader impacts of NbS on urban populations. This indicator measures the potential changes in health outcomes, such as the prevalence of chronic diseases and mortality rates, that can be attributed to environmental improvements brought about by NbS initiatives. Understanding shifts in morbidity and mortality is essential for evaluating the effectiveness of NbS in promoting public health and well-being.

Exposure to green spaces and improved urban environments has been linked to numerous positive health outcomes. Access to well-maintained green areas can reduce the risk of cardiovascular diseases, respiratory conditions, mental health disorders, and obesity by promoting physical activity, reducing pollution, and lowering stress levels (World Health Organization, 2017). Furthermore, the presence of natural elements in urban settings has been associated with decreased mortality rates, particularly due to reductions in air pollution and heat-related illnesses (Twohig-Bennett & Jones, 2018).

NbS contribute to reducing morbidity by improving environmental quality, such as through better air filtration, noise reduction, and temperature regulation. Initiatives like urban forests, green roofs, and wetland restoration directly influence environmental determinants of health, thereby mitigating risk factors associated with various diseases. Additionally, improved urban design that incorporates NbS encourages more active lifestyles, further reducing morbidity rates (WHO, 2017).

Despite these benefits, accurately estimating morbidity and mortality impacts presents several challenges. Health outcomes are influenced by a complex interplay of environmental, social, and individual factors, making it difficult to isolate the effects of specific NbS interventions. Longitudinal studies and robust epidemiological methods are necessary to establish causal relationships between NbS and health outcomes. Moreover, disparities in access to green spaces can lead to unequal health benefits across different socioeconomic groups, necessitating targeted strategies to ensure equitable health improvements (Jennings et al., 2017).

In conclusion, estimated morbidity and mortality is a vital indicator for evaluating the public health effectiveness of NbS. By reducing disease burden and improving survival rates, NbS not only enhance environmental sustainability but also contribute significantly to healthier and more resilient urban communities.

2.8. Research Gaps and Directions

Despite the growing body of literature on NbS, significant research gaps remain, particularly in relation to their social dimensions, long-term effectiveness, and integration into urban governance

systems. While NbS are widely promoted for their multifunctionality and alignment with global sustainability goals, empirical evidence on their social outcomes—especially in diverse urban contexts—remains limited and unevenly distributed across regions and disciplines (Seddon et al., 2021).

One major gap lies in the systematic assessment of social impacts. As discussed in previous sections, tools like SIA are underutilized in NbS planning and evaluation. Most existing studies focus on ecological performance or economic valuation, with less attention paid to equity, inclusion, and community well-being. There is a need for interdisciplinary research that develops and applies robust, context-sensitive indicators to capture the full spectrum of social outcomes, including procedural justice, distributional equity, and cultural relevance (Reed et al., 2022).

Another critical gap concerns the scalability and institutionalization of NbS. While pilot projects and localized interventions have demonstrated promising results, questions remain about how to scale NbS effectively without compromising their ecological integrity or social inclusivity. This includes understanding how NbS interact with existing urban infrastructures, land-use policies, and governance arrangements. Comparative studies across cities and regions could provide valuable insights into enabling conditions, barriers, and best practices for mainstreaming NbS into urban climate strategies (Frantzeskaki et al., 2019).

The temporal dimension of NbS also warrants further exploration. Many NbS deliver benefits over long time horizons, yet most evaluations are short-term, and project based. Longitudinal studies are needed to assess the durability of ecological and social benefits, as well as the adaptive capacity of NbS under changing climatic and socio-political conditions (Guehlstorf, 2025).

In addition, there is a lack of research on inclusive governance models that support co-creation and power-sharing in NbS planning. While participatory approaches are often advocated, their implementation varies widely, and their effectiveness is not well understood. Future research should examine how different forms of participation—informative, consultative, collaborative—affect the legitimacy, equity, and outcomes of NbS interventions (Reed et al., 2022).

Finally, place-based research is essential to ground global frameworks in local realities. The case of Brussels, as explored in the previous section, illustrates the importance of context in shaping the design, implementation, and social impact of NbS. More empirical studies are needed in diverse urban settings, particularly in the Global South, where climate vulnerabilities are high, and institutional capacities may be constrained (Reed et al., 2022; Reed et al., 2022).

In summary, advancing the field of NbS requires a more integrated, interdisciplinary, and equity-oriented research agenda. Addressing these gaps will not only enhance the effectiveness of NbS but also ensure that they contribute meaningfully to just and sustainable urban futures.

3. Methodology

This chapter outlines the methodology and research design as an integral part of the European project GREEN-INC, aimed at analyzing the effectiveness of NbS through the lens of social indicators. The framework provides a structured approach for data collection, and visualization, ensuring a systematic assessment of the selected social indicators. These indicators reflect the social transitions influenced by NbS interventions, offering insights into their broader societal impact in local scale.

By employing a structured methodological approach, this study focuses on gathering empirical data through direct citizen engagement, ensuring that the research findings are rooted in firsthand community experiences. This ensures that the research findings are deeply rooted in firsthand community experiences, providing a more authentic and reliable understanding of the social outcomes of NbS initiatives. The research follows a survey-based methodology, targeting local citizens to assess their perceptions of completed NbS projects in the city. This approach is meticulously designed to capture the nuanced views and experiences of the community members who are directly impacted by these interventions.

The methodological process consists of clearly defined and interlinked phases, each dedicated to specific aspects of the research. These phases include survey design, data collection, and data analysis. The structured approach ensures the accuracy and relevance of the gathered information by directly involving community members at every stage. Through systematic engagement and robust analytical methods, the study aims to provide reliable insights into the social outcomes of NbS initiatives.

By integrating community perspectives, the study aligns with the principles outlined by Pellerey & Torabi Moghadam (2025), who emphasize the importance of inclusive climate actions and the need for place-based frameworks to assess the effectiveness of NbS in urban environments. Their work underscores the significance of involving local communities in the evaluation process to ensure that the social impacts of NbS are accurately captured and understood.

As part of the broader framework, this study evaluates the effectiveness of selected social indicators, as presented in Figure 7, derived from citizen perceptions using the case of Brussels, Belgium.

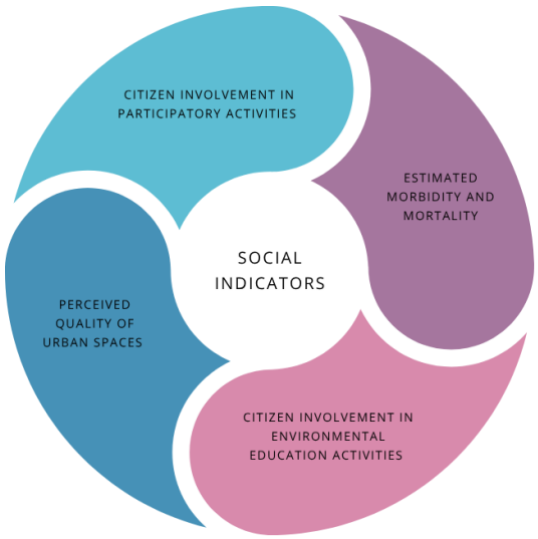

Figure 7 Selected Social Indicators

In Figure 8, the step-by-step research process is illustrated, outlining the methodological approach adopted in this study. The figure visually represents each phase, from survey design and data collection to analysis and interpretation, ensuring a clear understanding of the structured workflow.

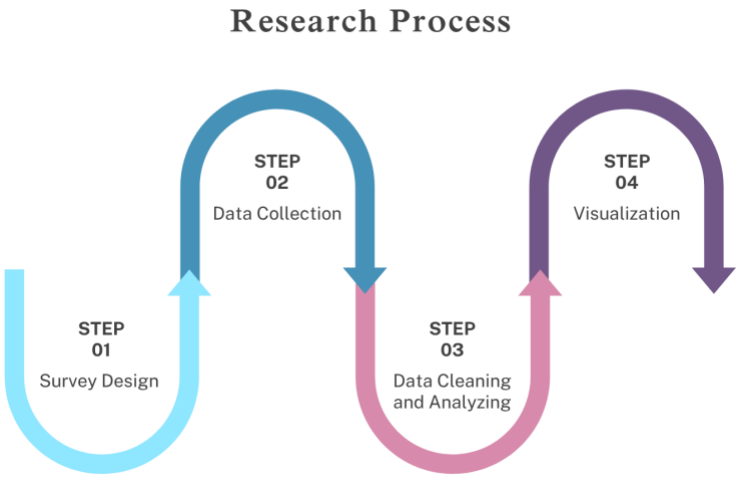

Figure 8 Methodology Diagram

3.1. Survey Design

The primary objective of this research was to assess the social indicators based on citizens' perceptions of NbS projects through direct interaction. To achieve this, an in-person data collection approach was deemed most appropriate. This method was selected to ensure the acquisition of rich, context-specific data that accurately reflects public attitudes and lived experiences. A structured survey was identified as the optimal tool for this purpose, enabling the research team to

engage directly with residents and gain deeper insights into how local communities perceive and interact with NbS interventions in their neighborhoods (Sturiale et al., 2023; Nunes et al., 2021).

To enhance engagement and participation, a structured questionnaire was developed, incorporating both closed- and open-ended questions. This design facilitated a balance between efficiency and depth: closed-ended questions allowed for rapid responses and simplified data analysis and normalization, while open-ended questions captured unexpected and nuanced perspectives that could not be anticipated beforehand. This mixed-format approach ensured that the survey was both analytically robust and flexible enough to accommodate diverse citizen responses (Wray & Barrett, 2022).

The final questionnaire comprised 24 questions, organized into several sections. Each section corresponded to specific social indicators identified in the analytical framework, in addition to a general information section at the beginning. This structure was designed to enhance the comprehensiveness of the questionnaire, improve clarity and flow for participants, and facilitate a more systematic analysis of the collected data (Asokan et al., 2019). The questionnaire was meticulously crafted to cover various dimensions of public perception, including environmental awareness, perceived benefits and challenges of NbS, and community engagement levels.

As illustrated in Figure 9, which presents an excerpt from the questionnaire, Section 7 is dedicated to the social indicator titled "Citizen Involvement in Participatory Activities." This section includes a series of close-ended questions designed to assess the extent and frequency of respondents' participation in NbS-related activities, such as community workshops, co-design sessions, or local environmental initiatives.

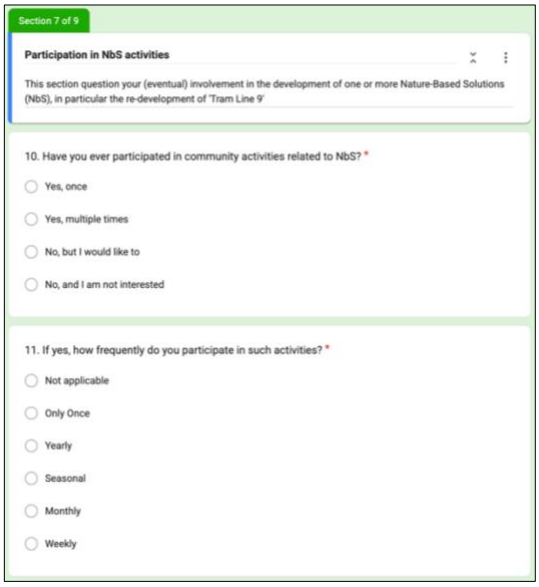

Figure 9 Closed-ended Question Sample

Following these structured items, as shown in Figure 10, an open-ended question invites participants to share their overall thoughts and any unexpected perspectives regarding NbS. This qualitative component was included to capture insights that may not be fully addressed through predefined response options, thereby enriching the dataset with diverse and potentially novel viewpoints. This approach aligns with best practices in participatory research, which emphasize the importance of capturing lived experiences and fostering inclusive engagement in the co-creation of nature-based solutions (Nunes et al., 2021).

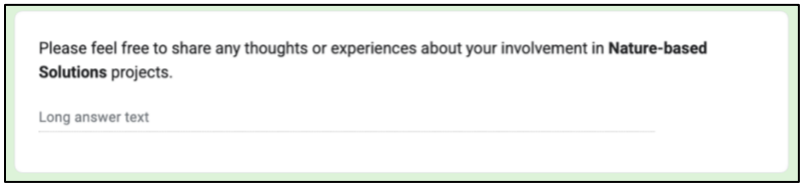

Figure 10 Open-ended Question Sample

Given that this research is part of a broader European project, the questionnaire was initially designed in English to align with the project's overarching framework and ensure consistency across participating regions. To promote inclusivity and ensure that all voices within the Brussels community were adequately represented, the questionnaire was also translated into Dutch and French. These translations were carried out in accordance with best practices in multilingual survey design, aiming to preserve the psychometric properties of the original instrument and maintain conceptual equivalence across languages (Zavala-Rojas et al., 2022)

After the translation of the original model, each version of the questionnaire was further adapted to reflect the specific context of three distinct case studies within the Brussels region. This contextualization ensured that the questions remained relevant and resonant with the lived experiences of respondents in each area. As a result, three tailored versions of the questionnaire—each in English, Dutch, and French—were developed and deployed for data collection. This multilingual and case-specific adaptation aligns with established practices in cross-cultural and multilingual research, which emphasize the importance of linguistic and contextual sensitivity in survey design to ensure validity and inclusivity across diverse populations (Sha & Aizpurua, 2025; Hammarberg, 2025).

Finally, to ensure the questionnaire was both comprehensive and effective, it was piloted with stakeholders and university experts in all three languages. Feedback from these tests was used to refine the questions, improve clarity, and ensure that the survey was accessible to a wide range of participants. These tests also helped identify any potential biases or ambiguities in the questions, allowing the research team to address these issues before the full-scale data collection began (Schroedler et al., 2023).

3.1.1. Correlation between Survey Questions and Indicators

As outlined in the previous sections, the questionnaire was explicitly structured to align with the four social indicators identified in the analytical framework: Citizen Involvement in Participatory Activities, Citizen Involvement in Environmental Education Activities, Perceived Quality of Urban Spaces, and Estimated Morbidity and Mortality. To ensure analytical clarity and facilitate targeted data collection, the survey was divided into distinct thematic sections, each corresponding to one of these indicators.

As indicated in Figure 11, Following the general information section, which gathered demographic data and introduced the concept of NbS and the specific project context, the questionnaire transitioned into indicator-specific modules. Each module included a combination of closed- and open-ended questions designed to capture both measurable trends and nuanced perceptions related to the respective indicator. This modular structure not only enhanced the internal coherence of the instrument but also allowed for a more systematic and indicator-driven analysis of the data (Asokan et al., 2019; Wray & Barrett, 2022).

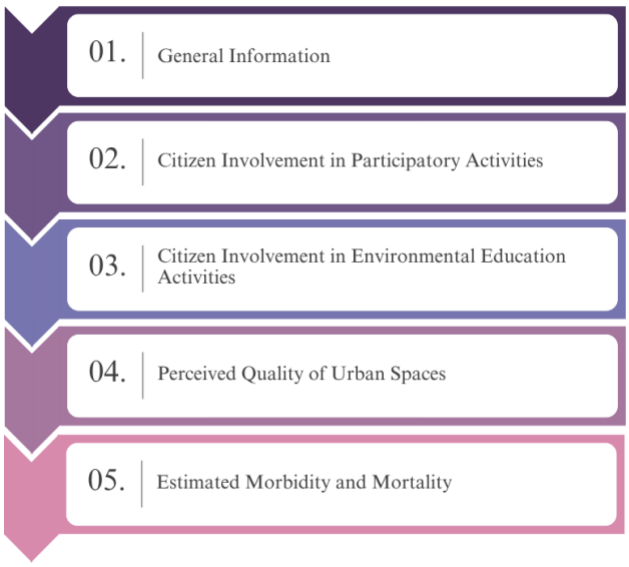

Figure 11 Survey Modules Overview

The first indicator-specific module focused on Citizen Involvement in Participatory Activities. This section included questions designed to assess whether respondents had ever participated in community activities related to NbS, the frequency of such participation, and whether these activities were associated with a specific NbS project. These items aimed to capture both the extent and nature of civic engagement, providing insight into how local communities interact with and contribute to the co-creation and implementation of NbS initiatives. This approach reflects the

growing recognition of participation as a fundamental component of inclusive urban regeneration and sustainable NbS implementation (Nunes et al., 2021; Kiss et al., 2022).

The second module addressed Citizen Involvement in Environmental Education Activities, with questions exploring the frequency of participation in educational initiatives and the degree to which these were connected to NbS projects. This section was intended to evaluate the role of environmental education in fostering awareness, knowledge, and behavioral change, particularly in relation to sustainability and urban ecological resilience. Environmental education has been shown to play a crucial role in enhancing environmental literacy and empowering communities to engage with NbS (Nunes et al., 2021).

The third section of the questionnaire examined the Perceived Quality of Urban Spaces. Respondents were asked to evaluate various dimensions of urban areas influenced by NbS, including their aesthetic appeal, maintenance, perceived safety, cultural vibrancy, and emotional significance. These questions were designed to elicit subjective assessments of how NbS interventions shape the physical and symbolic qualities of urban environments, thereby influencing residents' everyday experiences and sense of place. Research has demonstrated that well-designed and inclusive green spaces can significantly enhance urban quality of life and foster emotional attachment to place (Kiss et al., 2022).

The final module focused on Estimated Morbidity and Mortality, operationalized through self-reported indicators of physical and mental wellbeing. Participants were asked whether they regularly encountered or engaged with NbS in their daily lives and whether they perceived these spaces as contributing to their mental health, for instance by reducing stress or providing access to restorative green environments. These items provided an indirect measure of the potential health benefits associated with NbS, aligning with broader public health objectives and the growing body of evidence linking urban nature to improved wellbeing (Nunes et al., 2021).

This structured and indicator-aligned approach is consistent with best practices in survey methodology, particularly in interdisciplinary and policy-relevant research, where clarity of purpose and alignment between research questions and data collection instruments are essential (Sturiale et al., 2023; Nunes et al., 2021). Moreover, by explicitly linking each section of the questionnaire to a specific social indicator, the study ensured that the collected data could be directly mapped onto the analytical framework, thereby enhancing the validity and interpretability of the findings.

3.2. Data Collection

To raise awareness about the research and the ongoing changes in the neighborhood, approximately 500 flyers were distributed to residents' mailboxes within the defined case study area. These flyers introduced the project, its objectives, and the identity of the research team,

aiming to build trust and ensure transparency with the local community (Pellerey & Torabi Moghadam, 2025). This initial outreach was crucial in establishing a connection with the residents and encouraging their participation in the study.

Subsequently, a series of pop-up sessions were organized across different locations within the study area, where interested citizens were interviewed using the prepared questionnaires. These sessions were conducted in English, Dutch, and French, with both the flyers and questionnaires translated into all three languages. This multilingual approach was essential for ensuring accessibility and inclusivity across the linguistically diverse population of Brussels, and for promoting equity in participation. Furthermore, all interviewers were proficient in these three languages, allowing them to communicate effectively with participants and create an open, respectful environment for dialogue.

The pop-up sessions were strategically scheduled at various times and locations to maximize reach and convenience for participants. This approach ensured that a broad cross-section of the community could be engaged, capturing a wide range of perspectives and experiences. The data collection process was designed to be as inclusive and participatory as possible, reflecting the diverse voices within the community and providing a comprehensive understanding of public perceptions towards NbS projects.

To maximize reach and convenience for participants, both physical questionnaires and an online version were provided. This ensure that a broad cross-section of the community could be engaged, capturing a wide range of perspectives and experiences. The data collection process was designed to be as inclusive and participatory as possible, reflecting the diverse voices within the community and providing a comprehensive understanding of public perceptions towards NbS projects in Brussels. (Schroedler et al., 2023).

3.3. Data Cleaning

To ensure consistency and facilitate ease of analysis, all responses from the questionnaires, regardless of the language in which they were completed, were translated into English. This step was crucial for maintaining unity in the dataset and ensuring that all responses could be analyzed together in a coherent manner. Additionally, it allows for possible further analysis by the GREEN-INC team and facilitates comparison of results across different cities within the main framework of the project. The translation process was meticulously carried out to preserve the meaning and nuances of the original responses, thereby maintaining the integrity of the data (Scribbr, 2021).

Once translated, the data underwent a thorough cleaning process. This involved checking for and addressing any inconsistencies, such as incomplete responses or ambiguous answers. The cleaned data was then organized into sections based on the structure of the questionnaire. Data cleaning is

an essential step in research as it improves the accuracy and quality of the data ahead of analysis (Costanzo, 2025).

For questions related to satisfaction and perceived quality of projects, responses were standardized on a Likert scale, where participants rated their satisfaction from 1 to 5. This scale provided a clear and quantifiable measure of satisfaction, facilitating more straightforward analysis and visualization. The use of a Likert scale allowed for the aggregation of responses and the identification of trends and patterns within the data. This approach not only enhanced the clarity of the data but also improved the robustness of the subsequent analysis (Tableau, 2025).

By translating all responses into English and standardizing satisfaction ratings, the data cleaning process ensured that the dataset was both comprehensive and ready for detailed analysis. This meticulous approach to data cleaning was essential for deriving meaningful insights and ensuring the reliability of the research findings. Ultimately, these steps made the data ready for better visualization, enabling clearer and more effective presentation of the results.

3.4. Analyses and Visualization

Following the data cleaning process, the organized and standardized dataset was prepared for visualization. Visualization was a critical step to enhance the interpretation and communication of the findings, making complex information more accessible and easier to understand (Kelleher & Wagener, 2011). Data visualization helped highlight key patterns, trends, and relationships within the responses, providing a clear overview of participant perceptions and behaviors across different categories.

The visualizations were primarily constructed using pie charts and percentage distributions, selected for their effectiveness in presenting categorical and ordinal data in a straightforward and comparative format. Variables such as gender, age, education level, awareness of NbS, citizen involvement in participatory and environmental activities, and perceived quality of urban spaces were visualized. These graphs allowed for immediate visual comparison between groups and facilitated the identification of significant patterns across different indicators (Evergreen, 2017).

Special attention was given to the design of the graphs to ensure clarity and avoid cognitive overload. Color coding was applied consistently to distinguish between different response categories while maintaining readability for all viewers, including those with color vision deficiencies. Additionally, axes were standardized to percentage scales, ensuring consistency and ease of comparison across different questions. The visualization design followed established best practices to maintain neutrality and avoid misleading representations (Few, 2009).

For Likert scale responses, particularly those related to satisfaction and perceived quality, stacked bar charts were used to display the distribution of ratings from 1 (very dissatisfied) to 5 (very satisfied). This method enabled a comprehensive view of satisfaction levels while allowing for

easy identification of central tendencies and variations among different projects and indicators (Tableau, 2025).

Overall, the visualization process was meticulously planned and executed to transform raw survey data into clear, concise, and insightful visual outputs. Effective visualization not only supported the analysis but also enhanced the communication of results, ensuring that the findings could be understood by a broad audience, including policymakers, researchers, and the public.

4. Result

This chapter presents the findings of the empirical research conducted in Brussels as part of the European GREEN-INC project. The study explores the social impacts of Nbs for fostering more ICAs. The primary objective is to evaluate how NbS initiatives contribute to broader social transitions by analyzing a set of carefully selected social indicators as indicated in Table 1.

Indicators
Citizen Involvement in Participatory Activities
Citizen Involvement in Environmental Education Activities
Perceived Quality of Urban Spaces
Estimated Morbidity and Mortality

Table 1 Social Indicators

The analysis is based on data collected through structured surveys administered to residents and stakeholders in district level, resulting in a total of 91 valid responses. These responses provide a robust foundation for assessing public perceptions and experiences related to NbS interventions in the urban context of Brussels.

These indicators were chosen to offer a multidimensional perspective on citizen interaction with NbS, emphasizing aspects such as awareness, participation, satisfaction, and perceived well-being.

The results are presented in the order of the four social indicators, followed by a cross-case analysis that highlights key differences, commonalities, and lessons learned from the implementation of NbS across the selected projects.

In addition to presenting the results for each indicator, this chapter includes a comparative evaluation of three case studies—Living Pannenhuis Roundabout, Cognassier Water Path, and Tram Line 9. By using the shared indicators as a benchmark, the comparative analysis enables an assessment of the relative success of each initiative in advancing inclusive climate action and promoting community-based environmental transformation.

4.1. Demography of Participants

Understanding the demographic characteristics of the survey participants is essential for contextualizing the social impacts of NbS in Brussels, which will be analyzed in this section.

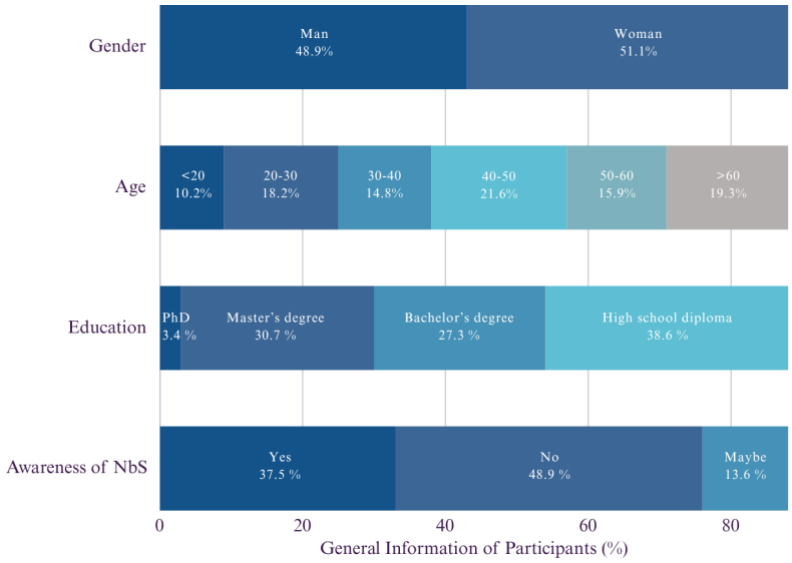

Figure 12 Demography of Participants

As shown in Figure 12, gender distribution was nearly balanced, with 51.1% identifying as women and 48.9% as men, ensuring gender inclusivity in the dataset. The age profile of respondents was also well distributed across generations: 10.2% were under 20 years old, 18.2% aged 20–30, 14.8% aged 30–40, 21.6% aged 40–50, 15.9% aged 50–60, and 19.3% were over 60. This spread reflects a broad generational engagement with NbS initiatives and allows for age-sensitive interpretations of the results.

In terms of educational attainment, the majority of participants had completed at least secondary education. 38.6% held a high school diploma, 27.3% held a bachelor's degree, 30.7% held a master's degree, and 3.4% held a PhD. This indicates a relatively well-educated sample, which may influence levels of environmental awareness and civic participation.

Regarding awareness of NbS, responses revealed a knowledge gap: 48.9% of participants reported no prior awareness of the concept, while 37.5% were familiar with it, and 13.6% were uncertain.

This finding provides initial insight into the participants' informational background, offering a clearer perspective for interpreting the subsequent results presented in this chapter.

4.2. Citizen Involvement in Participatory Activities

The analysis of citizen involvement in participatory activities reveals critical insights into the level of public engagement with NbS initiatives in Brussels. Based on the survey data, as shown in Figure 13, only 20.5% of respondents reported actively participating in participatory processes related to NbS. In contrast, 33% indicated that they had not participated but expressed interest in doing so, while a significant 46.6% stated that they had neither participated nor were interested in such activities.

These findings suggest a substantial gap between potential and actual engagement. While the proportion of active participants remains relatively low, the fact that over half of the respondents (53.5%) are either engaged or open to engagement indicates a latent opportunity for expanding participatory practices. This highlights the importance of designing inclusive and accessible participatory mechanisms that can convert interest into action. The high percentage of disinterest, however, underscores the need for targeted outreach strategies to address barriers such as lack of awareness, perceived irrelevance, or institutional mistrust.

Further insights are provided by the breakdown of participation frequency. Among those who have participated, 30% reported doing so only once, suggesting that many experiences are isolated rather than sustained. Regular engagement remains limited, with 17.2% participating weekly and 13.8% monthly. Seasonal and annual participation account for 20.7% and 13.8%, respectively, indicating that many participatory activities are event-based or tied to specific project timelines rather than embedded in ongoing civic processes.

The predominance of one-time participation points to a need for more robust follow-up mechanisms and long-term engagement strategies. Ensuring continuity in citizen involvement requires not only the institutionalization of participatory practices but also the cultivation of trust and relevance through transparent communication and tangible outcomes. Moreover, the relatively low levels of frequent participation suggest that existing participatory frameworks may not be sufficiently engaging or accessible to sustain long-term involvement.

In the context of ICAs, these findings are particularly significant. Effective NbS implementation depends not only on ecological and technical considerations but also on the degree to which communities are involved in shaping and sustaining these interventions. The data underscores the necessity of embedding participatory processes within the broader governance of NbS to ensure that they are socially inclusive, context-sensitive, and reflective of local needs and aspirations.

In conclusion, while there is a foundational base of interest in participatory activities among citizens, actual engagement remains limited and sporadic. To enhance the social effectiveness of NbS, it is imperative to strengthen participatory infrastructures, reduce barriers to entry, and foster a culture of sustained civic involvement. These efforts are essential for realizing the full potential of NbS as tools for inclusive and transformative urban climate governance.

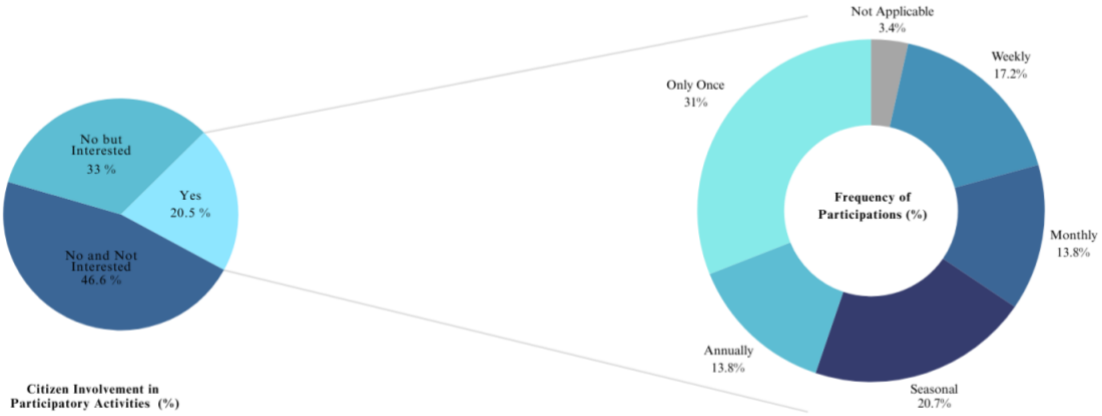

Figure 13 Outcomes of Citizen Involvement in Participatory Activities

4.3. Citizen Involvement in Environmental Education Activities

The analysis of citizen involvement in environmental education activities reveals a generally low level of engagement among the surveyed population. As indicated in Figure 14, a majority of respondents (52%) reported never having participated in any form of environmental education. An additional 30.7% indicated that they rarely engage in such activities. In contrast, only 9.3% of respondents stated that they participate frequently, while 8% reported seasonal involvement.

These findings suggest that environmental education remains a peripheral activity for most citizens, with limited integration into their regular routines. The high percentage of non-participation (over 80% when combining "never" and "rarely") points to a significant gap in public awareness and engagement with environmental learning opportunities. This lack of involvement may stem from several factors, including limited access to educational programs, insufficient promotion of available initiatives, or a general lack of perceived relevance or urgency regarding environmental issues.

The relatively low levels of frequent participation highlight a missed opportunity for fostering environmental literacy and stewardship at the community level. Environmental education is a critical component of NbS, as it equips citizens with the knowledge and skills necessary to understand, support, and sustain ecological interventions. Without adequate public understanding, the long-term success and social legitimacy of NbS projects may be compromised.

Moreover, the data underscores the need for more inclusive and accessible educational strategies. Tailored outreach efforts, multilingual programming, and community-based learning models could help bridge the participation gap, particularly in diverse urban contexts like Brussels. Integrating environmental education into schools, public events, and local media could also enhance visibility and encourage broader participation.

Additionally, the analysis of citizen involvement in environmental education activities, alongside the previous figure on participation in participatory activities, reveals a critical interrelationship between the two indicators. Notably, while 33% of respondents reported never having participated in participatory activities related to NbS, they nonetheless expressed interest in doing so. Similarly, over 80% of respondents indicated little to no involvement in environmental education activities. These parallel trends suggest that low engagement in one domain may reinforce disengagement in the other, creating negative externalities that weaken both participatory governance and environmental awareness. A lack of understanding or exposure to environmental education may limit individuals' confidence or motivation to take part in participatory activities, while limited participation may reduce opportunities for informal learning and knowledge exchange. This mutual reinforcement of disengagement highlights the need for integrated strategies that may simultaneously address both gaps.

In the context of ICAs, strengthening environmental education is essential for building a well-informed and engaged citizenry. It fosters a deeper connection between individuals and their environment, promotes pro-environmental behavior, and enhances the capacity of communities to contribute meaningfully to sustainability initiatives. Therefore, increasing citizen involvement in environmental education should be a strategic priority for policymakers and urban planners aiming to advance socially inclusive and ecologically resilient urban development.

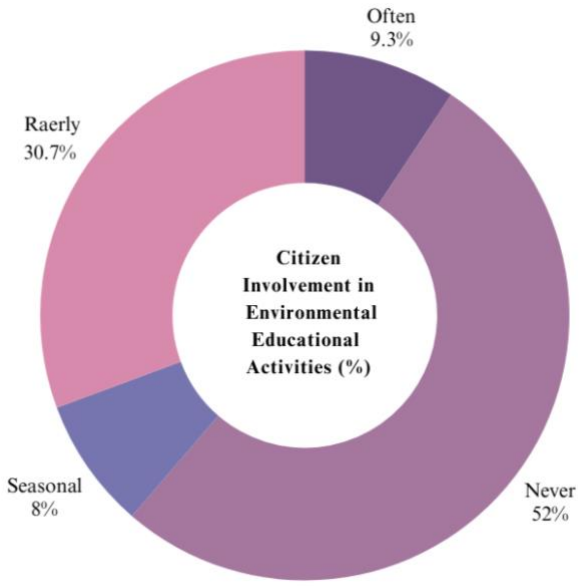

Figure 14 Outcomes of Citizen Involvement in Environmental Education Activities

4.4. Perceived Quality of Urban Spaces

The perceived quality of urban spaces is a critical dimension in evaluating the social effectiveness of NbS, as it reflects how residents experience and assess their urban environment. The survey explored five key aspects: the appeal of NbS, attachment to NbS, maintenance of NbS, safety of the area, and the vibrancy of cultural events.

As shown in Figure 15, respondents expressed high levels of satisfaction with the appeal of NbS, indicating that the visual and aesthetic integration of green infrastructure into the urban landscape is well-received. This positive perception suggests that the design and placement of NbS contribute meaningfully to the enhancement of public spaces and the overall urban experience.

Similarly, the attachment to NbS was met with favorable responses. Many participants reported a sense of connection to these spaces, which is essential for fostering place identity and encouraging long-term community stewardship. Emotional bonds with urban green spaces can enhance civic pride and promote sustained engagement with environmental initiatives.

The maintenance of NbS received more varied feedback. While a majority of respondents expressed satisfaction, a considerable portion reported neutral or dissatisfied views. This indicates that although maintenance efforts are generally effective, there may be inconsistencies in upkeep or unmet expectations in certain areas. Ensuring reliable and high-quality maintenance is essential to preserve both the functionality and public perception of NbS over time.

Perceptions of safety within NbS were mixed and emerged as a notable area of concern. While the majority of responses were generally positive, safety was a more sensitive and nuanced issue. Some respondents reported feeling unsafe, and a noticeable portion expressed neutral views. This highlights the importance of addressing safety explicitly in NbS planning through integrated approaches that consider both environmental and social factors—such as improved lighting, visibility, and community policing—to ensure all users feel secure in these spaces.

The vibrancy of cultural events associated with NbS spaces received the least positive feedback. Many respondents indicated a lack of cultural programming or community events, pointing to an underutilization of these spaces for social and cultural engagement. Enhancing the cultural dimension of NbS through inclusive and diverse programming could significantly improve their social value and relevance to local communities.

Here, it is also possible to see a connection with the previous indicators, which showed a remarkable number of people expressing willingness to participate in NbS-related activities despite never having done so. With a comprehensive and inclusive strategy—strengthened by the complementarity of cultural events and community involvement—it may be possible to bridge these two gaps, namely low participation and lack of cultural engagement, at once.

In summary, while NbS are generally appreciated for their aesthetic and emotional contributions to urban life, the findings suggest opportunities for improvement in maintenance, safety, and cultural activation. Addressing these aspects is essential to ensure that NbS function not only as ecological interventions but also as inclusive and socially enriching components of the urban fabric.

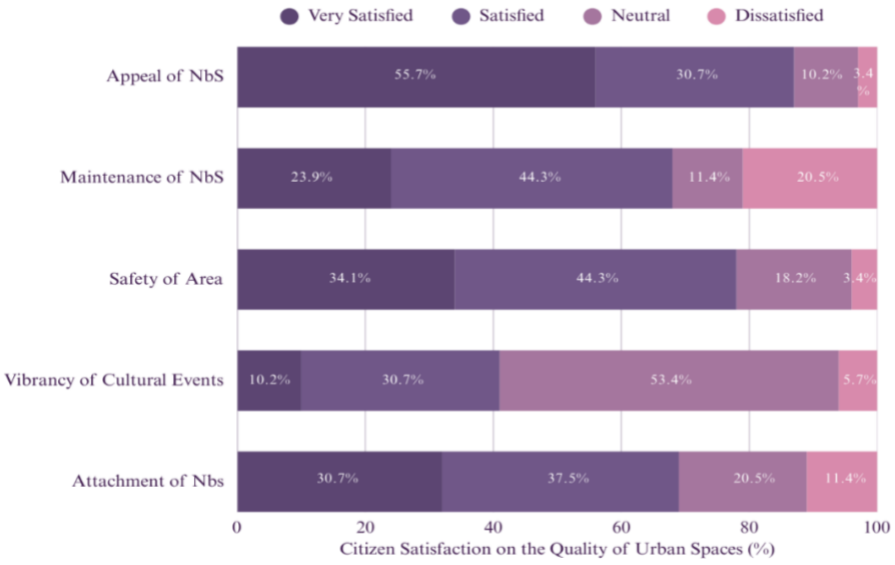

Figure 15 Outcomes of Perceived Quality of Urban Spaces

4.5. Estimated Morbidity and Mortality

The assessment of estimated morbidity and mortality, as reflected through self-reported changes in physical and mental well-being, provides valuable insights into the health-related impacts of NbS in urban environments. This indicator captures residents' perceptions of how NbS have influenced their overall health, particularly in terms of stress reduction, physical activity, and general wellness.

As shown in figure 16, the survey results indicate a strong positive perception of the health benefits associated with NbS. In terms of physical well-being, a substantial 64.8% of respondents reported that their well-being had increased significantly, while an additional 21.6% noted a moderate improvement. Only 12.5% reported no noticeable change, and a minimal 1.1% indicated a decline. These findings suggest that the presence of NbS contributes meaningfully to promoting physical health, likely through increased opportunities for outdoor activity, improved air quality, and enhanced access to green spaces.

Similarly, the data on mental well-being reflect a highly favorable outcome. A majority of 67% of respondents reported a significant improvement in their mental health, with 19.3% experiencing a moderate increase. Neutral responses accounted for 11.4%, while only 2.2% reported a decline. These results underscore the psychological benefits of NbS, which may include stress relief,

enhanced mood, and a greater sense of calm and connection to nature. The mental health benefits are particularly relevant in urban contexts, where exposure to natural environments can serve as a counterbalance to the pressures of dense, fast-paced city life.

The overwhelmingly positive responses across both dimensions of well-being highlight the potential of NbS to serve as public health assets. By fostering environments that support both physical activity and mental restoration, NbS contribute to reducing the burden of disease and enhancing quality of life. These outcomes align with broader public health goals and reinforce the value of integrating green infrastructure into urban planning as a preventive health strategy.

In conclusion, the findings from this indicator demonstrate that NbS are perceived not only as ecological and aesthetic enhancements but also as critical contributors to individual and community health. Their role in promoting physical and mental well-being strengthens the case for their inclusion in inclusive climate action strategies and underscores their multifunctional value in sustainable urban development.

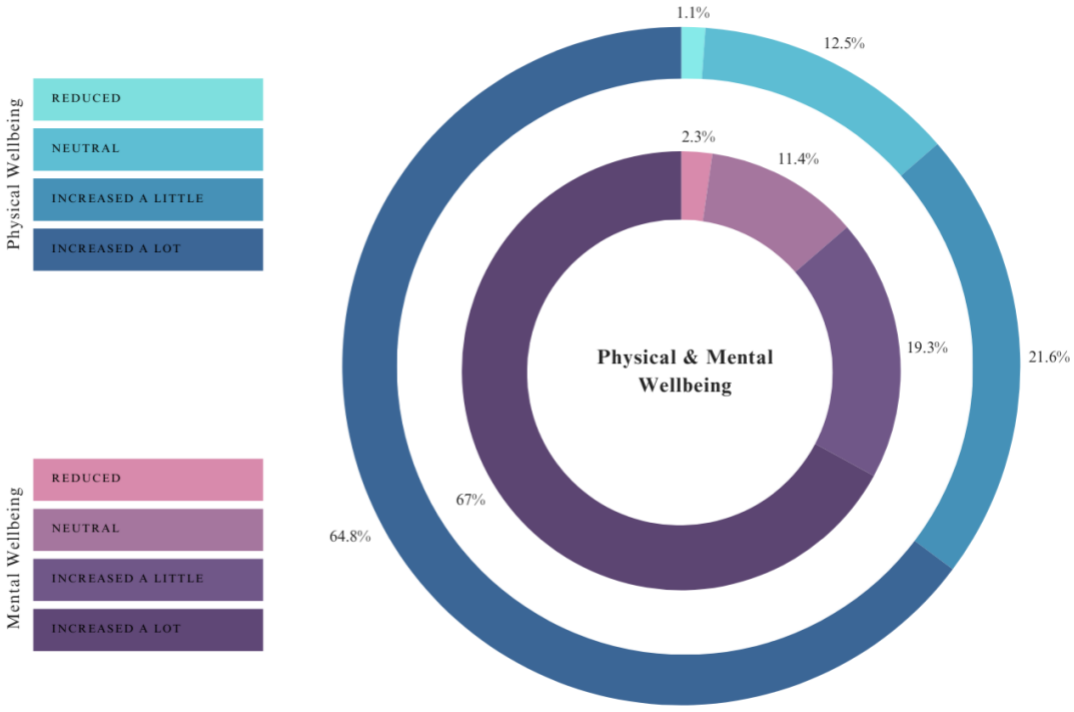

Figure 16 Outcomes of Estimated Morbidity and Mortality

4.6. Comparative Assessment of Case Studies Outcomes

The comparative analysis of participant engagement in daily life across the three case studies—Cognassier Water Path, Living Pannenhuis, and Tram Line 9—reveals noticeable differences in how NbS have been integrated into the everyday experiences of local residents.

As indicated in Figure 17, the Cognassier Water Path project demonstrates the highest level of daily engagement, with 92.00% of respondents indicating that the NbS intervention is actively part of their routine or lifestyle. This exceptionally high rate suggests that the project has successfully embedded ecological and social functions into the fabric of the community, likely through accessible design, multifunctional spaces, and strong community ownership.

Living Pannenhuis follows with a substantial engagement rate of 78.13%, indicating that the intervention has also achieved meaningful integration into residents' daily lives. While slightly lower than Cognassier, this figure still reflects a strong connection between the NbS and the local population, suggesting that the space is regularly used and valued for its environmental and social benefits.

In contrast, Tram Line 9 shows a comparatively lower engagement rate of 54.84%. Although over half of the respondents report daily interaction with the NbS, the figure suggests that the project may be less embedded in the community's routine or may serve more specialized functions, such as transit-related improvements, rather than broader social or recreational uses.

These findings highlight the importance of designing NbS projects that are not only environmentally effective but also socially embedded and accessible. Projects that facilitate regular interaction and serve multiple community needs tend to foster stronger engagement, which is essential for long-term sustainability and public support. The variation in engagement levels across the case studies underscores the need for context-sensitive design and inclusive planning processes that prioritize everyday usability and relevance to local residents.

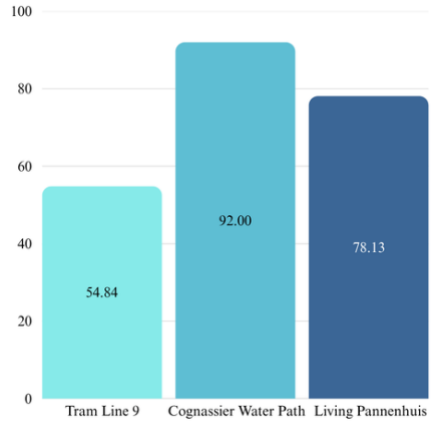

Figure 17 Participant Engagement in Daily Life Across Projects (%)

4.6.1. Citizen Involvement in Participatory Process Across Projects

As shown in Figure 18, the Cognassier Water Path project achieved the highest level of participation, with 28.00% of respondents reporting involvement in participatory processes. This reflects the project's effectiveness in enabling inclusive and participatory governance.

In contrast, Tram Line 9 reported a lower participation rate of 9.68%, indicating more limited opportunities for citizen involvement and suggesting that participatory processes were not central to the project's implementation. Living Pannenhuis showed the lowest level of engagement, with only 6.25% of respondents involved. This minimal participation may reflect a lack of participatory infrastructure or weak communication with the local community.

These findings underscore the importance of embedding participatory practices into the design and execution of NbS projects. Projects that actively involve citizens in decision-making processes are more likely to align with local needs, build trust, and ensure long-term sustainability. The variation in participation levels across the case studies highlights the need for tailored engagement strategies that consider the specific social and institutional contexts of each urban area.

In addition, when compared with levels of daily engagement, a clear correlation emerges; projects with higher participatory involvement also exhibit stronger integration into residents' daily lives. For example, Cognassier Water Path not only recorded the highest participation rate but also the highest level of daily engagement (92.00%). This pattern suggests that participatory design may play a critical role in enhancing community ownership and the routine use of NbS. Conversely, the lower participation rates observed in Living Pannenhuis and Tram Line 9 correspond with more modest levels of daily engagement, underscoring the importance of inclusive planning in promoting sustained interaction and community support.

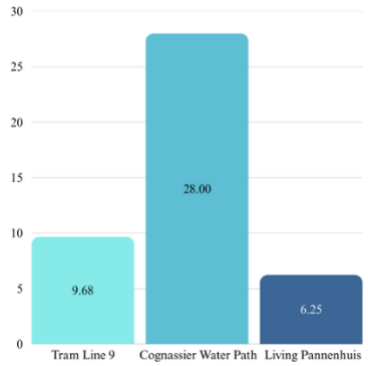

Figure 18 Citizen Involvement in Participatory Process Across Projects (%)

4.6.2. Citizen Involvement in Environmental Education Activities Across Projects

The comparative analysis of citizen involvement in environmental education activities across the three case studies—Tram Line 9, Cognassier Water Path, and Living Pannenhuis—reveals notable variations in levels of engagement.

As indicated in Figure 19, among the three, Cognassier Water Path demonstrated the highest level of involvement at 20.00%, suggesting a strong emphasis on educational outreach and community learning. Living Pannenhuis followed with a participation rate of 9.38%, indicating moderate engagement, while Tram Line 9 recorded the lowest level at 6.45%.

These variations reflect differing degrees of integration of educational components within each project. Higher levels of educational engagement, as observed in the Cognassier case, may have contributed to increased environmental awareness and a stronger sense of community connection, thereby reinforcing the social impact of the NbS. In contrast, lower participation in the other two cases suggests missed opportunities to build similar levels of awareness and involvement.

These findings highlight the importance of incorporating targeted and inclusive educational strategies into NbS initiatives. Projects that actively promote environmental learning tend to cultivate deeper community engagement and long-term support. As such, the evidence underscores the need for future NbS planning to prioritize environmental education as a fundamental element, particularly for initiatives seeking to advance social inclusivity and sustainability.

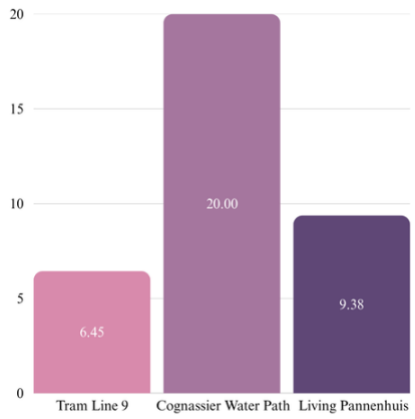

Figure 19 Citizen Involvement in Environmental Education Activities Across Projects (%)

4.6.3. Perceived Quality of urban Spaces Across Projects

The comparative evaluation of perceived urban space quality across the three NbS case studies—Tram Line 9, Living Pannenhuis Roundabout, and Cognassier Water Path—reveals distinct patterns in how residents experience and value these interventions. While aesthetic appeal was

consistently rated positively, other dimensions such as maintenance, safety, cultural vibrancy, and emotional attachment varied significantly.

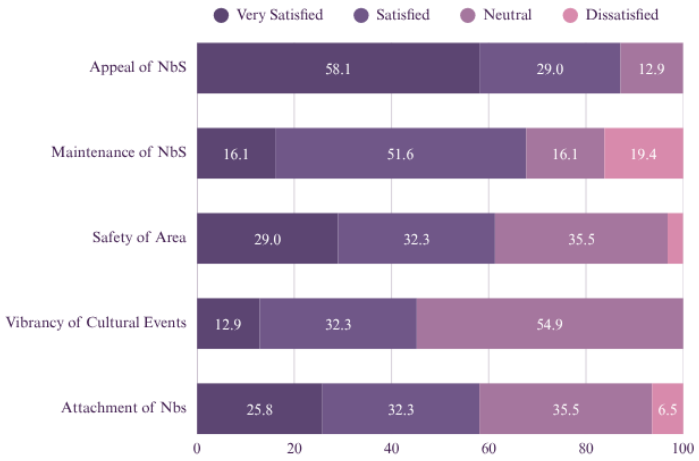

Figure 20 Tram Line 9: Citizen Satisfaction on the Quality of Urban Spaces (%)

Among all three sites, Tram Line 9 exhibits the highest concentration of positive perceptions for the appeal of NbS, with 58.1% Very Satisfied and 29% Satisfied. Maintenance satisfaction is moderate (67.7% total satisfaction), yet 19.4% expressed dissatisfaction, indicating room for improvement. Safety perceptions are fragmented: only 29% were Very Satisfied, while a significant 35.5% were Neutral, suggesting an ambiguous public sentiment. Cultural vibrancy and emotional attachment show weaker outcomes; over half (54.9%) were Neutral about cultural events, and attachment to NbS received only 25.8% Very Satisfied, implying less emotional engagement with the space.

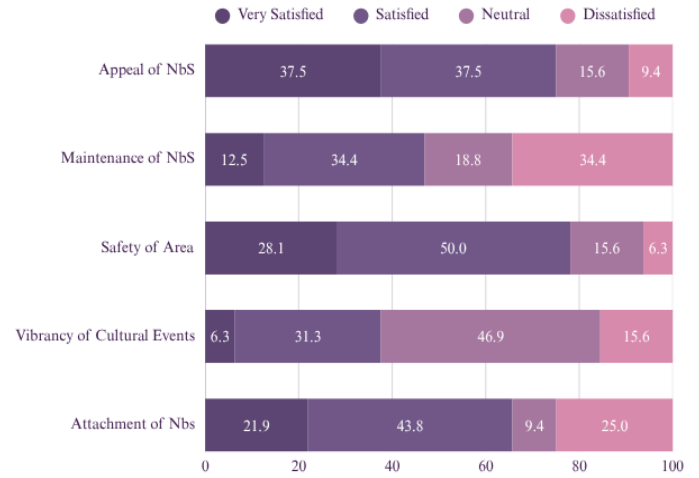

Figure 21 Living Pannenhuis Roundabout: Citizen Satisfaction on the Quality of Urban Spaces (%)

This site reflects a mixed satisfaction profile. Although Appeal of NbS received positive ratings (37.5% Very Satisfied, 37.5% Satisfied), perceptions of maintenance were more polarized—34.4% Dissatisfied, equal to those Satisfied. This sharp division suggests maintenance is a point of contention. Interestingly, Safety of Area was positively perceived (50% Satisfied, 28.1% Very Satisfied), likely reflecting physical improvements from redesigning the roundabout. However,

Cultural Vibrancy and Attachment received less enthusiasm, with 15.6% dissatisfaction in cultural activities and 25% dissatisfaction for attachment, hinting at a lack of deeper communal resonance or insufficient programming.

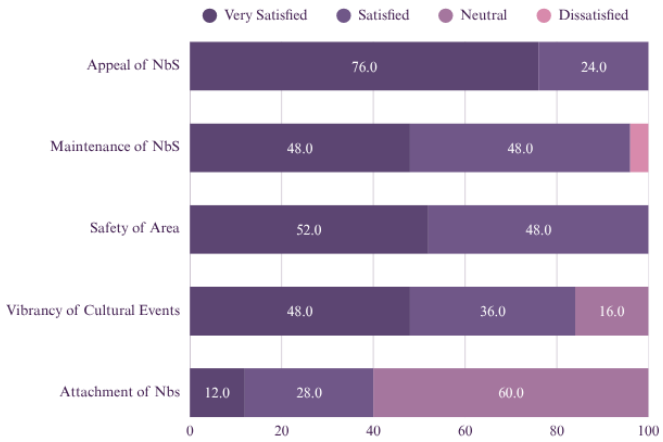

Figure 22 Cognassier Water Path: Citizen Satisfaction on the Quality of Urban Spaces (%)

This case shows exceptionally high satisfaction regarding both Appeal (76% Very Satisfied) and Safety (52% Very Satisfied, 48% Satisfied), distinguishing it as the most favorably received project. Maintenance was also well-perceived, with no respondents expressing dissatisfaction. Yet, the Attachment to NbS scored lower than expected, with 60% of respondents Neutral, suggesting that while the physical space is appreciated, emotional connection remains underdeveloped. The Cultural Vibrancy dimension also remains mixed, showing 16% dissatisfaction despite reasonable positive responses.

In Overall, when compared to the overall responses, each project demonstrates distinct strengths and weaknesses in perceived urban space quality. Cognassier Water Path stands out for its exceptional visual appeal, significantly exceeding the overall satisfaction average, but it underperforms in maintenance, safety, and cultural vibrancy, with nearly half of respondents expressing dissatisfaction in these areas. Tram Line 9 aligns closely with the overall averages in most categories, particularly in safety and attachment, but shows weaker performance in cultural vibrancy and maintenance. Living Pannenhuis Roundabout performs well in safety, surpassing the overall average, but records higher dissatisfaction in maintenance and lower engagement in cultural and emotional dimensions. These comparisons highlight that while aesthetic success is common, consistent maintenance, cultural programming, and inclusive design remain critical for aligning NbS projects with broader public expectations and the goals of ICAs.

4.6.4. Estimated Morbidity and Mortality Across Projects

The evaluation of estimated morbidity and mortality across the three NbS projects—Cognassier Water Path, Living Pannenhuis Roundabout, and Tram Line 9—offers critical insights into the perceived health impacts of urban green interventions. Rather than relying on clinical data, this

assessment draws on self-reported changes in physical and mental well-being, providing a community-centered perspective on how NbS influence everyday health outcomes. The results highlight not only the direct benefits of improved environmental quality but also the indirect effects of social engagement, emotional attachment, and routine interaction with green spaces on residents' overall wellness.

Among the three projects, Cognassier Water Path stands out, with the highest proportion of respondents (76%) reporting a significant improvement in their physical well-being. This suggests that the project's design and accessibility effectively encouraged physical activity and outdoor engagement. Living Pannenhuis follows, with 62.5% of participants noting a positive change, while Tram Line 9 registers a slightly lower rate at 58.1%. These variations in impact likely reflect differences in spatial design, usability, and integration into residents' daily routines.

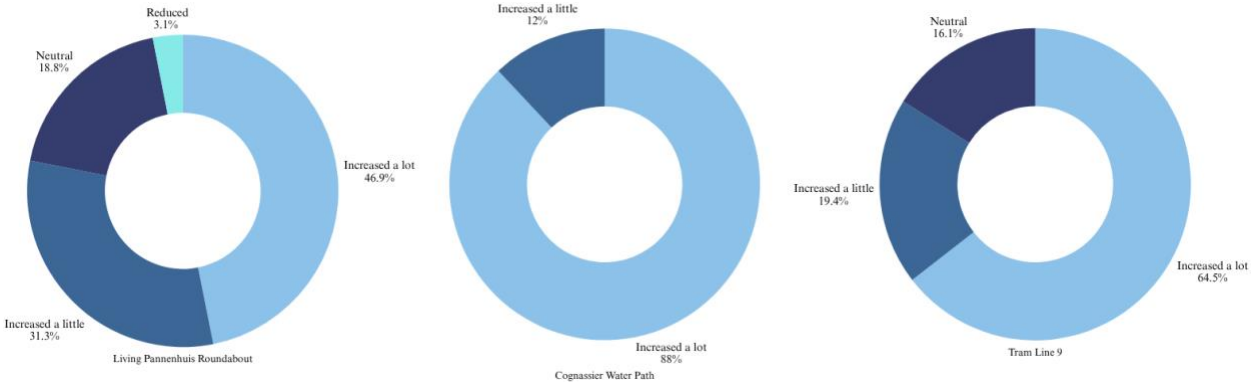

Figure 23 Physical Wellbeing Across Projects (%)

In terms of mental health, the Cognassier Water Path again leads, with 80% of respondents reporting a significant improvement. This is followed by Living Pannenhuis at 68.8% and Tram Line 9 at 64.5%. The higher mental well-being scores associated with Cognassier may be attributed to its immersive natural features and stronger community engagement, which foster a sense of tranquility and emotional connection to the space.

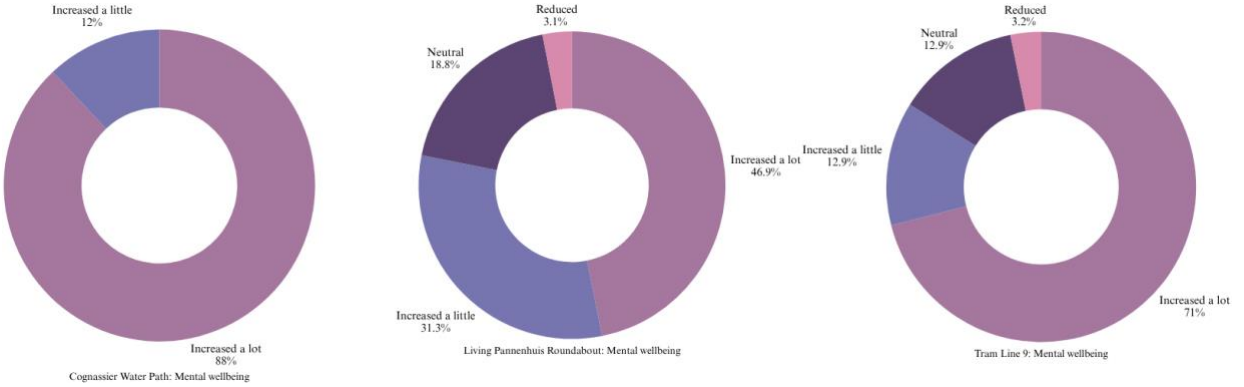

Figure 24 Mental Wellbeing Across Projects (%)

Notably, Cognassier Water Path, which demonstrated the highest perceived health benefits, also recorded the highest rate of citizen participation (28%). This alignment suggests a meaningful correlation between participatory engagement and improvements in both physical and mental well-being. Active involvement in NbS projects appears to foster a sense of ownership and emotional connection, which in turn supports mental health and encourages regular physical interaction with the space. Moreover, projects that achieved higher levels of satisfaction in terms of aesthetics and emotional attachment—particularly Cognassier—tended to report stronger health outcomes overall. These findings align with existing literature linking access to well-maintained, attractive green spaces with reduced stress, increased physical activity, and improved general wellness, reinforcing the value of inclusive, community-centered design in NbS implementation.

In conclusion, the health impacts of NbS projects are not isolated outcomes but are closely interconnected with broader social dimensions such as participation, education, perceived environmental quality, and frequency of use. Projects that successfully integrate these components—such as Cognassier Water Path—are more likely to deliver substantial and multifaceted health benefits. These correlations highlight the necessity of adopting holistic and inclusive approaches to NbS design and implementation in order to maximize their multifunctional value.

4.7. Outcomes and Correlations between Indicators

The analysis of Citizen Involvement in Environmental Education Activities, alongside Participation in Participatory Processes, reveals a critical interrelationship between these two indicators. Notably, while 33% of respondents reported never having participated in participatory activities related to NbS, many of them nonetheless expressed interest in doing so. Among those who had participated, 30% indicated they had done so only once, suggesting that many experiences were isolated rather than sustained. Regular and ongoing engagement remains limited.

Similarly, over 80% of respondents reported little to no involvement in environmental education activities. These parallel trends suggest that low engagement in one domain may reinforce disengagement in the other, creating negative externalities that weaken both participatory governance and environmental awareness. A lack of understanding or exposure to environmental education may limit individuals' confidence or motivation to take part in participatory activities. Conversely, limited participation may reduce opportunities for informal learning and knowledge exchange. This mutual reinforcement of disengagement highlights the need for integrated strategies that simultaneously address both gaps.

A comprehensive planning approach could help bridge these divides. Offering high-quality, accessible, and inclusive environmental education programs may not only increase awareness of NbS but also foster greater participation in related initiatives. Such programs can serve as entry

points for long-term civic engagement and help build sustained relationships between citizens and urban sustainability efforts.

Further supporting this interconnection, data from the Perceived Quality of Urban Spaces indicator (Figure 15) show that the vibrancy of cultural events associated with NbS spaces received the least positive feedback among all measured dimensions. This suggests that the quality and relevance of cultural programming may not meet public expectations and could be contributing to lower levels of engagement in both educational and participatory activities. Weaknesses in one area—such as cultural activation—may therefore have cascading effects on other social dimensions of NbS.

Finally, the Estimated Morbidity and Mortality indicator reinforces the importance of participatory engagement. The project that recorded the highest rate of citizen participation also demonstrated the most significant improvements in both physical and mental well-being. This alignment suggests a meaningful correlation between participatory engagement and perceived health benefits, underscoring the broader social value of inclusive NbS planning.

In summary, the findings demonstrate that the four social indicators—participatory involvement, environmental education, perceived quality of urban spaces, and health outcomes—are not isolated metrics but are deeply interconnected. Weaknesses in one area can undermine progress in others, while strengths can reinforce positive outcomes across the board. These interdependencies highlight the need for holistic, cross-cutting strategies in NbS planning that integrate education, participation, cultural relevance, and health promotion to foster more inclusive and resilient urban environments.

4.8. Final Remarks

Chapter 4 has presented a comprehensive analysis of the social impacts of NbS implemented in Brussels, focusing on four key indicators: citizen involvement in participatory activities, engagement in environmental education, perceived quality of urban spaces, and estimated morbidity and mortality. Through a comparative assessment of three case studies—Cognassier Water Path, Living Pannenhuis Roundabout, and Tram Line 9—the chapter has highlighted both the strengths and limitations of each project in fostering inclusive climate action and enhancing community well-being.

The findings reveal that while all three projects contributed positively to urban sustainability, Cognassier Water Path consistently outperformed the others across multiple indicators. Its high levels of citizen participation, frequent daily engagement, and strong emotional attachment correlated with the most significant improvements in both physical and mental well-being. This suggests that inclusive design, accessibility, and community-centered planning are critical drivers of NbS success.

Conversely, the relatively lower scores in environmental education and cultural vibrancy across all projects point to missed opportunities for deeper public engagement and long-term behavioral change. These gaps underscore the need for more integrated strategies that combine ecological interventions with educational outreach and cultural programming.

Importantly, the chapter demonstrates that the social impacts of NbS are not isolated outcomes but are deeply interconnected. Participation, education, perceived quality, and health benefits reinforce one another, forming a holistic framework through which NbS can support sustainable urban transitions. Projects that embrace this interconnectedness—by embedding inclusive governance, fostering emotional bonds, and promoting routine interaction—are more likely to achieve lasting social and environmental benefits.

In summary, As indicated in Figure 25, the results affirm the multifunctional value of NbS and their potential to serve as catalysts for inclusive, resilient, and health-promoting urban environments. They also provide actionable insights for policymakers and urban planners, emphasizing the importance of participatory processes, educational engagement, and culturally responsive design in future NbS initiatives.

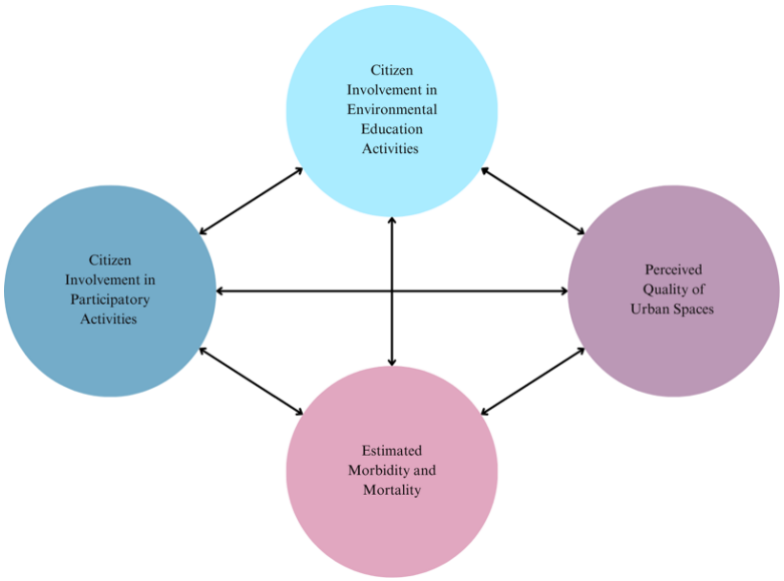

Figure 25 Interconnection of Social Indicators

5. Conclusion and Further Recommendations

This chapter concludes the thesis by synthesizing the key insights gained from the assessment of social indicators within the NbS for more ICAs in Brussels. Building upon the empirical findings and comparative analysis presented in the previous chapters, it reflects on the broader implications of the study for urban sustainability and participatory governance. The chapter begins by summarizing the main outcomes derived from the evaluation of selected social indicators, highlighting the strengths and limitations of the NbS projects examined. It then outlines the study's contributions to academic knowledge and practical urban planning. Finally, it presents a set of forward-looking recommendations aimed at enhancing the design, implementation, and evaluation of future NbS initiatives. These recommendations are grounded in the lived experiences of local communities and emphasize the importance of inclusive, place-based approaches in fostering resilient and socially just urban environments.

5.1. Summary of key findings

This study explored the social impacts of NbS in Brussels through the lens of four key social indicators: citizen involvement in participatory activities, engagement in environmental education, perceived quality of urban spaces, and estimated morbidity and mortality. The findings provide a multidimensional understanding of how NbS contribute to urban well-being, inclusivity, and resilience.

- Citizen Participation: While overall participation in NbS-related activities was relatively low, a significant portion of respondents expressed interest in becoming involved. This indicates untapped potential for civic engagement, which could be activated through more inclusive and sustained participatory frameworks.

- Environmental Education: Engagement in environmental education activities was limited, with over 80% of respondents reporting little to no involvement. This highlights a critical gap in public awareness and environmental literacy, suggesting the need for more accessible and engaging educational initiatives.

- Perceived Quality of Urban Spaces: Respondents generally expressed high satisfaction with the aesthetic appeal and emotional value of NbS spaces. However, concerns were raised regarding maintenance, safety, and the lack of cultural programming, pointing to areas where social infrastructure could be strengthened.

- Health and Well-being: The most positively perceived outcome was the improvement in physical and mental well-being. A majority of respondents reported significant health

benefits, particularly in projects with higher levels of community engagement and daily use, such as Cognassier Water Path.

- Cross-Indicator Correlations: The findings demonstrated that the social impacts of NbS are not isolated but are deeply interconnected. Participation, environmental education, perceived quality of urban spaces, and health outcomes mutually reinforce each other, forming a comprehensive framework through which NbS can contribute to sustainable, inclusive, and resilient urban development. Higher levels of educational engagement and citizen involvement were associated with stronger environmental awareness, greater community connection, and improved well-being, while lower levels of participation reflected missed opportunities to fully realize the social potential of these initiatives.

  Additionally, the findings indicate that projects which actively engage citizens in decision-making processes are more likely to align with local needs, foster trust, and support long-term sustainability. The observed variation in participation levels across the case studies underscores the importance of context-sensitive engagement strategies. These differences suggest that participatory approaches must be tailored to the social, cultural, and institutional characteristics of each urban area in order to enhance inclusivity and effectiveness in the implementation of NbS.

Collectively, these findings underscore the multifunctional value of NbS and their potential to support inclusive, sustainable, and health-promoting urban environments. However, they also highlight areas for improvement, particularly in fostering long-term civic engagement, expanding environmental education, and addressing social dimensions such as safety and cultural inclusion.

5.2. Contributions to knowledge

This thesis contributes to the growing body of interdisciplinary research on NbS by offering a comprehensive, empirically grounded assessment of their social impacts in support of more ICAs. While much of the existing literature has focused on the environmental and ecological benefits of NbS (Kabisch et al., 2017; Seddon et al., 2021), this study addresses a critical gap by systematically evaluating their social dimensions—particularly in urban contexts where inclusivity, equity, and community engagement are essential for sustainable development (Frantzeskaki et al., 2019; Walker et al., 2024).

One of the primary contributions of this research lies in the development and application of a place-based framework for assessing the social impacts of NbS. Drawing on the European GREEN-INC initiative, the study operationalizes a set of social KPIs that include citizen involvement in participatory processes, engagement in environmental education, perceived quality of urban spaces, and self-reported physical and mental well-being. These indicators were selected and

adapted to reflect the lived experiences of residents in Brussels, thereby offering a context-sensitive and scalable approach to social impact assessment—directly addressing the need for robust, interdisciplinary tools that capture procedural justice, distributional equity, and cultural relevance (Seddon et al., 2021; Vicarelli et al., 2023).

Methodologically, the thesis advances the field by integrating participatory research techniques with structured survey design and multilingual data collection. The use of in-person pop-up sessions and multilingual questionnaires ensured inclusivity and accessibility, particularly in a multicultural urban setting like Brussels. This approach not only enhanced the reliability of the data but also demonstrated the value of direct citizen engagement in evaluating the effectiveness of NbS—responding to calls for more inclusive governance models and co-creation practices in NbS planning (Reed et al., 2009; Pretty, 1995).

Empirically, the findings provide new insights into how NbS influence social outcomes at the neighborhood level. The study reveals that while NbS are generally perceived positively in terms of aesthetic appeal and emotional attachment, there are notable challenges related to maintenance, safety, and cultural vibrancy. Furthermore, the research highlights the significant health benefits associated with NbS, particularly in terms of improved mental and physical well-being. These findings underscore the multifunctional value of NbS and their potential to serve as both environmental and social infrastructure in urban planning—addressing the gap in long-term, community-centered evaluations of NbS effectiveness (Jennings et al., 2017; Twohig-Bennett & Jones, 2018).

Theoretically, this thesis contributes to the discourse on sustainable urban transitions by emphasizing the importance of integrating social indicators into NbS evaluation frameworks. It reinforces the argument that ecological interventions must be accompanied by inclusive governance mechanisms and community-centered design to achieve long-term resilience and equity. By foregrounding the social dimensions of NbS, the study aligns with and extends the work of scholars advocating for more holistic and participatory approaches to climate adaptation and urban sustainability (Raymond et al., 2017; Frantzeskaki et al., 2019).

Finally, the thesis offers practical contributions for policymakers, urban planners, and practitioners. The insights derived from the Brussels case studies provide actionable recommendations for enhancing the social effectiveness of NbS, including strategies for increasing civic participation, improving maintenance practices, and embedding cultural programming into green infrastructure projects. These recommendations are intended to inform future NbS initiatives not only in Brussels but also in other European cities facing similar socio-environmental challenges—contributing to the scalability and institutionalization of NbS within urban governance systems (Albert et al., 2021; Nunes et al., 2021).

5.3. Limitations and Challenges

While this study offers valuable insights into the social impacts of NbS in Brussels, limitations should be acknowledged. These limitations relate primarily to the challenges of conducting inclusive social research in a diverse urban context, as well as practical and structural constraints that influenced data collection and engagement efforts. Recognizing these factors is important for interpreting the findings accurately and for guiding future research in similar settings.

5.3.1. Public Engagement in a Multicultural Urban Context

One of the main limitations of this project, as with many social impact assessment studies, lies in the inherent challenges of fostering meaningful public engagement at the local level. In particular, conducting research in a city as complex and cosmopolitan as Brussels presents unique obstacles. Brussels is home to a highly diverse and multinational population, with a wide range of cultural identities, languages, migration backgrounds, and religious affiliations. Engaging such a heterogeneous population in a research process that seeks to measure social impacts and community perceptions requires careful planning, inclusive methodologies, and a high degree of cultural sensitivity.

In practice, reaching out to residents across this wide spectrum of backgrounds proved to be both time-consuming and methodologically demanding. It was important to design engagement strategies that were accessible and respectful to all individuals, regardless of their language skills, social status, or prior involvement in environmental initiatives. As shown in figure 26, below, 46.6 percent of the individuals who participated in our survey were not born to Belgian parents. This statistic illustrates the multicultural nature of the participant group, but also underscores the complexity of ensuring representativeness and equity in the engagement process.

Subsequently, when compared to official demographic data, the composition of this study's respondents closely mirrors the population structure of the Brussels-Capital Region. According to Statbel (2024), only 24.8% of Brussels residents have a Belgian background, while 40.2% are Belgians with a foreign background and 37.2% are non-Belgians. In this study, 46.6% of participants reported not being born to Belgian parents, which aligns well with the regional demographic profile. This observation not only highlights the complexity of implementing socially inclusive initiatives in a multicultural urban context like Brussels, but also suggests that the survey sample is broadly representative of the city's diverse population. As such, it reinforces the validity of the findings and strengthens the relevance of the insights drawn from the data.

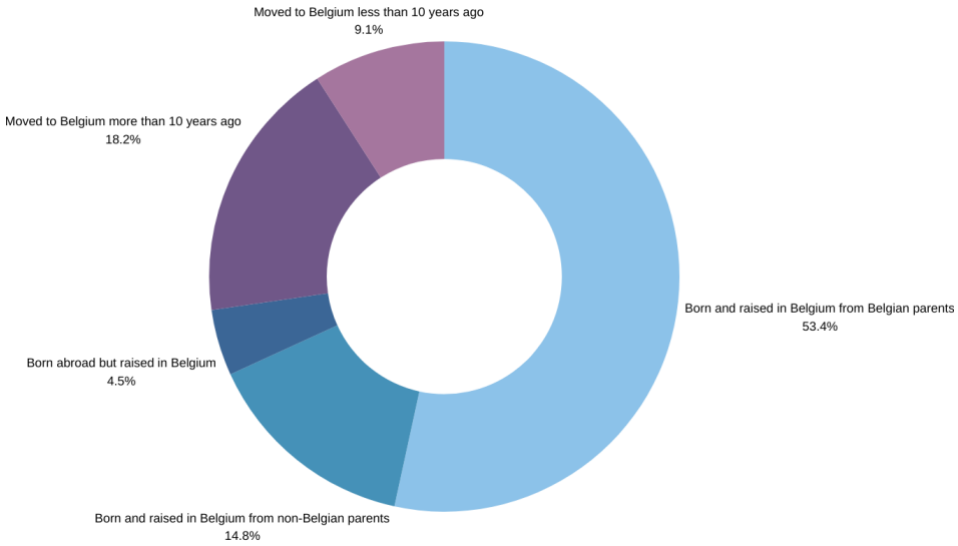

Figure 26 Respondent Demographics by Origin in Belgium

Such diversity, while greatly enriching to the overall social fabric of the city, made it particularly difficult to guarantee broad and inclusive participation across all demographic groups. Barriers such as language differences, varying levels of trust in institutions, differing environmental priorities, and unequal access to digital tools or public information all affected the extent to which people were willing and able to participate in the study. Consequently, achieving a high level of community engagement without compromising participants' rights to be heard or undermining the principles of equity and fairness proved to be a significant challenge. This issue must be acknowledged as a central limitation of the research. It also highlights the importance of designing more inclusive and adaptable engagement strategies in future studies, particularly those conducted in similarly diverse urban environments.

5.3.2. Bureaucratic and Institutional Complexity

Another significant challenge encountered in this research relates to Belgium's unique and complex bureaucratic structure. As a federal state with multiple linguistic and regional communities, Belgium operates under a multilayered governance system designed to reflect and accommodate its cultural diversity. While this structure is necessary and appropriate for ensuring representation across different linguistic groups, it also introduces administrative complexity that can hinder coordination and decision-making. The governance system is divided into municipal, regional, and national levels, each with distinct responsibilities and authority. This fragmentation can create challenges for the implementation of cross-cutting initiatives such as NbS, especially when efforts must align with policies and approvals across multiple levels of government (De Rynck, 2016).

Furthermore, the presence of two official languages—Dutch and French—adds an additional layer of complexity to both governance and research. Each administrative level may operate in a

different language, making communication and collaboration between institutions more difficult and time-consuming. This linguistic diversity, while culturally valuable, can result in slower decision-making processes and pose difficulties for researchers trying to build partnerships, obtain data, or engage in policy dialogue. These bureaucratic and linguistic challenges, inherent to Belgium's federal structure, must be acknowledged as key challenge of this study, particularly when considering the practical aspects of stakeholder engagement and institutional collaboration.

5.3.3. Age Representation

Another notable challenge encountered in this study pertains to the age distribution of participants. Engaging a broad age range in public research—especially on topics related to climate action and urban sustainability—often presents difficulties, as different age groups vary in their levels of interest, accessibility, and modes of civic participation. These generational differences can influence not only participation rates but also the perspectives shared during the research process.

In this study, the age distribution of respondents was relatively balanced across age groups. As illustrated in the Figure 27, approximately 35.2% of participants were over the age of 50, including 15.9% aged 50–60 and 19.3% aged over 60. Younger age groups were also well represented, with 10.2% under 20, 18.2% aged 20–30, and 14.8% aged 30–40. When compared to national statistics from Statbel (2024), which report that around 20% of the Belgian population is aged 65 and over, and approximately 59% falls within the 20–64 age range, the survey sample aligns closely with the actual demographic structure. This suggests that, despite the common challenges of age representation in public engagement research, the study successfully captured a diverse generational profile.

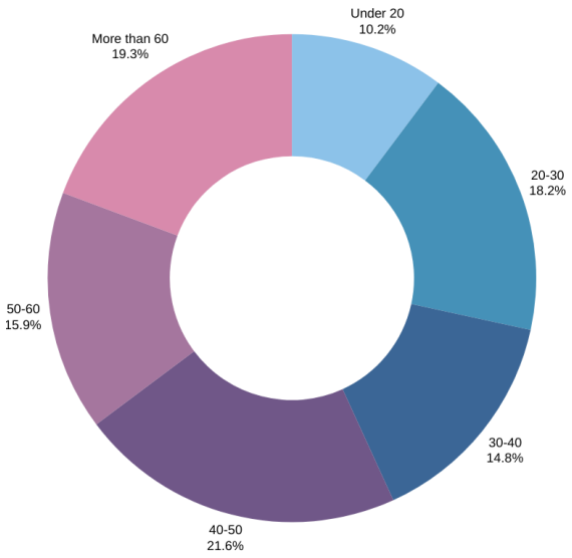

Figure 27 Age Distribution of Respondents

Also, to further support participation among older adults—who may face barriers related to digital literacy—physical (paper-based) surveys were distributed alongside digital formats. This dual approach proved effective in mitigating access issues and ensuring inclusivity. Existing research supports this strategy, noting that older individuals are generally less engaged with digital technologies, which can limit their involvement in online-based public research initiatives (Van Deursen & Helsper, 2015). While age representation is often a methodological concern, in this case, the data indicates that the challenge was met with a well-balanced and inclusive engagement strategy.

5.4. Recommendations

Drawing from the empirical findings presented in chapter 4 and in response to the research gaps outlined in Section 2.8, this section presents a set of targeted recommendations aimed at advancing the social effectiveness, inclusivity, and long-term integration of NbS within urban governance. These recommendations are grounded in the need for more robust social impact assessment, inclusive governance models, and scalable, context-sensitive approaches to NbS implementation.

- Develop and Apply Robust SAI Tools: To address the underutilization of SIA in NbS planning (Seddon et al., 2021), future projects should adopt interdisciplinary, place-based frameworks that incorporate both qualitative and quantitative indicators. These should include procedural justice, distributional equity, and cultural relevance to ensure a comprehensive understanding of social outcomes (Albert et al., 2021; Raymond et al., 2017).

- Institutionalize Inclusive Governance and Co-Creation: Given the limited research on effective participatory models (Reed et al., 2009; Frantzeskaki et al., 2019), NbS initiatives should embed co-creation and power-sharing mechanisms into their governance structures. This includes moving beyond consultative approaches to foster collaborative decision-making that empowers marginalized communities and builds long-term trust.

- Promote Long-Term and Adaptive Monitoring: To address the lack of longitudinal studies on NbS (Seddon et al., 2021), monitoring frameworks should be designed to capture social and ecological outcomes over extended timeframes. This will help assess the durability of benefits and the adaptive capacity of NbS under changing climatic and socio-political conditions.

- Enable Cross-City Comparative Research: To overcome the gap in comparative studies across diverse urban contexts (Kabisch et al., 2017), future research should support cross-city collaborations that examine enabling conditions, barriers, and best practices for

mainstreaming NbS. This will enhance the transferability of insights and inform policy at broader scales.

- Ground Global Frameworks in Local Realities: As highlighted in the Brussels case study, place-based research is essential for adapting global NbS frameworks to local needs (Walker et al., 2024). Future initiatives should prioritize context-sensitive design and evaluation, ensuring that NbS reflect the lived experiences and priorities of local communities.

5.4.1. Further Recommendation: Leverage Digital Tools for Inclusive and Adaptive Urban Governance

To support the implementation of the above recommendations and address persistent barriers to participation, monitoring, and scalability, the integration of digital tools should be prioritized across all new urban initiatives—not only NbS. Digital platforms such as citizen panels, mobile apps, and interactive dashboards can significantly enhance public engagement, communication, and data-driven planning.

These tools enable real-time feedback, broaden access to civic processes, and help overcome traditional barriers such as time constraints, language diversity, and digital exclusion. In multicultural cities like Brussels, digital platforms can be designed to support multilingual interfaces and inclusive participation, ensuring that diverse voices are heard and integrated into decision-making.

Moreover, digital tools facilitate efficient data collection and adaptive management, allowing planners to monitor social and environmental indicators continuously and respond quickly to emerging needs. This supports long-term evaluation and aligns with the call for more longitudinal and scalable approaches to NbS (Seddon et al., 2021).

As Van Deursen & Helsper (2015) emphasize, digital inclusion is essential for equitable civic engagement. Therefore, future urban strategies should embed digital infrastructures that are accessible, transparent, and responsive enabling faster, more inclusive, and more effective planning and governance across all domains of sustainable urban development.

References

- Adams, R. (2014). Urban design and the quality of urban spaces. Urban Studies Journal.
- Albert, C., et al. (2021). Social impact assessment for nature-based solutions. Environmental Science & Policy.
- Arnstein, S. R. (1969). A ladder of citizen participation. Journal of the American Institute of Planners, 35(4), 216–224.
- Asokan, G. V., et al. (2019). Survey design and data collection in urban studies. Urban Research & Practice.
- Berkes, F. (2009). Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. Journal of Environmental Management, 90(5), 1692–1702.
- Cohen-Shacham, E., et al. (2016). Nature-based solutions to address global societal challenges. IUCN.
- Costanzo, M. (2025). Data cleaning for social research. Journal of Data Science.
- De Rynck, S. (2016). Multilevel governance in Belgium. Public Administration Review.
- European Commission. (2023). Nature-based solutions policy framework. Brussels: EC Publications.
- Evergreen, S. D. H. (2017). Effective data visualization: The right chart for the right data. SAGE Publications.
- Fankhauser, S., et al. (2023). Social dimensions of climate resilience. World Bank Policy Research Working Paper.
- Few, S. (2009). Now you see it: Simple visualization techniques for quantitative analysis. Analytics Press.
- Frantzeskaki, N. (2019). Nature-based solutions for urban resilience. Urban Sustainability Journal.
- International Union for Conservation of Nature (IUCN). (2016). Global standard for nature-based solutions. IUCN Publications.
- IPCC. (2022). Sixth assessment report. Intergovernmental Panel on Climate Change.
- Jennings, V., et al. (2017). Urban green space and health equity. International Journal of Environmental Research and Public Health.

- Kabisch, N., et al. (2017). Nature-based solutions to climate change adaptation in urban areas. Springer.
- Kabisch, N., et al. (2021). Nature-based solutions and urban resilience. Springer.
- Kelleher, C., & Wagener, T. (2011). Data visualization in environmental science. Environmental Modelling & Software.
- Klein, R. J. T., et al. (2022). Social vulnerability and climate adaptation. Climate Policy Journal.
- Morrissey, J. (2000). Indicators of citizen participation. Community Development Journal.
- Nunes, L., et al. (2021). Citizen engagement in urban sustainability. Cities Journal.
- OECD. (2023). Civic engagement and public trust. OECD Publishing.
- Pellerey, V., & Torabi Moghadam, S. (2024). A place-based framework for assessing inclusive climate actions. Urban Sustainability & Security Lab.
- Raymond, C. M., et al. (2017). Nature-based solutions for urban resilience. Nature Sustainability.
- Reed, M. S., et al. (2009). Stakeholder participation for environmental management. Biological Conservation.
- Seddon, N., et al. (2021). Global recognition of nature-based solutions. Nature Climate Change.
- Statbel. (2024). Population structure of the Brussels-Capital Region. Belgian Statistics Office.
- Tomatis, A. (2023). Social vulnerability and climate change. Climate and Society Journal.
- Twohig-Bennett, C., & Jones, A. (2018). The health benefits of the great outdoors. Environmental Research.
- UN-Habitat. (2022). World cities report. United Nations Human Settlements Programme.
- United Nations. (2023). Climate action and sustainable development. UN Publications.
- Urban Brussels. (2024). Living Pannenhuis Roundabout and Tram Line 9 project reports. Brussels Regional Government.
- Vicarelli, M., et al. (2023). Social and economic impacts of NbS. Environmental Economics Review.
- Walker, G., et al. (2024). Equity and nature-based solutions in urban flood management. Environmental Justice Journal.

- World Bank. (2023). Building resilience through social protection. World Bank Group.
- World Health Organization. (2017). Urban green spaces and health. WHO Regional Office for Europe.