GREEN INFRASTRUCTURE AND STORMWATER MANAGEMENT IN URBAN AREAS: APPROACHES, METHODS AND IMPLEMENTATION DYNAMICS

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1. INTRODUCTION

Stormwater management in urban areas has become an increasingly complex planning and design challenge due to intensified urbanization pressures, climate change, and transformations in land use patterns. Within the natural hydrological cycle, a significant portion of rainfall is retained by soil, infiltrates into the ground, or is delayed through vegetation before becoming surface runoff. However, the expansion of impervious surfaces during urban development disrupts this balance, causing rainfall to rapidly convert into surface runoff (Paul and Meyer, 2001). This process not only increases runoff volumes but also leads to a range of interconnected problems, including heightened flood risk, deterioration of water quality, and additional pressure on urban infrastructure systems. Conventional grey infrastructure approaches have traditionally addressed these issues by rapidly collecting and conveying stormwater away from urban areas. Such approaches, however, treat stormwater as a waste to be disposed of rather than as a resource, often resulting in solutions that lack long term sustainability (Barbosa et al., 2012).

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In recent years, green infrastructure based approaches have emerged as alternative and complementary strategies in stormwater management. Green infrastructure aims to retain, delay, and regulate stormwater within the urban environment through vegetation, soil based systems, and semi natural elements. These approaches offer the potential to simultaneously reduce surface runoff, mitigate flood risk, enhance infiltration, and improve water quality (Ahiablame et al., 2012).

Addressing stormwater management solely as an engineering driven drainage issue has led to significant implementation challenges, particularly in cities with diverse climatic and spatial characteristics. In high rainfall regions, poorly scaled or context-insensitive solutions often fail to deliver expected performance and may even generate additional risks (McDonnell et al., 1997). Consequently, contemporary stormwater management requires an integrated perspective that considers hydrological processes alongside urban form, land use, and maintenance and governance frameworks.

The purpose of this book chapter is to present a comprehensive conceptual and methodological framework that enhances understanding of the relationship between green infrastructure and stormwater management in urban areas. The chapter first introduces the fundamental concepts related to green infrastructure and stormwater management, followed by a detailed discussion of stormwater management objectives and functions, including surface runoff control, flood mitigation, infiltration, rainwater harvesting, and water quality improvement. In doing so, the chapter aims to provide a solid theoretical foundation for both academic research and planning and design practices.

2. GREEN INFRASTRUCTURE AND STORMWATER MANAGEMENT: CONCEPTUAL FRAMEWORK

Green infrastructure is commonly defined as a spatial network that supports ecological processes and maintains the continuity of natural systems within urban areas. This network consists of vegetation, soil systems, water bodies, and semi-natural elements, designed not only for aesthetic or recreational purposes but also to sustain ecosystem services. In the context of stormwater management, green infrastructure serves as a mechanism to restore balance to disrupted components of the urban hydrological cycle (Fletcher et al., 2015).

Conventional grey infrastructure systems primarily focus on rapidly collecting and conveying stormwater away from urban spaces through pipe networks. While this approach may temporarily control surface runoff, it often disrupts natural infiltration processes, limits groundwater recharge, and weakens the cyclical role of water within ecosystems. In contrast, green infrastructure aims to retain, delay, and manage stormwater within the urban environment by mimicking natural hydrological processes. From this perspective, green infrastructure represents not only an engineering solution but also a spatial and ecological planning approach (Ahiablame et al., 2012).

In international literature, the relationship between green infrastructure and stormwater management is framed through several conceptual approaches. Low Impact Development (LID) emphasizes source control through small scale, distributed practices (Jia et al., 2015). Similarly, Sustainable Urban Drainage Systems (SUDS) and Water Sensitive Urban Design (WSUD) conceptualize stormwater not merely as a drainage issue but as an integral component of urban design (Bartons and Arton, 2007; Ferrans et al., 2022). The shared principle across these approaches

is the prioritization of on site retention and controlled management of stormwater rather than rapid conveyance (Bekiryazıcı, 2023).

The conceptual link between green infrastructure and stormwater management is fundamentally shaped by the spatial organization of hydrological processes. Key mechanisms such as interception, infiltration, surface runoff, and evapotranspiration can be reconfigured through green infrastructure components. Vegetation and soil layers, in particular, prevent rainfall from immediately becoming surface runoff, allowing water to be stored and delayed within the urban fabric. Trees and green spaces play a critical role in this process, extending beyond visual benefits to directly influence stormwater retention and delay (Berland et al., 2017).

However, it would be misleading to suggest that green infrastructure alone provides a universally sufficient solution for stormwater management. Soil conditions, groundwater levels, rainfall regimes, and urban density significantly influence the effectiveness of green infrastructure practices. In high-rainfall cities, infiltration-based solutions may exhibit limited performance and fail to deliver anticipated hydrological benefits. Accordingly, the conceptual framework must address green infrastructure as a context-sensitive and multi-scalar planning strategy rather than a one-size-fits-all solution (McDonnell et al., 1997).

Urban open spaces and urban furniture elements can also be considered integral components of green infrastructure systems. At the local scale, open space design, the use of permeable surfaces, and the placement of urban furniture directly affect the behavior of stormwater within urban settings. Studies conducted in the Turkish context indicate that sustainable open space and urban furniture design can enhance the effectiveness of

green infrastructure applications (Dinçer et al., 2020). This highlights the importance of addressing green infrastructure not only through large-scale systems but also through design details that shape everyday urban spaces.

3. OBJECTIVES AND FUNCTIONS OF STORMWATER MANAGEMENT

Stormwater management represents a multidimensional process that extends beyond the conventional practice of conveying rainfall away through drainage systems. Contemporary approaches aim to regulate the behavior of stormwater within urban systems by jointly addressing hydrological, ecological, and spatial processes. Within this framework, stormwater management encompasses a set of core functions, including the reduction of surface runoff, mitigation of flood risk, enhancement of infiltration, rainwater harvesting, and improvement of water quality (Ferrans et al., 2022).

This section examines the primary objectives and functions of stormwater management under five main headings, with each function discussed in relation to green infrastructure from both conceptual and practical perspectives.

3.1. Control and Reduction of Surface Runoff

The control and reduction of surface runoff constitute one of the most fundamental objectives of urban stormwater management. During urbanization, the replacement of natural surfaces with impervious materials such as asphalt and concrete significantly limits rainfall–soil interaction, causing precipitation to rapidly transform into surface runoff. As a result, rainfall bypasses natural regulatory processes within the hydrological cycle and imposes immediate pressure on urban drainage systems (Fryd et al., 2012).

Increased surface runoff not only burdens drainage infrastructure but also intensifies flood frequency, accelerates the transport of pollutants through surface waters, and generates abrupt changes in flow regimes within urban water systems. Consequently, contemporary stormwater management approaches prioritize the reduction and delay of runoff at its source. This principle aims to retain stormwater within the urban environment for as long as possible and to maintain its interaction with natural processes (Ahiablame et al., 2012).

Green infrastructure practices provide effective tools for controlling surface runoff. Systems such as permeable pavements, rain gardens, bioswales, and green roofs prevent rainfall from immediately becoming runoff by enabling temporary storage on the surface or within soil profiles. Findings from hydrological modeling studies demonstrate that, when appropriately designed and context-sensitive, these practices can significantly reduce runoff volumes (Bekiryazıcı and Acar, 2024).

However, the effectiveness of green infrastructure in reducing surface runoff varies depending on site-specific conditions. In regions with high rainfall intensity, rapid soil saturation and limited infiltration capacity may restrict the performance of certain green infrastructure solutions. Studies examining the influence of infiltration rate changes on runoff generation indicate that once specific thresholds are exceeded, surface runoff may again become the dominant process (Zhang et al., 2019).

These findings highlight that surface runoff control cannot rely on isolated interventions alone but requires a multi-component and multi-scalar systems approach. Integrating green infrastructure with urban planning decisions, land-use patterns,

and maintenance strategies is essential for achieving long-term and sustainable reductions in surface runoff.

3.2. Flood Risk Mitigation

Flood risk mitigation represents one of the most critical objectives of urban stormwater management. The increasing proportion of impervious surfaces associated with urbanization causes rainfall to rapidly transform into high-discharge surface runoff, significantly elevating flood risk, particularly during intense precipitation events. While natural landscapes allow rainfall to be temporally distributed and balanced within the system, this equilibrium is largely disrupted in urban environments (Bekiryazıcı, 2023).

Conventional flood control strategies have primarily relied on the rapid conveyance of peak flows through drainage infrastructure. Although this approach may appear to reduce flood risk locally, it often transfers runoff downstream more quickly, generating new flood risks in other areas. Contemporary stormwater management perspectives therefore emphasize that flood mitigation cannot be achieved solely through hydraulic capacity expansion, but rather through an integrated understanding of rainfall–runoff relationships (Fletcher et al., 2015).

Green infrastructure based solutions contribute to flood mitigation primarily by reducing peak discharge and extending runoff travel time. Practices such as rain gardens, bioswales, green roofs, and urban green spaces provide temporary storage of stormwater within the urban system, thereby limiting abrupt increases in flow. Evidence from hydrological modeling studies indicates that when appropriately scaled and spatially distributed, these practices can substantially reduce flood risk (Bekiryazıcı and Acar, 2024).

However, addressing flood risk exclusively through physical infrastructure measures is insufficient. Flood risk is also closely linked to patterns of urban land use, building density, and human behavior. Risk analysis studies highlight that household-level adaptive behaviors and awareness play a significant role in flood risk reduction, alongside structural measures (Haer et al., 2017). This underscores that stormwater management is not solely a technical issue but also encompasses social and governance dimensions.

In high-rainfall cities, flood mitigation strategies must consider the context-sensitive application of green infrastructure. In areas with limited infiltration capacity, green infrastructure should be designed not primarily as a flood prevention tool but as a mechanism for runoff delay and temporary storage. This perspective enables green infrastructure to be positioned not as a substitute for grey infrastructure, but as a complementary component within an integrated flood management system.

In conclusion, flood risk mitigation is a complex objective that cannot be reduced to isolated interventions. Integrating the hydrological functions of green infrastructure with planning decisions, land-use strategies, and governance frameworks is essential for developing urban systems that are more resilient to flooding.

3.3. Infiltration and Groundwater Recharge

Infiltration and groundwater recharge represent one of the most critical yet often underemphasized functions of stormwater management, particularly in terms of long-term urban water balance. Within the natural hydrological cycle, a substantial portion of rainfall infiltrates through soil profiles, replenishing groundwater systems and maintaining dynamic interactions between surface and subsurface waters. In urban environments, however, this process is largely disrupted due to the expansion of

impervious surfaces and the degradation of soil structure (Fletcher et al., 2015).

Green infrastructure approaches aim to reestablish soil–plant–water interactions in order to enhance infiltration and support groundwater recharge. Practices such as infiltration trenches, rain gardens, and permeable surface systems encourage rainfall to infiltrate into the soil rather than rapidly converting into surface runoff. Under suitable ground conditions, these practices can contribute to both runoff reduction and the replenishment of groundwater resources (Bekiryazıcı and Acar, 2024).

Nevertheless, assuming that infiltration-based solutions universally produce positive outcomes in urban contexts can be misleading. Compacted soils, clay-dominated substrates, and areas with high groundwater tables often exhibit severely limited infiltration capacity. In such settings, rainfall infiltration remains restricted, and surface runoff reemerges as the dominant hydrological process. Several studies have demonstrated that limitations in infiltration rates directly influence the overall performance of stormwater management systems (Zhang et al., 2019).

Another significant constraint associated with infiltration practices in urban areas relates to the complexity of subsurface systems. The concept of “urban karst” highlights how underground infrastructure, drainage networks, and artificial voids can redirect water flow in unexpected ways. In these environments, infiltration practices may lead to unintended water accumulation, infrastructure damage, and localized saturation problems (Bonneau et al., 2017).

From a groundwater recharge perspective, the potential benefits of infiltration should be evaluated at regional and catchment scales. While infiltration can reduce surface runoff in the short term, it may contribute to the long-term sustainability of

water resources if properly aligned with soil characteristics and groundwater dynamics. Otherwise, infiltration based interventions may fail to deliver anticipated hydrological benefits and instead introduce new risks (Bekiryazıcı, 2023).

Accordingly, infiltration and groundwater recharge should not be treated as automatic outcomes of green infrastructure implementation, but rather as context-specific objectives requiring careful planning. The role of infiltration within stormwater management must be positioned within a holistic systems framework that simultaneously addresses runoff reduction, flood mitigation, and broader urban water management goals.

3.4. Rainwater Harvesting, Storage and Reuse

Rainwater harvesting, storage, and reuse practices extend stormwater management beyond runoff control and flood mitigation by framing rainfall as a resource rather than merely a flow to be managed. Within this approach, stormwater is considered a supplementary water source capable of reducing urban water demand under appropriate conditions. Increasing water scarcity and climate change–induced uncertainties have further amplified the relevance of rainwater reuse within urban water management strategies (Aladenola and Adeboye, 2010).

Rainwater harvesting systems typically rely on collecting runoff from roof surfaces and storing it in tanks after accounting for initial wash-off losses. The collected water is commonly used for non-potable purposes such as landscape irrigation, cleaning activities, and toilet flushing. Studies conducted on large building complexes demonstrate that well-designed rainwater harvesting systems can significantly reduce reliance on municipal water supplies (Ward et al., 2012).

However, the effectiveness of rainwater harvesting and reuse practices is strongly influenced by variables such as rainfall patterns, roof catchment area, storage capacity, and consistency of water use. In regions with irregular seasonal rainfall, limited storage volumes or extended dry periods may constrain system performance. This highlights that rainwater harvesting should not be viewed as a standalone solution but rather as a complementary component within integrated stormwater management strategies (Aladenola and Adeboye, 2010).

Beyond direct water savings, rainwater harvesting contributes indirectly to stormwater management by reducing the volume of runoff entering drainage systems during intense rainfall events. On-site storage can temporarily retain rainfall, thereby lowering peak flows and alleviating pressure on urban drainage infrastructure. The extent of this contribution, however, depends on system scale and spatial distribution (Fletcher et al., 2015).

Another critical consideration in rainwater harvesting systems is water quality and maintenance requirements. Inadequate filtration, insufficient maintenance, or mismatches between water quality and intended use can compromise system performance and pose risks to users. Accordingly, rainwater harvesting and reuse should be addressed not only through technical design but also through long-term operation and maintenance planning.

In conclusion, rainwater harvesting, storage, and reuse represent the resource-oriented dimension of stormwater management. The effectiveness of these practices at the urban scale depends on their integration with other green infrastructure solutions and context-sensitive planning approaches. Treating stormwater as a resource yields meaningful and sustainable

outcomes only when embedded within a holistic stormwater management framework.

3.5. Water Quality Improvement and Ecosystem Services

Water quality improvement represents one of the most critical functions of stormwater management, although it is often overshadowed by objectives related to runoff control and flood mitigation. In urban environments, stormwater interacts with a wide range of pollutants, including heavy metals, suspended solids, nutrients, and micro-contaminants, which are transported to receiving waters through surface runoff. This process adversely affects not only surface and groundwater quality but also the integrity of urban ecosystems (Paul and Meyer, 2001).

Conventional drainage systems prioritize the rapid conveyance of stormwater and therefore offer limited capacity for pollutant retention or treatment. In contrast, green infrastructure practices enable stormwater to be retained within the urban environment for longer periods, facilitating physical, chemical, and biological processes that contribute to water quality improvement. Soil layers, plant root systems, and microbial activity play key roles in filtering, transforming, and retaining pollutants before they reach aquatic systems (Fletcher et al., 2015).

Vegetation, and trees in particular, provide multiple ecosystem services related to stormwater quality. Through canopy interception, trees delay the conversion of rainfall into surface runoff, while their root systems enhance soil structure and filtration capacity. These processes reduce the transport of pollutants and lower contaminant concentrations within urban stormwater flows (Xiao and McPherson, 2016).

The effectiveness of green infrastructure practices in improving water quality varies depending on application type, plant selection, and maintenance conditions. Systems such as rain gardens and bioswales are effective in retaining suspended solids and certain heavy metals, whereas green roofs and permeable surfaces primarily improve the quality of first-flush runoff. Without adequate maintenance, however, pollutant accumulation may reduce system performance and generate new management challenges (Ward et al., 2012).

Water quality improvement should also be assessed from an ecosystem services perspective rather than solely through technical performance indicators. In addition to stormwater treatment, green infrastructure provides co-benefits such as microclimate regulation, biodiversity support, and enhanced urban livability. This multifunctional character underscores why green infrastructure should be regarded not merely as an engineering solution but as a comprehensive environmental planning tool (Bekiryazıcı 2024b).

In conclusion, improving water quality and supporting ecosystem services are integral components of effective stormwater management. The potential of green infrastructure in this regard becomes meaningful only through appropriate design, suitable vegetation selection, and sustainable maintenance strategies. Ultimately, the success of stormwater management depends not only on controlling water quantity but also on managing water quality within urban systems.

4. GREEN INFRASTRUCTURE PRACTICES AND DESIGN APPROACHES

Green infrastructure practices serve as spatial tools that translate stormwater management objectives into tangible design solutions. These practices aim to regulate stormwater behavior

within urban systems by simultaneously addressing multiple functions, including runoff reduction, flow delay, enhanced infiltration, and water quality improvement. However, the effectiveness of green infrastructure depends not only on the type of application but also on design strategies, spatial context, and maintenance conditions (Ferrans et al., 2022).

A fundamental design principle of green infrastructure is the management of stormwater at its source. Rather than collecting and conveying runoff to a single outlet, this approach emphasizes distributed, small-scale interventions embedded within the urban fabric. From this perspective, green infrastructure should be regarded not as a replacement for centralized drainage systems but as a complementary system that enhances their performance. Design processes must therefore consider not only individual application efficiency but also cumulative effects at the urban scale (Ahiablame et al., 2012).

Permeable pavements represent one of the most widely applied green infrastructure solutions in urban open spaces. These systems facilitate the movement of rainfall into underlying layers, reducing surface runoff and supporting infiltration. Nevertheless, their performance is highly dependent on sub-base design, maintenance frequency, and soil characteristics. Inadequate maintenance may result in clogging of pore spaces, significantly reducing system permeability (Bekiryazıcı and Acar, 2024).

Rain gardens and bioswales provide combined hydrological and ecological functions within green infrastructure systems. By temporarily storing runoff and extending flow duration, these practices contribute to both runoff control and water quality improvement through soil and vegetation-based processes. Plant selection, soil composition, and hydraulic capacity alignment are critical design factors that determine the success of these systems (Fletcher et al., 2015).

Green roofs enhance the applicability of green infrastructure in densely built urban areas by introducing vegetated layers on roof surfaces. These systems retain a portion of rainfall, delay runoff generation, and reduce runoff volumes. However, the extent of their contribution to stormwater management varies according to climatic conditions, substrate depth, and vegetation composition (Ward et al., 2012).

Urban green spaces and blue–green systems ensure the continuity of green infrastructure at the city scale. Parks, green corridors, and natural water bodies provide opportunities for stormwater storage and flow attenuation. The effectiveness of these areas depends on their integration with urban design decisions and land-use planning. Fragmented and disconnected green spaces often limit the hydrological benefits expected from green infrastructure networks (Paul and Meyer, 2001).

In conclusion, while green infrastructure practices offer robust tools for stormwater management, their success relies on context-sensitive design and planning approaches. When application type, scale, and spatial distribution are aligned with urban hydrological processes and land-use patterns, green infrastructure can deliver effective and sustainable stormwater management outcomes.

5. EVALUATION AND MODELLING METHODS

Assessing the effectiveness of green infrastructure–based stormwater management practices requires the application of appropriate evaluation and modelling methods. These processes extend beyond measuring the technical performance of individual interventions and include the comparison of impacts, scenarios, and decision alternatives across multiple scales. Due to the

inherent complexity of urban hydrological processes, stormwater management evaluations often rely on the combined use of quantitative modelling and multi-criteria assessment approaches (Fletcher et al., 2015).

Hydrological modelling represents one of the most widely used tools in stormwater management evaluation. Such models numerically represent rainfall runoff relationships, enabling the analysis of variables such as runoff volume, peak discharge, flow duration, and storage capacity. Models developed for urban environments incorporate parameters related to imperviousness, land use, and drainage infrastructure, allowing different management scenarios to be compared. These tools are particularly valuable for anticipating the potential hydrological impacts of green infrastructure practices (Paul and Meyer, 2001).

However, the direct applicability of modelling outcomes depends heavily on the accuracy and context-sensitivity of model inputs. The temporal resolution of rainfall data, the representation of soil properties, and the parameterization of green infrastructure components strongly influence model reliability. Previous studies emphasize that models applied in high-rainfall regions may generate misleading results if local site conditions are not adequately represented (Bekiryazıcı, 2023).

The limitations of hydrological modelling have increased the relevance of multi-criteria decision-making methods in stormwater management. These approaches enable the simultaneous consideration of hydrological performance alongside economic, environmental, and spatial criteria. Through multi-criteria assessment, green infrastructure alternatives can be evaluated not only in terms of technical efficiency but also with respect to feasibility and sustainability (Bekiryazıcı and Acar, 2024).

Evaluation indicators vary according to the objectives of stormwater management. Metrics such as peak discharge and runoff volume are central to objectives related to runoff reduction and flood mitigation, whereas pollutant loads, filtration capacity, and vegetation performance gain importance when water quality and ecosystem services are considered. This diversity of indicators demonstrates that no single metric can adequately capture all dimensions of stormwater management (Fletcher et al., 2015).

Scale is another critical dimension in evaluation and modelling processes. Assessments conducted at parcel, street, neighborhood, and catchment scales often yield different priorities and outcomes. While small-scale interventions may produce noticeable local effects, achieving meaningful results at the urban scale requires consideration of spatial distribution and interactions among practices. Accordingly, evaluation frameworks should be designed to account for cross-scale relationships (Bach et al., 2014).

In conclusion, evaluating green infrastructure and stormwater management practices involves a level of complexity that cannot be addressed through a single method. The integrated use of hydrological modelling, multi-criteria decision-making, and context-specific indicators enables more realistic and actionable outcomes. This holistic approach plays a critical role in strengthening the link between scientific knowledge and planning and design decisions in stormwater management.

6. CHALLENGES AND LIMITATIONS IN IMPLEMENTATION

Although green infrastructure–based stormwater management approaches demonstrate substantial potential in conceptual and empirical studies, their implementation is often

constrained by a range of technical, spatial, and governance-related limitations. These constraints frequently result in underperformance or long-term sustainability challenges. Consequently, the effectiveness of green infrastructure in stormwater management must be assessed not only through design principles but also through implementation and operational conditions (Fletcher et al., 2015).

One of the primary challenges in practice is the lack of context-sensitive application. Many green infrastructure solutions proposed in the literature are developed for specific climatic and soil conditions and may fail to deliver expected hydrological benefits when transferred directly to different urban contexts. In high-rainfall cities in particular, infiltration-based practices often exhibit limited effectiveness due to soil saturation and elevated groundwater levels (Bekiryazıcı, 2023).

Another critical limitation arises from the disconnect between design and implementation. While green infrastructure systems are often conceptually well-designed, insufficient attention to material selection, construction details, and workmanship during implementation can significantly reduce system performance. This issue is especially evident in permeable surfaces and biologically based filtration systems. In addition, inadequate post-construction maintenance frequently leads to rapid functional decline (Ward et al., 2012).

Institutional and governance constraints also play a significant role in limiting the widespread adoption of green infrastructure. Stormwater management responsibilities are commonly distributed across multiple agencies and disciplines, leading to coordination challenges and fragmented decision-making. Furthermore, the long-term maintenance and monitoring requirements of green infrastructure demand a level of

institutional commitment that is often underestimated compared to conventional infrastructure systems (Fletcher et al., 2015).

Public awareness and user behavior constitute another important dimension influencing the success of green infrastructure implementation. Individual perceptions of flood risk and household-level adaptive behaviors can affect both the acceptance and effectiveness of stormwater management measures. Behavioral risk analysis studies indicate that when technical solutions are complemented by increased awareness and adaptive practices, flood risk reduction outcomes can be significantly enhanced (Haer et al., 2017).

Finally, insufficient monitoring and evaluation represent a major limitation in green infrastructure implementation. Many projects are not systematically monitored after construction, and the resulting data are rarely incorporated into subsequent design and planning decisions. This gap hinders the development of green infrastructure as a learning system and disrupts the feedback loop between practice and knowledge generation (Paul and Meyer, 2001).

In summary, the challenges encountered in green infrastructure and stormwater management implementation extend beyond technical shortcomings. Addressing climatic and spatial context, design–implementation consistency, institutional capacity, maintenance requirements, and social factors collectively enables a more realistic and sustainable assessment of green infrastructure potential.

7. LOCAL CONTEXTUAL ASSESSMENT AND CONCLUSIONS

The effectiveness of green infrastructure–based stormwater management approaches largely depends on their

compatibility with the physical, spatial, and governance characteristics of the local context in which they are implemented. Factors such as rainfall regime, soil conditions, building density, and the configuration of open spaces directly influence the hydrological performance of green infrastructure practices. Accordingly, stormwater management should be addressed not through universal solutions but through context-sensitive approaches that account for local conditions (Fletcher et al., 2015).

At the local scale, open space design and urban furniture elements play a significant role in determining the functionality of green infrastructure systems. The use of permeable surfaces, the placement of urban furniture, and the continuity of open spaces directly affect stormwater behavior within urban environments. Studies conducted in the Turkish context indicate that sustainable open space and urban furniture design can enhance the hydrological and ecological contributions of green infrastructure practices (Dinçer et al., 2020). These findings suggest that green infrastructure should be evaluated not only through large-scale systems but also through design details that shape everyday urban spaces.

Planning green infrastructure in high-rainfall cities requires particular attention. In such contexts, limited infiltration capacity may constrain the performance of certain green infrastructure solutions. Therefore, local stormwater management strategies should integrate infiltration-based practices with approaches focused on runoff delay, storage, and controlled conveyance. This perspective enables green infrastructure to function as a complementary component to grey infrastructure systems rather than as a direct substitute (Bekiryazıcı, 2023).

The conceptual framework presented in this chapter evaluates the role of green infrastructure in stormwater

management from a multidimensional perspective. The reduction of surface runoff, mitigation of flood risk, enhancement of infiltration, rainwater harvesting and reuse, and improvement of water quality emerge as interconnected functions that must be considered collectively. Each function gains significance not in isolation but as part of an integrated urban system (Bekiryazıcı 2024a).

From an evaluation and modelling standpoint, it is evident that stormwater management cannot be adequately assessed using a single performance indicator. The combined use of hydrological modelling, multi-criteria decision-making approaches, and context-specific indicators allows for more realistic and actionable outcomes. This holistic evaluation framework strengthens the connection between scientific knowledge and planning and design decisions (Bekiryazıcı and Acar, 2024).

In conclusion, green infrastructure and stormwater management should not be regarded solely as technical solutions. Successful implementation requires an interdisciplinary perspective, context-sensitive design strategies, and long-term maintenance and monitoring processes. While this chapter highlights the potential of green infrastructure in stormwater management, it also emphasizes the limitations that must be addressed to realize this potential in a realistic and sustainable manner.

Within this context, the chapter aims to provide a comprehensive theoretical foundation for graduate studies, academic research, and urban planning and design practices. Reconsidering the role of green infrastructure in stormwater management through system-based and locally adapted approaches will contribute to the development of more resilient and sustainable urban environments.

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