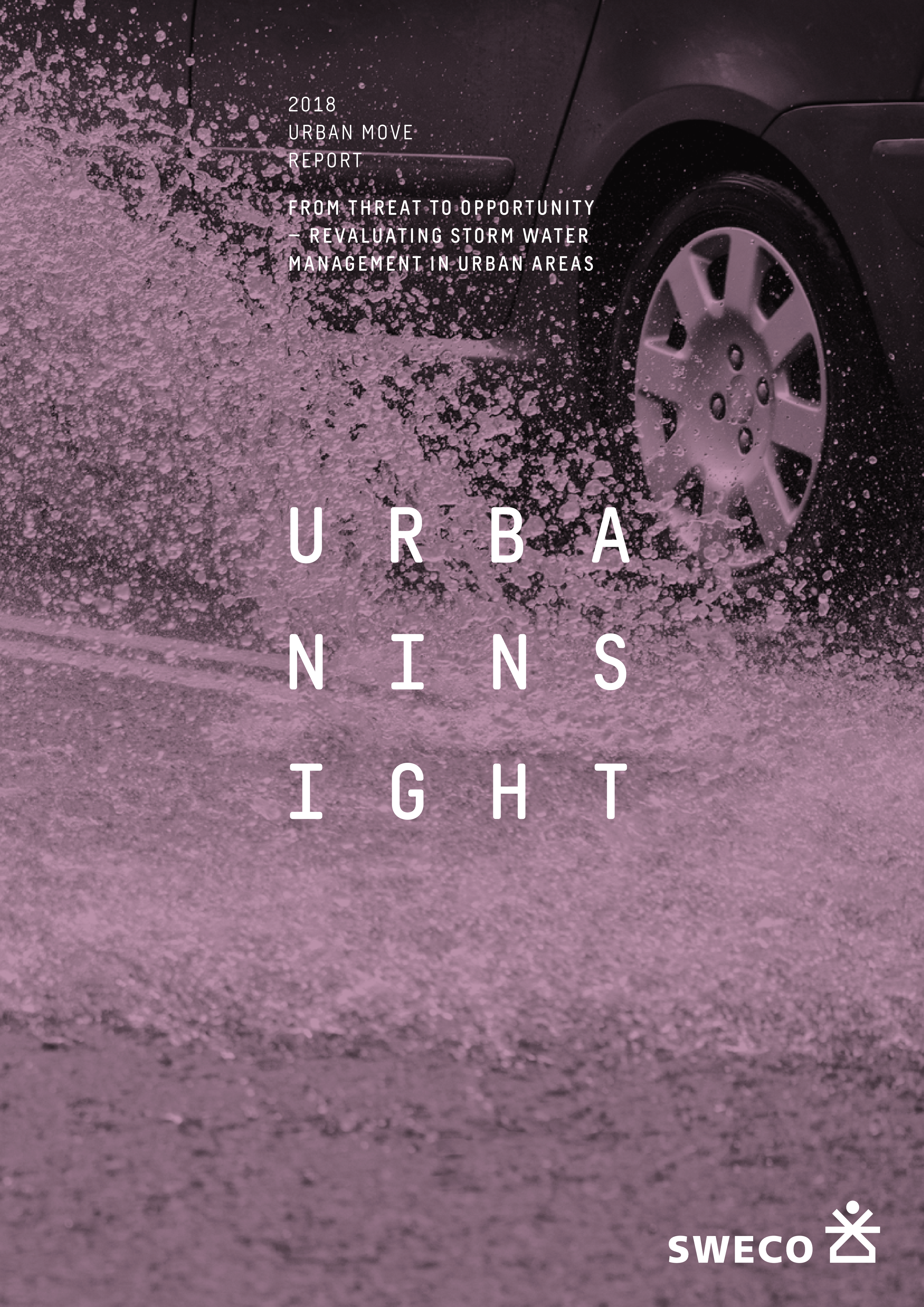

2018
URBAN MOVE
REPORT

FROM THREAT TO OPPORTUNITY – REVALUATING STORM WATER MANAGEMENT IN URBAN AREAS

URBAN INSIGHT

SWECO

FROM THREAT TO OPPORTUNITY – REVALUATING STORM WATER MANAGEMENT IN URBAN AREAS

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MOBILITY
NEEDS
SUSTAINABLE
STORM WATER
MANAGEMENT
MEASURES.

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1. INTRODUCTION

In recent decades we have seen dramatic scenes of flooding streets appearing regularly in the media. Meanwhile, prominent scientists are warning that extreme weather conditions (droughts and floods) might become even more common in the future. This means that the demands on storm water management[1] infrastructure in European cities will be greater than ever before. How can we improve storm water management in a way that is sustainable, effective and contributes to liveable cities? How can we face the environmental problems of water pollution from storm water?

Traditional approaches to centralised water supply and urban drainage systems are insufficient to meet current and future challenges. Why is that? Greater population densities and expanding impervious surfaces in urban areas intensify pressure on storm water drainage systems. Other challenges such as climate change, and the need for better living standards, including improved health, imply the need for change and a move towards storm water management that is more sustainable. Apart from the standard economic, ecological and social dimensions of the word, "sustainable" also expresses our desire to live in a place of high living and service standards characterised by highly responsible behaviour to the surrounding environment.

Water management in urbanised areas has changed dramatically in recent centuries, not least in terms of storm water drainage. The attitude has changed from "we do not care", to "get the water out of the city as quickly as possible", "bring me clean drinking water but drain storm water far away from me" to a more integrated approach using conventional "hard" engineering alongside "soft" landscaping – green infrastructure[2]. Without storm water management of our urban areas, flooding would affect the lives of citizens living, working and moving through these areas, and prevent the movement of goods and information.

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1) There are various approaches to managing excess water originating from rain and snowfall. It traditionally includes drainage of water through infrastructure such as sewers, but increasingly sophisticated sustainable approaches with various "Blue-Green Infrastructure" measures are needed.
2) Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life.
European Commission (2016) *Green Infrastructure* [Online] Available at: http://ec.europa.eu/environment/nature/ecosystems/index_en.htm, Accessed 04/10/2018

"TO ENSURE SUSTAINABLE QUALITY OF LIFE IN LIVEABLE AND ATTRACTIVE CITIES, WE NEED TO UTILIZE MANY DIFFERENT IDEAS AND PERSPECTIVES ON STORM WATER MANAGEMENT FROM STORM WATER PROFESSIONALS AS WELL AS CITIZENS."

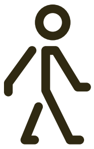
The "Blue-Green Infrastructure" approach is of particular importance in securing a sustainable future and generating multiple benefits in the environmental, ecological, social and cultural spheres. It requires a co-ordinated interdisciplinary approach to water resource and green space management from institutional organisations, industry, academia, and local communities and stakeholders. Depending on the scale of the solution, an integrated storm water system could consist of "natural" measures like green roofs, planters, green belts, swales, wetlands, grassed dry retention ponds or raingardens combined usually with other, more "artificial" measures, for example underground infiltration or/and detention and retention tanks etc. Various terminology is used for such integrated approaches, for example: **Sustainable Drainage Systems (SuDS), Water-sensitive Urban Design (WSUD) in Australia, and Low-impact Development (LID) or Best Management Practice (BMP) in the United States, and blue-green cities and Blue-Green Infrastructure (BGI).**

Storm water should not be considered as a threat, but rather as a positive landscape element that, together with vegetation, constitutes protective temperature islands in cities. The "Blue-Green" Infrastructure approach significantly influences city transport and the strategy of human mobility planning in general. This calls for deep, well-timed and long-term co-operation of city development plan stakeholders. This is the way to build future liveable cities.

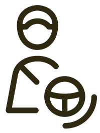
Mobility needs can be combined with green and blue infrastructure, which include sustainable storm water management measures, and together bring sustainable quality of life in liveable and attractive urban areas in Europe.

2. CITIZEN PERSPECTIVES ON STORM WATER MANAGEMENT IN URBAN AREAS

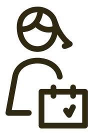
Storm water management affects citizens in urban environments in different ways. The views of pedestrians are different from motorists, and the views of those involved in designing and managing our cities may be different again. These perspectives need to be considered in planning and managing storm water to ensure sustainable quality of life in liveable and attractive urban areas in Europe. Different perspectives on the role of storm water in urbanised areas are listed below.



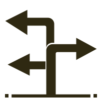
PEDESTRIANS
I don't like rainy weather – there are a lot of puddles on the street, and motorists splash pedestrians with their cars. I remember when the street was flooded, I could not get out of the house or go to work. Water was everywhere, it was horrible. It's much better when there is no storm water on the street. I like green areas with trees along the street, I find them relaxing.



DRIVERS
Rainy weather and water on the street mean I have to drive slower and more carefully. It's much better when there is proper drainage for the roads, storm water runs away quickly from the road surface. In our city I have noticed some changes in the driving system of one district, a lot of two-way streets have been changed to one-way streets, and the gained space has been changed to green areas with trees. It's nice, but there are a lot of restrictions, and the speed limit has been reduced. I've also noticed that there's not too much water on the road surface when it rains.



CITY PLANNERS, LOCAL AUTHORITIES, DECISION MAKERS
We would like to fully support contemporary trends in urban drainage, especially implementing Blue-Green Infrastructure in suburbs and new locations. Unfortunately, the application of such ideas in a city centre is a long-term plan requiring significant changes to existing city infrastructure and, of course, it is a capital-intensive process. We understand that street space is used by different people, and we want to be fair not only to residents but also to commuters and visitors. Therefore, we should plan changes not only in water management and living infrastructure, but also in overall city planning priorities, city transport requirements, and opportunities for sports activities.



TRAFFIC PLANNERS
Urban mobility patterns and needs are constantly changing and becoming increasingly varied. In our city we systematically promote environmentally friendly means of transport like public transport, walking and cycling. Such a prioritisation opens new possibilities for more attractive design of streetscapes and a recovery of the public space. Of course, this calls for a change of paradigms in the planning and organisation of traffic and also opens a space for a discussion on the topic of retrofitting Blue-Green Infrastructure for improved storm water management.

STORM WATER MANAGEMENT PROFESSIONALS

A key aim of storm water management in urbanised areas is to create pleasant spaces for people in which to live, which in turn requires management of storm water quantity (and quality) to an acceptable level. Storm water management experts in Europe share their insights and perspectives about the role of storm water management below.

“STORM WATER SHOULD BE MANAGED BY ALLOWING WATER TO BE PART OF OUR DAILY LIVES, NOT SOMETHING TO GET RID OF BUT SOMETHING TO SEE, TO TOUCH AND TO INTERACT WITH.”
Alvaro Fonseca, Chief Advisor – Climate Adaptation and Resilience, Sweco Denmark.

“STORM WATER SYSTEMS ARE NOT ALWAYS MANAGED APPROPRIATELY IN THE URBAN AREAS IN COUNTRIES I HAVE WORKED IN. AND BECAUSE OF CLIMATE CHANGE THE URGENCY TO MANAGE STORM WATER IN A SUITABLE WAY IS INCREASING. EVEN IN THE NETHERLANDS, WITH A LONG HISTORY IN WATER MANAGEMENT AND A WELL-DEVELOPED WATER MANAGEMENT SYSTEM, WE HAVE TO ADAPT AND FIND NEW INNOVATIVE SOLUTIONS TO DEAL WITH THE EFFECTS OF CLIMATE CHANGE.”
Enrico Moens, Program Manager Climate Change, Sweco Netherlands.

“WE NEED TO CHANGE OUR APPROACH TO CITY WATER INFRASTRUCTURE. A GUIDELINE DOCUMENT ASSESSMENT OF SEWER SYSTEMS IN URBANIZED CATCHMENTS WAS CREATED ON REQUEST OF THE STATE ENVIRONMENTAL FUND OF CZECH REPUBLIC (2009) TO SUPPORT IMPLEMENTATION OF NEW STORM WATER MANAGEMENT.”
Dr. Ivana Kablekova et al., Czech Technical University in Prague, Czech Republic[3]

3) Translation of a quote from: AČE ČR (2009) *Metodická příručka Posouzení stokových systémů urbanizovaných povodí* (PSSUP) (Online) Available at: http://www.opzp.cz/soubor-ke-stazeni/17/5237-metodicka_prirucka_stokovy_system_090604.pdf, Accessed: 04/10/2018

3.
STORM WATER MANAGEMENT IN URBAN AREAS – WHAT WE KNOW


STOP

The traditional approach for safe discharge of rainwater into a receiving waterbody during rainfall-runoff processes in urbanised areas, either in combined sewers and/or in storm water drainage systems, dramatically changed during the 20th century due to the expansion of urban areas. Conventional "hard engineering" approaches (sewers etc.) have been complemented, and in some cases replaced, with more natural approaches using Blue-Green Infrastructure, for example a system of measures such as green belts, grassed dry retention ponds or raingardens. Integrated master planning and modelling has also become a key part of storm water management in urban areas.

At the European level, there are various pieces of legislation relating to water management, affecting storm water management to some degree, notably the Water Framework Directive (WFD) requiring the protection and enhancement of waterbodies. The other main pieces of EU directives relating to water include: Floods Directive (2007), Water Pollution by Discharges of Certain Dangerous Substances (2006), Groundwater Directive (2006), Habitats Directive (1992), Urban Waste Water Directive (1991), Bathing Water Directive (1976)[4].

The European Commission defines green infrastructure as "a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings"[5, 6]. Blue-Green Infrastructure can be used as a way to achieve the aims of some of the directives listed above. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life.

The implementation procedure of some legislation has changed local (country) standards and led to guidance documents and policy advice for larger authorities, organisations and land managers. Legislation defines a framework of possible infrastructure changes, and outlines the responsibilities of local institutions and other bodies. Table 1 provides a brief review of approaches to Sustainable Drainage System (SuDS) in some EU countries, as perceived by selected experts involved in storm water management in those countries.

4) Susdrain (undated) Policy documents [Online] Available at: http://www.susdrain.org/resources/policy.html Accessed 06/12/2017
5) European Commission (2013) Building a Green Infrastructure for Europe, European Commission, Luxembourg, p7
6) European Environment Agency (2017) Green Infrastructure and Flood Management Promoting cost-efficient flood risk reduction via green infrastructure solutions, European Environment Agency, Luxembourg

Table 1: Summary of expert perspectives on SuDS in a selection of European countries[7]

	OVERVIEW	LEGISLATION REQUIRING SUDS	MAINTENANCE
Sweden	SuDS is increasingly being installed in new developments, existing drainage is not being replaced, SuDS is an additional improvement.	No, however EU WFD affects the need for treatment and flooding regulations relating to new urban areas.	Responsibility is unclear in the regulations and varies from case-to-case. With end-of-pipe solutions such as ponds, wet utility services are typically responsible. For raingardens/planters/structural soils, municipalities are usually responsible.
Denmark	SuDS are enforced in any new urban development, regardless of whether it is private or public investment. Retrofitting of existing urban areas to include SuDS is also an important part of the paradigm shift towards more sustainable storm water management systems, but remains a challenge due to space restrictions and conflicts of interest, i.e. removal of parking places to make room for blue-green areas.	Legislation fosters co-operation between municipalities and water companies; the latter being allowed to fund SuDS dealing with water from streets, roofs, parking areas and other paved areas.	Ownership responsibility and maintenance of SuDS remains a challenge. Legislation allows for the establishment of flexible maintenance schemes between municipalities and water companies.
Czech Republic	Although the principles of SuDS are known within the professional community, they have not been implemented in the legislation. Hence, there are only a few small projects where blue-green solutions have been implemented.	Legislation requires developers to solve problems of accumulation of rainwater in built-up/paved areas, preferably using methods of infiltration.	Sewerage owners are responsible for maintenance and preparing and executing 10 year-Infrastructure Asset Recovery Plans. Municipalities manage green areas. SuDS maintenance responsibilities have not been defined in legislation.
Netherlands	The approach to storm water management is increasingly focusing on SuDS, including blue-green solutions, stimulated by national government (Spatial Adaptation)[8]. There is discussion about investment and maintenance of blue green solutions and how to persuade developers to implement SuDS.	Blue-Green Infrastructure is not currently required as part of legislation, but there are guidelines and good examples for public and private organisations to implement blue green solutions to mitigate the effects of climate change.	In general, public organisations such as municipalities and/or water boards are responsible for the maintenance of Blue-Green Infrastructure. It is also possible that developers are responsible depending on contractual obligations to the public organisation concerned. In some cases, there is an agreement with citizens to maintain small-scale blue-green solutions.
UK	Surface water is managed by a complicated combination of public and private network of authorities. Despite an active online industry community (Susdrain website) and the implementation of many SuDS projects, including a few large-scale retrofit SuDS schemes, there are few incentives for developers; with a lack of clear funding and robust legislation there are practical difficulties moving things forward.	The National Planning Policy Framework guides development of new storm water management systems in England. The guidelines do not include strict requirements to implement SuDS for new developments, although the Flood and Water Management Act 2010, calls for a SuDS Approving Body (SAB) to be set up within lead local flood authorities (LLFAs). In Scotland the enactment of the Water Environment and Water Services (Scotland) Act 2003 made Scottish Water responsible for SuDS that deal with the run-off from roofs and paved surfaces within property boundaries, and made the use of SuDS obligatory when dealing with surface water drainage from new developments.	In England, currently no organisations have a statutory obligation to take on the management of schemes over the lifetime of the development. In some instances, developers can be required to maintain or fund maintenance of SuDS. From January 2019 in Wales, the intention is to have SuDS SAB responsible for the adoption of SuDS meeting certain conditions. In Scotland, SuDS are mandatory for new developments since 2006, and Scottish Water are responsible for approving SuDS for their adoption, with maintenance agreements between the water company, LLFA and private developers.

7) Information provided by Agata Banach and Fredrick Toller (Sweden), Alvaro Fonseca (Denmark), Vladimír Havlík (Czech Republic), Enrico Moens (Netherlands), Doug Lewis (UK)
8) Ministry of Infrastructure and the Environment, and the Ministry of Economic Affairs (2017) Delta Programme 2017. Work on the Delta. Linking taskings, on track together [Online] Available at: https://deltaprogramma2017.deltacommissaris.nl/viewer/publication/1/1-delta-programme- Accessed 05/12/2017

3.1 SUSTAINABLE URBAN STORM WATER MANAGEMENT

Sustainable storm water management schemes must be integrated design solutions involving a set of measures suitable to specific local conditions. Such an integrated storm water system has not only to consider and manage storm water in present climatic conditions, but also all potential future climate change scenarios (e.g. more intense rain events, less rain, rising temperatures etc.). Comprehensive long-term planning for storm water is crucial and should involve integrated designs utilising various innovative technical solutions, including Blue-Green Infrastructure. The use of Blue-Green Infrastructure is an important tool that can generate multiple benefits (see Box 1).

Box 1: Multiple benefits of Blue-Green Infrastructure.

Benefits of Blue-Green Infrastructure

- Pollution control, improved air and water quality
- Cost savings compared to operations and maintenance of traditional drainage systems
- Community amenities – attractive green areas, health and well-being benefits
- Improved habitats for wildlife
- Flood prevention and reduction
- Encouraging natural groundwater recharge
- Adaptation to climate change
- Innovative uses of SuDS in traffic management

There are three basic recommended stages to be taken when managing storm water in urbanised areas:

- The first step is based on the idea of keeping storm water where if falls and **retaining** it locally.
- If the amount of water is too great for local retention, then in the second step it is necessary to store storm water in extra **storage** capacity – either naturally or artificially created.
- Excess storm water that cannot be retained or stored has to be, in a third step, slowly **drained** through available or created waterways.

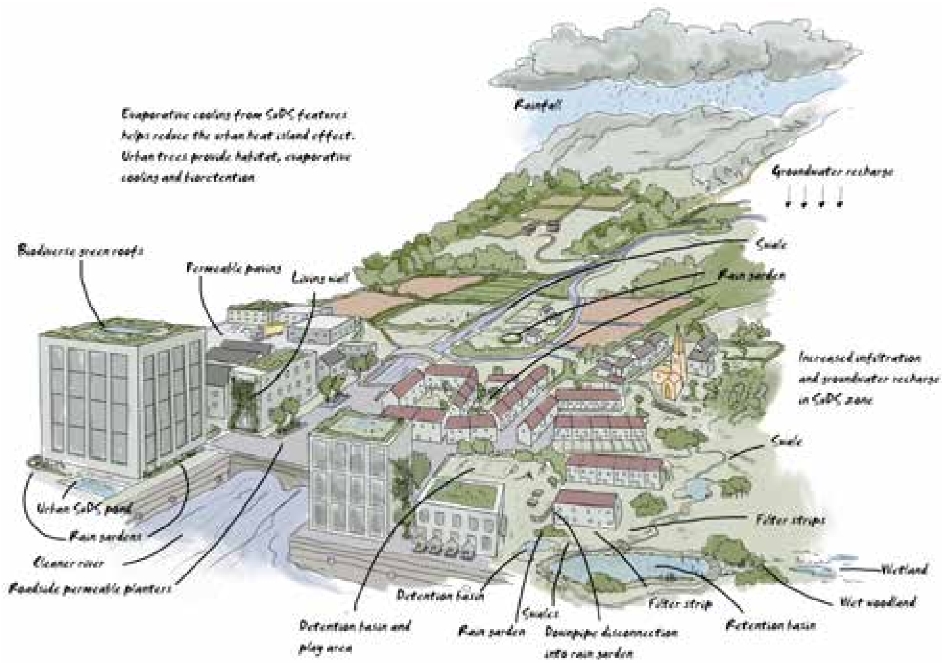
From the point of view of key stakeholders including states, communities, business/industry groups, academia and non-governmental organisations, the overall process should rely on adopting a long-term approach to planning. Communities can also elaborate plans that allow for the integration of selected projects within other community development plans including master plans.

> "LOCAL COMMUNITY INVOLVEMENT IS ESSENTIAL AND HELPS TO ENSURE THAT SUSTAINABLE DRAINAGE SYSTEM SCHEMES ARE APPROPRIATE FOR LOCAL AREAS."

With an effective participation strategy, guidance and public education, local communities have the opportunity to learn, ask questions, raise issues, and ultimately ensure Sustainable Drainage System (SuDS) implementation benefits communities in the best possible manner.

Ill. 1: Benthemplein Water Square, Rotterdam: Innovative use of SuDS in a multifunctional city centre open space for rainwater storage and recreation. Photo: Arnoud Molenaar, City of Rotterdam

Depending on the scale of the solution, an integrated storm water system consists of "natural" measures – such as various green roofs, planters, green belts, grassed dry retention ponds or raingardens – typically combined with other, more "artificial" measures, such as underground infiltration or/and detention and retention tanks etc. Ill. 1 shows an example of "artificial" measures – hard landscaping water storage basins that retain water during rain events, and also provide space for sports and recreation after water is infiltrated and/or pumped out. The water square stores rainwater falling on the square and also from the roofs of surrounding buildings in basins, and thus helps to relieve pressure on the city's drainage system. This water square is also a nice example of the "Resilience by Design approach" applied by the city of Rotterdam. Ill. 2 illustrates a variety of measures which can be used when implementing SuDS. Two inspiring case studies from Sweden and Scotland are described in Box 2 and Box 3.



Ill. 2: Urban catchment with SuDS. Illustration: The RSPB and the Wildfowl & Wetlands Trust[9]

9) Graham, A., Day, J., Bray, B., Mackenzie, S. (2012) Sustainable drainage systems – Maximising the potential for people and wildlife – A guide for local authorities and developers, The RSPB and the Wildfowl & Wetlands Trust

The images below show several projects throughout Europe that illustrate how storm water management can add value to cities and citizens, with resourceful and sustainable solutions.

Ill. 3, above left: Grey to Green project, Sheffield – retrofitting SuDS into multifunctional city centre streets and spaces, UK. Photo: Sheffield City Council

Ill. 4, below left: West Street, Ashford, UK – existing street retrofitted with a rain garden and storm water planters with inflow of rainwater run-off from carriageway. Photo: Sweco UK

Ill. 5, above right: Gladsaxe station, storm water management in urban areas, Sweco Denmark. Photo: Niels Nygaard

Ill. 6, below right: Local cleaning of storm water run-off in plant beds, and adjacent secondary overflow path with possibility for flow attenuation, Stockholm Royal Sea Port/ Norra Djurgårdsstaden. Photo: Stockholms stad

Box 2: Case Study – Stockholm Royal Sea Port.

Case Study – Stockholm Royal Sea Port[10]

"The Royal Seaport Innovation will become a sustainable urban area and an international model for sustainable urban development."

The award-winning Stockholm Royal Sea Port project is the largest urban development area in Sweden, (390 ha), with 12,000 new homes and 35,000 workplaces, and is located in a former industrial area. Sustainability, including climate change adaptation and biodiversity, is a key feature of the project. Goals relating to storm water include adaptation for future higher sea level and climate change with more intense rain events, offering attractive public spaces and integrated storm water systems (SuDS). SuDS methods have included green planters along streets and infiltration surfaces in a central park.

Storm water management strategies were developed for the project and include key principles such as hard surfaces not connected directly to the drainage system, storm water should be detained and used for irrigation – promoting biodiversity; no increased pollutant load at recipient; raingardens designed for two-year flooding events.

Sweco was involved in the storm water management systems in every stage of the project, from strategies, developing new measures, technical support, design of public spaces such as roads, parks and squares.

The project received a C40 Cities Climate Leadership Group award for the best sustainable urban development project in 2015, presented at the UN Climate Change Conference in Paris.

Contributed by Agata Banach, Sweco Environment

Ill. 7: Stockholm Royal Sea Port / Norra Djurgårdsstaden. Illustration: Adept & Mandaworks

10) Banach, A. (2017) Storm Water Management – Stockholm Royal Seaport – an award-winning project (presentation)

Box 3: Case Study – Catchment based Surface Water Management in Scotland.

Case Study – Catchment based Surface Water Management in Scotland (2008 – 2016)

Sweco UK carried out a programme of works including multiple Surface Water Management Plans (SWMP), feasibility studies and detailed design for flood risk mitigation, and SuDS master planning solutions for areas of South Dalmarnock, Glasgow and Cumbernauld.

In South Dalmarnock, for Clyde Gateway, a Glasgow regeneration company, green networks were used to address site drainage, including an innovative “flood finger” river interface, capable of mitigating loss of floodplain storage caused by land raising as part of the redevelopment, and providing attractive flood defence. A SuDS basin and riparian landscape was constructed in 2013 at the site of the former Dalmarnock Power Station, and construction commenced for the residential plots in 2018. As part of the Cumbernauld SWMP for Scottish Water, the largest (volumetrically) SuDS detention pond solution in Europe at 22,000 m^3 total capacity, was designed and constructed using a “cascading pond” design. The scheme was delivered 40 per cent under budget, realising savings of approximately £2 million.

Consultation and involvement of the local community was an important stage. There were multiple benefits as part of the project, including culvert daylighting, greenspace enhancement, creating capacity in existing watercourses, storm water and combined sewers to facilitate future development objectives and public amenity benefits without the need for wholesale sewer upgrades.

Contributed by Sweco UK

Ill. 8, left: Clyde Gateway South Dalmarnock Masterplan. Illustration: Clyde Gateway Regeneration Company

Ill. 9, right: Scottish Water Cumbernauld SuDS ponds.

The images below show several projects throughout Europe that illustrate how storm water management can add value to the inhabitants, with creative and sustainable solutions.

Ill. 10, above left: Imaginative "wiggly wall" running through SuDS storage basins providing an enjoyable space for the local community, Australia Road, London, UK. Photo: Robert Bray Associates

Ill. 11, below left: SuDS in a residential area, Switzerland.

Ill. 12, above right: Testing permeable paving. Photo: Sweco Netherlands

Ill. 13, below right: Green roof, Stockholm Royal Sea Port / Norra Djurgårdsstaden. Photo: Stockholm Stad, Exploaterings-kontoret

3.2 FINANCIAL ASPECTS OF BLUE-GREEN INFRASTRUCTURE

It is important to consider the design, construction and maintenance costs of Blue-Green Infrastructure. Experience from many European countries suggests that maintenance costs and responsibility for maintenance of Sustainable Drainage Systems (SuDS) is usually more challenging than the cost of implementing SuDS in new developments. Responsibility for maintenance of SuDS needs to be clearly defined in legislation. However, financial costs of implementation can still present obstacles, particularly when robust legislation requiring SuDS is not in place. Various tools exist for comparing costs, potential benefits and cost savings over the lifetime of projects. For example, the *Benefits of SuDS Tool (BeST)*[11] described in Chapter 4.

An interesting approach to financing SuDS projects has been adopted in Denmark. In a change of paradigm, legislation was changed to allow water utilities to slightly increase their tariffs on the condition that they design and implement public storm water solutions based on SuDS dealing with water from streets, roofs, parking areas and other paved areas. The scheme also provided for flexibility in terms of ownership and maintenance between water companies and municipalities, making the latter ultimately SuDS asset owners. The scheme originally allowed utilities to finance 100 per cent of all project costs. Currently, the maximum level of financing is 75 per cent, which means municipalities need to cover 25 per cent of all project costs, excluding maintenance costs, which are agreed on a consensus and case-by-case basis. The 75/25 rule respects EU co-financing policy, but has also reduced the number of projects, as municipalities prioritize other public investment areas, and thus we see a reduction in investment targeting SuDS.

SuDS are sometimes incorrectly viewed as being more expensive than conventional storm water management. This misconception comes from too narrow a focus on investment costs for projects in city centres. On the contrary, they are usually more cost effective than conventional methods, and they also bring additional multiple benefits. Experience from the United States can give us some useful perspectives in this respect, when considering the financial costs of green infrastructure in general.

Ill. 14: SuDS in residential area Baunebakken, Hvidovre, Greater Copenhagen – bio-retention infiltration trench for roof water management. Photo: Sweco Denmark

11) Susdrain (Undated) B£ST (Benefits of SuDS Tool) [Online] Available at: http://www.susdrain.org/resources/best.html Accessed 05/12/2017

Box 4: Experience from the United States.

Experience from the United States

- A study carried out in the United States of 479 green infrastructure projects found that 44 per cent of green infrastructure projects reduce total costs compared to the 25 per cent that increased the costs.[12]
- A green infrastructure project in Philadelphia is due to cost $1.2 billion compared to over $6 billion for "grey" infrastructure over 25 years. It is estimated that: 250 people will be employed annually in green jobs; property values will increase by up to $390 million near parks and green areas over 45 years; reduction of up to 140 deaths caused excessive heat over 45 years; visits to parks and recreation sites will increase.[13, 14]
- It was estimated that a green infrastructure plan in New York City will cost $1.5 billion less than investments needed for grey infrastructure. It was also estimated that sustainability benefits over a 20-year period would range from $139–418 million. The plan estimates that "every fully vegetated acre of green infrastructure would provide total annual benefits of $8.522 in reduced energy demand, $166 in reduced CO_2 emissions, $1,044 in improved air quality, and $4,725 in increased property value".[13, 15]

Ill. 15: High Line, New York – an old railway repurposed into an elevated green park, storm water can drain into plant beds, helping to reduce storm water run-off.

12) American Rivers, Water Environment Federation, American Society of Landscape Architects, EcoNorthwest, (2012) Banking on Green: A Look at How Green Infrastructure – Can Save Municipalities Money and Provide Economic Benefits Community-wide, [Online] Available at: https://www.asla.org/uploadedFiles/CMS/Government_Affairs/Federal_Government_Affairs/Banking%20on%20Green%20HighRes.pdf Accessed 06/12/2017
13) American Society of Landscape Architects (Undated) Professional Practice – Green Infrastructure: Cities [Online] Available at: https://www.asla.org/ContentDetail.aspx?id=43535 Accessed 06/12/2017
14) Focht, M.A., (Undated) Green City, Clean Waters: Green Infrastructure – The Philadelphia Story, American Society of Landscape Architects, (Presentation) Available at: https://aslathedirt.files.wordpress.com/2013/12/dupontsummit-asla-120613_final.pdf Accessed 06/12/2017
15) New York City Department for Environmental Protection (2010) NYC Green Infrastructure Plan, A Sustainable Strategy for Clean Waterways, NYC Environmental Protection. Available at: http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_LowRes.pdf Accessed 06/12/2107

3.3 A WIDER PERSPECTIVE – MOBILITY AND QUALITY OF LIFE

The Blue-Green Infrastructure approach to storm water management represents a new approach to city planning, which brings the opportunity for a new city landscape with more green areas. The design of sustainable urban drainage systems does not exist as a stand-alone procedure: it requires the full attention and co-operation of citizens and stakeholders in the urban planning process.

Sustainable storm water management is also essential in flood management to allow free movement through urban areas, for goods to reach their destination, and for information to travel through cities. Transport infrastructure has to meet a multifunctional role. Raised roadways or embankments serve not only as a subgrade for various transport lines, they are also part of flood protection. The street becomes a multifunctional conveyance system combining traffic, a pedestrian zone, utilities conduit and waterway for retaining, storing and draining storm water.

The idea of minimizing environmental pollution, by city transport diversification for example, brings different traffic to the city. Heterogeneous ecological city transport, including active mobility in everyday life, is a great opportunity for building green streets, relaxing zones for pedestrians, parks and for implementation of protective storm water measures.

With proper consideration in the urban planning process, Sustainable Drainage Systems (SuDS) can also be used to help reduce heavy traffic by making foot and bike mobility more attractive, and thus alleviate vehicle traffic. For example, SuDS can be used to create more enjoyable, cleaner and safer streets. Using green belts, pedestrian safety can be improved by separating vehicles from pedestrians, controlling movements of pedestrians, leading them to pedestrian crossings, and slowing traffic by narrowing road sections. The use of such schemes must be as part of the urban traffic planning process to ensure the desirable positive traffic flow impacts.

The above-mentioned facts emphasise once again the basic idea that careful planning on the level of storm water protection, optimal utilization of storm water and its overall integration into city infrastructure helps in building a better place to live.

Ill. 16: Sustainable storm water management helps to create safer cities and better places to live.

Ill. 17: Australia Road, London, UK – SuDS measures including permeable paving, planted basins, rain gardens, and disconnected down-pipes as part of a safe and attractive landscape for the community, providing storm water collection and storage benefits, helping to reduce flooding and river pollution. Photo: Robert Bray Associates

Ill. 18: Use of SuDS in traffic calming in Stockholm. Photo: Sweco Environment – Stormwater Management

Ill. 19: SuDS in residential area Baunebakken, Hvidovre, Greater Copenhagen, Denmark – storm water detention pond. Photo: Sweco Denmark

4. BLUE-GREEN INFRASTRUCTURE CONTRIBUTES TO SUSTAINABLE CITIES

Blue-Green Infrastructure has an important role in contributing to sustainable cities, e.g. improved use of rainwater, flooding and biodiversity benefits, water quality improvements, and health and well-being benefits. Blue-Green Infrastructure can also contribute to the delivery of six of the UN 2030 Agenda Sustainable Development Goals relating to: sustainable management of water; resilient infrastructure, inclusive and sustainable industrialization and innovation; action to combat climate change; making cities inclusive, safe and resilient; and ensuring healthy lives and well-being[16].

It is important to consider how the sustainability of cities, and how Sustainable Drainage Systems (SuDS) case studies and approaches, can be compared and benchmarked to continue to make improvements in urban areas. To do this, suitable performance indicators are needed, the selection of which depends on the issues to be evaluated. Various tools have already been prepared to enable comparison of cities in terms of sustainability and water management in general, or to assess the most appropriate SuDS measures for different situations. Some examples can be found in the following sources[17, 18, 19].

Ill. 20 & 21, above left and right: SuDS can provide valuable attractive, safer routes to work and school and so promote more sustainable transport. Photo: Robert Bray Associates

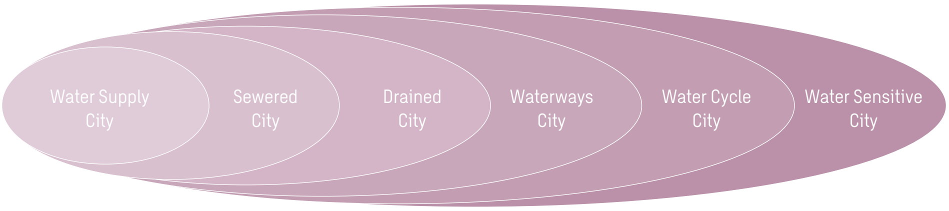
Ill. 22, below left: Blue-Green Infrastructure has an important role in contributing to inhabitant's health and well-being.

Ill. 23, below right: Attractive swale solution as part of a new public space adjacent to and connecting with Dalmarnock railway station, Glasgow, Scotland. Photo: Gaye McKay

16) United Nations General Assembly (2015) Transforming our world: the 2030 Agenda for Sustainable Development, Resolution 70/1, United Nations [Online] Available at: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E Accessed 06/12/2017
17) Sweco, Bosch Slabbers, Deltares, , Witteveen+Bos, The Royal Netherlands Meteorological Institute (KNMI) (2013) About [Online] Available: http://www.climateapp.org Accessed 30/11/2017
18) British Water (2005), Guidance to proprietary sustainable drainage systems and components – SUDS, British Water in partnership with the Environment Agency, London
19) Van Dinther, D., Weijers, E., et al (2016) Designing green and blue infrastructure to support healthy urban living, ECN, Petten

Ill. 24: Vegetated retention pond providing retention of storm water run-off, removal of suspended solids and reduction of nitrogen, Sweden. Photo: Sweco Environment – Stormwater Management

Another example providing a methodology for measuring cities against various water-related indicators and ranking them according to a City State Continuum framework is the Water Sensitive Cities Index (see Ill. 25).



Ill. 25: The City State Continuum – Water Sensitive City Transitions. Illustration: Brown, Keith and Wong (2009)[20], Wong and Brown (2009)[21] cited on the Water Sensitive Cities website[22]

The index benchmarks cities on seven thematic goals related to key attributes of water sensitivity – the ability to deliver safe and reliable water services in an eco-friendly manner. The goals consist of 34 social, technical, and ecological indicators. Details can be found on the Water Sensitive Cities website[22].

The cost effectiveness of SuDS schemes in comparison to conventional storm water measures is an important consideration. SuDS have been shown to be more cost effective in many cases. The whole life cycle of a project must be considered in cost analysis, plus the additional benefits SuDS schemes bring. The *Benefits of SuDS Tool (BeST)* was developed by CIRIA to estimate the monetary value of 22 benefits SuDS can bring, which can be used to provide a business case for SuDS projects.[23]

20) Brown, R., Keath, N. and Wong, T. (2009). Urban water management in cities: Historical, current and future regimes. Water Science & Technology, 59(5), 847-55
21) Wong, T. H. F. and Brown, R. R. (2009). The water sensitive city: principles for practice. Water Science & Technology, 60(3), 673-682
22) Brown, Keith and Wong (2009), Wong and Brown (2009) [Original Sources] cited in CRC for Water Sensitive Cities (2016) Water Sensitive Cities Index – Key product features [Online] Available at: https://watersensitivecities.org.au/solutions/water-sensitive-cities-index/key-product-features/ Accessed: 05/12/2017
23) Susdrain (Undated) B£ST (Benefits of SuDS Tool) [Online] Available at http://www.susdrain.org/resources/best.html Accessed 05/12/2017

5. CONCLUSIONS AND RECOMMENDATIONS

The process of implementing Sustainable Drainage Systems (SuDS) cross all urban areas in Europe has been slow. More impervious surfaces in urban areas together with changes in climate increase the threat of flooding from surface waters, and the potential for failure of existing drainage systems. Existing conventional drainage systems are insufficient to deal with increased storm water volumes.

In the case of new developments, the application of SuDS seems to be a matter of careful planning and design. In the case of existing urban areas, especially in city centres, SuDS implementation is much more complicated. Impermeable surfaces and existing infrastructure in areas of limited space make changing drainage systems difficult. However, change is still possible. Retrofitting city centre streets usually consists of diverting surface water away from drains through ditches, bio-swales, flow-through planters and similar measures. Installation of such facilities usually makes streets narrower, and can require two-way streets to be changed into one-way streets. By early co-operation in the urban planning process, not only can negative traffic flow impacts from such schemes be avoided, but opportunities can be taken to improve mobility through making alternative means of transport more attractive. This brings us back to the need for careful, close and well-timed co-operation, early consideration at the master planning stage, creativity, consultation and partnership between all stakeholders.

The early involvement and participation of the local community in the planning process is essential for successful implementation of SuDS. With an effective participation strategy, guidance and public education, SuDS implementation can also change community life to the extent that people are involved in local initiatives.

Another challenge for SuDS implementation is maintenance responsibility and costs. Arrangements for maintenance of SuDS systems should be considered during the early stages of design. Neglecting this step can turn good SuDS implementation into a non-functional set of facilities.

Legislation in many countries is not sufficiently rigorous to deliver SuDS implementation in all new developments and existing urban areas (see Table 1 for a summary of selected countries). To increase implementation of SuDS and overcome a lack of awareness and insufficient understanding of SuDS, stronger legislative support, well-elaborated design guidelines, and long-term financial justification are needed. Blue-Green Infrastructure should become an integral part of transport infrastructure.

Ill. 26: Storm water challenges needs sustainable solutions to reduce flood risk, increase biodiversity and lower the costs of water treatment in urban areas. Legislation in many countries is not sufficiently rigorous to deliver SuDS implementation.

5.1 THE WAY FORWARD

In recent decades, we have seen dramatic scenes of flooding streets. At the same time we are facing challenges from a changing climate and environmental problems such as water pollution from storm water. Greater population densities and expanding impervious surfaces in urban areas intensify pressure on storm water drainage systems. These challenges, and the need for better living standards, including improved health, imply the need for change and a move towards storm water management that is more sustainable.

Blue-Green Infrastructure can provide essential benefits to storm water flood management as part of wider flood protection schemes for extreme weather events and co-benefits to society and the economy. It can also provide additional benefits such as increased biodiversity, recreational opportunities, and carbon sequestration, which makes for a compelling investment case. BGI can also serve as an effective climate change adaptation measure, helping us to prepare for extreme weather conditions.[24]

After studying examples of successful development of infrastructure around the world we can conclude that the key aspects in the way forward are:

- **Raise awareness of the multiple benefits of SuDS,** in particular those relating to health and well-being, the cost savings of SuDS over the life-time of such projects, and the role of SuDS in supporting the achievement of the UN 2030 Sustainable Development Goals. The support of the public, politicians, decision makers and developers of SuDS is essential. The benefits of SuDS should be used to campaign for **stronger and clearer legislation** in requiring SuDS in new developments and existing urban areas.
- **Establish sustainable and verified design principles.** Guidelines and toolkits that support new and innovative approaches, reduce flood risk, increase biodiversity and reduce the costs of water treatment need to be identified. These should also promote master planning, climate change modelling and consideration of local conditions, e.g. rainfall intensity and impact on SuDS from salt used in cold environments. These should be disseminated through a Europe-wide independent industry community hub on sustainable storm water management that shares best practice, for example, see *susdrain*, an industry community platform for those involved in sustainable drainage in the UK[25]. The business case for SuDS should be promoted, including cost benefits. Make use of and inform existing business resources such as the World Business Council for Sustainable Development[26].
- **Planning and co-operation** – close and well-timed **co-operation**, early consideration at the **master planning** stage to foster creativity, consultation and partnership between city planners, architects, urban drainage engineers, ecologists and landscape architects are key. This co-operation has already resulted in new sustainable storm water master plans, incorporating **Blue-Green Infrastructure**. Co-operation in incorporating SuDS into urban areas during the urban planning process, can also make alternative mobility options, such as cycling and walking, more attractive than driving, and so alleviate vehicular traffic.
- **Local communities and various stakeholders** must be involved in the process of planning, design, and implementation of sustainable drainage systems at an early stage. With an effective participation strategy, guidance and public education SuDS can improve community life where people are involved in local activities.

24) European Environment Agency (2017) Green Infrastructure and Flood Management Promoting cost-efficient flood risk reduction via green infrastructure solutions, European Environment Agency, Luxembourg
25) Susdrain (undated) susdrain, [Online] Available at: http://www.susdrain.org/ Accessed 30/11/2017
26) World Business Council for Sustainable Development (2017) How we drive sustainable development [Online] Available at: http://www.wbcsd.org Accessed 05/12/2017

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7. REFERENCES

FOOTNOTES AND NUMBERED REFERENCES:

1) There are various approaches to managing excess water originating from rain and snowfall. It traditionally includes drainage of water through infrastructure such as sewers, but increasingly sophisticated sustainable approaches with various "Blue-Green Infrastructure" measures are needed.
2) Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life.
European Commission (2016) *Green Infrastructure* [Online] Available at: http://ec.europa.eu/environment/nature/ecosystems/index_en.htm, Accessed 04/10/2018
3) Translation of a quote from: AČE ČR (2009) *Metodická příručka Posouzení stokových systémů urbanizovaných povodí* (PSSUP) (Online) Available at: http://www.opzp.cz/soubor-ke-stazeni/17/5237-metodicka_prirucka_stokovy_system_090604.pdf, Accessed: 04/10/2018
4) Susdrain (undated) Policy documents [Online] Available at: http://www.susdrain.org/resources/policy.html Accessed 06/12/2017
5) European Commission (2013) Building a Green Infrastructure for Europe, European Commission, Luxembourg, p7
6) European Environment Agency (2017) Green Infrastructure and Flood Management Promoting cost-efficient flood risk reduction via green infrastructure solutions, European Environment Agency, Luxembourg
7) Information provided by Agata Banach and Fredrick Toller (Sweden), Alvaro Fonseca (Denmark), Vladimír Havlík (Czech Republic), Enrico Moens (Netherlands), Doug Lewis (UK)
8) Ministry of Infrastructure and the Environment, and the Ministry of Economic Affairs (2017) Delta Programme 2017. Work on the Delta. Linking taskings, on track together [Online] Available at: https://deltaprogramma2017.deltacommissaris.nl/viewer/publication/1/1-delta-programme- Accessed 05/12/2017
9) Graham, A., Day, J., Bray, B., Mackenzie, S. (2012) Sustainable drainage systems – Maximising the potential for people and wildlife – A guide for local authorities and developers, The RSPB and the Wildfowl & Wetlands Trust
10) Banach, A. (2017) Storm Water Management – Stockholm Royal Seaport – an award-winning project (presentation)
11) Susdrain (Undated) B£ST (Benefits of SuDS Tool) [Online] Available at: http://www.susdrain.org/resources/best.html Accessed 05/12/2017
12) American Rivers, Water Environment Federation, American Society of Landscape Architects, EcoNorthwest, (2012) Banking on Green: A Look at How Green Infrastructure – Can Save Municipalities Money and Provide Economic Benefits Community-wide, [Online] Available at: https://www.asla.org/uploadedFiles/CMS/Government_Affairs/Federal_Government_Affairs/Banking%20on%20Green%20HighRes.pdf Accessed 06/12/2017
13) American Society of Landscape Architects (Undated) Professional Practice – Green Infrastructure: Cities [Online] Available at: https://www.asla.org/ContentDetail.aspx?id=43535 Accessed 06/12/2017
14) Focht, M.A., (Undated) Green City, Clean Waters: Green Infrastructure – The Philadelphia Story, American Society of Landscape Architects, (Presentation) Available at: https://aslathedirt.files.wordpress.com/2013/12/dupontsummit-asla-120613_final.pdf Accessed 06/12/2017
15) New York City Department for Environmental Protection (2010) NYC Green Infrastructure Plan, A Sustainable Strategy for Clean Waterways, NYC Environmental Protection. Available at: http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_LowRes.pdf Accessed 06/12/2107
16) United Nations General Assembly (2015) Transforming our world: the 2030 Agenda for Sustainable Development, Resolution 70/1, United Nations [Online] Available at: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E Accessed 06/12/2017
17) Sweco, Bosch Slabbers, Deltares, , Witteveen+Bos, The Royal Netherlands Meteorological Institute (KNMI) (2013) About [Online] Available: http://www.climateapp.org Accessed 30/11/2017
18) British Water (2005), Guidance to proprietary sustainable drainage systems and components – SUDS, British Water in partnership with the Environment Agency, London
19) Van Dinther, D., Weijers, E., et al (2016) Designing green and blue infrastructure to support healthy urban living, ECN, Petten
20) Brown, R., Keath, N. and Wong, T. (2009). Urban water management in cities: Historical, current and future regimes. Water Science & Technology, 59(5), 847-55
21) Wong, T. H. F. and Brown, R. R. (2009). The water sensitive city: principles for practice. Water Science & Technology, 60(3), 673-682
22) Brown, Keith and Wong (2009), Wong and Brown (2009) [Original Sources] cited in CRC for Water Sensitive Cities (2016) Water Sensitive Cities Index – Key product features [Online] Available at: https://watersensitivecities.org.au/solutions/water-sensitive-cities-index/key-product-features/ Accessed: 05/12/2017
23) Susdrain (Undated) B£ST (Benefits of SuDS Tool) [Online] Available at http://www.susdrain.org/resources/best.html Accessed 05/12/2017
24) European Environment Agency (2017) Green Infrastructure and Flood Management Promoting cost-efficient flood risk reduction via green infrastructure solutions, European Environment Agency, Luxembourg
25) Susdrain (undated) susdrain, [Online] Available at: http://www.susdrain.org/ Accessed 30/11/2017
26) World Business Council for Sustainable Development (2017) How we drive sustainable development [Online] Available at: http://www.wbcsd.org Accessed 05/12/2017

ADDITIONAL GENERAL REFERENCES:

– CIRIA (Undated) *ciria* [Online] Available at: https://www.ciria.org/ Accessed 06/12/2017

– European Commission (2016) *The EU Water Framework Directive – integrated river basin management for Europe*, [Online] Available at: http://ec.europa.eu/environment/water/water-framework/index_en.html Accessed 06/12/2017

– Ministerstvo zemědělství (Undated) *The Ministry of Agriculture of the Czech Republic* [Online] Available at http://eagri.cz/public/web/en/mze/ Accessed 06/12/2017

– Smart City Wien (Undated) Step 2025 – *Urban Development Plan* [Online] Available at: https://smartcity.wien.gv.at/site/en/urban-development-plan-2025, Accessed 06/12/2017

– Stratil-Sauer, G., & Telepak, G. (2015) *Vienna's New Sustainable Urban Mobility Plan "together on the move"* (Presentation for 2nd European Conference on Sustainable Urban Mobility Plans) [Online] Available at: http://www.eltis.org/sites/eltis/files/17-06-2015_telepak-viennas_new_sump.pdf Accessed 06/12/2017

– Woods Ballard, B., Wilson, S., Udale-Clarke, H., Illman, S., Ashley, R., Kellagher, R., (2015) *The SuDS Manual*, CIRIA, London

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