Exploring the costs and benefits of protecting and enhancing biodiversity in new residential developments

A Literature Review

July 2026

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Abstract

Overall, Nature-based Solutions (NbS) are seen as cost-effective, locally adapted, and innovative approaches, with an outsized impact. Along with frequently being able to offer the same functionality as traditional (grey) infrastructure, incorporating NbS into developments is shown to provide a multitude of concurrent benefits across environmental, social, and economic markers, whilst also enhancing resilience, and offering long-term adaptability. Although a wealth of generalised NbS information does exist in the literature, fully integrated cost-benefit analyses for NbS in new housing developments are not in abundance, certainly not in an Irish context. In fact, the reviewers did not encounter any study that could be said to account for the full comprehensive range of associated benefits that nature can provide in this type of context. Due to the compounding levels of complexity involved with each new metric added, studies (understandably) tend to focus on a subset of the most tangible and quantifiable parameters, often only focusing on one specific benefit that is most readily measurable. This presents challenges in making a coordinated and robust case for investment. However, despite the narrowly filtered lens through which studies are often conducted, positive Cost-Benefit Analyses (CBA) or Benefit-Cost Ratio (BCR) outcomes are still apparent, offering promise and potential for their integration.

Aside from the direct implementation of NbS measures, the integration of nature and biodiversity more broadly can be seen as a hugely valuable addition to new developments.
Access to green and blue spaces, and healthy habitats rich in biodiversity are clearly attractive selling points. Developers will often seek to emphasise the availability of, and proximity to these types of areas and natural features - reinforcing the long-held view of leafy suburbs as being highly sought-after places to live. Beyond mere compliance requirements, tick-box exercises, and optional aesthetics, nature can be viewed as a strategic and depreciable asset that is well worth investing in. Studies which seek to quantify the values that nature can provide often focus on a more generalised urban environment. Although not necessarily pertaining to new housing developments, the associated benefits can still be said to directly apply in many scenarios. The topic of rainfall (and water more generally) is highly relevant in an Irish context, the management of which regularly emerges throughout the research, where various applications of

Sustainable Urban Drainage Schemes (SuDS) are frequently seen as the preferred option over the more established and conventional hard engineering approaches. In terms of wider structural shifts that are needed - it is evident that enhanced collaboration between relevant stakeholders, wider policy integration, and acknowledgment of how private

developments can assist in addressing local and national biodiversity-related targets, will all be integral in advancing the case for NbS.

Introduction

With the premise that biodiversity and natural systems are not consistently conserved or enhanced during the creation of new residential developments, this document seeks to make the business case for nature, through a review of associated cost-benefit analysis-based research. This study offers numerous examples and clear evidence for the value of integrating nature and biodiversity in new housing developments. It foregrounds new insights and thinking, advocating for a recognition of natural elements as strategic assets and investments, rather than mere compliance costs.

Ireland is facing a 21st -century housing crisis (characterised by a target of building 300,000 new homes between 2025 and 2030) while simultaneously confronted with a national biodiversity emergency where over 90% of protected habitats are in poor, unfavourable status. Coupled with the increased severity and frequency of storms and rainfall events in Ireland (and the resultant heightened flood risks) there are growing calls for the central role that NbS can play as a mechanism in reconciling these seemingly competing demands, while helping to both mitigate and ameliorate impacts. In a rapidly changing climate, traditional hard engineering approaches may not be as effective - or may even exacerbate the problem. Conversely, the financial value of investing in nature can extend far beyond the project site, potentially providing multiple downstream benefits.

This academic and grey literature review can be seen as a prelude to a far more expansive piece of work that is required to create an even more tangible, and bespoke industry-ready resource. In terms of research methodology, it is almost exclusively a desk-based study, with minimal primary research conducted. Where this occurred, it took the form of consultation with subject–matter experts who were known to the project team. However, for the next stage of the project, a substantial primary research component will be required. In terms of structure, the document progresses from more general to more specific in how it approaches the subject. The first part of the document explores the broader context, including the role of natural capital, and making wider arguments for the integration of biodiversity, and for urban NbS in particular. This is followed by case studies and examples from both Ireland and the UK. The second part of the document then dives into the costs and benefits of specific NbS measures, with examples again from Ireland, the UK, and further afield.

This document is intended for professionals involved in residential development, planning, and investment, including property developers, sustainability managers, building designers, urban planners, and landscape architects, both in the public and private sectors. It offers a solid rationale for protecting and restoring biodiversity in new residential developments, particularly in the form of NbS.

About this project

This project was initiated in January 2026, with a first draft completed in February. In March, an online focus group was organised to sound check the document and to test its applicability with a small group of relevant stakeholders, helping to inform the direction of the study. The document was finalised in July 2026.

This research received support from the National Parks and Wildlife Service (NPWS) of the Department of Housing, Local Government & Heritage (DHLGH).

About the Irish Green Building Council

The Irish Green Building Council (IGBC) provides leadership for a sustainable built environment. The IGBC is a registered charity with over 480 corporate members drawn from all parts of the value chain, from occupiers, design professionals, contractors, suppliers, academics and public authorities, and is affiliated with a global network of 70 national councils within the World Green Building Council. This allows us to create workable solutions and tools to deliver transformative change towards a sustainable built environment. The IGBC is also the national partner of the Renovate Europe campaign in Ireland. Renovate Europe is the only EU-wide campaign focusing exclusively on ambitious renovation of the building stock in the EU and is the voice for energy-efficient renovations, taking a technology-neutral, integrated, and holistic approach to energy-efficient renovation.

The IGBC is looking to transform the Irish industry to sustainable practices through policy creation, education and the provision of tools to measure and accelerate progress.

Protecting and enhancing biodiversity in the built environment is one of the IGBC's priorities. Since 2022, the organisation has been running webinars and training for building professionals, as well as a successful multi-disciplinary community of practice that meets quarterly to discuss common challenges and learn from each other. This work has been complemented by several research projects, including the development of Irish

case studies on the protection and enhancement of biodiversity in our buildings, with funding from Construct Innovate and the Land Development Agency, as well as a report on key actions required to ensure the protection and enhancement of biodiversity becomes the new norm in residential developments. The latter was developed in partnership with Trinity College Dublin and with the support of the Housing Agency, through extensive stakeholder engagement. Further information on this work can be found at: here.

About Natural Capital Ireland

Natural Capital Ireland (NCI) is a not-for-profit organisation with a mission to value, protect, and restore Ireland's natural capital and ecosystem services. NCI is entering its second decade as the leading voice for the natural capital approach in Ireland, advocating for its integration into public policy and corporate strategy, promoting informed public and private sector decision-making, and assisting in the development of natural capital accounting. NCI is governed by a Board, administered by a Secretariat, and guided by a cross-sector Steering Committee comprising representatives from the private sector, academia, environmental NGOs, government departments and agencies, and other subject-matter experts. NCI has a growing national profile, with more than 6,700 followers across its social media channels and approximately 1,600 newsletter subscribers. Further information on NCI's research, publications, and activities is available on the Natural Capital Ireland website.

Defining the challenge

The upfront capital expenditure (CapEx) and ongoing operational expenditure (OpEx) costs of enhancing biodiversity and implementing NbS in new housing developments are borne by certain entities (e.g. private developers), yet they aren't necessarily the ones who directly experience or profit from the flow of benefits associated with enhancing natural systems. Correspondingly, the wider beneficiaries do not directly pay for the privilege. The multitudinous co-benefits that accrue from implementing these types of measures tend to be more long-term, less visible and less tangible. This phenomenon is quite widely documented, where for example it was noted in Lozano et al. (2024) that investments in urban NbS have proven particularly challenging as the benefits take time to accrue. A recent Dublin-based study assessing the **benefits of urban tree canopy found that they tend to be undervalued** as a resource in cost-benefit appraisals, due to the long-term accretive and distributed nature of beneficial returns (Clinton *et al.*, 2026).
It has been observed that **many ecosystem services are in fact public goods and provide multiple benefits which may not offer direct financial returns for the private sector** (United Nations Environment Programme, 2026). Similarly, a core challenge which has been identified is that to date most of nature's benefits have no financial market value, even though nature is fundamental to human survival and flourishing. By extension, it has been argued that there is limited discourse around the public good element of NbS, which acts as a considerable deterrent for private sector investment. Correspondingly, the vast bulk of urban NbS interventions are found to be publicly financed, where private entities (e.g. urban developers and private businesses) generally only engage with these measures in response to regulatory requirements (e.g. planning controls) or, sometimes as a result of private financial incentives or Social Licence to Operate (SLO) initiatives (European Investment Bank, 2023). Emerging in the late nineties, the term 'social license to operate' initially applied to extractive industries, where say a mining project is perceived to have the approval, and the broad acceptance of the wider society to conduct its operations. As such, it needs to be socially acceptable to the local community (Joyce and Thomson (2000) via (Lunshof, 2024).

This scenario presents a clear point of friction, a predicament for stakeholders - why should the relevant parties protect and invest in nature upfront? What is the motivation for them? This asymmetrical incentive environment could be said to be one of the primary (but by no means the only) reasons as to the widespread exclusion of NbS in the provision of new residential developments. Many other factors could be attributed, not least amongst those being part of the prevailing policy environment. The following example visually demonstrates the crux of the issue, where the public good elements of NbS clash with split incentives - which serves to restrict levels of private investment. A common example of the split incentives' dilemma can be seen in the tension between someone

who needs (and would benefit from) home energy improvements (e.g. a tenant) vs the party that has to make the investments (e.g. the landlord) (Jimenez, 2025). The hypothetical example below represents the redevelopment of a pocket park for climate resilience, with the incorporation of natural stormwater filtration, rainwater tanks for irrigation, and active and passive recreation opportunities. As can be seen, the **total sum of benefits associated with the investment (blue bars) outweigh its costs (red bars)**, yet the private monetizable benefits (e.g. the avoided cost of stormwater treatment, the avoided cost of irrigation for local community gardeners, and the carbon sequestration benefits) do not (European Investment Bank, 2023).

Figure 17 Illustration of costs and benefits of an urban nature-based solutions project[58]

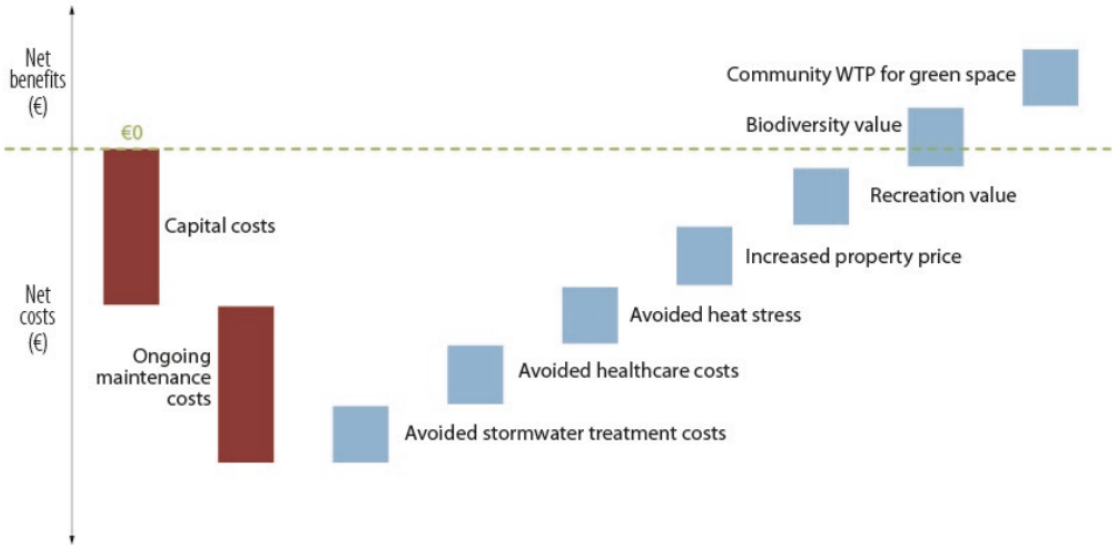

Fig.1: Schematic of associated costs and benefits of an urban NbS project (European Investment Bank, 2023)

Supposedly, a common misconception among developers is that **numerous (seemingly) competing obligations and priorities (i.e. protecting and enhancing biodiversity, protecting local landscapes, providing recreational opportunities, and advancing sustainable drainage)** are all separate concerns, and bring with them extra costs. However, **each of these elements can instead be viewed together in a far more unified way.**

Adopting a multi-functional green infrastructure approach can address these simultaneously, and thereby help to reduce costs, deliver high-quality developments, and engender a stronger sense of place
(Worcestershire County Council, 2015).

Context and background

The buildings and construction sector has a considerable impact on global climate change.

For Ireland, it's estimated that **the construction and built environment sectors account for 37% of carbon emissions**, on par with agriculture (IGBC, 2022). It's been noted that the built environment is the only sector in Ireland where emissions increased in 2024 (Climate Change Advisory Council, 2025). In addition to these emissions-based impacts, **the construction sector is said to be one of the biggest contributors to nature degradation**. The sector is hugely dependent on natural systems for providing crucial raw materials, along with flood regulation and climate stabilisation services (Global Canopy, 2026). As such, sector impacts on natural systems occur both directly on-site (e.g. through habitat destruction and fragmentation), and less visibly although possibly more insidiously through off-site activities in the wider supply chain, particularly regarding the extraction of raw materials and the production of end products (Jammet and Rondini, 2023). According to the UK Green Building Council, the built environment is *the* most resource-intense sector and they've been advocating for this concept of **Embodied Ecological Impacts**. Similar to embodied carbon, it seeks to address the effects of activities that impact on habitats and ecosystems through the extraction, manufacture, transport, installation, maintenance and end-of-life treatment of products required for use in the built environment (UKGBC, no date).

At its simplest, natural capital can be defined as 'the value of everything that comes from nature' (Knight, 2023). Natural capital is recognised as foundational to economic prosperity and human wellbeing (the 'world's most important asset') yet humanity's impact on the natural world has become grossly outsized, creating profound risks not just for the economy, but for the ability of well-being of current and future generations to survive and thrive (OECD, 2021). The industry is seen to represent a key leverage point in enabling a more nature-positive paradigm to emerge. Through funnelling investment and capital into more nature-centric designs (e.g. green roofs, urban forests and permeable pavements), the industry has the potential to facilitate a new infrastructure model, helping to reduce ecosystem loss and restore degraded landscapes (Global Canopy, 2026).

About Nature-based Solutions (NbS)

According to the European Commission, **NbS are 'actions which are inspired by, supported by or copied from nature', which 'use the features and complex system processes of nature, such as its ability to store carbon and regulate water flow, in order to achieve desired outcomes, such as reduced disaster risk, improved human well-being and socially inclusive green growth'** (European Commission, 2015). There is

increased awareness of the role of NbS in addressing pressing societal challenges, where they are seen as cost-effective, locally adapted, and innovative approaches that mobilise nature's intrinsic power, bringing natural processes into cities. NbS can actualise in some forms (e.g. green infrastructure) carrying with them a multitude of concurrent benefits across environmental, social, and economic sectors, whilst also enhancing resilience (Lozano *et al.*, 2024). As natural capital represents the foundation of successful solution implementation, it is critical to enhance its capacity (European Commission, 2015).

Nature-based Infrastructure (NBI) has been described as a subset of NbS, with a specific focus on infrastructure-type services such as flood control, water purification, and air quality enhancement, including measures such as wetland restoration and green roof installation. Along with providing many of the same functions as conventional infrastructure, **NbS and NBI often have lower ecological footprints while offering enhanced longer-term adaptability.** They also bring another dimension of value, i.e. a wide range of diverse co-benefits, ranging from the reduction of **urban heat island effect** to enhancing biodiversity (Contor, 2025). In their guidelines for planners on the design of low-carbon housing in Ireland, Barry *et al.* (2024) highlight the benefits of nature-based water attenuation (through SuDS) vs the more standard below-ground tanks. It showed huge reductions in runoff and can facilitate irrigation, while also enhancing biodiversity. Overall, the NbS option was shown to be far less carbon-intensive, particularly in reducing embodied carbon in the concrete that would be required. The **urban heat island effect** refers to the phenomenon whereby cities and built-up areas experience higher temperatures than surrounding areas. Where vegetation provides shade and cooling through natural processes, man-made surfaces & structures (e.g. concrete) tend to absorb and re-emit more heat (Gregory and Azarijafari, 2021).

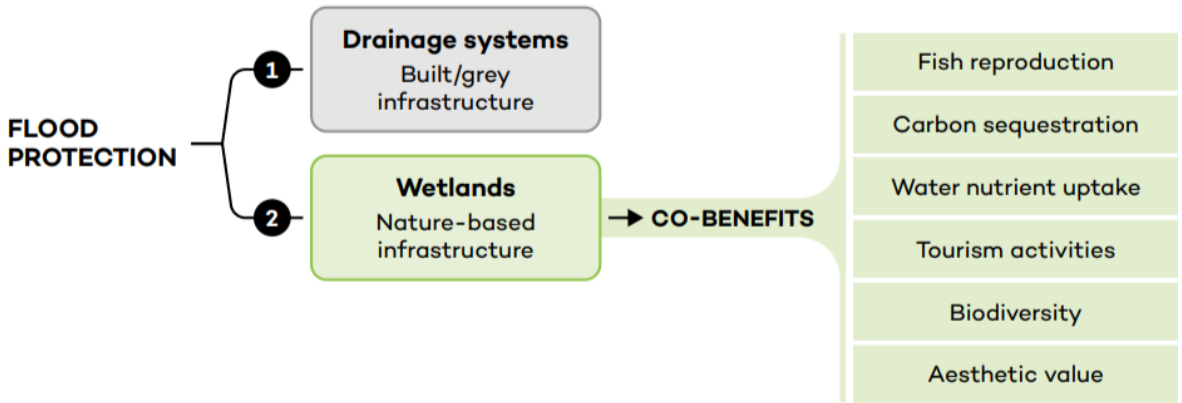

Fig.2: Simple diagram demonstrating the co-benefits of NbS vs. grey infrastructure (Contor, 2025)

Urban NbS

NbS tend to be broadly categorised, therefore 'urban' was most often selected as the closest proxy to residential (where residential is commonly seen as a subset of urban). For urban contexts, Invest4Nature have identified and categorised four different scales for NbS (Object, Neighbourhood, City, and Peri-urban) as displayed in the table below.

OBJECT	NEIGHBOURHOOD	CITY	PERI-URBAN
Buildings	Tree corridors	Green roofs at a systemic scale	Confluence parks combining river restoration with recreation
Eco-streets/green roads	Rebuilding a water stream	Blue-green city corridors	Forests
Green and pocket car parks	System of small canals linked to river		
Green roofs, walls and facades	Greening riverbanks		
Rain gardens	Redesign/redevelop former industrial/ residential areas		
Green playgrounds/ school grounds			
Vegetation dells			

In seeking to assess the co-benefits (and costs) of NbS in urban areas, Raymond *et al.*, (2017) developed an integrated framework that looked across 10 different societal challenges, which covered; Climate Mitigation and Adaptation, Water Management, Coastal Resilience, Green Space Management, Air Quality, Urban Regeneration, Participatory Planning and Governance Social Justice and Social Cohesion, Public Health and Well-being, and Economic Opportunities and Green Jobs. In recognising the interconnectedness and ripple effects of disparate issues, the authors found that **when a given NbS is directed towards a specific challenge, co-benefits are likely to be produced.** However, neutral effects as well as costs may incur for other challenges. The example given is of nature-centric flood peak reduction actions which can generate co-benefits for coastal resilience, and quality of life improvements. Conversely however, the

enhanced environmental qualities and associated increase in property value can also have knock-on effects for social justice and cohesion considerations, by amplifying gentrification.

Addressing the challenge: Making the case for NbS

To scale up NbS deployment, their economic value needs to be demonstrated, along with their integration into public finance and development strategies. Scaling investment in NbS can be achieved through showcasing their ability to generate revenues, and the cost-effectiveness of these types of interventions, which can be considerable when the totality of both public and private benefits of ecosystem services is quantified. It has been proposed that Environmental Impact Assessments (EIA) for the likes of infrastructure developments should have to account for the multiple additional benefits associated with ecosystem services (United Nations Environment Programme, 2026). At an EU level Molloy, Collier and Buckley (2024) note how NbS are increasingly being recognised for their contributory role in advancing significant EU policies as part of the European Green Deal - notably the EU Biodiversity Strategy for 2030 and the EU Adaptation Strategy - with their capacity for emissions reductions and climate adaption. Here, NbS are also seen as a valuable asset in the implementation of the EU Nature Restoration Law.

A systematic review assessing the application of cost-benefit analysis (CBA) for urban NbS found that CBAs tended to adopt a more social (as opposed to a private) perspective, where the emphasis was on building solutions and small-scale NbS measures. Notably, the authors found that **the costs associated with environmental externalities were largely absent, while only accounting for a limited number of benefits** (attributed to challenges in estimating their monetary values). Crucially however, they found that **the majority of studies demonstrated positive CBA outcomes, suggesting that NbS interventions are generally economically favourable** (Chelli, Brander and Geneletti, 2025). In previous work the same authors concluded that NbS offer economic advantages on a larger scale when compared to their scale of implementation (Chelli, Geneletti and Brander, 2023). In their policy brief looking at the benefit-to-cost ratio (BCR) of urban NBI, the researchers found that for all of the projects featured the BCR was greater than 1, indicating that investments produced a net positive result (Bechauf *et al.*, 2022).

A systematic review of NbS for disaster risk reduction (DRR) and climate change adaptation (CCA) found that NbS projects are substantially more effective in mitigating hazards than engineering-based solutions. Among the numerous studies assessed, 65% found that NbS are always more effective in attenuating hazards compared

to engineering-based solutions, while 26% found that NbS are partially more effective (Vicarelli *et al.*, 2024).

A key determinant of a sustainable city is the integration of NBI, where a study from the International Institute for Sustainable Development revealed superior cost-effectiveness and climate resilience of this approach. Based on case study evaluations they found that, for **NBI in cities, they are on average 42% cheaper and create 36% more value compared to solely depending on grey infrastructure, if avoided costs and co-benefits are considered** (Bechauf *et al.*, 2022). A study investigating the integration of NbS in high-rise residential developments in Vancouver found that for those built for sale, green features were exaggerated, misrepresented, or presented as future commitments. While in residential developments that were purpose-built for renting, integration was found to be more legitimate (Fung, 2025). The study indicated that **the practice of exaggerated sustainability claims (leading to greenwashing) can be attributed to the increase in desirability in incorporating these features into new developments.**

Urban NbS investment and market growth projections

The practice of investing in NbS has been described as a 'high-return, long-term strategy for economic resilience and intergenerational well-being' (United Nations Environment Programme, 2026). However, **investment into NbS is massively underfunded,** with current estimates putting it at $200 billion per year, which amounts to about one-third of the funds required to achieve various climate and nature targets. Strikingly and antithetically however, the volume of finance flows supporting so-called 'nature-negative' activities dwarfs this figure, estimated at $7 trillion per year (only accounting for direct impacts). **When assessing the potential for NbS rollout, urban contexts are seen to offer some of the highest growth opportunities, due to factors such as; the prevalence of existing readily available policy instruments** e.g. the use of building codes to encourage/require green roofs, and higher population densities resulting in greater numbers of people experiencing the benefits of NbS (European Investment Bank, 2023).

According to a Euro-wide report on investing in NbS, when taking a 'business as usual' investment projection (starting at €3.04 billion in 2021) annual growth is estimated at €304 million (European Investment Bank, 2023). The same study identified 1,034 examples of urban NbS projects, roughly divided into the following categories: urban regeneration; the creation of urban parks; and the creation of gardens. Financing data however was only available for 35% of projects. Of these, 34% indicated investments between €1 million and

€10 million, while a considerable number (20%) reported investments above the €10 million mark. Investments in this higher range were mostly associated with the development of new green areas (parks and gardens) and the retrofitting of urban districts with green measures such as green walls and roofs. In totality, investment is calculated at €5.7 billion since 2000. With the urban landscape covering an estimated 222,000km^2 across the EU and UK projected to grow at a rate of 3% per decade (Maes *et al.*, 2020), the potential addressable market for NbS looks set to steadily increase. Ireland alone has seen a similar (although slightly more modest) rate of urbanisation, with about 45% of the population in 1960 being defined as urban, rising to about 64% in 2024 (Statista, 2026).

Valuing Natural Capital in new Residential Developments

In striving to make the findings as relevant and close to home as possible, the following section looks exclusively at research from Ireland and the United Kingdom (UK). The UK offers an ideal focal point for our analysis, not simply because it's our closest neighbour with a similar climate, but because the jurisdiction offers numerous examples of progressive, nature-integrated, and forward-thinking developments, strongly influenced by the recent introduction of Biodiversity Net Gain (BNG) legislation.

Case Studies from Ireland

Valuing urban natural capital in the capital

Although not specifically geared towards residential developments, a new study from researchers in Dublin City University and the Royal College of Surgeons in Ireland by Clinton et al. (2026) evaluates the impacts of **urban natural capital through the dual lens of health and resilience.** The study is resolute in its findings. It strongly argues that **the provision of urban forestry and greening strategies should not be viewed as optional aesthetic extras, but rather as investments in natural capital that deliver a number of tangible returns, with ecosystems being just one of those**. Due to their capacity for air pollutant removal, and their contribution to reducing premature deaths, they can simultaneously be regarded as **public health interventions.** Whilst in pure economic terms, **the costs associated with de-paving, planting, and maintenance were outweighed by the costs associated with avoided pollution, and with stormwater savings in the long run.** Thus, potential savings through budgetary cuts were seen as particularly counterproductive and short-term focused, as the study demonstrated for every €1 million cut from annual maintenance operations this would result in a two-percentage-point drop in final canopy, and a two-million-cubic-metre

reduction in stormwater retention. To underscore this point, **the authors conclude that NbS and natural systems (such as urban trees, soils and permeable surfaces) should be considered 'depreciable capital assets',** backed by the corresponding necessary investment in maintenance. Correspondingly, **maintenance funding can be viewed as a proxy insurance mechanism, 'protecting the city's natural capital portfolio against long-term degradation'.**

The team adopted a system dynamics approach, analysing specific indicators and potential outcomes, based on four distinct scenarios for Dublin City on a 15-year timeline out to 2040. **The most favourable 'Policy-aligned' (Scenario 1)** charts a trajectory based on current commitments and includes **sustained tree planting together with the associated necessary maintenance, alongside moderate de-paving (indicating the inclusion of blue-green infrastructure), supported by a healthy level of community engagement.**
Tree cover under this scenario for the Dublin City Council jurisdiction reached 14.16 % (an increase on the current tree cover which sits at 7.87%). Regarding hydrological outcomes, Scenario 1 was **associated with 48.49 Mm^3 of avoided runoff**, where another scenario only resulted in 3.15 Mm^3. Similar patterns could be observed for air quality assessments, where a policy-aligned approach corresponds to **measurable reductions in $PM_{2.5}$ and NO_2, along with their associated contribution to reductions in mortality rates.** When assessing the cumulative returns on investment across all indicators, Scenario 1 saw the greatest return coming in at **€9.16 million**, while the poorest returns were seen from Scenario 3 ('Planting with low maintenance') which resulted in a negative return of -€6.28 million

The prevalence of urban NbS in an Irish context

For their study on the identification and assessment of best practice in NbS (for climate action and ecosystem restoration) in Ireland, Molloy, Collier and Buckley (2024) highlighted 81 different schemes and case studies across the country. These were all categorised under 8 distinct typologies: Agroecosystem, Integrated Constructed Wetlands, Rivers, Peatland, Woodland, Wetland, Marine, and Urban Greening (where **Urban Greening represented the most prevalent type**). The authors sought to align the ecosystem services associated with the NbS examples. They found that almost half (48%) of interventions included carbon sequestration, 40% provided water attenuation, 25% for infiltration, 10% for pest control, 7% for coastal protection, and 7% providing nitrogen fixing in soil. **35% of the NbS projects identified in the study relate to flood management.**

Dublin: In 2016 researchers from the UCD School of Geography (as part of a project with the four Dublin local authorities and the Office of Public Works) made a very interesting

correlation regarding wealth disparity. By mapping the extent of street trees across Dublin (approx. 60,000 out of 100,000 trees total), they found a direct relationship between the paucity of street trees and levels of deprivation. By overlaying maps of tree canopy cover against property prices, it becomes evidently clear that **wealthier areas have significantly more trees** (Kavanagh and Flynn, 2016). The discrepancy in tree cover is no mere statistical blip. **On one side you have Ballsbridge for example, where for every tree there are only 8-10 residents, while in Dublin 8 this rises to one tree for every 30 residents.** In Ballybough, on the other extreme however, you only have one tree for every 200 residents (Kelly, 2016).

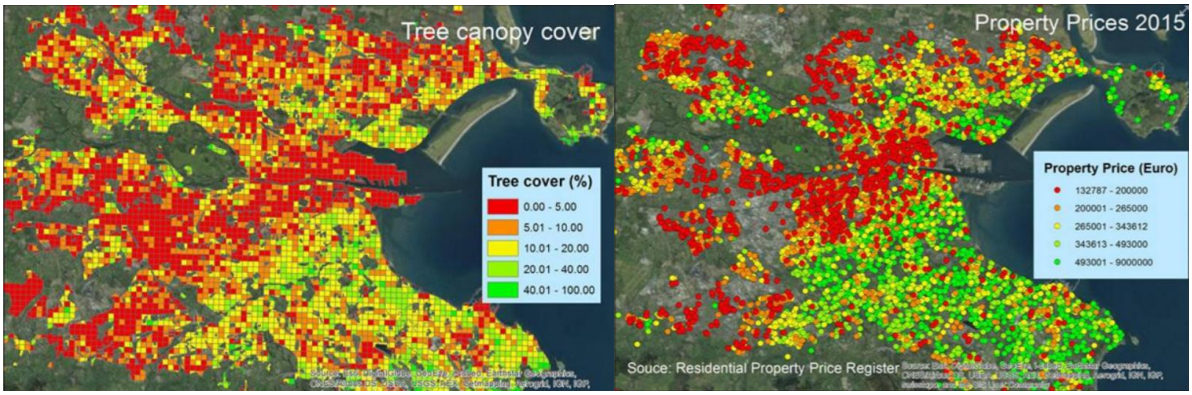

Fig.3: Overlaying tree canopy cover with property prices in Dublin showing a direct correlation between the two (Kavanagh and Flynn, 2016)

In January 2026, LAWPRO began inviting expressions of interest from Local Authorities in identifying suitable urban-focused NbS projects, to be delivered by the end of the year. Where possible, Local Authorities are encouraged to **leverage finance from existing locally managed funds**, including through maintenance of the environment (parks, playgrounds, footpath replacement and improvement programmes, and discretionary improvements works programme. The accompanying guidance document lists a number of benefits associated with NbS, including:

- Improving water quality in our receiving water bodies thus benefiting human, marine and aquatic health
- Reduced flood risk and water channel erosion
- Reduced flows and pressure on the Local Authority Surface Water drainage network and/or Uisce Éireann combined drainage networks
- Reduced pollution by trapping any pollutants at source
- Protecting groundwater recharge
- Improved road safety through landscape interventions
- Create a high-quality public realm
- Increased biodiversity
- Enhanced visual amenity

- Improved air quality
- Reduction of noise pollution
- Potential for lowering capital and operating costs

The call has a particular focus on **rainwater management and water quality,** where it forms part of a wider €42 million targeted focus on water quality for 2026, with the EU Water Framework Directive (WFD) representing a key policy driver (EPA Catchments Unit, 2026).
This funding opportunity is closely in line with a recommendation from Cronin (2025) of linking grants to regional restoration priorities.

Water management as a key focus area

On the topic of flood management, **the wider consideration of water management is generally regarded as being of the highest degree of importance and relevance in an Irish context, where measures seek to address and manage both water quantity and water quality.** By extension, wastewater treatment (and the corresponding infrastructure) plays a central role in the provision of new housing in Ireland.

In February 2026, Uisce Éireann announced the completion of a €550 million upgrade of the Ringsend Wastewater Treatment Plant in Dublin. Previously operating above capacity (it's estimated that the plant handles up to 40% of all of Ireland's wastewater), it is now positioned to serve 2.4 million people in the Greater Dublin Area. Now that the project is completed, Uisce Éireann argues that it will facilitate sustainable development across the Greater Dublin Area, supporting housing needs and economic growth, while also providing environmental co-benefits for Dublin Bay (Lee, 2026). A similar story (albeit on a smaller scale) can be seen playing out in Arklow,in dire need of a significant wastewater treatment upgrade, as for decades raw effluent and untreated waste was discharged directly into the local river and marine environment. Despite its proximity to Dublin and potential growth as a strategic hub, the town's growth has been severely restrained by the lack of a proper municipal wastewater treatment plant. That has changed now with the construction of an architecturally renowned plant in 2025, which is set to boost local economic activity and enable the tripling of Arklow's population (to 36,000 inhabitants) along with significant benefits for local ecosystems (O'Toole, 2025). It's not just the larger towns and cities that have been experiencing overcapacity and long-overdue upgrades, it is noted that in a number of smaller communities (such as Cloughjordan in County Tipperary) you currently cannot build a house due to the lack of wastewater capacity (O'Donovan, 2025).

Recognising this need for wastewater services, and the time and expense associated with traditional grey infrastructure approaches, there's a strong case to be made for leveraging NbS to help to sustainably address these issues and to unclog delays in the planning system, thus enabling new housing developments to proceed more rapidly. A case in point is that of Dunhill's Integrated Constructed Wetland (ICW). Dunhill is a village of 230 people situated beside the Anne Valley in County Waterford. It is home to the first integrated constructed wetland in the country - a series of five ponds or 'cells'. Built 25 years ago by Uisce Éireann (and later extended in 2012) it offers an extremely effective NbS to the problem of wastewater treatment. Nature's wetlands are highly efficient ecosystems, ideal for cleaning and filtering dirty water through a range of natural processes. Due to it being a UV/gravity/vegetation--based solution, it's a very cost-effective and low-maintenance intervention vs traditional grey infrastructure deployments. The novel low-impact approach delivers a series of positive co-benefits for nature through enhanced biodiversity, and on the social side with the development of Dunhill Ecopark as a public and community amenity, also providing a valuable educational resource (Lee, 2025) (Uisce Éireann, no date).

Fig.4: Aerial view of Dunhill's Integrated Constructed Wetland (ICW) (VESI Environmental, no date)

NeighbourWood Communities

A new vision for nature-centric residential developments in Ireland has been proposed, with County Wicklow being proposed as the initial site. Recognising the dual crises happening both in housing, and biodiversity loss, the proponents are advocating for a new model through integrating nature restoration into a new housing model, thereby addressing both issues simultaneously.

The following is a description of the nascent innovative model from its proponents. '10 Passivhaus-certified homes on a dedicated residential site, each permanently bound by covenant to one hectare of native woodland held in perpetuity by the NeighbourWood Stewardship Trust. Every home includes integrated solar, ground-source heat pumps,

battery storage, and water treatment. Homeowners pay a transparent annual fee covering estate management, woodland stewardship, and energy infrastructure. The energy savings exceed the fees - residents come out ahead financially while funding permanent ecosystem restoration. One hectare of native Irish woodland, thoughtfully established and permanently protected, sequesters carbon over decades, generates measurable biodiversity co-benefits, improves water quality, creates community connection, produces verified environmental credits, and qualifies for government support. That value doesn't disappear after the homes are sold. It compounds, year after year, for a hundred years' (Anderson, 2026).

Case Studies from the UK

Wider context

Nature, and the ecosystem services it provides, are fundamental to the functioning of the UK economy (Environmental Audit Committee, 2025b). According to the latest available figures from the Office for National Statistics (ONS) relating to the UK's natural capital accounts, **the total asset value of ecosystem services in the UK was £1.6 trillion in 2023.** The ONS states that "Any natural resource or process that supports human life, society, and the economy is an important part of our natural capital" (Office for National Statistics, 2025). In their accounting taxonomy the ONS currently measure 16 specific ecosystem services, the total annual value of which was estimated to be £41 billion in 2023. However, they assert that these **estimations represent only a partial or minimum valuation of the totality of what nature provides**, where it is not feasible to include all of the possible ecosystem services. For the purposes of this study, three of the featured services are particularly relevant: urban heat regulation, recreation (health benefits), and recreation and aesthetic (house prices). However, although also relevant, **flood protection from natural resources is not included**.

The **urban heat regulating service** evaluated by the Office for National Statistics assesses the capacity of green and blue spaces (e.g. parks and lakes) to help cool urban environments on hot days (defined as temperatures ≥ 28°C) through an avoided costs lens. In 2023, this **was estimated at just over £1 billio**n. In a cultural context, the **recreation (health benefits) service calculates value based on the perceived benefits of people visiting nature for at least 120 minutes per week. It was estimated that it amounted to £7.9 billion in 2023 (with 19.9 million people gaining benefits). This service had the highest asset value in 2023, at £508 billion.** Within the cultural sphere, another service which is highly relevant to this study relates to the **value of house prices, where value is associated with proximity to green and blue spaces, in**

conjunction with the aesthetic value ('visual amenity') of these spaces. These amounted to an estimated £7.5+ billion in 2023.

Trees and hedgerows: Researchers estimating the cost-benefits of investing in hedgerows found that for **every £1 spent, they return as much as £3.92** - resulting from key ecosystem services and associated economic activities, including biodiversity enhancement, carbon sequestration and small-scale woodchip production. The positive cost-benefit ratio is closely related to the location and management of the hedgerows. It's important to note that the figure of **£3.92 does not include key ecosystem services relating to water regulation and air pollution reduction** (evaluated via a different non-compatible methodology) and thus may be undervalued (Organic Research Centre, 2021). A separate study from Broadmeadow *et al.* (2023) found that the **natural capital value (assessed over 100 year timeline) of flood regulation delivered by Britain's trees (both within and outside woodlands) was an estimated £25.1 billion (£7,974/ha) equating to £843 million/yr (£268/ha/yr) when compared to bare soil.** A previous analysis looking at the cost-benefits of woodlands found that for every £1 spent on afforestation, an average of £2.79 is estimated to be returned in quantified economic and social benefits (Cambridge Econometrics, 2020).

A recent (and potentially ground-breaking) strategic assessment exploring the ramifications of **global biodiversity loss and the potential of ecosystem collapse** has found that they represent a **significant threat to UK national security and prosperity.** The assessment asserts that 'every critical ecosystem is on a pathway to collapse' (where collapse means an irreversible loss of function beyond repair). Correspondingly, the authors have identified a number of cascading risks associated with ecosystem degradation which includes - geopolitical instability, economic insecurity, severe impacts on global food production, conflict, migration and increased competition for resources (HM Government, 2026).

Natural capital as critical national infrastructure

Developing in parallel with these findings and assessments, another recent report strongly advocates for natural capital to be **formally recognised as critical national infrastructure (CNI)**. It justifies this stance by asserting that the deterioration or compromise of natural capital 'would severely impact essential services, economic stability, and national security', putting it on par with the 13 existing CNI sectors, including food, water, and health. The authors argue that **natural capital considerations should be duly positioned on equal footing with other forms of physical infrastructure** across policy making, strategic planning, public spending, and investment (Nichols, Wilson and Seville, 2026).

Nature - an integral element in the development of sustainable and resilient communities

Under its 'Plan for Change', the current UK government has outlined a target to **build 1.5 million new homes** over the course of the current Parliament (up to July 2029), equating to 370,000 homes a year (GOV.UK, 2024), while it has been remarked that housebuilders currently have no incentive to make the homes desirable, sociable, or healthy places to live in (Moore, 2026). According to a selection of UK government ministers, nature and biodiversity considerations are seen as a primary reason for their administration's ambitious housing targets not being delivered (Laville, 2025). With the interests of specific species being blamed for curtailing construction activity, nature is being held up (quite literally) as the scapegoat. In stark contrast to this position, the findings of a recent Member of Parliament (MP) inquiry strongly challenge this narrative. The House of Commons committee report titled 'Environmental sustainability and housing growth', opposes what they describe as a **'lazy narrative that nature is a blocker to housing delivery'.** The report authors acknowledge that meeting the demands for new housing provision, whilst simultaneously striving to restore nature and address climate change, represents a 'complex policy balancing act'. Nevertheless, it is argued that, not only is nature *not* responsible for housing delays, but instead it's **an integral element in the development of sustainable and resilient communities.** Correspondingly, it is contended that the seemingly competing exigencies of nature restoration, emissions reductions, and house building, can (with the help of considered foresight and rigorous planning) be addressed concurrently (Environmental Audit Committee, 2025a). To support this point, it is argued that one of the characteristics of much-loved places is that they **'make the most of nature'** (Moore, 2026).

Design guidance for new build developments

In January 2026, the UK government published updated design guidance for new build developments, part of what is being described as 'the biggest planning rewrite in a decade' (GOV.UK, 2026). Within the guidelines, seven features are presented for what can be considered 'well-designed' neighbourhoods.

Alongside consideration given to aspects such as enhanced liveability, ensuring freer movement and active travel, and incorporating public space, both climate and nature interests are highlighted. **New builds will now be expected to integrate both climate mitigation and adaptation measures. Nature is viewed as fundamental to liveability - greatly supporting health, wellbeing, and people's quality of life**. **A suite of design principles that support nature have been drafted up**. These include the provision of a network of high-quality, biodiverse, strategic, multi-functional green infrastructure systems, that support quality of place, biodiversity, and active travel. Green infrastructure

networks can include everything from country parks to green roofs. **Improving and enhancing water management is recognised as a space where nature can play a pivotal role, where mitigating flood risk and enhancing flood resilience are core tenets of the design principles.** Through the integration of existing natural water systems along with new water features, incorporated alongside green and brown roofs, swales, rain gardens and rain capture, multifunctional sustainable urban drainage systems (SuDS) can be created. The totality of benefits to be born out of integrating nature into new well-designed developments are numerous. In what are often described as ecosystem services (the services which flow from natural capital) these can be classified as Regulating, Provisioning, Cultural and Supporting - offering a helpful framing matrix to categorise the multiple benefits.

- **Regulating**
    - Climate mitigation and adaptation
    - Shading and cooling
    - Noise mitigation
    - Air quality
    - Enhanced water management
    - Flood risk mitigation
- **Provisioning**
    - N/A
- **Cultural**
    - Enhanced health and wellbeing
    - Enhanced liveability and quality of life
    - High-quality green space
- **Supporting**
    - Flourishing diverse ecosystems
    - Healthy natural environment
    - Biodiversity

(Ministry of Housing, Communities and Local Government, 2026).

According to Susdrain, **the Department for Environment Food and Rural Affairs (Defra) has conducted a number of comparative studies looking at the costs and benefits of SuDS vs traditional drainage infrastructure**. Of the studies that were assessed throughout the UK, **all showed that the integration of SuDS was the cheaper option** (Susdrain, no date).

A Framework for a Nature-positive Built Environment

In February 2026, the UK Green Building Council launched its 'Framework for a Nature-positive Built Environment'. **The Framework has been designed to help align nature-positive ambitions across the built environment, offering a unified structure to aid informed decision-making.** The Framework supports practitioners in taking clear, structured steps to avoid harm, restore and regenerate nature, and contribute meaningfully to the global nature-positive goal.

A nature-positive built environment 'asserts that buildings, infrastructure, and places deliver benefits for nature, onsite, offsite, and through embodied ecological impacts in the value chain and throughout the asset life cycle'.

The document also highlights intersection points and co-benefits of enhancing nature, where nature is seen to epitomise four distinct, fundamental roles: Nature as a Carbon Manager, Nature as an Enabler of the Circular Economy, Nature as a Provider of Climate Resilience, and Nature as Fundamental to Social Value, our Health and Wellbeing (UKGBC, 2026).

Water neutrality at new development sites

Berkeley Group have collaborated with Thames Water in exploring the viability of water neutrality at new development sites. According to the Environment Agency, the Southeast of England can be considered a 'seriously water-stressed' area. Meanwhile, Defra seeks to introduce a National Water Target, which would mean a 20% reduction of water flowing into the public supply by 2050. With a projected concomitant rise in population for the Southeast region (where Thames Water operate) there is now an onus on new developments in these water-stressed areas to reduce their volume of water abstraction from natural sources.

The new approach hinged on a hypothesis whereby **water usage for the new development could be offset partly through retrofitting and reducing water consumption in existing homes and businesses in the surrounding area** (and thus offsetting the forecasted water demand). The projected **consumption totalled 45,633 litres/per day**, while the **offsetting activities** were anticipated to exceed that, **totalling 56,670 litres/per day** (Thames Water and Berkeley Group, 2023).

Also, in the Southeast of England, back in September 2021 Natural England (the government's adviser for the natural environment) issued a statement whereby the actions of the utility company Southern Water might be having an adverse effect on internationally protected habitats in the Arun Valley. This resulted in the adoption of the

'precautionary principle', which sought to ensure that no additional adverse effects would occur. By extension, this situation effectively meant that **planning applications for new developments around the wider Horsham area were immediately curtailed, unless 'water neutrality' could be proven** (Beuden and Collins, 2025).

Following an agreement between government, regulators, and industry, as of November 2025 the bottleneck has been freed. This will allow for the construction of 4,000 homes that had been stalled, while also facilitating the construction of an additional estimated 17,000 homes. These new builds contribute to the government's 1.5 million home target, a central aspect of their 'Plan for Change'. Through the new agreement between Defra, Natural England, the Environment Agency and Southern Water, the utility company is required to reduce its water abstraction, as well as engage in habitat restoration (which the company itself will pay for) (GOV.UK, 2025).

The Phoenix, Lewes

Designs are in place for the groundbreaking redevelopment of a 7.9 hectare brownfield (former industrial estate) site in Lewes, in the Southeast of England, a place where 'nature isn't an afterthought but the central organising principle' (Journal of Biophilic Design, 2026).

Known as the Phoenix, the new residential development is the flagship project of architects and urban designers Human Nature. It is poised to become the UK's largest bio-based development, with 685 homes planned, where natural materials such as timber, hemp, and lime will be core to their construction. Affordability is to be a big consideration with up to 210 affordable homes, or 30% of the total number. The idea is to create opportunities for people to connect with natural systems, with these nature-integrated spaces seen to enhance mental health, community connection, and a sense of belonging. Characteristics, as we've already seen, that aren't generally associated with new modern developments. There's an acknowledgement that biodiversity considerations can sometimes become a tick-box exercise, yet for Human Nature these instead are core pillars of their approach. Courtyards in the Phoenix are to be designed as rain gardens, acting as a defence mechanism for the local river during peak times by absorbing excess run-off. Food production is also a central focus, with public areas to be heavily planted with fruit and vegetables (Pertusini, 2025).

Fig.5: The Phoenix, Lewes (Credits: Human Nature with Periscope, no date)

Berkeley Group

The Berkeley Group is the UK's leading homebuilder in large-scale brownfield redevelopment, and is publicly listed on the London Stock Exchange. Its pre-tax profits for the 6 months to October 31st, 2025, were £254million, with a 14.2% pre-tax return on equity. Nature and Climate Action comprise 2 out of their 10 strategic priorities for 2030. They currently have 58 developments committed to biodiversity net gain (BNG), where their goal is to create a BNG for every development. Due to their strategic focus on urban brownfield sites, there is significant potential for uplift in this metric, with one of their sites expected to eventually reach a 258% positive BNG in the long-term (which speaks to the accretive nature of these benefits, which can appreciate over time).

Together with JTP Architects, Berkeley is developing what can be described as a hugely ambitious undertaking - both in terms of the scale of new homes being constructed, and the level of biodiversity integration. The Green Quarter is being built on the 88-acre site of a former gasworks in West London, and is set to become one of the capital's largest regeneration schemes. With an initial application for 3,750 homes in 2010, as of February 2026 under the company's latest masterplan, this figure has more than doubled with the potential for 8,000 new homes. In the Group's investment pitch deck titled 'Why Buy at the Green Quarter?', one of the ten reasons to invest is the level of nature-centricity, where the Group claims, it is set to become one of the most biodiverse developments in the UK.

Fig.6: The Green Quarter, West London (Credits: Berkeley Group, 2022)

What this looks like in practice:

- 93% BNG
- 17+ acres of podium gardens
- The creation of over 13 acres of parkland
- 70% of irrigation water will be from storm water
- Creating infrastructure to link to the adjoining 90-acre Minet Country Park
- Up to 2,500 new trees being planted

To facilitate the new tree planting, the Group have even created their own on-site tree nursery. The development is not without its criticism however, with some objectors believing that the development is actually too big for the area and hasn't been designed for the housing needs of the current residents of Southall.

Another of their massive London regeneration developments (Kidbrooke Village) has been equally, if not more, ambitious in its approach to embedding nature. **There's been a conscious move away from highly manicured landscapes**, **where the Group have been working with London Wildlife Trust in the transformation to a more rewilded landscape** - with 85 acres mosaic of wetlands, wildflower meadows, sports pitches and playgrounds. They are striving to strike a balance between levels of biodiversity and levels of maintenance, where cost reduction is a contributory factor. According to their Divisional Development Director, Paul Prichard, "There is no doubt that **investing upfront in the establishment of wilder greenery and landscapes has helped us to reduce maintenance costs later on".**
This integration of nature is also seen to drive additional financial advantages. Far beyond what may be a considered a 'cosmetic afterthought', the planting of quality greenery by Berkeley from the outset was seen as a prudent and pivotal way to **increase the value of the site**
(Davy, 2026) (Berkeley Group, 2025) (Berkeley Group, no date) (Butler, 2026)

(Create Streets and Berkeley Group, 2023).

Fig.7: Nature integrated into high-density residential development in Kidbrooke Village (Credits: Berkeley Group, 2022)

Understanding the costs and benefits of specific NbS and Green Infrastructure

A note on costs

The following set of NbS were drawn from consultation with industry, and what emerged from the literature, as being some of the most commonly used in Ireland.

When assessing the financial returns and viability of various NbS and Green Infrastructure, it becomes difficult to provide accurate figures on the provision of these types of measures, due to the sheer number of variables involved (i.e. site size, location, type, density of housing, quality of surrounding habitats) (Worcestershire County Council, 2015). **As such, the costs outlined below are merely indicative**.

In addition, given recent escalating costs in the construction sector (particularly for fuel and building materials) prices may quickly prove to be outdated - a situation which, incidentally, may also enhance the appeal of NbS. Given the exact specifications and requirements of individual sites and projects, a range of representative costs is to be expected. In addition, specific and reliable up-to-date costs were not available in the literature for every NbS. Unless otherwise stated, the costs outlined below are applicable to the Irish market.

For detailed cost estimates in specific projects, engaging a relevant Consultant or Quantity Surveyor familiar with Irish planning regulations is advisable.

A note on definitions

In Ireland, challenges remain around the variety and ambiguity of definitions relating to NbS. For example, the authors of an NbS identification study chose to not include urban parks and street trees, as these were seen to represent legacy green infrastructure that have since been redesignated as NbS retrospectively. As such, they argue the need for a "comprehensive and shared definition for NbS for policymakers for implementation across sectors" (Molloy, Collier and Buckley, 2024).

Urban greening could be seen as somewhat of a high-level umbrella term that may be open to interpretation as to what falls under the category. Again, for Molloy, Collier and Buckley (2024) urban greening can be described as the integration of green spaces into urban areas, which may include parks, tree planting, green roofs, or other greening strategies applied to permeable surfaces, soil, grass, shrubs, trees and water.

Nature-based Sustainable Urban Drainage Systems (NB SuDS) can also paint quite a broad brush, and interpretations may vary when you get down to specifics. For Molloy, Collier and Buckley (2024) they are described as a 'network of vegetated areas and open spaces… that replicate natural ecosystem services'. Under their definition they include the likes of green roofs, porous pavements, and rain gardens - all of which could also be considered urban greening, so there is a high degree of permeability between these terms.

Making the distinction between NbS and SuDS

Although these measures and approaches may occasionally overlap in their design and implementation, they are by no means interchangeable, and it's important to note the distinction between the two. According to Igoe *et al.* (2025) **the benefits associated with SuDS can be classed under four criteria: Water Quantity; Water Quality; Amenity; and Biodiversity. Notably, a SuDs measure satisfies all criteria in order to be categorised as such.** As discussed, integrating nature is fundamental to NbS. However, NbS interventions must also satisfy all four of the above criteria. So, in this context, **NbS include SuDS considerations, but SuDS don't necessarily include NbS considerations.**

SuDS can be categorised in a number of ways, but a useful way to think about them is by dividing them into three high-level groupings: SuDS in open spaces, SuDS in roads, and private SuDS (Cambridge City Council, no date). Notice the overlap in where different measures can be implemented

- **SuDS in open spaces (typically located in public open space):** Ponds and wetlands, Infiltration and retention basins, Filter strips, Swales, Rain gardens (bioretention), Filter drains, Canals and rills
- **SuDS in roads (typically located on roads):** Filter strips, Swales, Rain gardens (bioretention), Filter drains, Canals and rills

Private SuDS (typically located within the boundaries of private properties): Green roofs, Permeable driveways and parking, Soakaways, Proprietary treatment systems, Geocellular storage (preferably combined with rainwater harvesting)

Property level SuDS: On this topic, a guidance document has been developed for managing rainfall in Dublin City through property level SuDS. The document highlights that the same sewer network across most of Dublin City has to handle both rainfall and foul water emanating from the likes of toilets. **The demands on this limited-capacity sewer system are increasing, heightened by the effects of climate change and higher levels of urbanisation. In response, the report advocates for the installation of property level SuDS (in the form of rain planters, rain gardens, and other vegetated SuDS measures).** The advantage of these types of SuDS is that they only need minimal space (McCloy Consulting and & Robert Bray Associates, 2023).

Fig 8. SuDs Property Level Guide, Dublin City Council (McCloy Consulting and & Robert Bray Associates, 2023)

Green spaces, Green infrastructure

Urban green spaces have been defined as any urban areas that are either completely or partially covered by vegetation, such as grass, trees, or shrubs, including parks, gardens, forests and meadows, as such many of the above highlighted NbS can fall into this category also. The outcomes and benefits of investing in urban green spaces include increases in property values, physical and mental health, biodiversity, water retention and groundwater recharge, carbon sequestration, reduced exposure to heat, and reduced exposure to air pollution (Bechauf *et al.*, 2022).

According to Panduro, Nainggolan and Zandersen (2024), the term 'urban green space' can encapsulate a number of different spaces, from local housing association playgrounds to cemeteries. A multitude of aspects can affect the cost - from activity type, remediation needs, labour costs, and the size, scale and ambition of the given project. Their study cast a wide net and looked at cost estimations for green spaces across Europe, the US, and China. Tentative estimates put green space establishment at a mean price of €59.98/m^2, and a median of €31.73/m^2. The mean maintenance costs of urban green spaces came in at €1.79/m^2, while the median maintenance cost 0.93m^2.

Dublin: A 2020 study which looked at the impact of green spaces on Dublin property prices found a positive correlation whereby a **10% increase in park space within 2km of a dwelling is associated with a 5.5% increase in price.** The authors found that for the average property in Dublin, 3.4% of the space located within 2km is green space. With an approximate 480,000 households in Dublin, the estimated total residential real estate value that can be attributed to green space is €3.4 billion (Gillespie, Lyons and McLaughlin, 2020).

A UK report (which references numerous studies) has advocated for the re-greening of streets and squares. It highlights the positive physical health benefits associated with greenery - including enabling more physical activity, along with its association with less prevalence of low birth rate, maternal diabetes and glucose management in pregnancy, and irritable bowel diseases. Cost-benefit analysis showed **a positive impact of £6,495 per person living within 500m of a small new park** in an urban area, which has been attributed to a combination of several quantified markers including; **less depression (£750), higher cognitive development (£150), reduced mortality (£2,999), reduced crime and a higher house price (£3,375)** (Create Streets and Berkeley Group, 2023).

London: In seeking to corroborate previous findings demonstrating the positive mental health benefits associated with urban greenspaces, a 2015 London-based study explored the correlation between **urban street tree density and antidepressant prescription rates.** Through their analysis, the researchers found that **the boroughs of London which had a higher density of street trees were associated with lower antidepressant prescription rates** (even after controlling for potential confounders). The study demonstrates that urban street trees can be seen as a positive urban asset which can assist in the reduction of negative mental health outcomes (Taylor *et al.*, 2015).

Toronto, Canada: A study based in Toronto, Ontario explored the associations between urban trees and greenspaces and population health. The researchers combined high-resolution satellite imagery and individual tree data with health perception self-reports from the Ontario Health Study. Remarkably they found that having **10 more trees in a city block enhanced health perception producing a similar effect as an increase in personal income of $10,000**, and moving to a neighbourhood with $10,000 higher median income or being 7 years younger. While **having 11 more trees in a city block was associated with a decrease in cardio-metabolic conditions similar to an increase in annual personal income of $20,000** and moving to a neighbourhood with $20,000 higher median income or being 1.4 years younger (Kardan *et al.*, 2015).

It's important to think about these spaces in a more systemic and cohesive way, where elements of green infrastructure do not exist in isolation. In order to benefit from the full range of advantages available, it's necessary to take a more integrated network approach, striving to reach a critical mass of green infrastructure in a given area (Worcestershire County Council, 2015). A perfect example of the whole being greater than the sum of the parts.

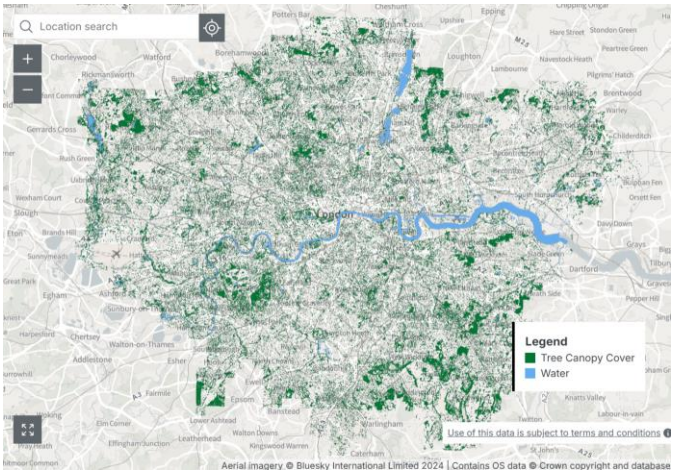

Fig. 9: Tree canopy cover of London (London Datastore, 2024)

Bioretention systems and infiltration solutions

Bioretention systems is somewhat of an overarching term which can describe a number of different approaches, but can loosely be defined as areas of shallow landscaped depressions designed to allow runoff to accumulate and filter through the soil into a drain below (Cambridge City Council, no date) (Southern Regional Assembly, 2022).
Bioretention systems and nature-based stormwater infrastructure can include bioswales, rain gardens, wetlands, and street trees. Where traditional grey stormwater infrastructure is designed to move water away quickly, NBI operates in-situ, where water is leveraged as a resource (Bechauf *et al.*, 2022).

In China, the implementation of NbS for flood prevention at city scales created the so-called Sponge Cities. Here, the vegetated area could store more rainwater than hard surface in a heavy rainstorm, which reduces runoff loss and the risk of flooding (via (Lozano *et al.*, 2024).
The total volume of rainwater runoff reduced by Beijing's urban green spaces, for example, has been estimated to be 154 million m^3 and the amount of reduced runoff per hectare green space was 2494 m^3 (Zhang et al., 2012).

Although China pioneered the concept and coined the term "sponge city," Copenhagen has also emerged as a global model for urban resilience. After a severe flood in 2011, the city unveiled its Cloudburst Management Plan—a comprehensive, citywide strategy designed to strengthen defenses against heavy rainfall and storm surges, while also enhancing resilience to periods of drought

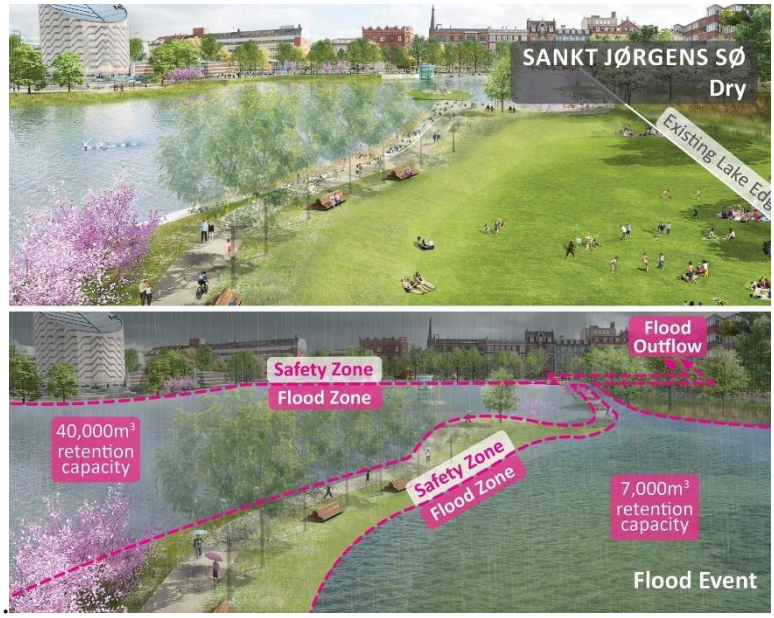

Figure 10: Copenhagen (credits CITY OF COPENAGHEN)

Swales/bioretention areas

Swales are generally flat-bottomed shallow channels covered by grass and/or other vegetation. They are used to collect and/or convey water to infiltration or a watercourse (Cambridge City Council, no date). Swales can come in different forms:

- A Conveyance and Attenuation Swale which is a shallow vegetated channel;
- A Dry Swale is a Conveyance Swale which includes the incorporation of a filter medium and underdrain system.
- A Wet Swale is a Conveyance Swale, which has been designed to deliver wet and/or marshy conditions at the base (Igoe *et al.*, 2025).
- Bioswales on the other hand have been defined as rain gardens on a slope (National Transport Authority, 2023).

Swales can potentially be low-cost, low-tech, eco-friendly filter systems, but they're not without their limitations. They are best suited to relatively small catchments, where they can be integrated into the early stages of a SuDS system (Harty, 2019).

Costs

Although an agricultural setting, grants are available for swales under the Farming for Water EIP which come in at €680/unit (with max 3 units) where the minimal length is 20m, and the maximum length is 50m (Farming for Water, 2024).

Benefits

- Effective at managing and delaying runoff, provides interception capacity, and traps pollutants via infiltration (with the filtering effects of vegetation)

- Bioretention systems (such as ponds, swales and raingardens) are effective in peak discharge control with an average reduction above 40%
- Effective at enhancing local habitats and biodiversity, providing connections to existing wildlife corridors, while offering more aesthetic streetscapes
- Can help cool local microclimates and reduce urban heat island effect (through evapotranspiration from vegetation)
- Maintenance requirements on par with (or less than) traditional landscape features
- Can act as an interconnector between various NbS measures (as part of a more holistic NbS management train)
- (Lozano *et al.*, 2024) (Igoe *et al.*, 2025) (Butler, 2023) (Southern Regional Assembly, 2022)

Fig.11: Dry Swale - Min Ryan Park, Wexford (Igoe et al., 2025)

Rainwater gardens

Rain(water) gardens are areas of vegetation that are positioned slighter lower than the level of the surrounding ground. They are engineered SuDS through which rainwater is directed overland, instead of channelled directly through traditional routes. Rainwater filters down through the soil where it's collected in subsurface perforated drainage pipes. In an optimal scenario these gardens should maximise the volume of water that can infiltrate through to the ground below (National Transport Authority, 2023). On a smaller scale, rainwater planters (boxes) use rainwater from your roof, and come in a range of sizes. They can be made from concrete, stone, brick, and timber, and they can accommodate small trees, shrubs, herbs, flowering plants, and flowers. Dublin city Council offers easy-to-follow guidance on their construction and installation (Stack, Gannon and Hurson, 2021).

Costs

For the type and size of the rainwater planter outlined in its guidance document (about 1m^2) Dublin City Council estimate the cost to be between €250 and €300 (Stack, Gannon and Hurson, 2021).

Benefits

Rainwater planters can be effective in slowing the flow of rainfall, particularly during heavy rainfall where excess water is held, while the soils and vegetation in the planter can remove pollutants by filtering the water. In addition, they can be aesthetically pleasing, help keep your local river clean, can help with pollinators, and can increase vegetation in your garden or space (Stack, Gannon and Hurson, 2021).

These rain box planters (which have been installed on a pilot basis across Dublin City) have shown they provide good capacity for rainwater attenuation, along with being popular among local residents (Molloy, Collier and Buckley, 2024).

At a high-level rain gardens have the following benefits, along with their associated economic considerations:

- ➔ Wastewater treatment: Replacement cost, e.g. Reduction in water management costs
- ➔ Regulation of water flows: Replacement cost, e.g. Reduction in water management costs
- ➔ Moderation of extreme events: Avoided damage cost, e.g. Reduction in costs associated with flood damages
- ➔ Aesthetic appreciation: Behavioural linkages/Value transfer, e.g. Estimate the WTP for aesthetic improvement
  (Chelli, Geneletti and Brander, 2023)
- ➔ Adaptability: Their flexible design allows them to the incorporated into existing environments, can be constructed with similar kit to traditional infrastructure
- ➔ Space maximisation: Even small areas can make effective rain gardens
  (National Transport Authority, 2023)

Fig. 12: Rain Gardens in Pollerton Road, Carlow (Igoe et al., 2025)

Permeable pavements/surfaces

Permeable surfaces can include a number of different types of pavements, pavers and other measures that serve the dual functions of stormwater infiltration and a structural surface. They assist in collecting water at source and filtering through the paved surface before infiltrating into the ground below (for further distribution). Although it can prove to be an effective measure, it needs to be integrated into a wider NbS management train, as alone they don't offer additional uplifts in nature or biodiversity. They can be utilised in more heavily asphalted areas such as car parks (Southern Regional Assembly, 2022) (National Transport Authority, 2023).

Costs - *Block Paving Cost Breakdown*

- ➔ **Material Costs (**Per m^2): Permeable blocks: €30 - €50
- ➔ **Labour Costs** (Per m^2): Standard laying: €25 - €40, Complex patterns: €35 - €55, Ground preparation: €10 - €20
- ➔ **Additional Costs to Consider:** Site Preparation- Existing paving removal: €15 - €30 per m^2, Excavation: €10 - €25 per m^2, Skip hire (if needed): €200 - €400, Levelling/grading: €10 - €20 per m^2
- ➔ **Extras**: Edging/kerbing: €15 - €30 per linear metre, Steps (per step): €150 - €400, Drainage channels: €40 - €80 per linear m, Pointing/jointing: €8-€15 per m^2, Sealing: €5-€12 per m^2

➔ **Factors Affecting Paving Costs:** Ground conditions, Access, Pattern complexity, Drainage requirements, Size (Trusted Tradesman Ireland, 2026).

Benefits

- **Permeable pavements** can reduce stormwater flow by around 75-80% (Kõiv-Vainik et al., 2022a) (via (Lozano *et al.*, 2024).

Lamb Drove, UK:

Lamb Drove is a residential development of 35 affordable homes (developed and owned by Cambridge Housing Society) constructed in 2006 on a one hectare site. The Lamb Drove SuDS scheme was designed to highlight practical and innovative sustainable water management techniques (incorporating SuDS and property flood resilience and resistance) within new residential developments. SuDS measures used include; water butts, permeable paving, green roofs, swales, filter strips, detention and wetland basins, and retention ponds.

It was found that SuDS provided 10% savings on construction costs compared to a traditional scheme. The use of SuDS also resulted in quality of life improvements, water quality improvements, and biodiversity enhancement (Susdrain, 2011).

Interpave conducted a later case study of a SuDS scheme at Lamb Drove, which by then had seen 13 years of use. **The SuDS Monitoring project assessed the performance of the SuDS over time, compared with those of a conventional piped drainage system on another nearby development, similar in size and density.** The study showed that **both capital and maintenance costs (i.e. whole-of-life costs) associated with Lamb Drove were far lower than those for the conventional piped drainage system at the Control Site**, estimating capital cost savings of £314 per home, and between 20-25% lower maintenance costs than traditional drainage systems at the control site (Interpave, 2019).

Fig.13: Final design of Lamb Drove SuDS system (Royal Haskoning) via (Susdrain, 2011)

Tree pits, urban trees, and urban forestry

Urban forests include trees in a number of contexts - trees in gardens, along streets, in protected areas and in watersheds, which can be individual trees and the associated vegetation and soil beneath them.

Tree pits can be designed using structural soils or deep concrete retaining features. Tree pits can be considered a standalone NbS measure, but they are most effective when incorporated with other NbS within an NbS management train.
(National Transport Authority, 2023) (Igoe *et al.*, 2025).

Costs

Acknowledging the large degree of variability and specific requirements of tree pits, estimated costs (from 2019) are in the range of €1,500 to €1,800 (+ VAT) per m^3 of root space (Kenny, 2019).

The 2025 budget for tree and hedgerow management across South Dublin County Council was €4.59 million (which is not broken down for specific areas or programmes). However, out of the total budget provision, around €650,000 has been earmarked for the planting of 3,500 trees across the jurisdiction (South Dublin County Council, 2024). This would equate to about €185 per tree (indicative planting costs only).

Benefits

- ➔ Surface water management services through transpiration, interception, increased infiltration and treatment of contaminants
- ➔ Can help cool local microclimates and to reduce urban heat island effect (through evapotranspiration from vegetation)
- ➔ Urban trees offer health and psychological benefits
- ➔ Enhances local biodiversity offering rich habitats
- ➔ Carbon sequestration capacity

(Igoe *et al.*, 2025) (Southern Regional Assembly, 2022)

A major study looking at the role of **urban trees in reducing land surface temperatures in European cities** found them to be hugely effective. The study examined satellite-derived land surface temperatures (LSTs) and land-cover data from 293 European cities. It found that when compared to continuous urban fabric, urban tree coverage across most European cities (in summer and during hot extremes) generally resulted in lower temperatures, of up to 12°C less) (Schwaab *et al.*, 2021).

A study seeking to quantify some of the values of the urban tree system in Lisbon, Portugal (based on a total of 41,247 trees) found that they provide services valued at $8.4 million annually, while maintenance costs are $1.9 million. The study posited that, for every $1 invested in tree management, residents would receive $4.48 in benefits. These benefits were seen to accrue from a multitude of disparate sources - energy savings ($6.20/tree), $C0^2$ reduction ($0.33/tree) and air pollutant deposition ($5.40/tree), while stormwater runoff reduction came in at $47.80/tree, and increased real estate value equated to ($144.70/tree) (Soares *et al.*, 2011). US$ was used as they were compared to US cities in this study.

In the US, estimating the value of Portland's 236,000 street trees was the topic of a 2010 study. Using a custom mode, the researchers found a positive correlation between the close proximity of **urban trees and an associated increase in local property prices, where on average $8,870 was added to the price of a house.** Crucially, the authors found that, in Portland, the benefits associated with street trees far exceed the maintenance costs (Donovan and Butry, 2010). More recently, Portland launched an ambitious expansion of its city-wide tree planting and tree care activities, aiming to plant at least 15,000 trees over the next three years (more than doubling its current annual efforts). This initiative will be funded thanks to $40 million from the Portland Clean Energy Community Benefits Fund, the climate justice fund seeded by a 1% tax on large retailers in the city (Wozniacka, 2025).

In the US, going back nearly 25 years, the benefits of urban forests were already starting to be quantified, where a study assessed the **rainfall interception capacity** of street and

park trees in Santa Monica, California. Utilising a simulation model, the authors estimated that the **annual rainfall interception potential of the near 30,000 trees was 193,168m³ (6.6 m³/tree)**, which worked out as 1.6% of total precipitation. Consequently, the estimated value of avoided stormwater treatment and flood control costs associated with reduced runoff was **$110,890 ($3.60/tree)** (Xiao and McPherson, 2002).

A later study in 2006 on the air pollution removal capacity of trees and shrubs encompassed 55 cities across the entire contiguous United States, where removal is just one way they affect air quality. Although varying across cities, the estimated total volume of air pollution (across carbon monoxide (CO), nitrogen dioxide (NO2), ozone, particulate matter < 10 µm (PM10) and sulphur dioxide (SO2)) equalled 711,000 metric tons. **These removals equate to an annual value of $3.8 billion** (Nowak, Crane and Stevens, 2006).

Fig.14: Trees at DCU St. Patrick's Campus, Dublin (Southern Regional Assembly, 2022)

Waterways, attenuation ponds and wetlands

Ponds and wetlands can be described as water features with a permanent pool of water, providing both attenuation and wastewater treatment services, designed so that the water level can rise during high rainfall events and offer temporary storage for excess water. A differentiating factor between ponds and detention basins, is that ponds hold water in both wet and dry weather (Igoe *et al.*, 2025) (Cambridge City Council, no date) (Southern Regional Assembly, 2022).

Lakes and wetlands cover everything from marshes and swamps to peatlands and mangroves offering a plethora of ecosystem and infrastructure services - from heavy metal and nutrient removal, reducing nitrogen concentrations, flood water regulation and mitigation capabilities, and vast carbon storage capacity (Bechauf *et al.*, 2022).

Benefits

- ➔ Efficient way to attenuate stormwater runoff whilst also providing filtration and pollution remediation services
- ➔ Reduce flood risk and enhance water quality
- ➔ High ecological, aesthetic and amenity benefits. Ponds create stable aquatic environments for species
- ➔ Ponds can be created in virtually any relatively flat open area
- ➔ Ponds and wetlands can provide a final `polish' to remove residual pollution

(Molloy, Collier and Buckley, 2024) (Igoe *et al.*, 2025) (Cambridge City Council, no date). (Southern Regional Assembly, 2022).

In the US, a Triple Bottom Line (TBL) benefit-cost assessment looking at the merits of green and traditional infrastructure approaches for controlling Combined Sewer Overflow (CSO) events, was undertaken by the City of Philadelphia's Water Department. They found that green infrastructure approaches provide a series of important benefits to the community that the more traditional approaches did not. Taking a 40-year time horizon, the study found that the combined option (comprising 50% low impact/green infrastructure) was projected to create cumulative benefits worth $2.84billion, compared to only $122million created by the grey infrastructure option (Stratus Consulting, 2009).

Enhancing city liveability for residents was the focus of another study in Singapore which sought to quantify the amenity benefits of waterway renewal projects, where reservoirs, drains, and in particular canals, are renovated and integrated into the surrounding environment. The Singapore-based study found that the resale prices of flats located within 500m of canal restoration sites increased by 1.6%, resulting in an estimated total uplift of between S$336 and S$504 million. This uplift has been interpreted as an indicator of the increased value the restoration projects have provided the residents. The figure also exceeds the total costs associated with Singapore's Active, Beautiful, Clean Waters (ABC Waters) Program, offering evidence that the benefits of urban waterway renewal projects can outweigh the costs (Polyakov *et al.*, 2022).

Using house prices as a proxy for determining the economic value of green space, a study from Malaysia identified a significant inverse relationship between residential property values and distance from Putrajaya Wetlands Park. It found that property values decrease by 5.9% per km as the distance from the Putrajaya Wetlands Park increases, indicating the vital role that green space plays in urban development (Syafiqah *et al.*, 2017).

Fig. 15: Singapore's Active, Beautiful, Clean Waters (ABC) ABC Programme (EBRD, no date)

Green and blue roofs

Green roofs are surface structures designed around living vegetation. They can be classified as extensive or intensive, with the differentiation relating to the depth of the vegetation growth, where extensive roofs will average around 20cm, while thickness for intensive roofs averages around 50cm. Effectively, this tends to mean that regular houses can be retrofitted with extensive roofs, without needing to bolster the load-bearing capability of the building.

Extensive green roofs are said to be the most common type (Sika Ireland, no date), commonly made using sedum (hardy, low-growing succulents from the Sedum family). Green roofs will generally comprise a plant layer, a growing media, a filter layer, a root barrier layer, and a protection layer (Panduro, Nainggolan and Zandersen, 2024). Extensive green roofs tend to be more lightweight, with self-sustaining vegetation requiring lower maintenance. While intensive green roofs require more maintenance, they can provide benefits on par with a small city park (Southern Regional Assembly, 2022).

As roofs can be difficult environments for plants to thrive, careful consideration must be given to their design in the context of the surrounding area (Cambridge City Council, no date). With an estimated 40-50% of sealed surfaces in urban environments constituting roofs, green roofs have a pivotal role to play in stormwater management, where the immediate water runoff from vegetated roofs can be reduced by 50-90% (Ansel and Diem, 2010).

As a subset of green roof systems, blue roofs are those which are more specifically geared towards their water attenuation capabilities. If a blue roof doesn't also include the co-benefits associated with green roofs, then it cannot be considered a true NbS (Igoe *et al.*, 2025).

Costs

- ➔ Extensive / Sedum Roof (€75-120/m^2) - **requires very low maintenance**
- ➔ Biodiverse / Wildflower (€100-150/m^2) - **requires slightly more maintenance**
- ➔ Intensive / Garden Roof (€150-300/m^2) - **requires regular maintenance**

(BookMyRoofer.ie, 2025)

Additional factors which may impact costs include;

- ➔ Structural assessment (**which may cost in the region of €500-€800)**
- ➔ If reinforcement works required, this could **add between €1,000 to €5,000**
- ➔ Larger roofs may benefit from economies of scale: Although total costs may be higher, **the price per metre can be better value**
- ➔ **Accessibility** is a big determiner of costs, where **restricted access can increase prices**

Estimated Cost Breakdown for a Green Roof (for a standard 50 sqm extensive sedum roof on a residential extension in Ireland)

1. Planning and design consultation: **Between €500 and €800**
2. Waterproofing layer: Estimated at **€1,500 to €2,500**
3. Drainage system and soil layers: Around **€1,200 to €1,800**
4. Sedum plants or pre-grown vegetation mats: **Typically, €2,000 to €3,000**
5. Labour and setup: Can range from **€2,500 to €4,000**

This adds up to a **combined total of between €7,700 and €12,100 (which works out at roughly €154 to €242 per square metre)** (McEvoy, 2023) (Gardenmaintenance.ie, 2025).

Cost comparison of adding a green roof to a garden shed/storage

Approach: DIY

- **Approximate Cost Per m^2: €25-50 (materials only)**
- **Pros:** Lowest cost, complete control
- **Cons:** Requires skills, time-consuming

Approach: Kit System

- **Approximate Cost Per m^2: €60-120**
- **Pros:** Simplified installation, consistent results

- **Cons:** No installation worries, professional finish

Approach: Pre-built

- **Approximate Cost Per m^2: 30-50% premium over standard sheds**
- **Pros:** No installation worries, professional finish
- **Cons:** Highest initial cost, limited design options

Note: Green roofs work best on flat or low-pitched roofs (up to about 20° without special retention measures) (MacQueen, 2026)

Benefits

At a high-level green roof have been shown to provide the **following benefits,** along with their associated **economic advantages:**

- ➔ **Air quality regulation: Avoided damage cost**, e.g. Avoided costs in terms of health (reduction in hospitalization)
- ➔ **Regulation of water flows: Replacement cost,** e.g. Reduction in water management costs
- ➔ **Aesthetic appreciation**: Behavioural linkages, e.g. Estimate the (willingness to pay) WTP for aesthetic improvement
- ➔ **Increase roof longevity: Avoided cost**, e.g. Avoided cost of replacing the roof
- ➔ **Thermal insulation** (providing insulation against temperature extremes): **Avoided cost**, e.g. Avoided cost of energy
- ➔ **Space-saving:** Their implementation **doesn't require additional land** to provide benefits
- ➔ **Heat island:** Can assist in combating the urban heat island effect

(Chelli, Geneletti and Brander, 2023) (Igoe *et al.*, 2025)

Green roofs, green walls, green facades, vegetated surfaces and vertical greening systems

- ➔ **Retain greater amount of water, delay water run-off, reduce air temperature, and contribute to reducing the urban heat island effect** by reflecting more light because of higher albedo (up to 30%) than artificial surfaces (via (Lozano *et al.*, 2024)
- ➔ Green roofs can **reduce energy demand** for air-conditioning up to 60%, can cool neighbouring streets up to 3°Celsius, can reduce peak flow volume of heavy rain up to 96% and can reduce run-off up to 70% (via (Lozano *et al.*, 2024)
- ➔ The **retention rate** of green roofs may range from **29% to 100%**, with an average retention just under 78 % depending on the depth of the rainfall (Rasmussen, 2006) via (Lozano *et al.*, 2024)

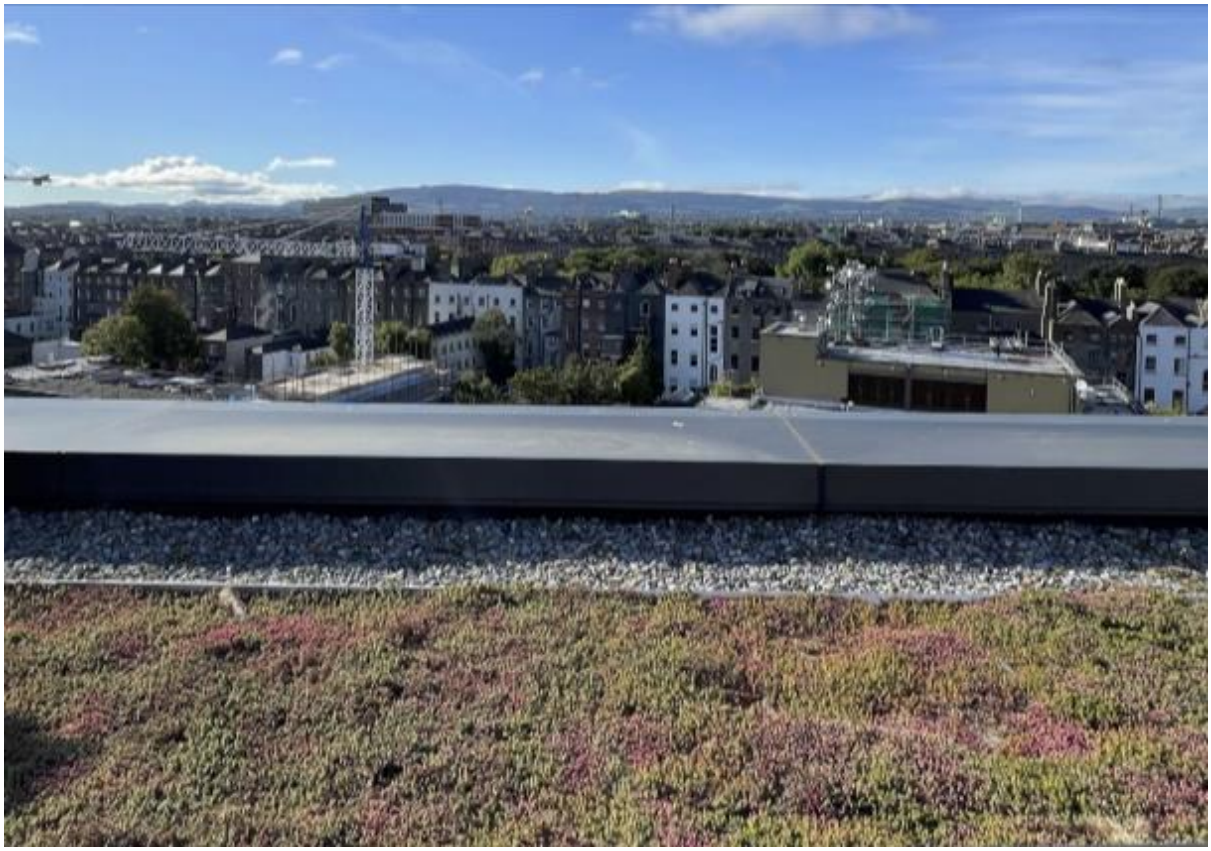

Fig.16: Green roof in Dublin (Dusty Gedge) via (McCloy Consulting and Robert Bray Associates, 2021)

In 2014, Hamburg (Germany) launched its pioneering Green Roof Strategy, with the ambitious target of greening 70% of new and suitable existing roofs. Financial incentives were utilised, including subsidies of up to 60% of green roof installation costs, cumulatively providing €3.5 million in funding between 2014 and 2024. In just 6 years, green roof extent increased from 124 to 168 hectares, where they now retain up to 50% of annual rainfall, reducing pressure on drainage systems and helping to mitigate flooding (Diadem, 2024).

New York City has introduced a Green Roof Property Tax Abatement. This incentive program offers a one-time property tax abatement (one-year length) for properties that have green roofs. The abatement equates to $10/sq ft of green roof space. The benefit is capped at whichever is less: $200,000 or the amount of property taxes due for the building that tax year (NYC Department of Finance, no date).

New York: Stormwater management and green roof ROI (Draus, 2022). A new 5-story condominium located in New York. Constructed in 2021, it contains a mix of 24 high-end residential units with exterior and underground parking. It also includes a 1020m^2 (11,000 sf) rooftop amenity space with a green roof.
Issue: Excessive groundwater, underground stormwater tank needed relocating. Couldn't sacrifice underground car parking spaces (had to match number of units).

Approaches: Internal storage - costly, too much space, high maintenance.
Green roof to 'purple roof' - enhanced water detention, no loss of parking, reduced peak stormwater runoff by 95%, facilitated the sale of all 24 units (including the previously-earmarked salvaged interior space).
Additional cost of purple roof: $196,488
Credit for not requiring underground storage tank: $75,000
Actual cost of purple roof: $121,500
Result: Developer was able to sell two additional units for a total of: $1,800,000

Conclusion and next steps

Technical toolkits and guidance documents

In accordance with the findings and recommendations of (Molloy, Collier and Buckley, 2024) **there is still a need for technical toolkits, and guidance documents for NbS,** although the more recent work by (Igoe *et al.*, 2025) goes a long way in helping to plug this gap, with the framework guidance from (Southern Regional Assembly, 2022) also providing a very useful resource. Beyond a static document however, (Molloy, Collier and Buckley, 2024) advocate for a 'comprehensive, freely available database of NbS in Ireland, with evidence of their benefits (social, economic, environmental)'. Similarly for Cronin (2025), advocating for a **centralised NbS platform to share knowledge, tools and data**. A resource that would allow a given party to make direct comparisons between conventional (grey) infrastructure versus nature-based (green) infrastructure approaches (where they are specifically pertaining to housing developments) would be hugely valuable. It's one thing choosing the right NbS (the 'what') but it's also essential to understand their implementation (the 'how'). Ideally this interactive resource would offer robust and intuitive discoverability features (e.g. filtering and sorting) allowing users to search for specific NbS types, and specific scenarios.

What's required beyond the scope of this project

It is clear from the literature that NbS cannot be viewed in isolation. There is widespread recognition of the role of public policy in helping to shape a more fertile environment for NbS to develop. Nature-centric considerations (including restoration) need to be far more systematically integrated into national policies, where efforts need to be aligned with existing frameworks, including the EU Nature Restoration Law, and the 4th National Biodiversity Action Plan (Cronin, 2025). There needs to be more acknowledgment of their role in addressing key national targets, through directly linking NbS and SuDs with wider sustainable development objectives and sectoral plans. It's argued that nature's value must be central to strategic urban planning, where development strategies span multiple

interconnected sectors - from health to water. As such, no single panacea or silver bullet has been identified that can satisfy the split incentive dilemma, which can fully translate or transfer the full range of societal co-benefits from nature into a financial mechanism that rewards the private developer. **A significant challenge that has been identified in an Irish context is the sheer variety of guidelines that may need to be adhered to-from density to green space. This fragmented and piecemeal approach can inhibit the cost-effective Natural Capital approach to implementation of measures**. On this point, when the totality of public and private co-benefits are properly accounted for, NbS (and related initiatives) can truly demonstrate their value and cost-effectiveness, as the positive indirect benefits that flow from their deployment may reduce costs and burdens in other domains. In order to bring more cohesion, there **are calls to establish a National NbS Taskforce, comprising an inter-departmental body to coordinate efforts from local to national scale** (Cronin, 2025).

NbS and SuDS need to be designed and incorporated from the very beginning of a project's lifecycle, where successful implementation requires collaboration, and adopting a longer-term perspective, particularly as retrofitting these measures can prove prohibitively expensive.

Nature-enhanced desirability and associated housing affordability

As a readily available metric, it is quite common in studies for researchers to use house prices as a proxy for quantifying the economic value of NbS (and urban green space more generally). Although an attractive selling point, it can potentially be problematic, as it all depends on which angle you are looking from. This accompanying rise in property value can be very beneficial for the developer and the homeowner, yet also raises serious questions around equity and affordability. Therefore, some caution is urged on the promotion of NbS and biodiversity solely through this lens.

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Appendix I

Acronyms and Definitions

BCR	Benefit-to-cost ratio
Blue roof	Roof system is explicitly designed to store water and attenuate runoff before a controlled release, and in its true form refers solely to this attenuation capacity. It may or may not include co-benefits for water quality improvement and biodiversity
BNG	**Biodiversity Net Gain:** An approach to development that is mandatory in England. It ensures that habitats for wildlife are left in a measurably better state than before the development took place. Developers must achieve a BNG of 10%, meaning the project must result in more or better-quality natural habitat than existed prior to development
CapEx	Capital Expenditure
CBA	Cost Benefit Analysis
Ecosystem Services	Services that an ecosystem provides and on which humans depend. These are commonly categorised as: provisioning services (food, water, wood); regulating services (climate regulation, flood control, disease regulation, and water quality); cultural services (recreation and ecotourism); and supporting services (soil formation, pollination and nutrient cycling)
Embodied Ecological Impacts	Refers to the off-site environmental consequences associated with upstream and downstream activities, such as habitat destruction or pollution resulting from raw material extraction, processing, and transportation.
Green Walls and Facades	**Green walls** are vertical structures that have different types of plants or other greenery attached to them. The greenery is often planted in a growth medium consisting of soil, stone, or water and usually features built-in irrigation systems. **Green facades** is a type of vertical garden installed on a building wall. It generally consists of a support structure and plants that are trained to cling to it and grow upwards.

Green Roof	Roofs with a vegetated surface that provide a degree of retention, attenuation and treatment of rainwater and promote evapotranspiration. As a nature-based solution, they provide benefits including water quality treatment, amenity and biodiversity.
Lakes and wetlands	Lakes and wetlands cover everything marshes and swamps to peatlands and mangroves offering a plethora of ecosystem and infrastructure services - from heavy metal and nutrient removal, reducing nitrogen concentrations, flood water regulation and mitigation capabilities, and vast carbon storage capacity
LSTs	Land Surface Temperatures
Nature Capital	Defined as 'the value of everything that comes from nature'
NBI	**Nature-based Infrastructure:** has been described as a subset of NbS, with a specific focus on infrastructure-type services such as flood control, water purification, and air quality enhancement, including measures such as wetland restoration, and green roof installation.
OpEx	Operational Expenditure
Permeable pavements/surfaces	A paving system that allows water to infiltrate into underlying layers or soils, reducing surface runoff and supporting stormwater management. However, in their most common hard format, they do not meet the criteria for NbS and should not be considered the primary option for sustainable urban drainage design
Ponds and wetlands	Water features with a permanent pool of water, providing both attenuation and wastewater treatment services, designed so that the water level can rise during high rainfall events and offer temporary storage for excess water.
Rainwater garden	A shallow planted depression in the ground that mimics natural temporary pools and stores rainwater
Swales	Shallow vegetated channel designed principally to convey and treat runoff. A Dry Swale is a Conveyance Swale that has the addition of a filter medium and underdrain system. A Wet Swale is a Conveyance Swale, designed to deliver wet and/or marshy conditions at the base.
Tree pits	Constructed underground structures used to create voided space to contain a soil and/or storage volume and protect the root space of one or more trees when located within a paved area
Urban forests/trees	An urban forest is defined as comprising all tree-dominated green areas in and around urban areas

Urban Heat Island	The phenomenon where urban areas experience higher air, surface, and soil temperatures compared to their rural surroundings. This temperature difference arises due to human activities and the built environment, such as buildings, roads, and other infrastructure, which absorb and retain heat more than natural landscapes like forests and water bodies
WFD	**Water Framework Directive:** The Water Framework Directive (WFD) requires Member States to use their River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs) to protect and, where necessary, restore water bodies to reach good chemical and ecological status, and to prevent deterioration.