Water as an Element of Urban Design: Drawing Lessons from Four European Case Studies

Carlos Smaniotto Costa, Conor Norton, Elena Domene, Jacqueline Hoyer, Joan Marull and Outi Salminen

Abstract One of the most challenging problems that urban areas will face in the future is adaptation to the effects of climate change, particularly with regard to local problems of water management (e.g., flooding caused by heavy rain events, degradation of urban streams, and water scarcity). Sustainable local management of stormwater calls for approaches that connect technical and ecological solutions with urban design aspects and socioeconomic factors. This in turn opens up great opportunities to advance knowledge toward the application of water-sensitive urban design (WSUD), an approach that integrates the water cycle into urban design to simultaneously minimize environmental degradation, improve aesthetic and recreational appeal,

C. Smaniotto Costa (✉)
Department of Urban Planning, Universidade Lusófona de Humanidades e Tecnologias, Campo Grande, 376, Lisbon 1749-024, Portugal
e-mail: smaniotto.costa@ulusofona.pt

C. Norton
School of Spatial Planning, Dublin Institute of Technology, Bolton Street, Dublin 1, Ireland
e-mail: conor.norton@dit.ie

E. Domene · J. Marull
Barcelona Institute of Regional and Metropolitan Studies (IERMB), Edifici MRA, Autonomous University of Barcelona, 08193 Bellaterra, Barcelona, Spain
e-mail: elena.domene@uab.cat

J. Marull
e-mail: joan.marull@uab.cat

J. Hoyer
Sustainable Urban and Infrastructure Planning, HafenCity Universität Hamburg, Hebebrandstraße 1, 22297 Hamburg, Germany
e-mail: jacqueline.hoyer@hcu-hamburg.de

O. Salminen
Department of Forest Sciences, University of Helsinki, Latokartanonkaari 7, 00014 Helsinki, Finland
e-mail: outi.m.salminen@helsinki.fi

W. Leal Filho and V. Sümer (eds.), *Sustainable Water Use and Management*, Green Energy and Technology, DOI 10.1007/978-3-319-12394-3_2

and support social cohesion. A comparative study of four case studies across Europe reveals some of the successes and limits of WSUD implemented so far and presents new considerations for future developments. Best practices on integrated management as well as concepts to re-establish natural water cycles in the urban system while ensuring water quality, river health, and sociocultural values are included. In the selected case studies, water takes a structuring role in urban development, which has been designed to serve diverse public functions and maximize environmental quality, urban renovation, resilience to change and sustainable growth.

Keywords Water sensitive urban design · Decentralized water management · Stormwater management · Open spaces · Urban development · Urban design

1 Introduction

Urban growth is a world phenomenon that implies a profound change in the natural environment. Urban development is a dynamic and very diverse process, and although with distinctions in terms of social and economic drivers and magnitudes of impact, it has a common feature: It is increasingly space intensive (UNFPA 2007). Considering space as a finite resource, the ever-increasing demand for land for urban purposes, e.g., for housing, workplaces, recreation, infrastructure, and transport networks, speeds up and intensifies processes of pressure on landscape and ecosystems.

More and more, the land-take affects the natural environment, both functionally and morphologically, with far-reaching effects also on the built environment, whose quality depends very much on the nourishing quality of the natural environment. Although these two aspects are part of the same process, they are usually not discussed and treated with the same concern and consideration. In numerous cases, urban growth results both in landscape fragmentation and in a substantial loss and degradation of open spaces. Open spaces, as components of the green infrastructure, are often treated as "potentially developable" land within the urban fabric. Rural zones, forests, and seminatural and natural water bodies are disappearing in favor of a high percentage of sealed-off ground. The land taken for urban purposes and related infrastructure affect biodiversity also, since it provokes degradation of habitats and reduction of the living space of species, along with the loss of landscape segments that support and connect the remaining habitats with each other (EEA 2010).

One of the most challenging problems that urban areas will face in the future is the adaptation to the effects of climate change, particularly with regard to water: in Southern Europe long drought periods followed by floods due to heavy rain events are expected, while increases in heavy rain events are expected in many parts of Northern Europe. Increasing problems with water quality in rivers and urban streams are among the challenges that Europe is facing in the future (IPCC 2012). Stormwater management policies in most European urban areas have traditionally removed water runoff from communities by burying water systems in underground impervious pipe and culvert infrastructures for the protection of human health and property, with a low priority in the conservation of natural water cycles.

In the context of this work, urban stormwater is to be understood under its broad meaning: rainfall and snowmelt that seeps into the ground or runs off the land into storm sewers, streams, and lakes. When functioning well, the conventional urban water infrastructure systems are effective. However, the increase of urban population, expanding land uptake and soil sealing, and climate change effects along with growing environmental concerns raise questions on the limits of its functionality. The practice of conveying (storm) water away from urban areas results in wasted economic resources and loss of opportunities for making use of alternatives for the sustainable development of cities. Sustainable alternatives include the increase of water supply via decentralized stormwater systems or harvesting, the improvement and strengthening of the urban environment by reducing the risk of natural events, as well as making cities more distinctive and attractive through the reduction of impervious surfaces and the enhancement of infiltration and detention. Moreover, alternative water "elements" enrich the urban landscape and create high landscape values, which makes cities more attractive with a well-defined identity.

To respond to future challenges as well as to seize the opportunities, stormwater management is best tackled by decentralized and locally appropriate approaches in a tight connection with urban development issues. This calls for approaches that break from the traditional pipe-bound systems and combine stormwater management, sustainable urban design, policy change, and capacity building. Such practice change can be logistically and technically more difficult than just discharging stormwater into the drains or watercourses, and change is still often perceived irrelevant by service managers and the local communities (Hoyer et al. 2011). More integrated and innovative alternatives to the conventional management of stormwater are emerging. Integrating practices is seldom problem free due to a limited culture of cooperation between stormwater managers and urban planners and often unexpected institutional barriers. Greatest public and political support emerges out of the process when examples of successful integration are shown (Barbosa et al. 2012). In fact, water-sensitive urban design (WSUD) measures apply to all aspects of change in the built environment and urban management. These aspects are extensively discussed with the help of the four practical cases analyzed: Dublin (Ireland), Santa Coloma de Gramenet (Spain), Cascais (Portugal), and Nummela (Finland). These cases are examples of an alternative approach to local stormwater management. Their motivation, achievements and barriers are discussed in the following sections.

2 The Undergoing Process of Urbanization, Land-Take, and Stormwater Management

Sustainability calls for effective ways for cities both to reverse the level of land-take in a socially and economically meaningful way and to include the urban landscape aspects in planning procedures and decision-making processes. Heading toward sustainable urban stormwater management, cities are faced with several challenges. Coping with these challenges will put urban areas increasingly under pressure on account of the sensitive problems of resource inefficiency and waste. Five issues are hereby paramount:

1. Growing urban population: More and more people will be living in urban areas in the future. In 2012, already around 41 % of the EU27 population lived in urban areas (Eurostat 2012). The growth of urban population puts enormous pressure on water infrastructure systems, as cities are one of the main water resource consumers, as well as one of the main polluters. With the rise of population, an expansion of land-take and soil sealing can be expected, which will negatively affect stormwater infiltration and storage capacity at local level. This leads to reduced groundwater recharge rates, increased surface runoff, deficient soil water storage, and not sufficient availability of water for vegetation. Moreover, due to the fact that urban streams are receiving waters for stormwater runoff from urban areas, there is an observed ecological degradation of streams draining urban land. Walsh et al. (2005) describe degradation as elevated concentrations of nutrients and contaminants, altered channel morphology, with the reduction of biotic richness along increased dominance of tolerant species.
2. Climate change: Some climate change models predict changes in the frequency and intensity of meteorological extreme events. Forecasts are uncertain; in Europe, an increase in long-term droughts in summer and an increase in heavy rain events are expected (IPCC 2012). Long-term droughts will lead to a shortage in available water suitable for urban vegetation and can lead to a shortage of drinking water as well. In Australia, a drought that lasted more than 10 years provoked the heavy decrease of drinking water resources, e.g., in the metropolitan area of Melbourne, 35 % reductions were experienced (MW, n.d.). Drought concerns particularly those countries in Southern Europe, such as Greece, Italy, Portugal, and Spain, where the climate is dry and hot. Moreover, increases in frequency of heavy rain events in central and northern parts of Europe (e.g., Nordic and Baltic countries, the Netherlands, Germany), as well as heavy rain events in the south (e.g., in Tuscany in November 2012), forecast greater intensity floods with high damage potential. Changes in winter freeze–thaw weather patterns in the northern cities and cities of high elevation may cause additional challenges such as rain on frozen grounds; ice cover on a lawn can act as a highly impervious surface for wintertime rain.
3. Inflexible and cost-intensive systems: Existing systems for stormwater management, which are based on pipes and culverts, are not flexible enough to be adapted to uncertain changing conditions from increased urban development or climate change. This leads to unmanageable stormwater runoff. Adapting the existing (mostly centralized) systems to current and future changes calls for higher running costs and investments which municipalities may not be able to afford in the near future. Therefore, there is a need for more flexible, decentralized systems (Cettner et al. 2013; Hoyer et al. 2011). As pipeless alternatives

and open stormwater management systems are not hidden under streets, they need more space in the urban fabric. When planned and implemented together and within the green infrastructure, such systems can result in both capital and maintenance cost reductions.

4. Stormwater is seen as having no value: Urban water management is historically driven by the engineering sector and based on pipes and sewers, from providing drinking water up to the collection and treatment of wastewater. In this system, stormwater is seen as having no value. Thus, stormwater, despite its inherent qualities, is still today discharged to public sewers and pipes, while there are many opportunities to use this water in urban environments. The SWITCH project evaluated several stormwater management experiences across the world, and this has shown that stormwater can be an important resource in urban areas (Hoyer et al. 2011). In particular, some urban subsystems may achieve water self-sufficiency by means of rainwater harvesting (Farreny et al. 2011a). Harvested stormwater can be used for devices, where drinking water quality is not necessary, such as for toilets, industry, landscape irrigation, and water features in public spaces. Using stormwater contributes to safe drinking water and aquifers as well as the improvement of livability in the city. To tap water-fed installations in the urban landscape, water features utilizing stormwater can be designed with gravity flow and dynamically vitalize the scenery year round even in cold climates. Hence, a paradigm shift valuing stormwater as a resource can be used to promote both water and energy conservation.
5. Lack of acceptance for sustainable systems: Some of the EU countries, particularly Germany and the UK, are already quite advanced in developing new approaches and techniques for sustainable stormwater management tackling all the problems mentioned above. The decentralized rainwater management (DRWM) and sustainable urban drainage systems (SUDS) in the UK can be cited as examples. However, acceptance of these systems is still low even in the respective countries (Domènech and Saurí 2012; Hoyer et al. 2011). Even when the positive effects of sustainable alternatives are well demonstrated and described, their incorporation as components of urban infrastructure is still seen as a "tree huggers" alternative and not as a technically sound standard. There is a potentially widening gap between what is known and what has been converting into reality. There are several issues that can be identified as reasons for the lacking of acceptance of decentralized stormwater management systems:
   (a) Too strong technical focus and a need for change: Decentralized stormwater measures have been predominantly shaped by the technical sector, which resulted in the development of different techniques (e.g., swales, infiltration trenches, retention basins) with corresponding technical guidelines. However, and unfortunately, stormwater facilities have often been engineered just according to technical points of view without considering socioeconomic and urban design aspects. In consequence, too few projects have been applied in a manner that is appreciated by the community (Echols 2007). Furthermore, hydraulic engineering-driven

design underestimates the importance of phytotechnologies; vegetation and associated microbes are the key to water quality improvement in sustainable stormwater design. Stormwater management should move from a regulated requirement into “a clear value added component of good design” (Hoyer et al. 2011: 16).

(b) Missing integration with urban design: Most of the technologies for decentralized stormwater management have been advanced with regard to technical design and functionality, but what has been disregarded so far is their potential to be integrated in urban areas and the establishment of appropriate standards and guidelines along with policy support. The results of the EU project SWITCH have shown that integration of water management into the urban development is critical. Therefore, identifying opportunities to adapt and integrate form and design of the urban water systems is essential. A look at a few existing projects shows that there is a potential waiting to be tapped. Among professionals, there is a perception of the legal requirements related to the provision of drainage services that inhibits the utilization of non-piped solutions (Cettner et al. 2012). There is specifically a need to explore possibilities that enable the development and easy application of locally adapted solutions, which contribute to a transition to more sustainable water management and ultimately the development of (water) smart communities. Current urban planning practice also commonly neglects watersheds as a basis for water sustainable design (Krebs et al. 2013). The high damage potential of the forecasted climate change floods is coupled with poor urban planning: in many locations dense urban development with little or no landscape structure continues near to flood and erosion sensitive areas. This gives rise to increased imperviousness and the potential for high levels of poor quality run-off to enter receiving and conveying streams in the event of heavy rainfall. Planning for the location and extent of urban structures (both the problems causing imperviousness and the sustainable management offering mitigation structures) in regard to natural waterways requires watershed-sensitive design across municipality borders and through collaborative actions within all landowners.

(c) Uncertainties in economic issues: As Chocat et al. (2007) note, sustainable stormwater management is often regarded as being more expensive than conventional solutions of stormwater drainage. In fact, the costs are the most frequent argument for not using more sustainable systems, although in several circumstances, they are in fact cheaper (Farreny et al. 2011a, b). Such calculations may be based on retrofitted designs on top of existing sites with much associated renovation works and, most importantly, commonly disregard the positive effects that sustainable stormwater management structures bring for increasing the amenity and livability of an urban area. Such values are not easy to be calculated in monetary means (Smaniotto 2007). With regard to the fact that urban areas need to be prepared for being adapted to the effects of intensification of land use, with the likelihood of additional ground sealing, and climate change, and both producing high extra costs for expanding existing stormwater pipe systems, such argument even becomes outdated. Project reviews and research results have shown that the earlier the engineers and urban designers cooperate in the planning process, the cheaper the implementing sustainable solutions become (Hoyer et al. 2011). Thus, in this way, synergies can be better used and complex solutions, which might cause high investment and maintenance costs can be avoided. An early and continuous collaboration can make proper use of synergies and complex solutions, which might cause high investment and maintenance costs, avoided. Each landscape requires its own solution, with respect to the natural environment and its interdependences. Sustainable solutions can usually be found for any given site and implemented with long-term cost efficiency.

(d) Fragmented responsibilities and strong competition around open spaces: As sustainable stormwater management techniques are mostly focused on infiltration, they often require to be installed on or above the surface, and therefore, they influence the design, usability, and aesthetics of the urban spaces to a large extent. This raises conflicts particularly in densely built-up areas, where different requirements and interests rule for the available open spaces, such as traffic, recreation, and greenery. This leads to high competition, where stormwater management is often not going to win (Smaniotto and Hoyer 2013). By using synergies and combinations of stormwater techniques beyond the techniques for infiltration and adapting these to the local conditions, the development of integrated solutions can be initiated, which in consequence can be used to create multifunctional spaces. Such spaces can thus, besides integrating stormwater management systems, give rise to recreation facilities and/or habitat conservation, enhancement and creation measures. Based on the principles of landscape ecology and an ecosystem approach to land use planning and management, such measures enable the creation of networks connected by water which simultaneously provide habitat and stormwater corridors.

(e) Lack of public awareness, public participation, and institutional capacity: Public awareness for urban surface water management issues is very limited, with the exception of severe events affecting communities such as drought or flooding. The majority of the urban population is not aware of the existence and functionality of methods, e.g., for rainwater retention, infiltration, and usage. In urban areas, there is often the problem that stormwater management facilities can just be used on publically owned property. Contrary to this, initiatives, e.g., Portland, USA, or Melbourne, Australia (SWITCH project), show that private owners can make important contributions toward implementing approaches for managing stormwater on site. Therefore, incentives need to be developed and public knowledge on the effects of sustainable stormwater management raised (Domenech and Sauri 2012). Citizen involvement and better collaboration allow the construction of social capital that revalues the right to a healthy urban environment. Urban sprawl can lead to areas without identity and associated social instability. Well-sited and fitted stormwater landscaping can provide the identity and sense of place to a completely new development, as well as a rehabilitated area, allowing dwellers to take pride and ownership of their neighborhood. According to Florida (2002), the human capital plays the central role in the level of happiness with the environment and personal well-being, outperforming every other variable, including income. In addition, urban planners and local councils need support and exchange experiences and knowledge in order to be involved in WSUD practices (Farreny et al. 2011c).

3 The Rationale of Water-Sensitive Urban Design and Water as an Element of Urban Design

WSUD is a design and planning approach, developed in Australia and adapted in other locations (Coutts et al. 2013; Dolman et al. 2013; Fryd et al. 2013; Roy et al. 2008). It connects technical solutions for water management with urban design and socioeconomic aspects. Water-sensitive solutions comprise concepts of stormwater reuse and recycling in urban areas as well as concepts to re-establish natural water cycles in the city and ensure water quality and river health. This approach is, in a whole, not new, but it puts individual measures into a conceptual framework with determined guidelines and objectives. It manages the transition and offers an alternative to the traditional conveyance approach to stormwater management.

WSUD aims to integrate the water cycle in urban settings. It centers urban design and landscape planning in the heart of water management in order to reuse water on site including its permanent or temporary storage. The possible measures are multifaceted and range from detention and retention basins to lower peak flows, grassed swales, and vegetation to facilitate water infiltration and treatment of pollutants, to ecological restoration of channeled watercourses. A concept for sustainable stormwater management under the WSUD approach includes also comprehensive and far-reaching measures such as approaches to reduce the impervious surfaces and embrace green infrastructure. Rooftops are part of the urban water cycle and can be designed as blue roofs for temporary detention or as green roofs with added amenities by the vegetative cover.

The relevant feature is that WSUD measures detain and filter stormwater where it falls and use the synergies while creating natural and environmental values to enhance urban livability. The housing and road layouts that preserve vegetated landscape and minimize imperviousness can be mentioned as a classical example for intervention. Integrating sustainable water management in housing, residential, and industrial developments includes more compact settlement layouts, space-saving buildings, and minimal sealed surfaces. The last is also applicable for road layout, an objective of which is to decrease the length and width of low-traffic local roads and design a shorter road network. The space-saving measures allow the conservation and installation of drainage corridors and retention and detention basins. Well designed, these elements not only protect the water quality but also act as multipurpose spaces. Besides the technical solution and safeguarding of all other water uses that serve public interest (recreational, sports, educational opportunities, etc.), using water as an element of urban design requires also the attention to visual amenity and aesthetic aspects. High aesthetic values enrich the urban landscape contributing to the character and identity of an area. Attractive urban landscape is often associated with the reinforcement of cultural or social identity and sense of place and belonging. Hence, WSUD offers good prospects for promotion or innovation as potentials for waterfront residential areas, retail, and businesses, and facilities for leisure and recreation.

In the future, it is essential that stormwater management measures in urban settings consider environmental protection and urban design as a whole, recognizing that they cannot be patched up by separate sectoral decisions. Therefore, (re-) integration of water bodies in urban areas calls for cooperation across disciplines, to enable the development and implementation of comprehensive approaches. Considering local conditions and circumstances is a key aspect in successful planning, design, and implementation of water smart communities that coexist within the natural water cycles.

4 Examples of Local Stormwater Management in Europe: Achievements and Challenges

Urban intensification is a key factor in the four case examples outlined here. They all address issues of poor urban quality (in social and/or environmental terms) and seek alternative means of stormwater management. As a positive side effect, they all seek to achieve an improvement of the urban landscape as a whole. All four cases have a pioneer character in their contexts and regions and are used to showcase how with few economic resources much can be reached, as river/stream degradation and their restoration/revitalization are central parts of stormwater management.

In terms of geographic situation, the cases represent diversity in Europe, as they are from Southern, Western, and Northern Europe. These exemplify very different climatic conditions which lead to different approaches to managing water in the urban environment. Looking at climate change scenarios, the sites vary in regard to estimated changes in rainfall. The potential for droughts is present in the south, whereas snowmelt is another issue in the north. Finland and Ireland are at the maximum and minimum range of increased rainfall, and Portugal and Spain are at the maximum range of decreased rainfall within Europe. Therefore, the need and requirements for stormwater management vary among the cases, while the water runoff is permanent in Besòs and Nummela; it is seasonal in Cascais and sporadic Dublin. Also considering the urban form, these cities are also quite different, while the cases in Dublin and the river Besòs represent very urban settings; Cascais and Nummela correspond to mid-sized cities inserted in metropolitan areas; these differences impact on governance issues.

The cases share the need to manage stormwater in a more efficient way and one in which the citizens can also benefit. The cases represent a local, plan-led approach using different instruments rather than an ad hoc project-by-project approach. They all seek multiple benefits for the citizen and the environment and seek to make a strong contribution toward sustainable urban development. They all challenge conventional approaches to managing water in urban settings—the solely engineering approach. Importantly, the case studies show an attempt for cities to return to their origins, where water was the driver and the life-giver for the settlement. This chapter looks briefly at how this was attempted by the four different case areas.

5 Case 1: Water-Sensitive Urban Design as Part of the Green Infrastructure of Local Area Plans—Administrative Area of Dublin City Council, Ireland

5.1 Developing Green Infrastructure Strategies, with Detailed Plans and Proposals for Water-Sensitive Urban Design for Local Spatial Plans in the City

Dublin City Council and the Heritage Council of Ireland commissioned consultants Norton UDP and Áit, to prepare a pilot Green Infrastructure Strategy to inform two statutory, local spatial plans (Local Area Plans) in Dublin City. One area (Georges Quay) is located in a densely urbanized area in the city center, while the other (Naas Road) is, in contrast, located in the middle suburbs to the west of the city center in an area dominated by large-scale industry and distribution uses and on a major road artery of the city. The pilot study was a follow-up to the then recent policy paper *Creating Green Infrastructure for Ireland* (Comhar, The Sustainability Council for Ireland, 2010).

The Georges Quay area comprises some 14 ha and it lies on the south bank of the river Liffey in what could be described as a transition zone between the recent redevelopment of the city docklands and the established core of the city center. Parts of the area, nearest the city center, witnessed the first clustering of modern office development in the city in the 1960s, while other areas have witnessed only scattered, incremental redevelopment of traditional mixed use functions. Today, the area could be defined as "gray" in character, being fragmented in terms of urban form and lacking in local green spaces and biodiversity resources.

The green infrastructure strategy for the area envisaged a central role for WSUD, based on a local spatial structure of hubs and corridors through the existing urban structure of the area and surrounding areas. The multipurpose green infrastructure is also intended to meet sustainable transport objectives, by incorporating more generous and attractive footpaths which reduce road widths and incorporate new cycle ways. Biodiversity is also promoted through the development of new green spaces and corridors and measures in new and existing private development (see Fig. 1). The strategy presents a number of concept projects, including an experimental tree line, constructed in load bearing soil and connected to the piped surface water drainage system. The purpose of this concept is twofold: to attenuate surface water from the street and to provide a filter for water before it reaches the piped system. The overall concepts of the final Local Area Plan for the area are strongly influenced by the green infrastructure strategy and spatial concepts.

The strategy for the Naas Road was quite different in terms of priorities and spatial structure. The area is located on a long-established artery of the city, the Naas Road. The area does not present any coherent or memorable urban character. It comprises extensive areas of active and obsolete light industry and distribution, some more recent office and retail warehouse uses, disconnected but extensive public and private open spaces, and scattered groups of housing (see Fig. 2). Despite extensive culverting and insensitive, surrounding development, the Camac River, which flows to the river Liffey, remains a unifier for the larger area.

As with Georges Quay, the green infrastructure for the area was based on identifying and connecting multipurpose hubs or green spaces of various sizes and scales and developing a network of new and improved green corridors. The green infrastructure was developed on the basis of a multilevel spatial strategy which was broadly structured on the Camac and its tributaries. Space will be provided for a connected biodiversity along with new pedestrian and cycle links.

Fig. 1 Concept proposal for a multipurpose urban tree line, Georges Quay area, Dublin. *Source* Dublin City Council (2012)

Fig. 2 Spatial structure for the Naas Road area. *Source* Norton UDP and Ait Urbanism and Landscape (2012)

The strategy for Naas Road presented a number of concept proposals, including: a new multipurpose, water attenuation swale in a boulevard design idiom along the major road artery, proposals for uncovering the river in the existing industrial areas and reconstructed wetland along the banks of the Camac to enhance the character of the river, to manage and filter water and to assist in the flood risk management measures for the city (see Fig. 3). The green infrastructure strategies were included in the community consultation for the Local Area Plan for the Naas Road. The community response was positive, and the final Local Area Plan incorporates the spatial structure and many of the objectives and strategies of the Green Infrastructure Strategy.

The Dublin case examples show the importance of introducing WSUD concepts into the early stage of urban planning process and the potential to do so using the multipurpose concepts in green infrastructure.

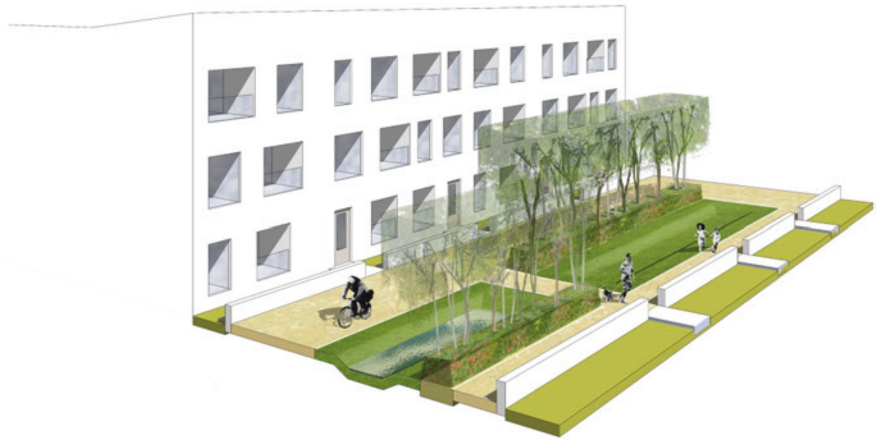

Fig. 3 Proposal for multipurpose swale for the Naas Road area. *Source* Norton UDP and Áit Urbanism and Landscape (2012)

6 Case 2: Besòs River—Metropolitan Area of Barcelona, Spain

6.1 Environmental Restoration and Flood Risk Protection in the Lower Course of the River Besòs

The Besòs River flows through the municipalities of Barcelona, Santa Coloma de Gramenet, Sant Adria de Besòs, and Montcada i Reixac, an urban area with a population of over two million people. The lower course of the Besòs River (9 km) has been profoundly altered by human action to support industrial and urban uses. The Besòs River has a clear Mediterranean character with irregular flows. Almost all of its water comes from reclaimed water and the transfer from other watersheds. The last stretch of the river was channeled in 1962, after a catastrophic flood. With the progressive reduction of the river channel, it lost hydraulic capacity and suffered from water pollution, ecosystem deterioration and marginalization during decades.

The environmental restoration project at the Besòs River started in 1996 with multiple aims: to recover the ecological and landscape quality of the river (then considered an open sewer), to improve the outflow from the Waste Water Treatment Plant of Montcada by implementing tertiary treatment based on the regeneration of wetlands, to increase the hydraulic capacity of the river, and finally, to use certain areas of the river for leisure purposes, with the development of the Besòs River Park (115 ha).

Broadly, the project defined two major areas of implementation, depending on the degree of urban development. In the first area, the main objective was to promote the ecological restoration of a river course with the design and development of constructed wetlands on the lateral margins of the riverbed. This area is 3.8 km long, restricted to the public and characterized by containing 60 plots (7.66 ha) of constructed wetlands that perform tertiary treatment to 30 % of the effluent from the Montcada wastewater treatment plant. Together with the 30 ha of meadows that surround the constructed wetlands, the site creates an attractive river ecosystem for birds and other species.

In the most urbanized part of the Besòs River Park, which passes along the municipalities of Santa Coloma and Sant Adria de Besòs and Barcelona, the main implementation actions included:

(a) Creating 13 ha of meadow landscape for public use;
(b) Improving public access to the river corridor landscape by building ramps;
(c) Extending the central channel width from 20 to 50 meters, and installing 5 inflatable dams to increase the hydraulic capacity of the river and to allow the creation of lagoons that favor the self-purification of water; and
(d) Establishing hydrological monitoring and alerting for rapid evacuation in case of flood risk, and emergency plan information (lighting, traffic lights, and signs).

The result of this regeneration process is the creation of the Besòs River Park (9 km and 115 ha). The project is the result of an initial agreement between the municipalities of Barcelona, Montcada i Reixac, Sant Adrià de Besòs, and Santa Coloma de Gramenet that has allowed to convert what has been considered an open sewer located within one of the most important green areas of the metropolitan Barcelona (Figs. 4 and 5). The Park has 22 public accesses (though ramps and stairs) to the green grassland area and a 5-km-long bike path. The area of public use is equipped with a flood warning system that guarantees user safety against flooding.

Fig. 4 Besòs River Park in Santa Coloma de Gramenet (*upstream views*). *Photograph* Pons-Sanvidal (IERMB) (2013)

Fig. 5 Besòs river park in Santa Coloma de Gramenet (*downstream views*). *Photograph* Pons-Sanvidal (IERMB) (2013)

Apart from the improvement of the environmental conditions and increased biodiversity, the Besòs River Park project has enhanced living conditions for the dwellers of municipalities on both sides of the river and it has attracted visitors from the metropolitan area to this water landscape (more than 500,000 visits every year). This, along with recent and planned changes to the new riverfront Besòs, will make the leap of scale necessary to meet the challenges of economic competitiveness, social cohesion, and environmental quality of the municipalities along the Besòs River.

7 Case 3: Ribeira de Sassoeiros, Cascais—Lisbon Metropolitan Area, Portugal

7.1 The Implementation of a Municipal Ecological Structure Along the Sassoeiros Stream (With the Collaboration of João Cardoso de Melo and Bernardo Cunha, EMAC, Cascais)

Ribeira de Sassoeiros is an ephemeral stream that flows through the Cascais municipality into the Atlantic Ocean. In order to enlarge the built-up areas and accelerate water runoff, the Sassoeiros bed has been narrowed and canalized over

Fig. 6 Concrete walls canalizing the Sassoeiros stream. Such monumental structures neither protect the residential areas from flooding nor offer a habitat for the riparian fauna and flora. *Photograph* Smaniotto (2013)

time. Due to uncontrolled urban expansion, the area along the Sassoeiros is suffering serious social, environmental, and flood problems. The result is the loss of permeable and productive soils and the complete destruction of riparian vegetation, as shown in Fig. 6.

The stream's canalization increased not only the runoff velocity but also the material flow. Habitat destruction, pollution, and soil erosion were detected as the main environmental problems. Floods became a recurring problem, causing economic damage and frequently homeless families.

Regarding the social fabric and mobility, the scarcity of bridges dictates the distance between the people on the two sides of the stream. The situation is aggravated by the absence of road hierarchy and the lack of equipped public open spaces.

In response to these problems, Cascais City Council started a project toward a comprehensive water management alongside a 1.6 km section of the stream in an area of 86,500 m^2 with a population of 4,029 people. However, the initial stages in 2009 followed classical engineering methods based on flow recovery and regularization of the stream. The Council recognized that the technical focus of the project was not solving the problems and moved its approach toward a more natural, biophysical engineering solution, in order to both stabilize the banks and reconstruct the riparian gallery. However, many of the technical plans were already implemented taking the space from innovative approaches available, as shown in Fig. 6.

The project is interesting in that while it primarily aimed at solving flooding problems, it also moved toward a more comprehensive approach for urban regeneration. The ongoing implementation of bioengineering-optimized measures not only provides a safe residential area but also aims to benefit from the ecological structure acting as an axis-supporting measure for urban revitalization allowing the creation of new social gathering places. The Council set as project objectives the following measures:

1. to manage the stream water flow through the construction of retention basins;
2. to stabilize the stream banks through the restoration of riparian galleries;
3. to improve riparian habitat; and
4. to create a pedestrian distribution axis throughout the stream allowing connectivity between the two sides of the stream, a measure that opens new opportunities for strengthening social cohesion.

This last objective is important, in that while the vehicular access, vehicle parking, and service areas are adequate and in some neighborhoods even oversized compared to the needs (see Fig. 7), the access for pedestrian and especially for people with disabilities is very poor or totally non-existent.

The ecological restoration of the Sassoeiros Stream opens the chance to use the stream as a backbone for integrating the implementation of ecological mitigation structures with the revitalization of social aspects within the nearby urban areas.

Fig. 7 The measures implemented 2013 for flood protection in the Sassoeiros stream. Without any other measures, e.g., settling adequate plants, the water flow will wash the banks away in the next rain. *Photograph* Smaniotto (2013)

With an extensive cultural heritage from centuries of historic influences, the City of Cascais has a variety of infrastructures (hotels, golf courses, roads, and public transportation) and a wide range of recreational facilities such as sand beaches, nature areas, and historical and urban parks. However, these are distributed unevenly across the municipality. The project along the Sassoeiros stream presents an opportunity to cope with these inequities. In Sassoeiros area, the City Council is tackling factors that functionally and unduly compromise other development aspects of the site or even the visual amenity of the whole area.

8 Case 4: Kilsoi Stream—Nummela Community, Municipality of Vihti, Finland

8.1 Making a Network of Water Quality Mitigating Wetland Parks Out of a Degraded Urban Stream

Nummela is an urban community of 11,000 inhabitants located by a shallow Lake Enäjärvi in the Municipality of Vihti. Due to its location within a commuter proximity to the capital Helsinki region, Nummela is urbanizing rapidly. Poor water quality in the lake raised concerns about stormwater quality. Fish deaths and blue green algal blooms reduce recreational amenities as well as habitat values provided by the lake.

Site analysis revealed that the majority of Nummela was located within a 550 ha subwatershed of the Lake Enäjärvi. No reference was made on local maps to the heavily altered stream draining to the lake. The clay stream was also disappearing from the landscape into storm sewers and culverts as a conventional measure to manage erosion by high and rapid stormwater pulses from the urbanized watershed during rain and snowmelt events, as shown in Fig. 8. Phosphorus, the limiting nutrient to the blue green algae, is transported to the lake bound in clay particles.

Actions toward sustainable stormwater management were initiated with the goal of mitigating the effects on the health of the receiving lake and stream, as well as the urban landscape as a whole. The municipality of Vihti, the Regional Environmental Institute (UUDELY), academic outreach (the Department of Forest Sciences of the University of Helsinki), a local Lake Enäjärvi protection association (VESY), and a regional watershed protection association (VHVSY) collaborate to carry out these goals. As the very first step, the straightened and eroded stream was restored by reintroducing its old local name, Kilsoi, into maps. Due to the significant land use changes within the watershed, no further stream restoration to any previous state in time was possible: Rather, natural processes respecting urban landscape design with stabilizing stream corridor vegetation and constructed wetlands were applied as water and urban landscape mitigation elements.

The most eroded 200 m stretch of the stream was stabilized. Widening of the stream was possible only to a very limited extent as preceding water-insensitive development had zoned private housing close to the bank of the stream. The sides

Fig. 8 Starting point in Nummela was rapid urbanization with a major community stream disappearing in culverts. *Photograph* Salminen (2007)

owned by the municipality hosted underground utility lines, which are often hidden in the easily excavated stream sides. Land use changes and high imperviousness within the upstream 260 ha urban watershed, as shown in Fig. 9, required stabilization of the receiving stream banks with rocks at the erosive flow heights. Biodegradable coconut meadow seed mats and native trees were planted at higher elevations to establish a stable stream corridor. Seed mat installation and tree planting were conducted as an awareness-raising and collaboration-enhancing municipality staff and local dweller's joint volunteer event. The stream bed self-established rapidly with wetland plants.

The cost of stream stabilization by vegetation and rocks was only 20 % of the originally intended culvert extension. The municipality engaged in preserving the rest of the stream open and zoned a broad park network space with no underground utilities along the stream Kilsoi. Following the change in zoning practice, a 2 ha constructed stormwater management wetland was planned and implemented at the mouth of the Kilsoi in 2010.

The aim of this wetland park, which is now named the Gateway (located both at the mouth of Kilsoi and at the main commuter road entrance to Nummela) was to

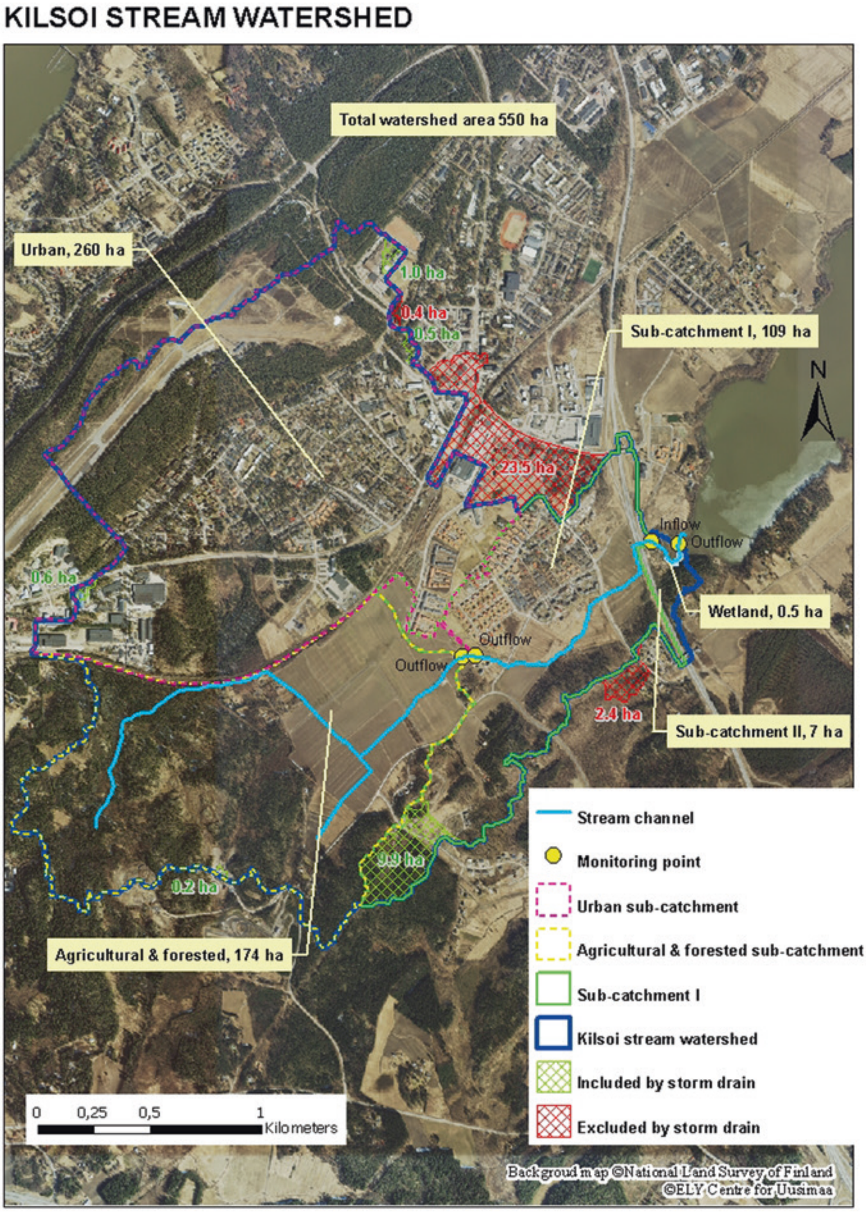

Fig. 9 The Kilsoi watershed includes a 260 ha stormwater sewer subwatershed. The yet remaining agricultural areas are undergoing urbanization. A wide wetland park area will be located along the entire length of the stream. Land use impact, as well as the impact of the constructed Gateway wetland park at the mouth of the Kilsoi stream, is monitored to improve design for water treatment landscapes. *Map by* Salminen and Jussila (2013)

treat water quality and manage flows and also to gain acceptance by urban dwellers for the treatment of wetland environments as urban green. Furthermore, habitat for sensitive species was attempted at the prior crop field site of clay soils. All drainage ditches were blocked to create amphibian habitat and wet meadows. A half-hectare of inundated wetland was excavated as wintertime dry construction, as shown in Fig. 10. Winter excavation is cost efficient and protects dormant vegetation. The stream was bypassed the construction site to avoid clay soils from entering the lake. Excavations were careful to avoid soil compaction. The excavated wetland rapidly self-established with over 100 native herbaceous species. Frogs, newts, and birds rapidly found the site. A nature trail with two bridges and a bird-watching tower was built. The cost of the two-hectare park establishment was minimal compared to construction costs of any conventional urban park. No impervious paving is present in the park.

Maintenance of the Gateway park includes moving the alignment of the one-kilometer-long nature trail by one meter each year. Meadow areas and the sediment-trapping pond at the beginning of the wetland area are monitored to establish a maintenance schedule for estimated every 5–10-year meadow cutting and sediment-trapping pond re-excavation. Water purification by the wetland, which only comprises 0.1 % of its watershed size, has reached up to 70 % turbidity (corresponding to clay-bound phosphorus) event reduction and 10% annual (over four seasons) reduction by the end of the fourth growth season (Salminen et al. 2012) . Interviews with the local dwellers have revealed that the constructed water environment parks have provided with local pride and sense of place, yet instead of focusing on water treatment, locals view the parks as dynamically changing with diverse places of beauty with sights and sounds of nature. Listening to singing birds such as the nightingale and watching spawning fish and amphibians has created vivid nature experiences. Local elementary schools visit the park regularly.

The municipality viewed the wetland park as both a cost-efficient park amenity to dwellers and a cost-efficient water management facility. An interest in improving knowledge on multifunctional landscaping grew strong among the

Fig. 10 The Nummela Gateway wetland park was constructed in 2010 by wintertime dry excavation, with some native trees planted on the site by an engaging volunteer event in May (*left*). In June 2013, the first children's summer camp was held at the site (*right*). *Photograph* Salminen (2010, 2013)

collaborators. The EU Life + 11 ENV/FI/911 Urban Oases funding was granted for 2012–2017 to expand knowledge and implementation of the constructed urban wetland parks within the Kilsoi watershed. Thanks to the acceptance gained by the Gateway wetland park, a seven-hectare water environment mitigation park is under construction upstream in the middle of urban Nummela.

9 Water-Sensitive Urban Design in Action: Drawing Lessons from Experiences in Four Case Studies

To illustrate and confirm the experience discussed in this chapter, a series of case studies have been analyzed in different cities across Europe. This analysis encompassed cities with a long urban history driven by different policies, government regulations, and community expectations.

Although part of the same process, urban development, green infrastructure, and stormwater management are not usually discussed and treated with the same concern and consideration. Urban development impacts as a process on the design of landscapes and cities as a whole in functional, aesthetic, and symbolic ways. For this reason, it is very important to increase understanding and knowledge of water sensitiveness in urban settings as well as political awareness about its importance, because these are crucial elements in all cities.

The case studies explored here demonstrate the variety of approaches adopted under very different conditions. They cover only a few topics of WSUD—rainwater harvesting, stormwater management, floodplain design, and constructed wetlands—but the range of options is enormous. There are a number of elements that have led to stormwater management and WSUD as concepts to re-establish natural water cycles and ensure water quality and river health. These experiences are vast, varied, and difficult to compare. However, a number of broad conditions for success and leading practices can be identified. The success conditions are grouped under four headings; early stage consideration, integration with urban design, active listening, and proactive and continuing work.

(a) Consider WSUD at the early stages of the planning process, not added as an afterthought.
    WSUD must be present at the early stages of the planning process, so that it can directly inform or influence local and city planning and plans. It must be part of the consultative process of planning process, where communities can engage with the concepts and accept advocate or reject them. Local communities are generally very responsive to concepts of water-sensitive urban design.
    The negative aspect of an afterthought can be illustrated by the case of Cascais. Even if the paradigm shift from a traditional approach to stormwater management has to be considered an improvement, the later addressing WSUD issues have now to cope with already implemented structures (see Fig. 7). Many of them do not match the rationale behind WSUD and

have anyhow to be integrated in the system. The project in Cascais is a kind of pioneer work, as in Portugal, there are no major experiences and national empirical evidences from bioengineering-optimized measures. Moving from a traditional approach needs time and effort. The positive aspect is that the Council is open to new experiences, developing ideas and taking the initiative. In Nummela, the combination of establishing sustainable stormwater structures while providing recreation areas for the inhabitants opens a new concept of an urban park. Furthermore, the cost efficiency, the added park amenities, and local knowledge gained from only a 200 m stream landscaping were enough to make a rapid shift in zoning to allow a broad chain of water mitigation park spaces along the thus revitalized urban stream. Such zoning was possible as the entire watershed is located within the same municipality which was also able to purchase the new park land.

(b) Water sensitiveness has to be an integral part of the urban design
WSUD will be most successful where multiple benefits, such as landscape or urban quality, recreation and amenity, walking and cycling, flood risk management, and biodiversity, can be achieved. It can also help to break down institutional silos (e.g., planners, engineers, landscape architects, architects, ecologists). Such actions might be used also to gain support and unlock funding, as the case of Besòs illustrates. Under the WSUD package, stormwater management should always create a little more scope for expansion and innovation. This can be a resource for local education, involvement, and empowerment, especially considering that planning of urban open space often involves a large number of stakeholders: local authorities, architects, developers, consultants, local inhabitants, and so forth.

Taking the case of Cascais, the ecological restoration of the stream enables not only the (re)integration of water into the urban landscape but also the creation of new connections, such as radial elements cutting through the mostly concentric urban fabric, opening new prospects for increasing environmental quality and recreation opportunities. In the case of Nummela, the importance of amenities such as the sounds of birds associated with the water treatment in wetland areas raised the issue of true multifunctionality and how the added values to the urban dwellers are much broader than any planning process currently considers.

There are also reservations about a dichotomy that inhibits WSUD actions—is stormwater an issue for the planning department or for the water department? Who is responsible for the construction and maintenance of the disciplines crossing structures? It is concluded that water professionals have unique opportunities to integrate stormwater management approaches within wider urban planning practice and hence are able to encourage the use of alternative systems that are more sustainable than using traditional pipes or sewers.

(c) Active listening to stakeholders and creating partnerships
The environmental degradation and river marginalization and the increasing environmental awareness and recreational and other demands from the population urge local and regional governments to find solutions. In the case of

Besòs, these issues resulted in 1995 in an institutional agreement between different municipalities. The municipalities of Barcelona, Santa Coloma de Gramenet, Sant Adria de Besòs, and Montcada i Reixac decided to start a series of programs and actions framed in a single project for the regeneration performance of the watershed, whose budget came mainly from European funds, and the establishment of the consortium for the defense of the river. On the other hand, political action was driven by a range of legislation and policy, in particular the EU Water Framework Directive (WFD) (2000/60/EC). All together, the Besòs case shows a great political commitment at different scales (local, subregional, and regional). Moreover, this project emerged from public concern, preliminary studies, and a high degree of cooperation between professionals of different fields, and the public stakeholder participation was very active in their preliminary stages.

Partnerships are crucial to sustainable delivery. Considering that the local community and their organization can be a valuable source of local knowledge and an incubator of ideas, they should be fully engaged in the process. Actions such as giving a name to a water treatment park or participating in the construction are both awareness raising and engaging to local dwellers. In the case of Nummela, these activities have also helped the decision of the municipality to acquire land from private owners who have learnt to view sustainable water management parks as a preferred future for their land.

(d) Proactive and continuing work

Actively listening to stakeholders and creating partnerships can be particularly difficult where interest in sustainable development and alternative stormwater management is low. WSUD cannot and should not place its reliance alone on positive stakeholder influence; councils must take their own initiatives to drive the idea forward. Proactive acting involves thinking, planning, and foreseeing in advance of a future situation, rather than just reacting on anticipated events.

Despite the improvements in the case studies, however, there is still room for improvement in the management of stormwater. In view of the future uncertainties from climate change and impacts from current legislation (especially the Water Framework Directive), stormwater management will need to take a more central role in all aspects of urban planning. For example, an integrated plan of stormwater management in the Metropolitan Region of Barcelona is needed, including extended measures of WSUD, to the occasional already existing experiences. The European Directive on the Assessment and Management of Flood Risk (2007/60/EC) can be a good framework to develop these plans. For a successful implementation of stormwater management, measures should be part of an overall strategy, with a strong political consensus, public acceptance, and stakeholder participation, and must be adapted to the particular (urban, socioeconomic, environmental, and climate) characteristics of each municipality.

Measures to re-establish healthy water systems, in particular preventing water bodies pollution and restoring their ecological balance, achieve standard levels that allow their integration into the urban fabric, once they do not pose any threat or risk to the population or environment. As the cases show the improvement in water quality, strengthening biodiversity and safe access opens up a new dimension in experiencing water and waterways in urban settings.

To benefit from all these aspects, it is explicitly necessary to work out a multidisciplinary approach, as the Dublin Strategy demonstrates—which included planners, engineers, landscape architects, heritage officers, and ecologists. In Nummela, both local and regional water protection associations complement the list of interdisciplinary municipal, academic, and regional government staff. A comprehensive scope is a necessity in the delivery of cost-effective and long-term sustainable solutions and this needs to span each phase of planning process, from goals setting to planning, design, construction and management.

The structural change with the shift from agrarian to industrialized and service economies, the deindustrialization, and the economic cycles (growth, decline, and regrowth) is a cumulative process involving almost all sectors of the urban development. These changes in the location patterns of industries have a spatial consequence: a growing number of brownfields. Such abandoned (urban) properties are often environmentally contaminated and therefore unusable. As in the case of Besòs, heavy industries are often strategically located on very attractive areas by the river banks. In many cases, there is no pressure to reuse such areas, leaving behind white spots in the urban fabric. These white spots, however, make land available with the possibility to develop a comprehensive approach to transform watercourses into linear structural elements.

The cases show that improved and well-managed water resources in the urban environment can provide a wide range of benefits to communities. And this despite the current trend of seeing stormwater in urban settings as more of a threat than an opportunity for improving the urban environment in different ways. Water is a vital asset, so there is nothing more fundamental than protecting it. A healthy environment has many benefits for the health of people and cities. Ensuring that waters are clean costs an enormous amount of resources and takes a huge amount of management effort but on the other side offers many opportunities to create sustainable and livable cities. Sustainable water management requires integrated, collaborative, and far-reaching approaches. While the paradigm shift requires resources for activation, the added benefits are numerous and long-term cost savings become enormous. In simple words, measures for a successful implementation of stormwater management should be part of an overall strategy, based on strong political will and social consensus, Which is backed by public acceptance and stakeholder participation and tailored to the particular urban, socioeconomic, environmental, and climate characteristics of each individual location.

References

Barbosa AE, Fernandes JN, David LM (2012) Key issues for sustainable urban stormwater management. Water Res 46(20):6787–6798

Cettner A, Söderholm K, Viklander M (2012) An adaptive stormwater culture? Historical perspectives on the status of stormwater within the Swedish urban water system. J Urban Technol 19(3):25–40

Cettner A, Ashley R, Hedström A, Viklander M (2013) Sustainable development and urban stormwater practice. Urban Water J:1–13

Chocat B, Ashley R, Marsalek J, Matos MR, Rauch W, Schilling W, Urbonas B (2007) Toward sustainable management of urban storm water. Indoor Built Environ 16 (3):273-285

Coutts AM, Tapper NJ, Beringer J, Loughnan M, Demuzere M (2013) Watering our cities: the capacity for water sensitive urban design to support urban cooling and improve human thermal comfort in the Australian context. Prog Phys Geogr 37(1):2–28

Dolman N, Savage A, Ogunyoye F (2013) Water-sensitive urban design: learning from experience. Proc Inst Civil Eng-Municipal Eng 166(2):86–97

Domenech L, Sauri D (2012) A comparative appraisal of the use of rainwater harvesting in single and multi-family buildings of the metropolitan area of Barcelona (Spain): social experience, drinking water savings and economic costs. J Clean Prod 19(6–7):598–608

Dublin City Council and The Heritage Council (2012). Green infrastructure strategies for local area plans. Dublin

Echols S (2007) Artful rainwater design in the urban landscape. J Green Build 2(4):1–19

EEA—European Environment Agency (2010) The European environment state and outlook. Copenhagen

Eurostat (2012) Around 40 % of the EU27 population live in urban regions and almost a quarter in rural regions. http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/1-30032012-BP/EN/1-30032012-BP-EN.PDF Accessed on 15 Jan 2013

Farreny R, Morales-Pinzón T, Guisasola A, Taya C, Rieradevall J, Gabarrell X (2011a) Roof selection for rainwater harvesting: quantity and quality assessments in Spain. Water Res 45(10):3245–3254

Farreny R, Oliver-Solà J, Montlleó M, Escribà E, Gabarrell X, Rieradevall J (2011b) Transition towards sustainable cities: opportunities, constraints, and strategies in planning. A neighbourhood ecodesign case study in Barcelona. Landscape Urban Plann A 43:1118–1134

Farreny R, Gabarrell X, Rieradevall J (2011c) Cost-efficiency of rainwater harvesting strategies in dense Mediterranean neighbourhoods. Resour Conserv Recycl 55(7):686–694

Florida R (2002) The rise of the creative class. Basic Books, New York

Fryd O, Backhaus A, Birch H, Fratini CF, Ingvertsen ST, Jeppesen J et al (2013) Water sensitive urban design retrofits in Copenhagen-40 % to the sewer, 60 % to the city. Water Sci Technol 67(9):1945–1952

Hoyer J, Dickhaut W, Kronawitter L, Weber B (2011) Water sensitive urban design—principles and inspiration for sustainable stormwater management in the city of the future. Jovis, Berlin

IPCC (2012) Summary for policymakers. In: Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, pp 1–19. http://www.ipcc-wg2.gov/SREX. Accessed on 04 Nov 2013

Krebs G, Rimpiläinen UM, Salminen O (2013) How does imperviousness develop and affect runoff generation in an urbanizing watershed? Fennia 191(2):143–159

MW—Melbourne Water. n.d. City of Melbourne WSUD guidelines. pp 10–11

Roy A, Wenger S, Fletcher T, Walsh C, Ladson A, Shuster W, Thurston H, Brown R (2008) Impediments and solutions to sustainable, watershed-scale urban stormwater management: lessons from Australia and the United States. Environ Manage 42(2):344–359

Salminen O, Ahponen H, Valkama P, Vessman T, Rantakokko K, Vaahtera E, Taylor A, Vasander H, Nikinmaa E (2012) Benefits of green infrastructure – socioeconomic importance of constructed urban wetlands (Nummela, Finland). In Kettunen et al (eds) Socio-economic importance of ecosystem services in the Nordic Countries – Synthesis in the context of The Economics of Ecosystems and Biodiversity (TEEB). Nordic Council of Ministers, Copenhagen pp 247–254

Smaniotto Costa C, Hoyer J (2013) Why invest in urban landscape? The importance of green spaces and water for urban sustainable development. In: Wagner I, Zalewski M, Butterworth J (eds) Ecohydrology in urban areas: experiences of the SWITCH demonstration, City of Lodz, Poland

Smaniotto Costa C (2007) Ökonomische Argumente für Grünflächenentwicklung. Stadt und Grün 2:13–19

SWITCH project—managing water for the city of the future. www.switchurbanwater. Accessed on 16 Nov 2012

UNFPA (UN Population Fund) (2007) The state of the World population 2007—unleashing the potential of urban growth. http://www.unfpa.org Accessed on 16 Nov 2012

Walsh C, Roy A, Feminella J, Cottingham P, Groffman P, Morgan R (2005) The urban stream syndrome: current knowledge and the search for a cure. J North Am Benthol Soc 24(3):706–723

Authors Biography

Carlos Smaniotto Costa (Ph.D.) is a Landscape Architect and Environmental Planner, graduated at the University of Hanover, Germany. He works in the fields of design of urban environment, open space planning, and urban development in Germany, Italy, and Brazil. His Ph.D. focused in landscape planning as directive for sustainable urban development. He is professor of Urban Ecology and Landscape Design at Universidade Lusófona, Lisbon, and the head of its Experimental Laboratory on Public Spaces. His research activities deal with issues of sustainable urban development strategies for integrating open spaces and nature conservation in an urban context.

Dr. Conor Norton is a Head of Department at the School of Spatial Planning, Dublin Institute of Technology in Ireland

Elena Domene is a researcher at the Barcelona Institute of Regional and Metropolitan Studies (IERMB) in Spain.

Jacqueline Hoyer is a researcher at Hafen City University in Hamburg, Germany.

Joan Marull is a researcher at the Barcelona Institute of Regional and Metropolitan Studies (IERMB) in Spain.

Outi Salminen is a researcher at the Department of Forest Sciences, University of Helsinki, Finland.