Lähde, Elisa; Rosqvist, Kajsa

Barriers preventing development of integrated stormwater management in Helsinki, Finland

Published in:
Re-City

Published: 01/01/2018

Document Version
Publisher's PDF, also known as Version of record

Please cite the original version:
Lähde, E., & Rosqvist, K. (2018). Barriers preventing development of integrated stormwater management in Helsinki, Finland. In M. Chudoba, & J. Rajaniemi (Eds.), Re-City: (Im)possible cities (pp. 29-48). Tampere University of Technology.

Barriers Preventing Development of Integrated Stormwater Management in Helsinki, Finland

Elisa Lähde
Kajsa Rosqvist

ABSTRACT

In recent years, the development of sustainable urban stormwater management has been much in focus in several cities in Finland due to climate change and new regulations. Urban adaptation to climate change requires solutions that combine underground and aboveground measures and processes. However, the transition towards a water sensitive city, where multifunctional green infrastructure and urban design reinforce water sensitive behavior, is not trouble-free. Various barriers have been identified, such as a lack of knowledge as well as unclear roles and responsibilities among stakeholders.

In the city of Helsinki, the present stormwater strategy has currently been updated to an integrated stormwater program. For this purpose, a workshop was organized for civil servants and experts working with storm water issues in different city departments. In the workshop, different measures and solutions required to reach the goals of the new program were discussed in order to define adequate actions. The preliminary goals of the strategy were: 1) the prevention of stormwater related problems, 2) climate-proof local and regional drainage, 3) qualitative and quantitative stormwater management, 4) use of stormwater as a resource in urban environments, and 5) integrated stormwater management within city administration.

The workshop discussions revealed that civil servants and experts knew and understood quite well the main goals of the program. However, the participants displayed gaps in other areas of knowledge. There was a lack of knowledge on sustainable drainage components and their variety of delivered ecosystem services. Stormwater management is still comprehended as a technological challenge with the multifunctionality of green infrastructure solutions not being fully utilized in urban design. Several approaches are needed to continue the development of the water-sensitive city in Helsinki, including more real life examples, broader stakeholder involvement outside the building sector, and a critical examination of existing planning procedures.

Keywords: integrated stormwater management, SUDS, urban water management, green infrastructure, water sensitive urban design

1. INTRODUCTION

1.1. Sustainable urban drainage systems

Increased precipitation and changing rainfall patterns are predicted to be one of the major effects of climate change (IPCC 2014). In combination with on-going urbanization and diminishing green spaces available, urban runoff will undoubtedly increase. This will in turn increase the risk of flooding and decrease the quality of receiving waters. As sustainable urban drainage systems (SUDS) are able to improve stormwater management in both quality and quantity as well as deliver additional related benefits, SUDS have been developed and promoted by an increasing number of communities worldwide.

SUDS restore natural environments and use natural processes (infiltration, evapotranspiration, filtration, retention, and reuse) to mimic the natural water cycle of a site. In different contexts, these practices can be referred to by other similar terms, such as low-impact development (LID), best management practices (BMP), water-sensitive urban design (WSUD), low-impact urban design and development (LIUDD), not to mention green infrastructure (GI) (Fletcher et al. 2015). Some of these approaches more heavily emphasize water quality and quantity management (e.g., LID), and others the provision of ecosystem services (e.g., GI). In this paper, the term SUDS is used to describe all kinds of sustainable urban drainage systems that deal with surface water in an alternative way to mainstream conventional drainage practices.

SUDS can be categorized into structural and non-structural solutions. Non-structural solutions can include urban planning and education (Elliott and Trowsdale 2007). Structural solutions can be categorized according to their function (such as on source management components, conveyance components and infiltration/detention components) including green roofs, rainwater tanks, permeable surfaces, bioswales, rain gardens, planter boxes, and vegetated basins (Susdrain 2017). For the best treatment result, a treatment train should be used (Revitt et al. 2014). It is a combination of multiple, complementary SUDS components designed to meet the needs of a particular environment to achieve a better overall quality and quantity management.

Structural SUDS components are multifunctional and can, in addition to stormwater management, deliver various other ecosystem services. These include air quality improvement, mitigation of climate change by reducing greenhouse gases, energy savings by shading and insulation, reduction of urban heat island formation, and improvement of community livability (such as aesthetics, recreation, and improvement of habitats) (Demuzere et al. 2014; Scholz 2014, Scholz et al. 2013). Ecosystem services can help cities transition towards more sustainable environments, which might be resilient to changing conditions in the future (Lundy and Wade, 2011).

1.2. The transition process of cities

In addition to climate adaptation, a growing demand of savings in infrastructure costs has led to a greater interest in the added value of multifunctional SUDS (Wright et al. 2016). In order to promote SUDS and related benefits, many cities worldwide have composed their own stormwater programs or strategies. In the programs, priority is awarded to on source management and detention of stormwater over conventional systems. This so-called priority order of stormwater management enhances the natural hydrology of the site even in post-development conditions.

In Finland, sustainable stormwater management is required by law (MRL 1999), and almost all large and midsize cities have implemented the requirements by conducting their own stormwater programs. Helsinki, the capital of Finland, released its own stormwater strategy in 2008 (City of Helsinki 2008) making it the first city in the country to do so. An interdisciplinary city internal working group together with a steering group drafted the strategy in order to promote interaction between different departments of municipal government (Salminen 2013, 13). The aim of the strategy was appropriate and site-based stormwater management. However, implementation of the existing strategy has not been completely successful (Salminen 2013, 41); thus, the present stormwater strategy is currently being updated to an integrated stormwater program.

This paper investigates the preconditions required to achieve the aims of the new integrated stormwater program. Data for the paper has been collected during a workshop organized within the city of Helsinki in April 2017. The purpose of the workshop was to address the aims of the new integrated stormwater program and find actions to jointly reach these aims with 21 civil servants and experts representing the different departments handling storm water management within the city of Helsinki.

During the workshop discussions, the participants identified any barriers of implementation concerning the present strategy, and proposed consequent actions to overcome them. However, many of the barriers preventing implementation can be difficult to identify, because they are embedded within organizational cultures, practices and processes (O'Donnell et al. 2017). Thus, the research questions of the paper are: 1) What kinds of barriers can the participants themselves identify? 2) Which other barriers can be identified in the workshop discussions?

The aim of the paper is to define the baseline understanding of stakeholders within the different departments of the municipal government dealing with stormwater management. This will help to create appropriate actions for an integrated stormwater program and to transform Helsinki into a water-sensitive city. For other cities and authorities outside Helsinki, the results of the paper can provide a valuable case for comparison and help to identify their own barriers.

2. INTEGRATED STORMWATER MANAGEMENT

For already a few decades, the decentralized, on source approach has been a new paradigm in urban stormwater management (Marsalek and Chocat 2002). Previously, urban drainage was seen only as a problem, but related opportunities, such as increased biodiversity and climate adaptation, are currently widely recognized (Ashley et al. 2013). This type of approach, called integrated stormwater management, emphasizes a use of multifunctional on source controls, a transition from traditional drainage to green infrastructures, and a consideration of additional environmental benefits (Mailhot and Duchence 2010).

An integrated stormwater management approach has been implemented in practice particularly in the northern cities and states of North America, such as Vancouver, Seattle, and Portland, and in Australian cities, such as Melbourne. Since their involvement in SUDS beginning in the 1990s, these cities have already been actively monitoring the effects of integrated stormwater management on drainage servicing, land use planning and environmental protection (Hottenroth et al. 1999; Brown et al. 2013). During the past two decades, there has also been a remarkable number of successful examples of realized SUDS projects. However, wide-scale implementation of SUDS has been limited (Brown 2005) because many cities are still heavily investing in mainstream conventional drainage practices (Wong and Brown 2009).

Brown et al (2009) have created a framework describing the transition population growth and climate change, and it is essential for all cities to invest in solutions that will also “deliver [a] long-term sustainable outcome” in water management (Brown et al. 2009).

Barriers hindering the implementation of SUDS have been identified in different studies (Kim et al. 2017; Ashley et al. 2015; Thorne et al. 2015; Brown and Farrelly 2009; O`Donnell et al. 2017). There are technical barriers that include suspicion concerning hydrological performance, service delivery and maintenance. However, socio-institutional barriers are more serious. These include a lack of confidence that decision makers and communities will accept, support, and take ownership of SUDS (Thorne et al. 2015). Stakeholders’ lack of knowledge hinders the planning and design of the solutions (Kim et al. 2017); moreover, despite several successful case examples, SUDS are still regarded as novel practices; the resistance to change existing practices also represents a relevant barrier (O`Donnell et al. 2017). Additionally, in the Finnish context, unstable procedures, unclear roles and responsibilities, a lack of knowledge and monitoring hinder the efficient implementation of integrated stormwater management (Salminen 2013, 41).

Different tools, models and frameworks have been designed to improve and facilitate communication and participation between different stakeholders (Ruiz et al. 2017). One of the most influential frameworks is the Three Points Approach (3PA), created by Fratini et al. (2012) and further developed by Sorup et al. (2016) and Digman et al. (2014), which aids in turning the problem of adapting to changing flood risks into a positive opportunity for the development and enhancement of urban areas. This is accomplished through utilizing the interactions and synergies between the surface water management system and society.

In the 3PA, three levels of stormwater management have been categorized for different rain events: 1) Technical optimization: where design standards for sewers and other infrastructure apply. This considers technical solutions which deal with defined design storms to prevent damage and meet service levels; 2) Urban resilience and spatial planning: involves dealing with extreme events, which becomes of necessity multi-disciplinary. The aim is to mitigate the impacts of future extreme events and allow adaptation; 3) Day to day values for small rain events: enhancing the value provided by options, awareness, acceptance and participation amongst stakeholders. Attention is paid to the way urban space is used and perceived.

The results of the three points approach are multifunctional solutions and opportunities for consensus in a decision-making process involving different stakeholders (Frantini et al. 2012). On a practical level, the implementation of 3PA would mean that the potential benefits of the stormwater management are emphasized when dealing with design storms or smaller rain events. The management of extreme events should be integrated into urban planning projects, such as redevelopment of an area, with an emphasis on damage control and multifunctional infrastructure (Digman et al. 2014).

In Scandinavia, the cities of Malmö in Sweden and Copenhagen in Denmark are the leading cities implementing the integrated stormwater management approach. Despite similar climate conditions, the two cities have chosen different approaches towards stormwater management (Haghighatafshar et al. 2014). In Malmö, since the early 1990s, there has been a shift towards open solutions in stormwater management. The main objectives of the SUDS are to decrease and slow down the runoff flow in the urban areas ensuring that the existing piping network does not become overloaded (Stahre 2008, 14). SUDS have simultaneously been used as a tool for urban improvement, for example, in Augustenborg (a local suburb).

Copenhagen, on the other hand, does not have a long history in SUDS, but due to intensive flooding in 2011, stormwater management is presently considered to be one of their priorities in urban planning (Haghighatafshar et al. 2014). The city has a new Cloudburst Management Plan (City of Copenhagen 2012), which proposes that public surfaces, such as parks, sport fields and open spaces, be used for temporary storage of stormwater during a heavy rain event. Flood protection of the city center is further emphasized by proposing additional measures, such as especial stormwater streets, waterways and underground tunnels, which could effectively lead stormwater to the sea and simultaneously increase local greenery. Therefore, with 3PA in mind, Copenhagen has focused during the last few years on solving the problems associated with extreme rain, while design rain and local green infrastructure have been more underlined in Malmö (Haghighatafshar et al. 2014).

The examples from Copenhagen and Malmö show the means by which SUDS are successfully used as local solutions, which can be combined with conventional techniques and retrofitted into existing drainage systems. Furthermore, they underline the ways in which a classically engineered piping system promoting efficient drainage offers a technocratic solution that diminishes our understanding of and connection with nature (Winz et al. 2011). By contrast, SUDS combine drainage functions and vegetation, and their role can be expanded from solely stormwater management to cover ecological targets and built environment services, such as identity or amenity. Furthermore, SUDS could potentially form a novel link between ecological, social and technical realms, thus creating a complex social-ecological system (Hoang and Fenner 2016; Flynn and Davidson 2016; Dunn et al 2017) where the different benefits of a total urban water cycle are included.

This kind of system approach considers draining functions together with flood protection, public health protection, environmental protection, amenity and recreation, carbon neutrality, economic development, equity and long-term sustainability, thus enlarging the traditional scope of engineered solutions (Wong and Brown 2009). Thus, optimal outcomes in urban stormwater management will only be achieved if the dynamics of climate, land use, ecosystems and society can all be considered, because the interactions between the components of the urban water cycle are as important as the individual components (Fletcher et al. 2013). This leads to the requirement to develop new types of working models and collaboration. Urban stormwater management is an inevitably complex issue requiring an integrated, transdisciplinary approach and systems thinking.

3. METHODOLOGY

The data was collected in a workshop organized on April 26, 2017 in the City of Helsinki Environment Centre. The workshop was organized to support the updating process of the existing stormwater strategy for the city of Helsinki into an integrated stormwater management program. Twenty-one participants representing all technical departments of municipal administration attended the workshop. These included the Public Works Department, Environment Center, City Planning Department, Real Estate Department and Building Inspection Department (due to the organizational rearrangements these departments were renamed in the beginning of June 2017). Other participants included the City Executive Office, Helsinki Region Environmental Services Authority, and Aalto University. All participants deal with stormwater issues in their daily work.

Updating the stormwater strategy to an integrated program is part of the iWater – Integrated Storm Water Management project, which is financed by the EU Interreg Central Baltic program. A particular municipal stormwater group consisting of 11 members from the key technical departments within the city is responsible for the updating process, and it has outlined tentative goals for the new integrated stormwater program based on an earlier survey of the departments and organizations present in the workshop (except Aalto University), the draft for the city's new strategy program (2017-2021) and the City of Helsinki Climate Adaptation Guidelines (2017-2021). The aim of the workshop was to inform various stakeholders within the city about the ongoing updating process and suggested tentative goals, while simultaneously discussing different needs and potential actions for the new program.

In the beginning of the workshop, the aim and schedule of the workshop were introduced to the participants. Then the participants were randomly divided into four small groups (1, 2, 3, and 4), thus ensuring that participants from the same department were not in the same group. Large paper charts were handed to every group (Figure 1). On the charts, the starting circle was drawn on the left side and the goals listed on the right. Between the starting circle and each goal a timeline was drawn. The first task of the participants was to list actions for achieving each of the goals and to add them in chronological order to the timeline with Post-it notes. Responsible bodies for the proposed actions were also added. Thereafter, two groups joined together presenting their own timelines to each other and identifying potential larger concepts. Finally, the identified concepts were prioritized.

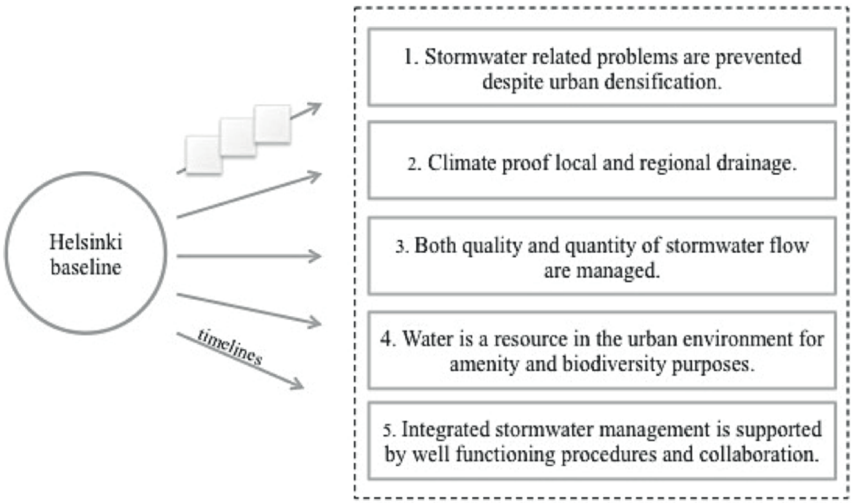

Figure 1: Image of the paper charts used in the workshop. The baseline situation is located on the left side and goals for the new strategy on the right. Participants were asked to add Post-it notes with proposed actions to the timelines drawn from the baseline to each of the goals.

The workshop lasted four hours including a 10-minute break for refreshments. Groups had a chairperson responsible for leading the discussion and ensuring that all the goals were handled. The discussions were lively with all able to contribute due to the small size of the groups. The workshop format helped to reflect on the aspirations and comparative knowledge of different participant groups. Researchers were among the members of two of the groups, but they refrained from consciously leading the discussion towards any specific direction or outcome. Discussions in each group during the filling of the paper charts were recorded and later transcribed. Participants also knew that discussions were being recorded. The data was analyzed to reveal distinctive themes that helped to identify the barriers for implementation of the integrated stormwater management.

4. RESULTS

4.1. Barriers identified by the participants

The participants were relatively familiar with the tentative goals of the integrated stormwater program. The discussion proceeded smoothly without misunderstandings or disagreements. This is not surprising, because goals 1-4 are the same in the earlier stormwater strategy and well known among those working with stormwater issues. The participants also shared the common understanding that stormwater runoff should be managed to achieve maximum benefits in the urban environment. Recreation possibilities and environmental benefits, such as biodiversity, were highlighted in several discussions.

Participants were able to recognize several barriers to effective stormwater management. The principal problem mentioned was the lack of knowledge on two levels:

1) On a technical design level, participants asked for recommendable Finnish examples of SUDS. Furthermore, a watershed-scale approach was lacking and stormwater management was only considered when entering the detail-planning phase. The need for an easily accessible database with technical information was mentioned several times. The database could show potential flood risk areas, as well as suitable places for stormwater detention and infiltration on a watershed scale. This would help planners to understand the effect of local urban densification projects on larger watershed hydrology.

2) On an administrative level, many knowledge related barriers were identified. It became apparent from several discussions that different stakeholders, such as planners, building supervisors, decision makers, developers, contractors or maintainers, do not share mutual skills and understanding. A good example here is a short discussion about the management priority order:

"I bet that if you go and ask developers about the priority order, they won't have a clue."
"But not all the planners will have one either."

Knowledge-sharing and management between different authorities and municipal organizations were seen to be problematic. Together with the general lack of roles and responsibilities, it hinders implementation of any existing strategy. Furthermore, the lack of indicators and monitoring was mentioned because it does not allow any feedback from accomplished actions.

The participants experienced that existing conventional practices and "the way things are done" are hard to change. Even the terminology related to a new approach can be challenging as revealed by a discussion about "natural stormwater management" (as SUDS is referred to in Finnish) and associated interrelations between the natural and technical systems:

"Which kinds of changes are required in our existing operational environment?"
"A change in attitude. It is a common thing to think that we don't want those puddles and ponds here."
"And terminology can be a bit difficult. Such as natural stormwater management, which creates stereotypically a vision of some sort of ditch in the brush and that is not wanted in an urban environment. We need more awareness, so that even if we carry out natural management, the solution doesn't necessarily need to imitate natural aesthetics. Natural processes can be integrated into a very urban context with compatible structures."

4.2. Additional uncovered barriers

Although participants independently named many hindering factors, there are two types of barriers that were not discussed, but which rose out of the recorded discourse. First of all, the terminology and functionality of different SUDS components are only vaguely known. Secondly, understanding about potential stakeholders is limited.

Although the goals of the stormwater strategy were familiar to the participants, the details of practical management and functionality of different SUDS components were not well understood. For example, as a method to decrease urban runoff, stormwater infiltration and permeable surfaces were mentioned much more often than detention structures; if infiltration were impossible because of the soil type, controlled conveyance was mentioned as an option. Furthermore, the participants did not necessarily possess the correct terminology as the following discussion concerning urban management options shows:

"I was thinking about those very small scale structures that could fit densely built areas. Like the ones they have in Malmö, in schoolyards and also on the streetscape, these built concrete channels with vegetation integrated. Or, how do you call them, the containers or such, which are located underground."
"Yes, geocellular storage tanks."
"Yes. And also utilization of roofs and facades. These should be known and used, and our basic operating model should be based on these kinds of solutions."

The concept of treatment train was not used in the discussion, which might be explained by the lack of practical knowledge. Different SUDS components were seen to be more alternative than complementary to each other. The participants had some understanding that components can create larger systems, but practical knowledge was not strongly evident. However, participants were themselves conscious of this barrier as the following discussion concerning the third goal reveals:

"I have listed some very general and nonspecific principles here. In general, we should use more intensively green structures and infiltration, and question the use of pipe drainage. Especially in the upper parts of the watershed, like, do we need to put water in the pipes every time? These measures are related to the implementation of the priority order. However, I haven't added who does it, or how it is done, or what is the practical action."
"Yes, these are very important issues. And it is very difficult to take it a step further. Like what would be the elaborated solution."
"Yes, (it is difficult) to name who does what."

3PA and differences in management actions between regular rain events and extreme rains were discussed in two groups. While it is well understood that the climate change will probably increase the need for flood risk management, the means to handle the extreme event management, the ways it differs from management of design rains or should be considered as part of spatial planning are not known in detail. Only one participant proposed especial multifunctional structures, where flooding could be allowed temporarily with the site being possibly used for other purposes at other times. A more common approach to the effects of climate change is better conveyance:

"We need to fix our stormwater drainage system"
"Does that mean reconsidering dimensions or what?"
"Well, that is quite difficult to say."
"But it doesn't help at all to make larger pipes on the source, water would only flow faster to the end of the pipe. We would need more sustainable drainage systems."
"Water detention maybe."
"Or we would need some sort of backup routes for excess water."
"Flooding routes."
"Yes, that's it. Flooding routes."

As a second uncovered barrier, the recognition of possible stakeholders is still limited. In Helsinki, the organizational structure of the municipal administration was reformed at the beginning of June 2017. Previous departments and municipal enterprises were reorganized into administrative sectors according to their functions. During the workshop, the organizational reform was under preparation and the participants firmly believed that the new organizational structure will solve problems related to collaboration and knowledge sharing between different actors in stormwater management.

However, the creation of strong integrated stormwater management practices requires acceptance from a wide range of stakeholders, including some not traditionally interested in drainage matters, such as the health or education authorities (Ashley et al 2015). These groups were not mentioned in the workshop discussions, although they are part of it, such as the city's climate change adaptation workgroup, because participants only concentrated on the planning and building sector operators. It is also a common understanding among participants that the value of benefits delivered by SUDS is targeted only to direct stakeholders, such as the maintenance side. In the following discussion concerning possible pilot structures, the monetary value of potential ecosystem services (such as health benefits) is not mentioned, but only the value of the collected water itself is recognized:

"If we were able to do pilot structures and people would see the benefits, the appreciation would follow. And it would be easier to build the next one, even if it was a bit more expensive."
"Yes. When thinking about investing costs and maintenance costs (of SUDS components), how are they related? I'm not familiar with this at all."
"It is a bit tricky, because a constructor is not normally responsible for maintenance. It doesn't matter to them if the solution is better or cheaper in the long run. They only go for something new if they are forced to do so."
"That is the reason why we should emphasize piloting, when we are developing public open spaces. In the maintenance phase, the saving could be the possibility to utilize water in irrigation. "
"Yes. Should you add the irrigation in the potential benefits here on the paper?"

5. DISCUSSION

The civil servants and experts of the city of Helsinki participating in the stormwater workshop mentioned relevant barriers to the implementation of the integrated stormwater program, such as a lack of knowledge, lack of native pilot projects and attitude challenges related to conventional practices. Based on the discourse, additional barriers were identified, such as a vague use of terminology, lack of understanding of the details of practical management or the functionality of different SUDS components. The results can be viewed in the light of SUDS presenting a new approach that will widen the previously technocratic traditional drainage system into a more complex social-ecological system combining not only urban hydrology, but also potential ecological and sociological benefits through ecosystem services (Flynn and Davidson 2016; Winz et al. 2011). In the past, water managers have often reduced this complexity by focusing on optimizing singular parts of the water cycle, such as piping drainage in isolation, without considering other dimensions of the total urban water cycle (Wong and Brown 2009). The results from the workshop in Helsinki reflect the challenges confronted when enlarging the scope from simple technical solutions to a more complex system.

Many examples show that integration of natural approaches for conveying and treating stormwater runoff in an urban environment has been difficult because existing routines, infrastructures, institutions and cultures are persistent and highly interwoven (Brown et al. 2013). The challenge of attitudes mentioned in the workshop are a sign of path dependency, a common phenomenon in sustainability-transitions (Markard et al. 2012) where socio-institutional routines of past practices prevent the adoption of better alternatives even when they are available. Furthermore, the vague understanding of the functionality of different SUDS reveals that stormwater management is still understood as a solely technocratic issue instead of regarding the opportunities of the complete social-ecological system. In the workshop, participants suggested that SUDS should substitute piping solutions without being able to name more specifically which SUDS function (e.g. source management, conveyance and infiltration / detention) could be used. Naturally, all the planners do not need to know the technical details, but an understanding of the basic management options would help to plan and route the movement of the water through built structures.

Since water in urban planning has traditionally been regarded as a one-dimensional element that needs to be removed from the urban space, it is demanding to comprehend SUDS as a multifunctional interface between the technological, social and ecological structures. It requires new skills and further research (Flynn and Davidson 2016) to consider the best approach to match the demands of an ecosystem service of a unique planning site with the potential ecosystem service provision of a combination of SUDS components. However, this approach could be highly rewarding from an urban design point of view. If the functionality and potential benefits of SUDS are correctly understood, it is possible to create comprehensive treatment trains that have high amenity, recreational, identity and ecological values (Haase 2015).

As social-ecological system interactions, multifunctionality and the value of SUDS related benefits (mainly ecosystem services) are still not completely understood, it can be hard to justify SUDS related investments. Moreover, this limits recognition of possible stakeholders. For example, if the potential of health benefits, such as reduced particular pollution or encouraged outdoor activity, were internalized, the public health sector could also be identified as a potential stakeholder. In order to effectively create and implement the integrated stormwater management program, communication between different stakeholders needs to be strengthened and adaptive transdisciplinary practices developed (Ruiz et al. 2015). To advance the sustainable management of urban water, it is essential to bring together stakeholders with differing backgrounds and interests to create new understandings and relationships.

Consequently, knowledge gaps hinder an accurate consideration of the space requirements of SUDS components in land use planning processes. This is further emphasized when flood protection measures are integrated into the urban environment. Adequate spaces and routes for management of extreme rain events should be recognized and combined with other urban functions. Climate change requires new ideas for a dynamic approach (Digman et al. 2014) where a multifunctional infrastructure and shared spaces help to adapt to climate change. Indeed, climate change enhances the necessity to better link stormwater management into urban planning and design, because there is uncertainty about the quantities of surface water generated in the future (Ashley et al. 2015). In Helsinki, the existing barriers are currently hindering the creation of this linkage.

Nevertheless, the participants were able to identify two possible turning points for the development of integrated stormwater management: the need for pilot projects and new organization. Pilot projects are valuable as research literature and case studies encourage a learning-by-doing approach, where local niche innovations gradually grow into regime changes and further into new institutional structures

(Dunn et al. 2017; Brown et al. 2013). Piloting allows mutual learning and offers an opportunity to test and study solutions that fit into the local social-ecological system.

Participants possessed a strong faith in the new sector-based organization of the city of Helsinki. A new type of collaboration with different stakeholders can indeed result in overcoming knowledge-related barriers (O'Donnell et al. 2017). Earlier studies show that at the beginning of the sustainability transitions the influence of a small group of frontrunners can be remarkable in bringing the requisite skills, knowledge, influence and resources required to navigate or steer the transition pathway (Dunn et al. 2017). Nevertheless, in the acceleration phase of transition, institutional work is essential. New technologies cannot be developed in isolation, but need to be socially embedded into the local institutional context (Wong and Brown 2009).

In the end, neither a fully green nor entirely grey infrastructure approach to stormwater management will likely be optimal at any location (Winz et al. 2011). Instead, long-term solutions should be based on the best assets of both the grey and green infrastructure; in addition, the unique characteristics of a local social-ecological system dealing with urban water should be carefully considered (Flynn and Davidson 2016). When scrutinizing the development of the city of Helsinki towards more sustainable urban water management, one can detect emerging innovation processes and technologies, which have begun to destabilize the existing practices. As a successful transition into integrated stormwater management requires co-evolution between external systemic changes (such as the pressure of climate change), the activity of frontrunners, institutional development, and experiments (Dunn et al. 2017), it is critical to facilitate mutual learning, networking, diffusion and the embedding of new technologies in order to further accelerate the transition development.

The workshop also demonstrated that different organizations of the city already have active forerunners, who possess essential knowledge about new technologies and their possibilities. However, there will not be one single actor, agency or discipline that could resolve these complex urban water issues on its own (Dunn et al, 2017); instead, actors need to form networks and collaborate across departments and sectors. There is a need for new formal and informal agents and networks that strengthen linkages across systems and enable knowledge exchange (Wenn et al, 2015). In that sense, the city's internal stormwater group is already a good initiative for cross-sectorial networking. Nevertheless, there is still a need for a critical examination of the way existing planning procedures support the formation and use of formal and informal linkages as well as creation of an adaptive administrative system.

The results of this paper are based on the single workshop event with a limited amount of participants. In order to gain a more in-depth understanding of the existing barriers to integrated stormwater management or the on-going transition process in Helsinki, the results could be used to compose a questionnaire or interview questions for a larger participant group. Especially the relation between the existing land use planning procedures and the stormwater management should be studied more carefully in order to enable the development of water-sensitive urban design practices and a deeper understanding of potential benefits delivered by an adequate use of SUDS. In addition, there might be some general policies that were not mentioned in the workshop, such as the new master plan of the city of Helsinki, or the demand for city densification that subliminally affects the way in which planners regard stormwater management.

6. CONCLUSIONS

The discussions in the workshop revealed that the civil servants and experts knew and understood well the preliminary goals of the new integrated stormwater program. However, the participants have other knowledge gaps preventing implementation of the integrated stormwater program. This lack of practical knowledge hinders the integration of stormwater management practices into land use planning, which complicates the climate change adaptation.

The purpose of an integrated stormwater program is to provide direction for future development plans and identify infrastructure needs. It was well understood among the workshop participants that a better urban environment is created if local hydrology can guide land use decisions. However, there is a lack of adequate tools to apply this principle in practice. Furthermore, a general lack of awareness is causing reluctance to change existing practices among various stakeholders.

It has been noted in this study that a desired transition to integrated stormwater management requires a systemic change from a technocratic approach to the implementation of a wider social-ecological system approach. Thus, the interrelationship of stormwater management must be considered with other sectors (such as energy, transport, health), and recognition of potential stakeholders should extend beyond city organization to other sectors, such as academia, industry, business, nongovernmental organizations, politics, and the local public. Collaboration with non-administrative actors would deliver a deeper understanding about SUDS related benefits, which in turn would help to close knowledge gaps and overcome the reluctance to support novel approaches. Changes in the existing planning procedures might be needed in order to enable extensive gross-sectorial collaboration.

In addition, it is important to understand that the five goals set as outcomes of the new integrated stormwater management program are still not the final phase. The city, its institutions and administration are engaged in a sustainability transition process where the new integrated stormwater management program is showing the direction and indicating a structural shift in the policies that govern the relationship between society and the environment. Nonetheless, work has just begun as examples of forerunner cities show that the development of a water sensitive city requires long-term and persistent action on a wide front, an adaptive approach, and a conscious building of active linkages in the new social ecological system.

* Note: The stormwater management program of the city of Helsinki was finalized during 2017 and will be sent to the city council for acceptance in 2018. Several of the identified challenges in this paper were transformed into actions listed in the program.

REFERENCES

Ashley, R. et al. (2013). "Water-sensitive urban design: Opportunities for the UK." *Proceedings of the ICE-Municipal Engineer*, 166, 65–76.

Ashley, R. et al. (2015). "UK sustainable drainage systems: Past, present and future." *Proceedings of the ICE-Civil Engineering*, 168, 125–130.

Brown, R. (2005). "Impediments to integrated urban stormwater management: the need for institutional reform." *Environmental Management* 36 (3), 455-468.

Brown, R. and Farrelly, M, (2009). "Delivering sustainable urban water management: A review of the hurdles we face." *Water Science and Technology,* 59, 839–846.

Brown, R., Farrelly, M. and Loorbach, D.A. (2013). "Actors working the institutions in sustainability transitions: The case of Melbourne's stormwater management." *Global Environmental Change,* 23, 701-718.

City of Copenhagen (2012). "Cloudburst management plan 2012". Retrieved July 31st 2017 from http://en.klimatilpasning.dk/media/665626/cph__cloudburst_management_plan.pdf

City of Helsinki, 2008. "Stormwater strategy." Retrieved July 31st 2017 from https://www.hel.fi/static/hkr/julkaisut/2008/hulevesistrategia_2008_9.pdf

Demuzere, M. et al. (2014). "Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure." *Journal of Environmental Management* 146, 107-115.

Digman, C., Ashley, R., Hargreaves, P. and Gill, E. (2014). "Managing urban flooding from heavy rainfall – encouraging the uptake of designing for exceedance. Lessons and success factors." *CIRIA C738b*, 16-20.

Dunn, G., Brown, R, Bos, J. and Bakker, K. (2017). "Standing on the shoulders of giants: Understanding changes in urban water practice through the lens of complexity science." *Urban Water Journal* 14 (7), 758-767.

Elliott, A. H. and Trowsdale, S. A. (2007). "A review of models for low impact urban stormwater drainage." *Environmental Modelling & Software,* 22, 394–405.

Everett, G., Lamond, J., Morzillo, A., Matsler, A. and Chan, F. (2015). "Delivering green streets: An exploration of changing perceptions and behaviours over time around bioswales in Portland, Oregon." *Journal of Flood Risk Management.*

Fletcher, T., Andrieu, H. and Hamel, P. (2013). "Understanding, management and modeling of urban hydrology and its consequences for receiving water: A state of art." *Advances in Water Resources* 51, 261-279.

Fletcher, T.D. et al (2015). "SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage." *Urban Water Journal*, 12 (7), 525-542.

Flynn, C. and Davidson, C. (2016). "Adapting the social-ecological system framework for urban stormwater management: the case of green infrastructure adoption." *Ecology and Society* 21 (4), 19.

Fratini, C.F., Geldof, G., Kluck, J. and Mikkelsen, P. (2012). "Three Points Approach (3PA) for urban flood risk management: A tool to support climate change adaptation through transdisciplinarity and multifunctionality." *Urban Water Journal* 9 (5), 317.

Haase, D. (2015) "Reflections about blue ecosystem services in cities."

Sustainability of Water Quality and Ecology 5, 77–83.

Haghighatafshar, S. et al. (2014). "Stormwater management in Malmö and Copenhagen with regard to climate change scenarios." *Vatten – Journal of Water management and Research* 70, 159-168.

Hoang, L and Fenner, R. (2016). "System interactions of stormwater management using sustainable urban drainage systems and green infrastructure." *Urban Water Journal* 13 (7), 739-758.

Hottenroth, D., Harper, C. and Turner, J. (1999). "Effectiveness of integrated stormwater management in Portland, Oregon Watershed." *Journal of the American Water Resources Association* 35 (3), 633-641.

IPCC (2014). *"Climate Change 2014: Synthesis Report". Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151.

Kim, J., Kim, H. and Demarie, F. (2017). "Facilitators and barriers of applying low impact development practices in urban development." *Water Resources Management* 31 (12), 3795-3808.

Lundy, L. and Wade, R. (2011). "Integrating sciences to sustain urban ecosystem services." *Progress in Physical Geography* 35 (5), 653-669.

Mailhot A. and Duchesne, S. (2010). "Design criteria of urban drainage infrastructures under climate change." *Journal of Water Resources Planning and Management* 136 (2), 201-208.

Markard, J. and Truffer, B. (2008). "Actor-orientated analysis of innovation systems: exploring micro-meso level linkages in the case of stationary fuel cells." *Technology Analysis and Strategic Management* 20, 443–464.

Marsalek J. and Chocat, B. (2002). "International report: Stormwater management." *Water Science and Technology* 46 (6-7) 1-17.

MRL (1999). Finnish Land Use and Building Act: Stormwater paragraph 103§. Retrieved July 22nd 2017 from https://www.finlex.fi/fi/laki/ajantasa/1999/19990132.

O'Donnell, E., Lamond, J. and Thorne, C. (2017). "Recognizing barriers to implementation of blue-green infrastructure: a Newcastle case study." *Urban Water Journal* 14 (9), 964-971.

Revitt, D., Lundy, L., Coulon, F. and Fairley, M. (2014). "The sources, impact and management of car park runoff pollution: A review." *Journal of Environmental Management* 146, 552-567.

Ruiz, A., Dobbie, M. and Brown, R. (2015). "Insights and future directions of transdisciplinary practice in the urban water sector." *Journal of Environmental Studies and Sciences* 7, 251-263.

Salminen, P. (2013). "Helsingin, Lahden ja Turun kaupunkien vertaisarvio ilmastopolitiikasta ja hulevesien hallinnasta". *Helsingin kaupungin ympäristökeskuksen julkaisuja* 15/2013, 13-41.

Scholz, M. (2014). "Rapid assessment system based on ecosystem services for retrofitting of sustainable drainage systems." *Environmental Technology* 35 (10), 1286-1295.

Scholz, M and Uzomah, V. (2013). "Rapid decision support tool based on novel ecosystem service variables for retrofitting of permeable pavement systems in the presence of trees." *Science of the Total Environment* 458–460, 486–498.

Sørup, H, Lerer, S., Arnbjerg-Nielsen, K., Mikkelsen, P. and Rygaard, M. (2016). "Efficiency of stormwater control measures for combined sewer retrofitting under varying rain conditions: Quantifying the Three Points Approach (3PA)." *Environmental Science & Policy* 63, 19-26.

Susdrain (2017). SuDS components overview. Retrieved July 31st 2017 from http://www.susdrain.org/delivering-suds/using-suds/suds-components/suds-components.html.

Stahre, P (2008). "Blue-green fingerprints in the city of Malmö, Sweden." *Va Synd*, 2008, 14.

Thorne, C., Lawson, E., Ozawa, C., Hamlin, S. and Smith, L. (2015). "Overcoming uncertainty and barriers to adoption of blue-green infrastructure for urban flood risk management." *Journal of Flood Risk Management*, 1–13.

Wen, B., Van Der Zouwen, M., Horlings, E., Van Der Meulen, B. and Van Vierssen, W. (2015) "Transitions in urban water management and patterns of international, interdisciplinary and intersectoral collaboration in urban water science." *Environmental Innovation and Societal Transitions* 15, 123-139.

Winz, I., Brierley, G. and Trowsdale, S. (2011). Dominant perspectives and the shape of urban stormwater futures. *Urban Water Journal*, 8 (6), 337-349.

Wong, T.H.F. and Brown, R. (2009). "The water sensitive city: principles for practice." *Water Science Technology* 60 (3), 673-682.

Wright, T., Liu, Y., Carroll, N., Ahiablame, L. and Engel, B. (2016) "Retrofitting LID practices into existing neighbourhoods: is it worth it?" *Environmental Management*, 57 (4), 856–867.