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ORIGINAL PAPER

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DESIGNING FOR WATER AND BEAUTY. THE INFLUENCE OF NATURE-BASED SOLUTIONS AND SUSTAINABLE URBAN DRAINAGE SYSTEMS ON THE AESTHETICS OF ARCHITECTURAL DESIGN OF SELECTED NEIGHBOURHOODS IN FRANCE AND POLAND

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ABSTRACT

The pursuit of healthier and more sustainable cities requires the adoption of nature-based solutions (NBS). In many cases, sustainable urban drainage systems (SUDS) are stipulated by the binding laws. Although they may add some financial burden for maintenance, they enhance the aesthetics of the architectural design. The primary objective of this study is to explore the potential of using SUDS to enhance the aesthetic appeal of architecture and to examine examples of good practice from two selected districts in France and Poland. The benefits of NBS for improved aesthetics and human health are reviewed. The regulatory frameworks are examined, followed by a discussion of the benefits, challenges and circumstances of SUDS. This study presents a comparison of the possibilities of introducing NBS in both countries. The neighbourhoods selected for this study demonstrate that NBS and SUDS may be feasible and improve the aesthetics of entire architectural complexes.

Keywords: nature-based solution, NBS, sustainable urban drainage system, SUDS, aesthetics, architectural design, neighbourhood design, France, Poland

INTRODUCTION

Urbanised areas worldwide face escalating pressures from climate vulnerability, rapid population growth, and the legacy of impervious surfaces that accelerate runoff and flood risk (Intergovernmental Panel on Climate Change [IPCC], 2023). Traditional urban drainage systems (pipes, concrete channels) are often inefficient and contribute to flooding, pollution, and the heat island effect. They are also often hidden or visually unappealing. On the other hand, the use of nature-based solutions (NBS) results in green townscapes, which are human-friendly and visually attractive.

NBS leverage nature and the power of healthy ecosystems to optimise infrastructure and protect people (International Union for Conservation of Nature [IUCN], n.d.). The IUCN defines NBS as 'actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human wellbeing and biodiversity benefits' (Cohen-Shacham, Walters, Janzen & Maginnis, 2016, p. 2). The European Commission (2015) emphasises that NBS work with natural

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processes rather than against them, delivering multiple co-benefits – environmental, social, and economic – simultaneously. Unlike traditional 'grey infrastructure' that serves single purposes, NBS are multifunctional. They can evolve and adapt to changing conditions, providing resilience to climate uncertainty in ways that fixed infrastructure cannot (Frantzeskaki et al., 2019). Moreover, NBS create visible, accessible landscape features that enhance urban aesthetics and provide everyday nature experiences for residents (Raymond et al., 2017).

NBS employed for the management of stormwater are SUDS, also known as green infrastructure or low-impact development. SUDS represent a suite of design strategies, e.g. green roofs, permeable pavements, dry rivers, bioswales, detention basins, etc. that mimic natural hydrologic processes to mitigate stormwater impacts. SUDS reduce the volume and rate of surface water runoff, aim to improve water quality, and help to enhance the biodiversity of the environment (MRMS, 2024). These systems work by infiltrating, storing, and slowly releasing stormwater, mimicking pre-development hydrological conditions while creating opportunities for ecological enhancement and public amenity (Woods Ballard et al., 2015).

While the environmental and economic advantages of SUDS are well documented, their aesthetic contribution has received comparatively less scholarly attention. This research gap is particularly significant given growing recognition that urban aesthetics profoundly influence public health outcomes, social cohesion, and place attachment (Kaplan & Kaplan, 1989; Gehl, 2010). The aesthetic dimension matters for several critical reasons. First, community support for implementing SUDS often depends more on perceived aesthetic quality than technical performance, with the visual appeal influencing political feasibility and maintenance commitment (Apostolaki & Jefferies, 2005). Second, the aesthetic qualities of urban nature – including visual complexity, seasonal variation, and sensory richness – mediate the psychological restoration and stress reduction benefits (Ulrich, 1984; Kaplan, 1995). Third, well-designed SUDS can increase property values and neighbourhood desirability, creating economic arguments for aesthetic investment that complement environmental justifications (Netusil, Levin, Shandas & Hart, 2014). Finally, a SUDS design that resonates with local landscape traditions can strengthen place identity and community pride, contributing to social sustainability (Gobster, Nassauer, Daniel & Fry, 2007).

This study focuses on the aesthetic advantages of integrating SUDS into the urban fabric, with the example of selected neighbourhoods from France and Poland. The primary aim of this research is to examine how NBS and SUDS influence the aesthetic quality of architectural design and contribute to the creation of health-promoting urban environments.

The specific research objectives are:

1. To analyse how regulatory frameworks shape aesthetic outcomes in implementing SUDS in France and Poland, identifying policy instruments and planning mechanisms that enable or constrain design quality.
2. To identify design strategies that successfully integrate SUDS with architectural aesthetics by examining specific technical solutions (green roofs, bioswales, retention ponds, permeable pavements, dry streams) and their visual integration with the built form.
3. To compare cultural approaches to nature-based urban design in French and Polish contexts, exploring how landscape traditions and aesthetic preferences influence the implementation of SUDS and the public perception.
4. To derive practical design recommendations for creating aesthetically successful SUDS that enhance urban liveability and foster community acceptance while meeting functional stormwater management requirements.

This study employs a comparative case study methodology, analysing two neighbourhoods that exemplify successful aesthetic integrations of SUDS: osiedle Pod Brzozami in Warsaw, Poland, and Cité-Jardin in Le Plessis-Robinson, France. These cases were selected based on demonstrated functional success over 10+ years, thoughtful aesthetic design, positive community reception, and contrasting cultural contexts.

The France-Poland comparison is particularly valuable because both countries operate within the European Union regulatory framework on water resource management, providing a common legislative baseline while exhibiting different implementation approaches. France's formal landscape heritage and mature economy contrast with Poland's naturalistic preferences and developing economic context. This enables exploration of how resources, culture, and regulatory maturity influence aesthetic outcomes. Both countries experience temperate climates with comparable hydrological conditions, controlling for environmental variables and ensuring meaningful comparison of design approaches. The authors' familiarity with both contexts, including language proficiency and professional networks, facilitated in-depth data collection and cultural interpretation.

Following this introduction, the paper examines the regulatory frameworks governing NBS and SUDS implementations in France and Poland, exploring how policy shapes design possibilities. The paper then discusses the aesthetic opportunities presented by SUDS, synthesising research on environmental psychology, biophilic design, and therapeutic landscapes. The case study section presents a detailed analysis of both neighbourhoods, followed by a comparative discussion of the findings and practical implications. The conclusion synthesises key insights and offers recommendations for policy, practice, and future research.

REGULATORY FRAMEWORK FOR SUSTAINABLE WATER SOLUTIONS

The implementation of NBS and SUDS in urban environments is increasingly governed by comprehensive regulatory frameworks that mandate their integration into architectural and urban design. France and Poland, two European Union member states, have developed distinct approaches to implementing sustainable water management solutions while also addressing aesthetic considerations in neighbourhood design.

European Union context

The deficit of freshwater is a constant worry for humankind. This is a common problem in France and Poland, as both countries have relatively limited resources of available freshwater (Eurostat data). Both France and Poland operate within the broader European Union regulatory framework, which provides the foundational directives for water management and sustainable urban development. The EU Water Framework Directive (Directive 2000/60/EC) establishes the legal framework for the protection and sustainable use of European waters, while the revised Drinking Water Directive (Directive (EU) 2020/2184) influences national obligations and incentives for water management across member states (Benöhr, 2022). These directives create a harmonised approach to water governance while allowing member states flexibility in implementation methods.

French regulatory framework

France has established a comprehensive legal framework for sustainable water management through successive water laws and basin-scale planning instruments.

The regulatory foundation consists of:

– National water laws (1992 and 2006): These laws introduced and strengthened basin-scale planning and regulatory tools. The 2006 law notably reformed groundwater governance and shifted management approaches, creating a more integrated approach to water resource management (Rinaudo, 2020). These laws establish the legal basis for implementing NBS and SUDS at the local level.
– *Schéma d'Aménagement et de Gestion des Eaux* (SAGE): These basin-level water management plans are produced by local basin commissions and can include opposable regulations – legally enforceable rules against third parties and administrative acts. This provides a direct legal mechanism to require specific water management measures, including NBS and SUDS, at the local scale (Liziard, Barbier & Fernández, 2020).

– Recent policy momentum: The Plan Eau (Water Plan) announced in 2023 signals national intent to accelerate implementation and adapt the regulatory framework to climate pressures while promoting proven solutions, increasing expectations on local authorities to deploy NBS and SUDS (Colas, 2023).

The practical implementation of sustainable water solutions in France operates through a multi-level governance system:
– Local regulatory responsibility: Basin commissions and municipalities draft SAGE-linked regulations and locally adapted rules to achieve plan objectives. This decentralised approach allows for regional adaptation while maintaining national coherence (Liziard et al., 2020).
– Municipal regulatory frameworks: Many local authorities implement regulatory and incentive frameworks to favour sustainable stormwater management. However, experts warn that overly rigid or poorly designed hydrological rules can be counterproductive, advocating for complementary, locally adapted rule sets based on rain-event methods and local objectives (Chocat et al., 2007).
– Basin plans and adaptation programmes: Published by basin agencies, these plans guide priorities including flood risk management, water resource protection, and ecological objectives, thereby shaping which NBS and SUDS measures are prioritised or required in projects (Roy, 2023).
– Technical flexibility: The regulatory approach emphasises a toolbox methodology with multiple solutions and sizes, privileging locally perceived essential objectives and appropriate levels of hydrological solicitation rather than one-size-fits-all prescriptions (Chocat et al., 2022).

When it comes to urban design and aesthetic implications, French regulatory instruments create both constraints and opportunities that influence urban design and neighbourhood architecture:
– Planning constraints on design: SAGE regulations and basin/municipal hydrological rules can impose functional requirements (infiltration, retention, discharge limits) that must be integrated into site layout, green-space distribution, and streetscape design (Liziard et al., 2020).
– Design integration requirements: Integrating SUDS and NBS typically requires architects and urban designers to allocate space for infiltration areas, swales, permeable surfaces, and retention basins while coordinating multi-functionality (public space, ecology, flood control) (Chocat et al., 2022).

In France, there are robust environmental regulations stemming from EU directives, e.g. the EU Water Framework Directive. There is constant pressure for green infrastructure, but implementation varies significantly between regions. In planning permits, aesthetic considerations often come second to functional requirements. Moreover, France's comparatively strong economy enables greater investment in sustainable infrastructure projects, yet cost remains a critical factor, particularly in densely populated urban areas.

Polish regulatory framework

In Poland, similarly to France, the environmental regulations stem from the EU Water Framework Directive. It defines, among other things, environmental objectives for surface waters divided into surface water bodies, e.g., river sections or water reservoirs together with their catchment areas, and for groundwater divided into groundwater bodies (anon, n.d.).

The main legal act in Poland is the Water Law (2001, 2017) and its implementing regulations. In addition to transposing the provisions of the Water Framework Directive, it contains a number of rules indirectly relating to small-scale water retention. One of the objectives of water resource management is to ensure adequate water quantity and quality for the population, protect against floods and droughts, and provide water for agriculture. The implementation of small water retention is, in a sense, the fulfilment of the recommendations of both

the Polish Water Law and the EU Water Framework Directive (Mioduszewski, 2018). The Water Law amended in 2017 contains a number of provisions relating to surface water retention (Ustawa z dnia 20 lipca 2017 r.). Colloquially, these changes to the Water Law are referred to as the 'rain tax' and introduced the obligation to pay fees for reducing natural land retention, i.e., for the so-called discharge of rainwater or meltwater from unsewered areas (Woźniak & Walczkiewicz, 2018).

Strategic documents at the national level that contain references to small retention include: the strategy for the protection of wetlands in Poland (*strategia ochrony obszarów wodno-błotnych w Polsce*), the national environmental policy (*polityka ekologiczna państwa*), the national strategy for the protection and sustainable use of biodiversity (*krajowa strategia ochrony i zrównoważonego użytkowania różnorodności biologicznej*), the rural development programme (*program rozwoju obszarów wiejskich*), the water management strategy (*strategia gospodarki wodnej*), and the draft national water policy until 2030 (*projekt polityki wodnej państwa do roku 2030*). These documents contain direct references to water resources management, including the development of small retention, or protection of wetlands (anon, n.d.).

At the provincial level, the main documents are the provincial small water retention programmes (*wojewódzki program małej retencji*). These programmes include plans for the construction of reservoirs and descriptions of non-technical forms of small water retention. Provisions related to the protection and management of water resources can also be found in provincial and municipal environmental protection programmes.

As in France, many local authorities implement incentive frameworks to favour sustainable stormwater management. At the local level, in places with difficult hydrological conditions, prone to local flooding, the local spatial development plans (*miejscowy plan zagospodarowania przestrzennego*) may stipulate the retention of rainwater within the plot boundaries.

Technical solutions have predominated in the current programmes for developing small-scale water retention in Poland – the main recommendations included the construction of reservoirs for recreational purposes or water supply. In the most recent studies, the researchers emphasise the need to implement non-technical methods: e.g. afforestation, protection of riparian landscape, as well as NBS and SUDS with micro basins. However, there is often no translation of these plans into practical actions (Mioduszewski, 2018).

Poland adheres to EU directives but faces numerous hurdles. Bureaucracy and inconsistencies between various levels of government (national, regional, and local) lead to fragmented planning regulations. The functionality is stipulated, but the aesthetics are not perceived as a priority. There is a need for clear national guidelines specifically addressing the aesthetic aspects of SUDS. Poland's economy is still developing compared to France. The resources available for aesthetic enhancements in SUDS projects may be limited. It is crucial to find cost-effective solutions that balance functionality and aesthetics.

THE AESTHETIC OPPORTUNITY

While the regulatory framework does not prescribe specific aesthetic standards for NBS and SUDS, the functional requirements create design opportunities that can enhance the visual quality of urban environments when properly integrated into architectural concepts. SUDS have the potential to create beautiful and engaging townscapes. This infrastructure can be more than just purely utilitarian. It can enhance urban aesthetics – defined as the visual quality and sensory experience of built spaces. Architectural aesthetics play a pivotal role in shaping human wellbeing, social cohesion, and place identity (Kaplan & Kaplan, 1989; Kaplan, 1995; Gehl, 2010). The integration of NBS and SUDS offers unique opportunities to enrich urban landscapes with dynamic water features and green corridors, thus transforming monotonous streetscapes into vibrant, biophilic environments. However, aesthetics depend on more than simply adding greenery; they require intentional design choices that balance functional performance with visual harmony.

France boasts a long tradition of formal landscape design, which has influenced the history of architecture and urban planning. The principles prioritised a focus on visual order, symmetrical layouts, and grand boulevards. French aesthetics tend towards formality, symmetry, and elegance. There is a long tradition and appreciation for manicured urban green spaces and parks with carefully controlled landscapes. Today, there is a growing movement towards *ville vert* (green city) initiatives, which incorporate nature into the urban fabric. We are facing the process of changing the basic foundation of the presence of nature in the city, and public parks of a new (second) generation (Trojanowska, 2020a). They are places where NBS and SUDS are employed. The park of the new (second) generation is a place where man allows natural rainwater infiltration, soil regeneration, and natural plant succession. The traditional method of garden development and maintenance, horticulture, gives way to a more ecological approach. We can observe that alongside the urban regeneration projects, when eco-neighbourhoods are built, NBS and SUDS are employed. In France, the appreciation for nature is present in a stylised and curated manner. However, the employment of NBS and SUDS requires education and citizen engagement to accept the new, sustainable aesthetics rather than opt for a more formal, symmetric design.

Poland's landscape is shaped by its turbulent history. Heavily destroyed during World War II, the Polish townscape required rapid reconstruction. The post-war reconstruction prioritised functionality and efficiency over aesthetics in many areas. Post-socialist history leaves a lingering legacy of prioritising functionality over beauty. In many neighbourhoods, we can observe utilitarian design with limited aesthetic considerations. Polish aesthetic preferences lean towards naturalistic design that reflects the country's rural heritage. In Poland, there is an appreciation for wilder, more informal landscapes. The strong connection to rural landscapes and vernacular architecture can be leveraged for aesthetically pleasing NBS and SUDS. The desire to reconnect with nature aligns with the potential of aesthetically pleasing SUDS, which can mimic natural ecosystems.

Environmental psychology and landscape aesthetics

There is a plethora of research on the health benefits of contact with nature (Largo-Wight, 2011). The review of research related to urban spaces reveals the importance of maintaining healing gardens, incorporating wooded parks and green space in communities, preserving pristine wilderness, and providing a clear view of nature outside (Largo-Wight, 2011). Recent empirical evidence has significantly strengthened this body of knowledge with a more nuanced understanding of the mechanisms involved.

A comprehensive systematic review by Wu, O'Keefe, Ding and Sullivan (2024) covering studies through 2023 found that while objective biodiversity metrics show mixed links with health outcomes, there is a consistent association between perceived biodiversity and mental health benefits, indicating that perception mediates many nature-health effects. This finding is particularly relevant for SUDS design, as it suggests that creating the perception of biodiversity may be as important as actual ecological diversity.

Large-scale longitudinal studies have provided robust evidence that regular use of green spaces or higher local green-space exposure is associated with better subjective wellbeing and lower psychological distress, with notably stronger protective effects for socioeconomically disadvantaged groups (Galera, Rodriguez, Santos & Martinez, 2025). This equity dimension adds important social justice considerations to landscape design decisions.

Recent experimental work has moved beyond simple 'green versus non-green' comparisons to identify specific spatial features that differentially support psychological restoration. Chen, Liu, Zhang, Wang and Li (2025) used virtual reality and physiological measures to demonstrate that overall area, gently sloped topography, and strategic planting height and strata are key design parameters for stress reduction and attention restoration. These findings provide actionable guidance for practitioners designing therapeutic landscapes.

Not only the green space (i.e. urban parks), but also blue space (i.e. rivers, canals, coast, lakes) received recognition for enhancing health and wellbeing, especially among women (Thomas, 2015). Green and blue spaces are perceived as distinct from the 'grey' urban environment. Growing evidence is documenting 'green'

and 'blue' spaces as 'therapeutic landscapes' (Völker & Kistemann, 2011; Bell, Foley, Houghton, Maddrell & Williams, 2018).

The development of SUDS offers possibilities to create health-promoting places (Trojanowska, 2020b; Trojanowska, 2025). Contact with an aesthetically pleasing green and blue environment may lead to stress reduction and mental regeneration. Recent case studies from Beirut demonstrate how facility quality, sensory plantings, shading, and social nodes in public green spaces are associated with improved mental wellbeing measures, providing evidence-based guidance for place-based improvements (Raad et al., 2025).

Biophilic design

According to the biophilia hypothesis, human beings need contact with nature (Wilson, 1984). Cities that offer the integration of nature into urban design are perceived as healthy and happy places to live (Kellert, Heerwagen & Mador, 2008; Beatley, 2011). Recent research has refined biophilic design theory and moved towards more implementable, evidence-based approaches.

A systematic review by Flores and Soria (2024) synthesised empirical evidence on specific biophilic design parameters, including natural light, materials, vegetation, and sightlines, reporting consistent benefits for productivity, emotional wellbeing, and patient recovery in built settings. However, the review also identified implementation barriers, including cost and technical knowledge gaps that need addressing.

Hung and Chang (2024) found that the holistic application of biophilic principles – particularly security, sensory richness, and integration of natural elements – predicts perceived restorativeness more strongly than any single formal attribute. This supports a systems approach to biophilic design rather than checklist--based implementations.

Innovative machine-learning approaches are now being used to translate perceptual data into concrete design guidance. Zhong and Ren (2024) used gradient boosting trees to predict emotional perceptions of nature-connectedness from landscape metrics, recommending specific compositional guidelines such as optimising the green view index and favouring distant open green spaces with nearby canopy layering to evoke positive emotions.

NBS and SUDS can mimic natural landscapes when cleverly designed. Recent research emphasises moving from pattern lists to quantified design levers (green view index, canopy proximity, mid-level planting, slope gradients) that practitioners can use to tune biophilic interventions for target psychological outcomes. If thoughtfully implemented, these systems offer everyday experiences of contact with nature to urban dwellers, such as views of nature through windows, pocket parks in interior courtyards, or linear parks as part of blue and green infrastructure. SUDS can be designed with native plants to create habitats for wildlife in urban areas while delivering measurable mental health benefits.

Sensory design

The presence of water features and native plants can stimulate all the senses, offering unique experiences. Varied plant colours, textures, and heights create visual interest. The range of dynamic seasonal colours and plant movement interacts with the surrounding architecture.

Apart from visual interest, water features may include fountains or shimmering streams for an auditory experience. The sound of water can be calming and engaging. Current research shows that these multisensory experiences are not merely additive but create emergent perceptual qualities that enhance the overall restorative value of the environment. Recent research has highlighted the critical importance of multisensory presentation of nature. Ha, Kim and Alam (2025) demonstrated that visual-auditory cues work synergistically to enhance restoration, with perceived biodiversity serving as a key mediator. This finding suggests that the sound of water features – whether fountains or shimmering streams – provides more than auditory pleasure; it actively contributes to the perception of ecological richness and subsequent psychological restoration.

Planting also offers tactile and olfactory stimulation. Moreover, edible plants, fruits, and herbs may become a tasty treat. Recent studies emphasise that successful sensory design requires careful attention to seasonal variation, maintenance requirements, and cultural preferences. People may interact with SUDS by walking along swales, crossing bridges, and observing wildlife, with each interaction providing multiple sensory inputs that contribute to the overall therapeutic value of the space.

Emerging research on pocket park design through environmental psychology perspectives (Han & Mamat, 2025) emphasises behavioural criteria that support diverse sensory experiences while ensuring safety and accessibility. This work provides specific guidance for creating small-scale interventions that maximise sensory richness within constrained urban spaces.

Health promotion and placemaking

Aesthetically pleasing SUDS may help to engage people and create a sense of place. Gesler (1996) defined therapeutic landscapes as places where 'physical and built environments, social conditions and human perceptions combine to produce an atmosphere which is conducive to healing'. The term 'health-affirming landscapes' refers to more common everyday places that unite the qualities of therapeutic landscapes to influence people's physical, mental, and spiritual healing (Trojanowska & Sas-Bojarska, 2018).

Recent research has expanded the understanding of how green spaces with SUDS can become health-promoting places. Trojanowska (2025) presents new evidence on therapeutic landscape research in eco-neighbourhood design, demonstrating how systematic integration of ecological and social design principles can create measurably beneficial environments. This work bridges the gap between therapeutic landscape theory and practical urban development.

Contemporary studies reveal two recurrent pathways through which nature delivers health benefits: (a) immediate stress-reduction and affective regulation, and (b) attention restoration and building long-term physical and behavioural capacities (Wu et al., 2024). Understanding these mechanisms allows designers to create interventions targeted at specific health outcomes.

The social and economic impacts of water-sensitive urban design (WSUD) are increasingly recognised as integral to health promotion. Khalaji, Zhang and Sharma (2024) reviewed evidence showing that SUDS and WSUD implementations create not only environmental benefits but also social cohesion, community engagement, and economic value that contribute to overall community wellbeing.

Recent work emphasises the importance of ecological knowledge in the public perception of urban greening. Russo (2025) found that public understanding of native plants' ecological benefits, including their role as larval food plants, significantly affects the acceptance and appreciation of urban green spaces. This suggests that educational components and interpretive design may enhance the health-promoting potential of SUDS installations.

Contemporary research also highlights the need for equitable access to health-promoting landscapes. Studies consistently show stronger protective effects of green space exposure for socioeconomically disadvantaged groups, suggesting that therapeutic landscape design should prioritise environmental justice considerations (Galera et al., 2025).

SUDS DESIGN CHALLENGES AND CIRCUMSTANCES

Implementation of NBS and SUDS may bring some challenges. Using traditional undergroundpipes may be perceived to be much easier in dense urban settings. Moreover, SUDS need a careful aesthetic design to be visually pleasing.

Space constraints

Urban areas often have limited space. SUDS require a large terrain. Some unusual design options, like green retaining roofs, vertical greening, and a combination of underground water tanks and surface urban drainage, may be needed.

Cost and maintenance

SUDS can have higher upfront costs than traditional drainage systems. Moreover, SUDS require ongoing maintenance, e.g. cleaning, pruning, weeding, etc. Even though there are some options to minimise cost, like using native hardy plants and designing for easy access, there is still an additional financial burden on inhabitants. Long-term benefits include reduced flood risk, improved water quality, and increased property values.

Public perception

Some people may be hesitant to accept 'natural' landscapes in urban areas. SUDS offer a dynamic landscape with seasonal plant variations that decay, hibernate during the winter, and are reborn in the spring. People require ecological education to accept a landscape that is not manicured with neatly ordered plants. However, in the long term, the NBS offers not only a healthy place to live but also increases public satisfaction and property values.

CASE STUDIES

In this study, two neighbourhoods with NBS and SUDS were identified as examples of good practices. One is from France and the other is from Poland. They were chosen based on their integration with the architectural context, use of native plant species, and visual complexity. Their aesthetic was highly appreciated by the public and the inhabitants. Both a literature review and study visits were conducted in each of the neighbourhoods presented.

Cité-Jardin, Le Plessis-Robinson, France

Authors: architecture – Maurice-Payret-Dortail, Paul Demay, Jean Festoc (1919–1939); urban renewal and new architecture – François Spoerry (1991–2000); landscape architecture – Diala Haddad (2008)

Project overview

The new Cité-Jardin is located in Le Plessis-Robinson, in the southern suburbs of Paris, France. The project revives the historic idea of the *cité-jardin* (garden city) and adapts it to the needs of a contemporary metropolitan area. The urban tissue is moderately dense and integrates housing blocks, services, and green public spaces. The neighbourhood comprises residential buildings of varied typologies, with commercial and community services located on the ground floors to animate the streetscape. Entrances are organised both from the street and from landscaped interior courtyards.

The main design objective was to combine heritage and innovation: to sustain the symbolic legacy of the early 20th-century garden cities while creating a functional, liveable, and environmentally sustainable neighbourhood. Special attention was given to greenery, water management, and public life to mitigate the nuisances of dense urban living and to foster a strong sense of community (Body & Navarro, 2010).

Design description

The design integrates a variety of SUDS into the urban fabric. Techniques include green roofs, permeable pavements, retention ponds, and bioswales. Water from rooftops and courtyards is collected and channelled into landscaped basins and infiltration areas, which both regulate stormwater runoff and create a pleasant natural setting.

Aesthetic strategies emphasise neo-traditional architecture – with pitched roofs, decorated façades, and arcades – combined with lush greenery, pergolas, and tree-lined pedestrian routes. The courtyards serve as recreational gardens, recalling the historical *cité-jardin* typology while offering modern ecological infrastructure. The design also incorporates references to classical French urbanism, with plazas, avenues, and carefully framed vistas.

Community feedback

Residents have expressed satisfaction with both the aesthetics and liveability of the neighbourhood. The balance of green courtyards and active ground floors has been praised for enhancing social interaction. Several inhabitants noted that the Cité-Jardin feels ‘like a small town within the city’, combining calm and beauty with accessibility to urban services.

In 2005, Le Plessis-Robinson won the European prize for urban flowering. In 2008, Le Plessis Robinson received the Grand Prix Européenne d’Architecture for ‘the reconstruction of the city and the best rebirth of an urban suburb’ (Body & Navarro, 2010).

Lessons learned

Le Plessis-Robinson’s Cité-Jardin demonstrates the value of combining heritage principles with contemporary ecological design. The integration of SUDS into aesthetically appealing courtyards has not only improved stormwater management but also increased property values and residents’ sense of belonging (Figs 1–2). Fifteen years after its completion, the complex remains well-maintained and continues to function as intended.

The project underlines that successful urban regeneration requires both technical solutions and cultural-symbolic dimensions. By reactivating the historic *cité-jardin* model, the designers created a neighbourhood that is ecologically resilient, socially vibrant, and culturally meaningful.

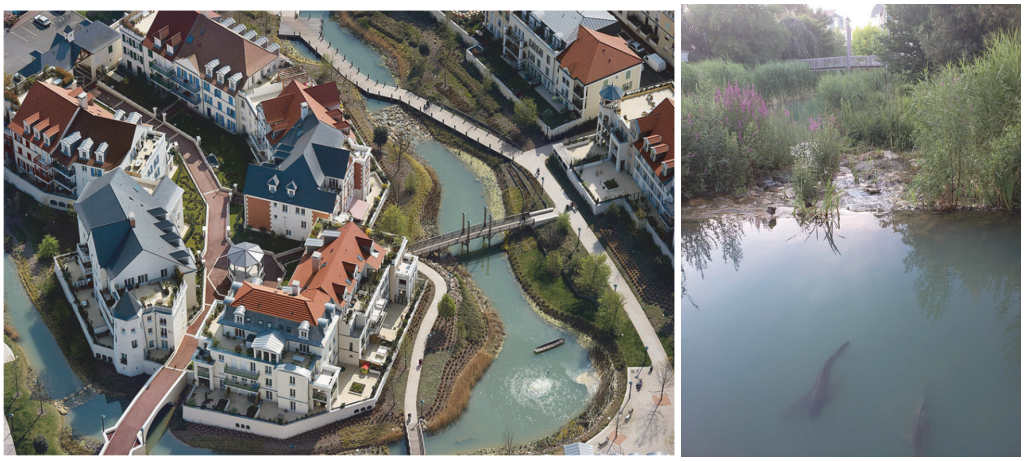

Fig. 1. Cité-Jardin, Le Plessis-Robinson: a one-kilometre artificial river traverses 21 ha of landscaped gardens featuring cascades, gentle slopes, and resting lakes

Source: © Valérie 92700, 2011 (photo on the left); the authors, 2025 (photo on the right).

Fig. 2. Cité-Jardin, Le Plessis-Robinson. The pedestrian path along the nature-based solutions and sustainable urban drainage systems offers a joyful walking experience to visitors and inhabitants

Source: photos by the authors, 2025.

The results from the case study interviews at Le Plessis-Robinson illustrate both the strengths and the limitations of integrating NBS and SUDS into neighbourhood design. On the one hand, the participants expressed a strong appreciation for the aesthetic qualities of the redeveloped landscape. The integration of water, vegetation, and carefully curated public spaces was repeatedly described as 'beautiful', 'charming' and a key factor in their attachment to place. These findings resonate with previous studies that highlight how water-sensitive design contributes not only to environmental resilience but also to cultural heritage and neighbourhood identity.

At the same time, the interviews underline important tensions. Several participants emphasised the fragility of the artificial river system, citing recurrent flooding, technical failures, and costly maintenance. This reflects a recurrent challenge in implementing NBS/SUDS: while their symbolic and aesthetic value is high, their performance depends on long-term management and technical robustness. The perception that 'it is not a real river' suggests that artificiality may weaken residents' trust in the durability of such interventions. Similarly, complaints about overgrown vegetation obscuring water views highlight the importance of maintenance in shaping the aesthetic experience.

Another key dimension is socio-economic. While the redevelopment has led to a remarkable increase in property values – sometimes surpassing Parisian averages – residents noted persistent inequalities between well-maintained apartments and degraded social housing. This demonstrates how the aesthetic and economic gains generated by NBS/SUDS can also reinforce social disparities, a risk that urban design policies must address.

Overall, these findings suggest that designing for water and beauty requires more than technical compliance with environmental regulations. The interviews show that residents value the symbolic and aesthetic presence of water, but they also reveal concerns about costs, fragility, and inequalities.

In this way, the case of Le Plessis-Robinson demonstrates that NBS and SUDS can indeed enhance urban beauty and attachment to place, but only if combined with careful long-term management and social inclusiveness.

Osiedle Pod Brzozami, al. KEN, ul. Płaskowicka, Warsaw, Poland, 2007–2011

Authors: architecture – Marek Budzyński, Zbigniew Badowski, Urszula Lewa; landscape architecture and SUDS – ABIES: Barbara Kraus-Galińska, Monika Wesołkowska, Magdalena Wnęk

Project overview

The neighbourhood is located in the Ursynów District of Warsaw, Poland. It forms part of a relatively dense urban tissue (Fig. 3). The complex houses 290 apartments, with local services and commerce located on the ground floor and accessible from the streets. They were designed to form the city façade, which should enrich the social life of the streets. The entrances to the apartments are located on both sides – the street and the interior courtyard. The interior courtyard is a green oasis with multiple water features designed to collect stormwater – SUDS. The designer's objective was to sustain the biosphere and isolate the inhabitants from the nuisances of city life (Budzyński, n.d.).

Fig. 3. Visualisation of the osiedle Pod Brzozami, Warsaw; view of the complex architecture in an orthoimage

Source: © Marek Budzyński Architekt sp. z o.o. (photo on the left); Google Maps, 2025 (photo on the right).

Design description

The intention was to retain stormwater within the urban complex. SUDS strategies employed are: green retention roofs, surface retention ponds, underground retention ponds, and a system of swales and dry streams. The stormwater from the buildings that have fewer than five levels is conducted via downpipes directly to the 'dry streams' in the recreational garden. The roof over the underground garage serves as a recreational garden. There are bridges over the dry streams, and numerous references to the Japanese gardens tradition (Fig. 4).

Fig. 4. Osiedle Pod Brzozami, Warsaw: view of interior courtyard with water features

Source: photos by the authors, 2025.

Community feedback

The inhabitants of the neighbourhood voiced their satisfaction. One of the inhabitants claimed that it is the most beautiful neighbourhood she has ever seen. The landscape architecture of the neighbourhood sparks admiration among the community. In 2022, this neighbourhood was awarded in the 39th edition of the 'Warszawa w kwiatach [Warsaw in bloom]' competition in the category of urban neighbourhoods – Spółdzielnia Inwestycji Mieszkaniowych Ursynów – osiedle Pod Brzozami I i II; alongside two other neighbourhoods – Wspólnota Mieszkaniowa Żoliborz Kraińskiego; and Robotnicza Spółdzielnia Mieszkaniowa Praga (Praga-Północ) (Zarząd Zieleni m.st. Warszawy, 2022).

Lessons learned

The aesthetics of the pure and clean white façades, almost devoid of any decorations, harmonise with the lush greenery of the interior court recreational garden that is rich in species (Fig. 4). The study visits 15 years after the completion reveal that the system is well-maintained and well-functioning. The employment of SUDS was stipulated by the local binding law. However, the implementation with aesthetic design increased the property value and inhabitants' satisfaction.

The space was limited in Warsaw; therefore, apart from ponds, underground water tanks were used to collect excess stormwater. There is constant maintenance, but the inhabitants claim it is not noticeable. The fact that there are 290 apartments that share the cost of maintenance of the interior courtyard makes the maintenance fees more feasible. All the apartments are privately owned; thus, the costs are balanced by the increase in inhabitants' satisfaction and increased property values.

DISCUSSION

Aesthetic integration as a design imperative

The analysis of both case studies reveals that the aesthetic success of NBS and SUDS extends beyond mere visual appeal to encompass deeper principles of environmental psychology and place attachment. In Warsaw's osiedle Pod Brzozami, the stark contrast between the minimalist white façades and the lush interior courtyard creates what Lynch (1960) termed 'imageability' – a memorable urban form that enhances wayfinding and spatial orientation. This design strategy demonstrates how SUDS can serve as organising elements

in urban composition, providing visual hierarchy and spatial definition that traditional grey infrastructure cannot achieve.

The case of Le Plessis-Robinson illustrates a different but equally effective approach, where SUDS are integrated into a neo-traditional urban fabric that references historical garden city principles while addressing contemporary environmental challenges. The one-kilometre artificial river system functions both as a spine for the neighbourhood's identity and as a practical stormwater management tool. This dual functionality exemplifies what Carmona, Heath, Oc and Tiesdell (2010) describe as 'performative landscapes' – spaces that simultaneously address multiple urban needs through integrated design.

Cultural aesthetics and regional adaptation

The contrasting aesthetic approaches in France and Poland reflect broader cultural attitudes towards nature in urban settings. French formal landscape traditions, rooted in centuries of geometric garden design, manifest in Le Plessis-Robinson's carefully controlled water features and structured plantings. The artificial river, while criticised by some residents for its 'unnaturalness', successfully translates classical French urbanism into contemporary sustainable infrastructure. This approach aligns with what Conan (2000) identifies as the French preference for 'nature cultivated' – natural elements subjected to human ordering principles.

Conversely, the Warsaw project embraces a more naturalistic aesthetic that reflects Polish cultural connections to rural landscapes and vernacular architecture. The dry streams and retention ponds mimic natural hydrological processes while incorporating Japanese garden influences, creating what might be termed a 'hybrid naturalism' that bridges Eastern European landscape preferences with international design vocabularies. This cultural adaptation suggests that successful SUDS implementation requires sensitivity to local aesthetic traditions rather than universal design solutions.

Maintenance as aesthetic practice

Both case studies highlight maintenance as a critical factor in sustaining aesthetic quality over time. The 15-year post-occupancy observations reveal that successful SUDS aesthetics depend on ongoing horticultural practices that balance ecological function with visual appeal. In Warsaw, the shared maintenance costs among 290 apartment owners create a viable economic model for landscape stewardship, while the collective ownership structure ensures consistent care standards.

The experience of Le Plessis-Robinson illustrates both the potential and the challenges of maintaining artificial water systems. Residents' concerns about flooding, technical failures, and overgrown vegetation reveal tensions between ecological succession and aesthetic expectations. This tension reflects what Nassauer (1995) describes as the 'aesthetics of care' – the need for visible human intention in landscape management to maintain public acceptance of ecological design.

The maintenance dimension also reveals important equity considerations. In Le Plessis-Robinson, disparities between well-maintained private areas and the neglected social housing sections demonstrate how aesthetic benefits can become markers of social stratification. This finding suggests that SUDS design must address not only technical performance but also social sustainability and equitable access to environmental amenities.

Regulatory frameworks and design innovation

The comparative analysis of the French and Polish regulatory approaches reveals how policy instruments shape aesthetic outcomes in SUDS implementations. France's mature regulatory system, with its basin-scale planning tools (SAGE) and municipal flexibility, enables more sophisticated integration of aesthetic considerations into functional requirements. The emphasis on 'locally adapted rule sets' (Chocat et al., 2007) allows for design innovation that responds to specific site conditions and cultural preferences.

Poland's evolving framework, while more prescriptive in its functionality requirements, offers opportunities for aesthetic enhancement that remain largely unexploited. The 'rain tax' mechanism creates economic incentives for SUDS adoption but lacks guidance on design quality standards. This regulatory gap suggests that aesthetic considerations require explicit policy attention rather than emerging organically from functional requirements.

The study findings support Ahern's (2013) argument that adaptive planning frameworks are essential for integrating multiple performance criteria in sustainable infrastructure design. Both countries would benefit from regulatory instruments that explicitly address aesthetic standards while maintaining flexibility for local adaptation and design innovation.

Sensory landscapes and therapeutic potential

The multisensory qualities observed in both case studies align with recent research on therapeutic landscape design and environmental psychology. The integration of water sounds, varied plant textures, and seasonal colour changes creates what Ulrich (1984) identified as 'supportive design environments' that promote stress reduction and psychological restoration. In Warsaw, the bridges over dry streams provide opportunities for contemplative movement through the landscape, while in Le Plessis-Robinson, the linear river system creates extended walking experiences that encourage physical activity and social interaction.

The wildlife habitats created by native plantings in both projects contribute to what Fuller, Irvine, Devine-Wright, Warren and Gaston (2007) term 'everyday nature experiences' that support urban biodiversity while enhancing residents' sense of connection to natural systems. These findings support the growing recognition that urban SUDS can serve as stepping stones in metropolitan ecological networks while providing immediate benefits for human health and wellbeing.

However, the study also reveals challenges in the public perception of dynamic, seasonal landscapes. Residents' preferences for 'manicured' appearances over ecological succession highlight the need for educational initiatives that help communities understand and appreciate the aesthetic qualities of naturalistic urban landscapes. This educational dimension is crucial for the long-term success of SUDS as aesthetic interventions.

Economic dimensions of aesthetic investment

Both case studies demonstrate positive relationships between the aesthetics of SUDS and property values, supporting the economic case for investing in design quality. The Warsaw project's sustained market performance 15 years post-completion suggests that well-designed SUDS create lasting value that justifies the initial aesthetic investments. Similarly, Le Plessis-Robinson's property values exceeding Parisian averages indicates that suburban locations can compete with urban centres when enhanced by high-quality environmental design.

These economic benefits extend beyond individual property values to encompass broader neighbourhood transformation. The award recognition received by both projects – Warsaw's 'Warszawa w kwiatach' competition and Le Plessis-Robinson's European prizes – demonstrates how aesthetic excellence in SUDS design contributes to civic pride and regional competitiveness.

However, the economic success of these projects also raises questions about affordability and social accessibility. The gentrification pressures evident in Le Plessis-Robinson suggest that aesthetic enhancement through SUDS may contribute to displacement of lower-income residents. This finding highlights the need for inclusive design strategies that distribute aesthetic and environmental benefits equitably across diverse communities.

Limitations and methodological considerations

The study's focus on successful examples provides valuable insights into best practices but may not fully capture the challenges and failures that characterise many SUDS implementations. The selection criteria emphasising 'high aesthetic appreciation' potentially introduce a bias towards projects with exceptional design resources and maintenance capabilities. Future research should examine a broader range of SUDS projects, including those with more modest budgets and less favourable site conditions.

The temporal dimension of aesthetic perception also requires further investigation. While both case studies demonstrate sustained aesthetic appeal over 15+ years, longer-term studies are needed to understand how SUDS aesthetics evolve with climate change, urban densification, and changing cultural preferences. The maintenance challenges observed in Le Plessis-Robinson suggest that aesthetic sustainability may require different strategies than ecological sustainability.

The study's European context also limits its generalisability to other climate zones and cultural contexts. The temperate climate conditions and specific regulatory frameworks in France and Poland may not translate directly to tropical, arid, or arctic urban environments, where different SUDS technologies and aesthetic approaches may be more appropriate.

Implications for design practice

The findings suggest several important considerations for practitioners designing SUDS in urban contexts. First, aesthetic integration must be considered from project inception rather than added as a superficial enhancement. Both successful case studies demonstrate how water management requirements can become organising principles for overall site design, creating coherent landscape narratives that enhance rather than compromise architectural concepts.

Second, the cultural dimension of aesthetic preference requires careful attention to local contexts and traditions. The contrasting approaches in France and Poland suggest that successful SUDS aesthetics emerge from dialogue between universal ecological principles and specific cultural landscapes. This finding supports calls for more participatory design processes that engage communities in defining aesthetic criteria for sustainable infrastructure.

Third, the maintenance dimension requires integration into project planning and financing from the outset. The economic models demonstrated in both case studies – shared ownership costs in Warsaw and municipal investment in Le Plessis-Robinson – provide templates for sustaining aesthetic quality over time. However, these models may require adaptation for different ownership structures and economic contexts.

Finally, the educational dimension emerges as being crucial for public acceptance of naturalistic urban landscapes. Both projects succeeded partly because residents developed an understanding and appreciation for ecological processes and seasonal change. This suggests that SUDS design should incorporate interpretive elements and community engagement strategies that build ecological literacy alongside aesthetic appreciation.

CONCLUSIONS

This study has demonstrated that NBS and SUDS represent far more than functional infrastructure – they constitute powerful tools for enhancing urban aesthetics and creating health-promoting environments. Through the comparative analysis of selected neighbourhoods in France and Poland, this research reveals how regulatory frameworks can successfully mandate sustainable water management while simultaneously fostering beautiful, liveable urban spaces.

Key findings

The case studies from Warsaw's osiedle Pod Brzozami and Le Plessis-Robinson's Cité-Jardin provide compelling evidence that well-designed SUDS can transform urban neighbourhoods into aesthetically pleasing, biophilic environments. Both projects successfully integrate water management with landscape architecture, creating dynamic water features that serve multiple functions: environmental resilience, sensory stimulation, and community gathering spaces. The positive feedback from residents in both locations underscores the importance of aesthetic considerations in sustainable urban design.

The regulatory analysis reveals that while France and Poland operate within the same EU framework, their implementation approaches differ significantly. France's more mature regulatory system and stronger economy enable greater investment in aesthetic enhancements, while Poland's developing framework prioritises functionality over beauty. However, both countries demonstrate that legal requirements for SUDS can be successfully implemented without compromising – and often enhancing – neighbourhood aesthetics.

Theoretical contributions

This research contributes to the growing body of knowledge on therapeutic landscapes and biophilic design by demonstrating how SUDS can serve as everyday interventions for urban health promotion. The study supports recent findings that perceived biodiversity and multisensory experiences of nature are crucial mediators of psychological restoration. By integrating water features, native plantings, and carefully designed pedestrian pathways, SUDS create opportunities for regular contact with nature that benefit mental health and social cohesion.

The aesthetic dimension of SUDS emerges as particularly important for public acceptance and long-term success. The study shows that residents value not only the environmental benefits but also the symbolic and cultural meanings of water in urban spaces. This finding challenges purely utilitarian approaches to sustainable infrastructure and argues for design strategies that address both functional and experiential qualities.

Practical implications

For urban planners and architects, this research provides evidence that aesthetic considerations should be integral to SUDS design from the outset, not treated as secondary enhancements. The success of both case studies demonstrates that investing in landscape architecture and maintenance creates long-term value through increased property values, resident satisfaction, and community pride.

Design recommendations for practitioners

Based on the comparative analysis, several practical guidelines emerge for creating aesthetically successful SUDS:

1. Plan aesthetics from inception: Do not add landscape design after the engineering is done. Visual quality, sensory experience, and spatial planning need to be part of the initial concept, not afterthoughts.
2. Align with cultural landscape traditions: The design approaches should match local aesthetic preferences. Formal French garden traditions work in France; naturalistic approaches resonate in Poland. Importing foreign design languages without considering local culture risks rejection by residents.
3. Design for multisensory experience: Think beyond visual appeal. The sound of flowing water, the scent of flowering plants, the texture of different surfaces – these sensory qualities make SUDS spaces memorable and restorative.
4. Ensure universal accessibility: SUDS spaces need smooth pathways, gentle slopes, rest areas, and multiple access points. They should work for all residents regardless of age, mobility, or socioeconomic status.

5. Plan for long-term maintenance: Set up adequate maintenance budgets and protocols from the start. Without ongoing care, even beautifully designed systems deteriorate. Both functional performance and aesthetic appeal depend on regular maintenance.
6. Foster social interaction: Include benches, gathering spaces, and pathways that encourage community use. Water management infrastructure should double as valued neighbourhood amenities where people actually want to spend time.
7. Educate residents: Many people need help in understanding naturalistic landscapes. Interpretive signage and community programming can build appreciation for ecological processes, seasonal changes, and the wildlife these systems support.

Social justice and inclusiveness

NBS and SUDS increase the accessibility of urban green spaces and promote inclusiveness and social justice. As they improve the microclimate, they mitigate the effect of urban heat islands and may serve as a good example of adaptation to climate change in large cities.

However, attention must be paid to the equitable distribution of high-quality SUDS across all neighbourhoods, not just affluent areas. The case studies demonstrate that aesthetically pleasing SUDS are achievable even in moderate-income social housing contexts, challenging assumptions that design quality is a luxury only wealthy communities can afford. Design processes should involve diverse community members to ensure SUDS serve as public goods accessible to all residents, avoiding patterns where sustainable infrastructure accelerates gentrification or creates exclusive enclaves.

Climate change adaptation

The findings take on particular urgency in the context of climate change. Urban areas worldwide face increasing challenges from extreme weather events – intense rainfall, prolonged droughts, and heat waves. SUDS are no longer optional amenities, but essential infrastructure for climate adaptation.

Both case studies demonstrate how SUDS contribute to climate resilience: managing stormwater during increasingly frequent heavy rainfall events, reducing local temperatures during heat waves through vegetation and water features, maintaining landscape function during dry periods through water retention and native plantings, and supporting biodiversity as species adapt to changing conditions. The aesthetic dimension becomes critical for ensuring public acceptance and long-term political support for the large-scale SUDS networks cities need to implement for climate adaptation.

Looking forward, climate projections suggest that temperate European cities will experience more Mediterranean-like conditions: hotter, drier summers punctuated by intense rainfall events. SUDS designed for these future conditions must be both resilient and attractive, supporting human and ecological communities through significant environmental change.

The study also highlights the importance of education and community engagement in fostering acceptance of ‘naturalistic’ urban landscapes. As cities transition from formal, manicured green spaces to more ecological approaches, residents need support in understanding and appreciating seasonal variations, natural plant succession, and wildlife habitats.

Limitations and future research

This study’s focus on European contexts and temperate climate zones limits the generalisability of the findings to other geographic and cultural contexts. Future research should explore how aesthetic preferences for NBS and SUDS vary across different cultural traditions and environmental conditions. Longitudinal studies tracking the aesthetic and functional performance of SUDS over extended periods would also provide valuable insights into design durability and maintenance requirements.

The socio-economic dimensions revealed in the Le Plessis-Robinson case study warrant further investigation. While SUDS can increase property values and neighbourhood attractiveness, they may also contribute to gentrification and social displacement. Future research should examine how to design inclusive NBS that benefit all residents rather than exacerbating urban inequalities.

The study's focus on successful examples, while useful for identifying best practices, limits the understanding of what causes SUDS projects to fail aesthetically. Future research examining less successful implementations would reveal important barriers and pitfalls to avoid.

Policy recommendations

Based on these findings, several policy recommendations emerge:

1. Integrate aesthetic standards into SUDS regulations: Planning authorities need design guidelines that address visual quality, sensory experience, and cultural appropriateness – not just technical performance. Regulations should require aesthetic considerations from the start, not treat them as optional extras.
2. Develop regional design manuals: Generic guidelines do not work. Cities need context-specific manuals featuring local best practices, native plant palettes, and design approaches that resonate with local culture. This would help ensure consistent quality across different projects.
3. Invest in long-term maintenance: SUDS need ongoing care to stay both functional and attractive. Funding mechanisms should cover lifecycle costs, not just installation. Without maintenance budgets, even well-designed systems become neglected eyesores.
4. Promote community education: Many residents need help in understanding and appreciating naturalistic landscapes. Interpretive signage, community workshops, and educational programming can build an appreciation for ecological processes, seasonal changes, and the wildlife habitats these systems support.
5. Ensure equitable distribution: High-quality SUDS should not be concentrated in affluent neighbourhoods while lower-income areas get only basic functionality. Policies should mandate good design across all communities, making beautiful, effective water management a right, not a luxury.
6. Include aesthetic performance metrics: Current SUDS evaluation focuses on technical criteria like water infiltration and pollutant removal. This is not enough. Aesthetic quality, user satisfaction, and social benefits should also be measured to complete the picture of how well these systems perform.

Final reflections

The transformation of urban drainage from hidden, purely functional infrastructure into visible, aesthetically pleasing landscape features represents a fundamental shift in how cities can integrate sustainability and beauty. The examples from Warsaw and Le Plessis-Robinson demonstrate that this integration is not only possible but highly beneficial for urban communities.

As cities worldwide grapple with climate change, urbanisation pressures, and public health challenges, the aesthetic dimension of sustainable infrastructure becomes increasingly important. Beautiful, well-functioning SUDS can serve as catalysts for broader urban transformation, creating neighbourhoods that are simultaneously resilient, healthy, and delightful to inhabit.

The evidence presented in this study suggests that designing for water and beauty is not a luxury but a necessity for creating truly sustainable cities. By embracing the aesthetic potential of NBS and SUDS, urban designers can craft environments that nourish both ecological and human wellbeing, fostering the kind of places where communities thrive in harmony with natural systems.

Future urban development must move beyond the false dichotomy between functionality and beauty, recognising that the most successful sustainable infrastructure serves multiple purposes: environmental protection, human health, social cohesion, and aesthetic delight. The neighbourhoods examined in this study point towards a future where water management becomes an art form, where water systems double

as community amenities, and where the practical necessity of climate adaptation creates opportunities for urban beauty.

In this vision, every rain garden becomes a pocket of biodiversity, every bioswale a linear park, and every retention pond a focal point for neighbourhood identity. The path forward requires continued collaboration between architects, engineers, landscape architects, urban planners, and communities to realise the full potential of designing for water and beauty in our rapidly changing urban world.

Authors' contributions

Conceptualisation: M.T. and M.H.T.; methodology: M.T. and M.H.T.; validation: M.T. and M.H.T.; formal analysis: M.T. and M.H.T.; investigation: M.T. and M.H.T.; resources: M.T. and M.H.T.; data curation: M.T. and M.H.T.; writing – original draft preparation: M.T. and M.H.T.; writing – review and editing: M.T. and M.H.T.; visualisation: M.T. and M.H.T.; supervision: M.T. and M.H.T.

All authors have read and agreed to the published version of the manuscript.

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PROJEKTOWANIE DLA WODY I PIĘKNA. WPŁYW ROZWIĄZAŃ OPARTYCH NA NATURZE I ZRÓWNOWAŻONYCH SYSTEMÓW ODWODNIENIA MIEJSKIEGO NA ESTETYKĘ PROJEKTÓW ARCHITEKTONICZNYCH WYBRANYCH DZIELNIC WE FRANCJI I W POLSCE

STRESZCZENIE

Dążenie do zdrowszych i bardziej zrównoważonych miast wymaga wdrożenia rozwiązań opartych na naturze (NBS). W wielu przypadkach zrównoważone systemy odwodnienia miejskiego (SUDS) są wymagane przez obowiązujące przepisy prawne. Chociaż mogą one powodować pewne obciążenia finansowe w zakresie utrzymania, to poprawiają jakość projektów architektonicznych. Zbadanie możliwości wykorzystania SUDS w celu zwiększenia atrakcyjności estetycznej architektury oraz przegląd przykładów dobrych praktyk z dwóch wybranych dzielnic we Francji i w Polsce to główne cele pracy. Przedstawiono korzyści płynące z NBS w celu poprawy estetyki i zdrowia ludzi. Przeanalizowano ramy regulacyjne, a następnie omówiono korzyści, wyzwania i uwarunkowania związane z SUDS. W opracowaniu porównano możliwości wprowadzenia NBS w obu krajach. Przykłady wybranych osiedli pokazują, że zastosowanie NBS i SUDS jest możliwe i poprawia estetykę całych zespołów architektonicznych.

Słowa kluczowe: rozwiązanie oparte na naturze, NBS, zrównoważony system odwodnienia miejskiego, SUDS, estetyka, projektowanie architektoniczne, projektowanie urbanistyczne, Francja, Polska