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Urban Storm Water Management: Possible Catalyst for Moving Towards a Water Sensitive City

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Abstract

Water sensitivity is the city's capacity to avoid water scarcity, flooding or waterways pollution, to express the community's values and aspirations regarding water and to quickly adapt to urban growth and climate change. Even highly recognized in the specific literature, the concept of water sensitivity failed to be institutionalized due to the lack of a benchmarking tool to globally understand it. In this idea, the article introduces the concept of water sensitive approach, developed for extreme climates, to different urban areas with a moderate climate and a low rate of water related disasters. Brussels Capital Region, the selected case study, has high institutional, technical, social and funding capacities to make a leap frog towards water sensitive practices in urban planning and design. Considering the city's large impermeable areas, demographical growth, density, and higher rate of precipitation every year, the administration has to change the current water management practices. In this idea, the transition to water sensitivity could come from storm water management practices. There is a large interest worldwide for sensitive storm water management practices and in order to be applied for Brussels' territory, an evaluation of their potential is necessary. A methodology that works in parallel with quantitative and qualitative evaluation tools and integrates a research by design approach is a valid solution to benchmark the concept of water sensitivity and to show its potential for urban agglomeration with moderate climates like Brussels. Based on this conclusion, the article introduces a future research that will analyze this hypothesis by investigating both traditional and sensitive storm water on the Brussels' territory, starting from the watershed scale to the neighborhood scale.

Keywords

Water sensitivity; storm water management; urban design, Brussels Capital Region; waterscape.

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Water in urban planning

Water has an active role in the city's livability: temperature, humidity and the feeling of well being (Arnfield, 2003), but even so, the city's present vulnerability in maintaining a proper water quality and quantity (floods or droughts) comes in conflict with the aspirations of a sustainable urban development (Koester, 2010).

Since the 19th century, traditional urban water management policies failed to control the human impact on the landscape and ecological processes regulated by the water cycle (e.g. erosion, surface and groundwater levels, water chemistry…). This system evolved when energy was less expensive and water was plentiful, thus, the tendency was to implement management systems that optimized the infrastructure. Most of the urban rivers were piped and moved underground, separated from the public space and in less contact possible with the citizens. Progressively, the piped rivers became infrastructures for the sewer system and lead to *Waterway pollution*. In Europe, in the 1950's, most of the cities followed the traditional UK model of combined sewer system (See Figure 1, collecting storm and waste water in the same infrastructure). In addition to this, as the population grew, traditional water sources seem insufficient to satisfy the ever-growing demand (*Water scarcity*) and started to be imported; this resulted in a higher amount of waste water entering the system. Besides this, the present tendency of less and heavier rains challenges the system, making the city's drainage difficult, leading to *Urban Flooding*. To summarize, nowadays, *urban flooding and waterways pollution*, enhanced by the spread of impervious areas, the overloading of the sewer system and the incapacity of water treatment stations to balance the human impact are the major water related concerns in urban planning.

In this context, water in urban areas is seen more as a cause of damage than a resource. This perception is enhanced also by the hard work for the reconstruction, recovery, or prevention against tsunami, typhoon, or river flooding (eg. Japan, Southern-East Asia, The Netherlands). Placing water as a central point in urban planning was therefore a mandatory measure in urban areas with a high risk of water related disasters. Such measure was not as important for urban agglomeration that shows a lower risk and a moderate climate.

These days, the continuous population growth in cities and the expansion of urbanized territories increases the risk of water related disasters in urban areas (urban flooding, waterways pollution, water scarcity) and, thus, the necessity of reinvestigating the role of water in urban planning practices. The return to a previous state or the reinforcement of current water infrastructures to supply, distribute, and treat water could not solve all the problems and could not improve the city's livability.

In the current international urban water management practices, alternative solutions for flooding, water scarcity, or pollution, which could reduce or counterbalance the impact of human settlements on the natural water cycle (Kotola and Nurminen, 2003), enabled a change in perception. Nowadays, the urban water management passes from being a technical issue that solves by global means the city's water supply, treatment, and drainage through the construction of physical infrastructure, into an important catalyst for urban development by enhancing the city's livability and by reducing the human impact on the environment.

New solutions started to be searched (Brown et al., 2006; De Graaf, 2009; Kaufmann, 2007; Mitchell, 2006), mainly in the Anglo-Saxon community, in areas with extreme climate, where heavy rains

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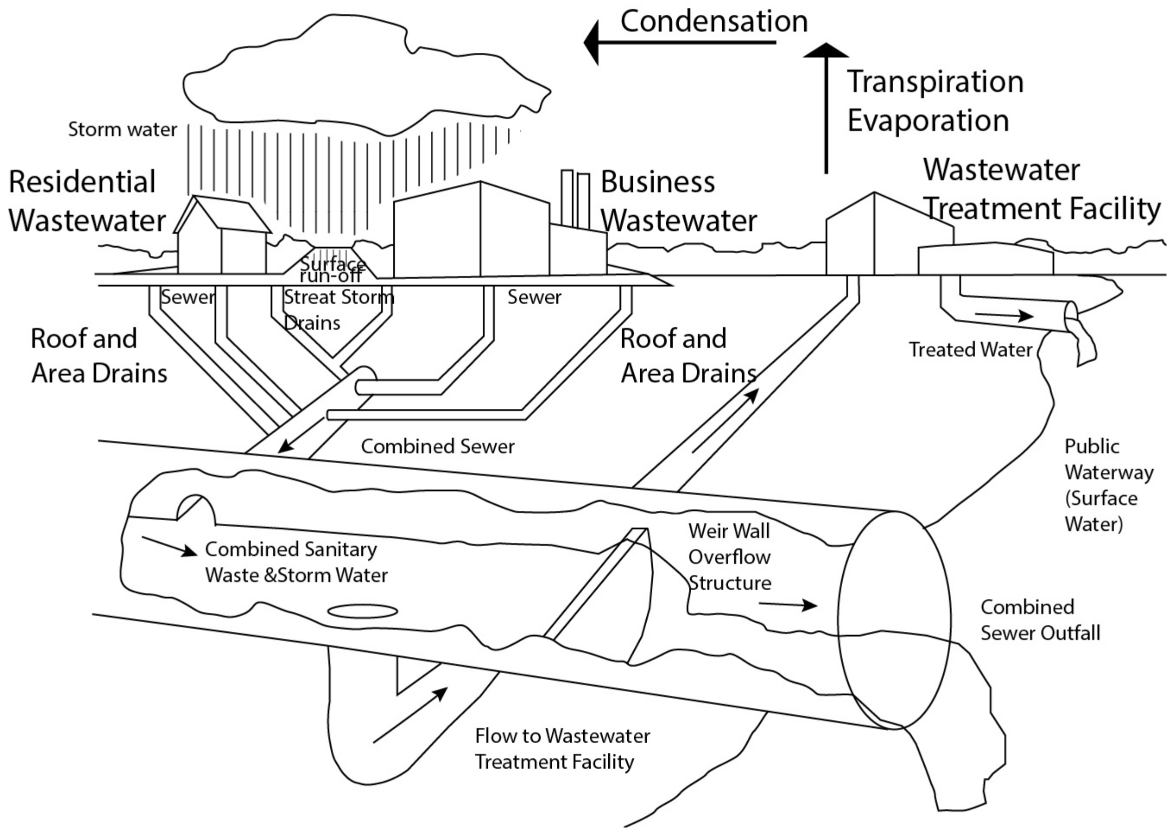

Figure 1.
Combined sewer system, the European model.

Source: St Louis MCD, Clean River Healthy, 2012. *Combine Waste Water Overflow* [jpg]. Available at: http://ecobrooklyn.com/wpcontent/uploads/2012/06/CombineWasteWaterOverflow.jpeg [Accessed 10 February 2013].

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follow long drought periods, in Canada, United States, or Australia, for example. Among the solutions proposed, the concept of Water Sensitive City (the city that integrates the water sensitive approach in the process of urban regeneration and development, WsC) -the water seen less as a hazard and more as a resource, became part of the sustainable urban development (Wong & Brown, 2009) and enabled the link between environmental issues and urban planning through an innovative vision.

Water sensitivity approach is the city's capacity to avoid water scarcity, flooding, or waterways pollution, to express the community's values and aspirations regarding water, and to quickly adapt to urban growth and climate changes.

This approach translated into urban planning practices can be defined by a series of guidelines. First of all, water sensitivity is an integrative approach. The entire urban water cycle -blue water (potable water), green water (rainwater), brown water (industrial waste water), or grey water (waste water)- is considered in the process of water reuse and recycling. Diversifying the water sources could be vital during droughts, but could also protect the environment. This attitude helps in saving potable water by using other water types, according to their level of treatment. For example, rainwater can be directly used for irrigations or for toilet flashing and washing. Secondly, water serves for multipurpose, apart from human or industrial consumption. An example is the water integrated in the public space to raise its attractiveness and to enhance the green spaces. The third guideline regards the governance. By finding flexible, diverse, global, and decentralized, interdisciplinary solutions, a change in the city's resilience to climate change and urban growth is expected. Recycling water at the housing level in a decentralized manner could reduce the quantity of waste water that enters the sewer system and could reduce, as a consequence, the risk of urban flooding. A decentralized system can be subject to failure if it is not controlled and coordinated by a global or centralized management that ensures the quality of the water used and treated. By remaining flexible, taking into account various scenarios of climate change and by including interdisciplinary solutions, the system is prepared to support urban growth and, in the same time, to protect the ecosystem. At last, for all this to become possible, an increase in the awareness regarding water management practices and aspirations among government, business companies, communities, and professionals, is required and represents a vital point to ensure the well functioning of the Water Sensitive City.

To summarize, water sensitive practices follow to use water from various sources and for multipurpose, to operate in an integrated, centralized, and simultaneously decentralized system, and to be resilient to urban growth and climate change.

Architects and urban designers have an important role in confronting concepts like the water sensitive approach to the site reality. In this way, as European architect, the author of this article questions the application of this concept in different environments with a moderate climate and a preeminent topography, by contrast with the extreme climate and flat relief of the Australian cities, were water sensitive approach was developed. In Europe, practices of sustainable water management are advancing quickly, especially after the 2010 European directive on this thematic. The following sections will take as a case study Brussels Capital Region, known as the European capital, with ambitions of also becoming the continent's greenest city in 2015. Brussels has indeed the potential

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to become an example of water sensitive city, but a better coordination and assessment of the ongoing initiatives is required. Storm water management, as a subset of the water sensitive practices, is the key point in this investigation and highlights Brussels' high institutional, technical, social, and funding capacities to achieve *water sensitivity*.

Water Sensitivity in moderate climates: Investigating the case of Brussels Capital Region, Belgium

The water sensitivity approach is a reaction to the extreme events related to water, but it does not necessarily mean that this condition is sufficient for the transition to this approach (eg. in Brisbane, Australia, the necessity for fast solutions to water scarcity made the administration return to traditional means like desalinization, (Brown & Keath, 2008), or that the concept can be applied just for extreme climates (eg. SWITCH project for European cities).

Following the concept of water sensitivity, most of the dense cities, with a low rate of water related disasters (windstorm, droughts, slides; Adikari and Yoshitani, 2009), like the Brussels Capital Region (or Brussels), could change to a more sustainable water management and solve the problems of waste and storm water system, water treatment, and urban flooding. In Brussels, the concept of water sensitivity has not yet been put in practice, but the context offers, however, important premises to support this city's transition. The following section investigates the capacity of Brussels to take in the water sensitivity approach and proposes storm water management as catalyst of transition.

Selecting Brussels as case study to evaluate the adaptability of water sensitivity approach in dense agglomeration with moderate climate is justified by the city's complex natural and institutional conditions. In present days, the city is defining its future directions of development. Placing water as central point for urban regeneration could provide a fresh direction and help architects, urban designers, and administrative to move towards a *sensitive* attitude regarding the surrounding environment.

The ecological, hydrographical, geological, meteorological, and institutional specificities of Brussels are important in the city's transition towards water sensitivity and they limit this concept's prospect applications.

First of all, it is important to mention that the city (see Figure 2) is situated in two river basins: Zenne's and Dyle's, tributaries to Belgium's main river, the Escaut. Even so, the waterways are little visible inside the city. Along the greatest part of its length, Zenne has been diverted into a system of culverts, starting from the 19th century, and replaced by an artificial channel in order to facilitate merchandises transportation to the North Sea (see Figure 3). Zenne's tributaries (see Figures 4 & 5) and basins are an important backbone of the city even if the watercourses were transformed into a drainage system using underground pipes (Water management plan, IBGE 2011). As a result, surface water lost its footprint in the city urban tissue.

Nowadays, citizens have direct contact with water just through artificial lakes, maintained partially with drinking water. Brussels' interesting topography is the only element that still shows that in the past Brussels was a water city. The new visions on the city's

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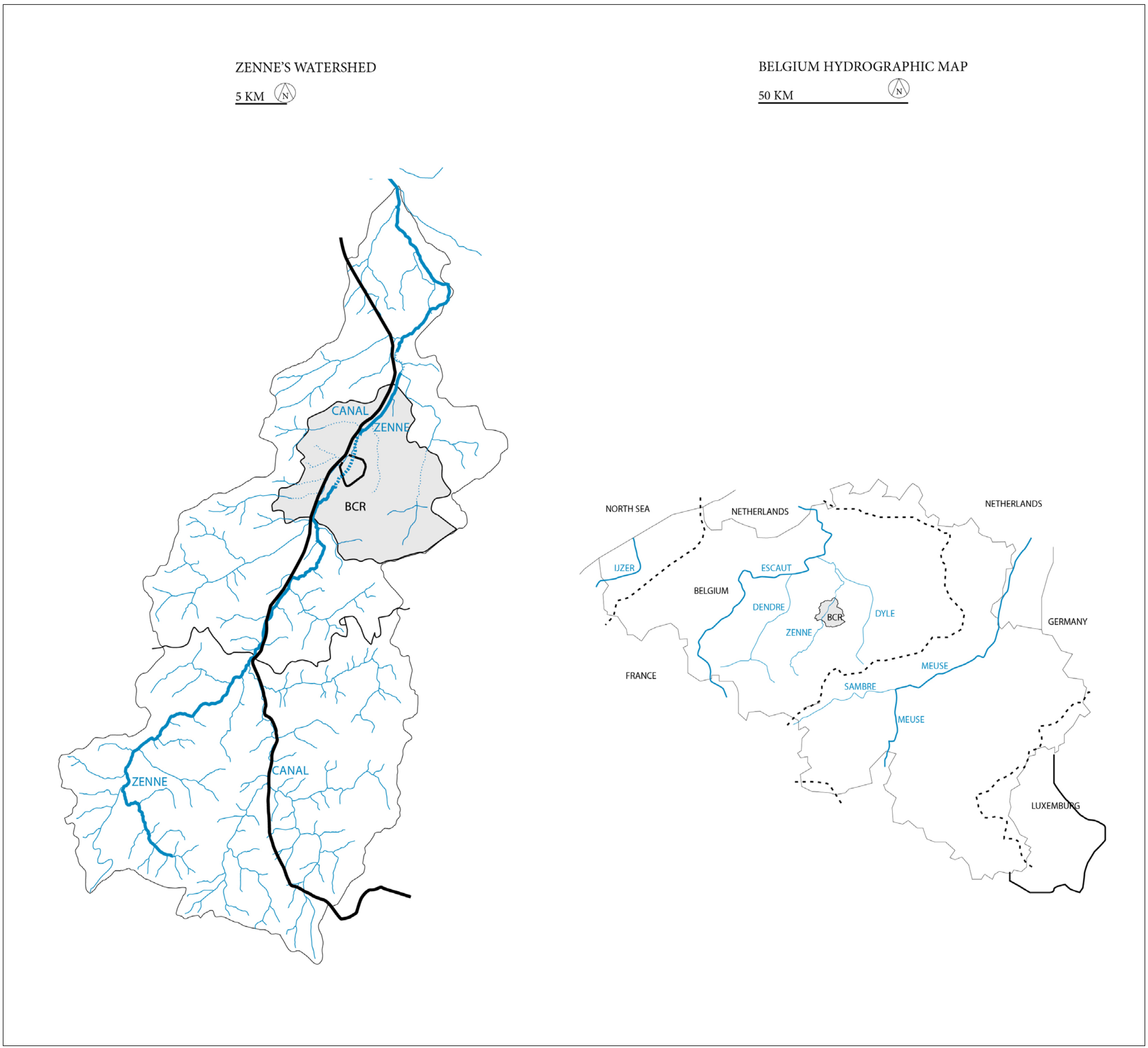

Figures 2, 3.

Hydrographical map of Belgium Kingdom with the location of Brussels Capital Region.

Source Fig.2: Wallonie Geoportail, 2012. *Wallon Region Hydrogeological map*. Available at: http://geoportail.wallonie.be/cms/home/geocatalogue.html?search-theme=theme_10&search-subtheme=-soustheme_1020# [Accessed 28 February 2013].

Source Fig.3: Centre Informatique pour la Region Bruxelloise (Computer Centre for the Brussels Capital Region), 2012. *Urbis Map*. Available at: http://irisbox.irisnet.be/vip/servlet/CCRLWebRequestServlet?$$controller=ccrl.server.controller.DocumentBrowser&Idmunicipality=CIBG&Language=fr&Idparentcategory=1289&Documentdate=&Showarchiveddocs=0&Showforms=0 [Accessed 10 May 2013].

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development should highlight its specificities and bring forward the importance of the valleys. Water should find again its place in the valley through a sensitive approach that takes into account the citizens' aspiration, and promotes, in the same time, the implementation of new innovative technologies. For some parts of the city exists already an increased awareness on water management among communities in the Maalbeek Valley through the program called New Urban Rivers (the harvesting of storm water permits the creation of new surface waterways that enhance the public space) or the revalorization of blue network in the Molenbeek and Woluwe Valleys. Even if they cannot be called sensitive approaches, these initiatives follow the same direction and stand as a proof of the city's capacity to take in water sensitive practices.

Brussels has a very diverse land specificities of: (i) the urban milieus: densely or sparsely built areas; (ii) the land use: mixed use, residential, tertiary; (iii) the geological conditions (East vs. West: sand vs. clay, relatively flat to hilly relief) (De Bondt and Claeys, 2010). This variety makes it difficult for the urban planners to elaborate a uniform plan for the city's development. A single approach can't be the solution. This is why the actions implemented in the valleys should be punctual and specific to the site, through a decentralized management.

On the other hand, the recent increase of heavy rainfall leading to falls within the sewer system is caused by the city's different hydro meteorological conditions than those observed in the 1960's, when it was designed. (Plan of the federal Belgian climate commission, 2010). In order to predict the changes required in the system, a series of climate change scenarios for a more precise effect on the amount of precipitations in Belgium (Environment Outlook 2030) can serve as guidelines: (i) wet climate scenario - increase in the level of precipitation generating runoff discharges, high level in the rivers, flooding, high soil water and groundwater levels in the winter; (ii) dry climate - low river flows, low soil water and groundwater levels during dry summer periods; (iii) moderate climate scenario (a middle scenario). This work of prevision is important. It obliges urban planners to find adaptable and flexible solutions to change the centralized system of water management and to make it more resilient to climate change and urban growth. Brussels' administration made significant steps forward in this direction by elaborating two directive plans: Storm Water Plan 2008-2011 and Water Management Plan 2011. Both of them enable new institutional concepts and high financial possibilities for water sensitive practices.

A last important issue concerns the position of Brussels in the centre of Belgium's Kingdom, a federal state, that makes it difficult to achieve an integrated regional water system due to the interconnectivity with the Walloon region for the water supply and Flemish Region (the Brussels' treated waste water and storm water drain reach the Scheldt basin). Even so, the impacts that a failed water system in Brussels might have had on the other regions transformed the city into a centre to start the transition towards water sensitivity.

Considering Brussels' characteristics, the transition towards a water sensitive approach could come from storm water management practices. Beside the favorable present context in terms of technological innovation, community awareness, institutional capacity and funding, a variety of land characteristics to implement the water sensitive approach,

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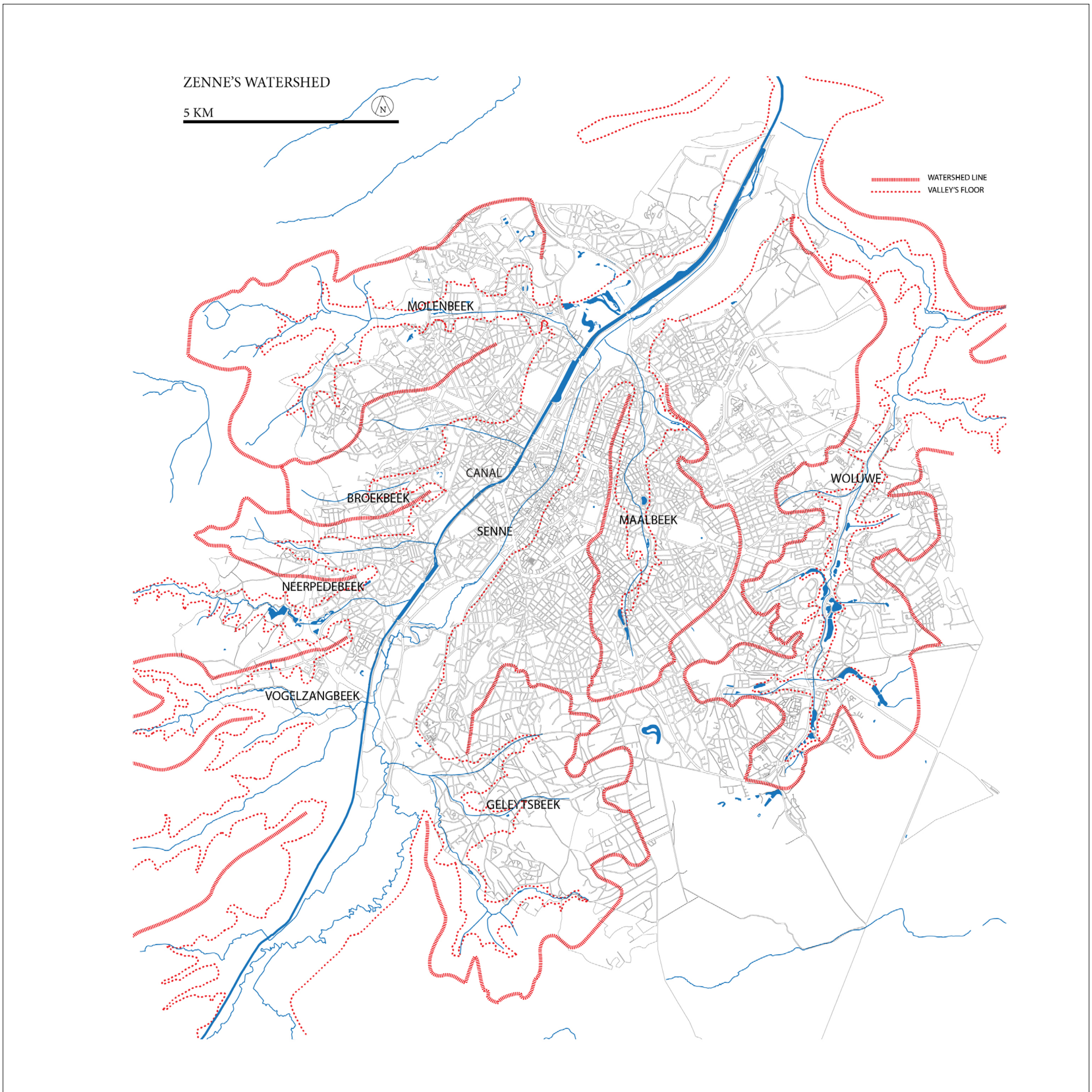

Figure 4.

Zenne and its tributaries: Brussels' Valleys.

Source: Centre Informatique pour la Region Bruxelloise (Computer Centre for the Brussels Capital Region), 2012. *Urbis Map* Available at: http://irisbox.irisnet.be/vip/servlet/CCRLWebRequestServlet?$$controller=ccrl.server.controller.DocumentBrowser&Idmunicipality=CIBG&Language=fr&Idparentcategory=1289&Documentdate=&Showarchiveddocs=0&Showforms=0 [Accessed 10 May 2013].

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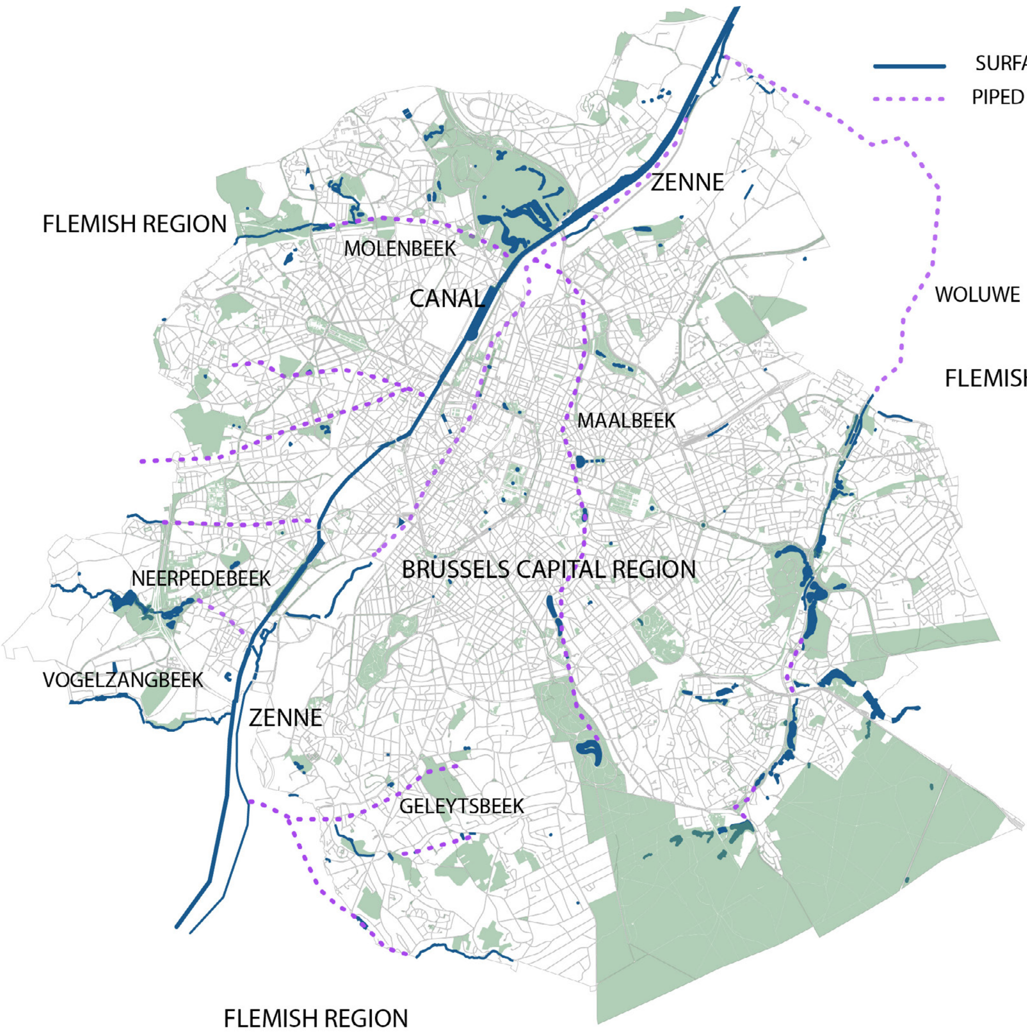

Figure 5.

Surface water and the underground piping of Brussels' main urban rivers.

Source: Centre Informatique pour la Region Bruxelloise (Computer Centre for the Brussels Capital Region), 2012. *Urbis Map*. Available at: http://irisbox.irisnet.be/vip/servlet/CCRLWebRequestServlet?$$controller=ccrl.server.controller.DocumentBrowser&Idmunicipality=CIBG&Language=fr&Idparentcategory=1289&Documentdate=&Showarchiveddocs=0&Showforms=0 [Accessed 10 May 2013].

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the city has significant problems of urban flooding and waterways pollution. These problems urge a practical solution for storm water management.

The urban flooding in the city is mainly caused by the incapacity of the combined sewer system to host waste and storm water in the same infrastructure. Moreover, Brussels' is a highly dense city with a large area of impermeable surfaces and long underground infrastructures for vehicles and public transport. Each summer, the city is vulnerable to high tides, some of the streets become impracticable, and metro stations and buildings' ground floors are flooded. To build a new separated sewer system due to the high costs and large works involved it is almost impossible. It is true that the administration is engaged in various programs and initiatives to find solutions, but all these solve partially the problem. The most common actions implemented are for storm water retention. Present legislation obliges each owner of a new built project to install a storm water retention basin on their land. The law is an example of decentralized system, being just a temporally solution and not necessarily implying the reuse of the collected storm water. At the city level, large scale retention basins were also built and the overflow of the sewer system is just postponed, in the same way, but not solved.

Brussels' is currently in an ongoing process to move towards water sensitivity and find its critical point in the storm water management practices. An understanding of the practices and concepts that are developed worldwide at the moment could be a source of inspiration for the European city. Thus, the following section highlights the role of storm water management in water sensitive practices.

Storm water management as a catalyst for change towards water sensitivity

The water sensitive approach follows the impact of all interventions on the entire water cycle. In the same way, clean water, rainwater, and waste water are perceived as flows in a continuous system and each intervention should find balance between them and, in the same time, should ensure environmental protection and livability.

In contrast to clean and waste water, storm water has just recently become recognized as a critical point in the urban water cycle due to the incapacity of the current system to avoid floods and waterways pollution in case of a heavier rain. As the future previsions about climate change are actually uncertain, storm water management has to take into account a multitude of scenarios. Variation in the amount of precipitation, disturbance of nature process of water evaporation, transpiration, condensation and infiltration, urban growth, are all factors that could increase surface run-off and enhance the occurrence of floods.

Traditional storm water management models show their limitations to adapt to urban growth and to ensure the environmental protection of waterways (see Figure 1, combined sewer system). Worldwide, there is evidence that alternative models are required (Ashley et al., 2007, Novotny and Brown, 2007, Wong and Brown, 2009). In this context there is a constant pressure from the citizens, public media, and non-governmental associations to find solutions which integrate storm water management in the urban water cycle. The same tendency can be noticed in Brussels.

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In this favorable context of innovation, among water sensitive practices, a significant attention on storm water is given in urban planning practices. Sensitive storm water management initiatives are in the present the most advanced subset of water sensitive practices in terms of ideas and concepts. Storm water resulted from a damage cause became an alternative resource for non-potable waters, part of urban landscape design, regeneration motor of urban waterways, and, most of all, the closest water source to the citizens (Wong & Brown, 2008).

Storm water management practices have enjoyed a large interest in developing urban design visions and proved their adaptability and efficiency in diverse environments. Even if not directly referred to as water sensitive practices at the time, successful projects demonstrated their "sensitivity" via practical results in: reducing quantity and velocity of run-off (New York 1980, the Blue belt Plan), increasing permeability by local interventions (Berlin 1980 - The Biotope/Green Area Factor for each parcel) or preventing sprawl (Taizhou City China 2006) (Arhen, 2007). These projects can be apprehended under green storm water infrastructure together with wetlands or retention basins and with a relatively recent concept, only partially researched in the current literature - New Urban Rivers, a contemporary vision on recreating new urban waterways as solution to avoid the overflow of the underground system, (Mauhaut V., 2011). All these initiatives envisage a new ecodynamic system that could reduce and delay the surface run-off and prevent urban flooding.

Although the above mentioned initiatives have defined the evolution of similar water sensitive practices in North America as Low Impact Development (LID), in UK as Sustainable Urban Drainage System (SUDS), or in the French speaking community as alternative measure to surface run-off, the recognition of their effectiveness depends on the case studies' specificities.

Disregarding their popularity, storm water sensitive practices, like most of the current water sensitive practices, are not yet able to orientate the process of planning and decision making about their potential due to the lack of a common understanding amongst institutions and citizens (Ison et al, 2009). This is ascribable to the lack of an appropriate assessment tool to evaluate the level of "water sensitivity" of different urban design initiatives (Priestley, Biermann and Laves, 2011). Without a proper evaluation framework, it is difficult to provide valid arguments that clearly show the adaptability of these solutions to different environments.

For this, a tool to evaluate and assess water sensitivity is useful to help communicate the effectiveness and adaptability of sensitive storm water management practices in different environments. In this way, an evaluation of the current situation can be achieved and an action plan for the future can be proposed.

Defining evaluation tools to measure sustainability is not a recent practice and a series of guidelines and indicators are already developed. After a short review of the present assessment of the available tools regarding water management, it can be concluded that generally they orientate and provide examples or toolkits to assess sustainability in terms of outcomes, rather than processes: performance indicators (Matos *et al.*, 2003), guidelines (DRUPSSuC 2011, WaterTime 2009), decision-support tools dedicated to a

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part or to the whole system (Forster et al., 2003), indicators for specific case studies WaterinCore and SWITCH indicators. On a first reading, the SWITCH indicators, together with WaterinCore, seem the most complete approaches on quantitative water assessment, but a qualitative assessment tool, such as questionnaire surveys and participatory research in evaluating water sensitivity are needed to complete the assessment (Sijbesma and Postma, 2008). To summarize, in the present does not exists a complete evaluation tool that follows the entire process and performance of a sensitive storm water practice. A mix of the available tools is crucial. Most of all, it is important the way this tool is applied on the case study. Indicators are important, but they need to be connected to the design solution. The role of architects and urban designers is to create this connection through a research by design approach were solutions are not unique, but various.

Conclusion: Benchmarking the concept of water sensitivity by using in parallel evaluation tool and research by design methodology?

In the present Brussels is not considered a water sensitive city, even if, as was stated above, it has an interesting policy to move towards. Recognizing its potential is important at this point. A clear plan of actions that continues this direction is needed. This article wishes to put in front the positive aspects of the current situation in the city, but also to point out that there are serious concerns that demand a quick answer. A solution could be the benchmarking of the concept of water sensitivity on the case of Brussels. While this article serves to define water sensitivity in rapport to urban planning and to inscribe it in the context of moderate climate, a future research will question the methodology needed. Now, a first direction can be given to the future research.

As it was stated in the previous section, various quantitative evaluation tools specific to water management are available that can measure the performance of water sensitive practices, but are less able to follow the process. Thus, the tools should be searched in various domains such sociology, for qualitative measures to understand the actions' impact on the citizens. The mix of the two types of evaluation is closer to the water sensitive approach that is to express the citizens' aspiration regarding water.

The better understanding of the land capacity to adapt to sensitive storm water practices could show its potential in urban planning to prevent hazards, to improve the city's livability, and to enhance the urban environment. The research by design methodology, the constant assay of various projects could be a means to achieve this.

Could a methodology that works in parallel with quantitative and qualitative evaluation tools and integrates a research by design approach be a solution to benchmark the concept of water sensitivity for urban agglomeration with moderate climates like Brussels? A future research will evaluate this hypothesis by investigating both traditional (such as combined storm water systems or end of pipe solutions) and sensitive (such as green storm water infrastructure and new urban rivers) storm water through an appropriate assessment tool, like quantitative and qualitative indicators and a research by design methodology on the Brussels' territory by looking in the same time at the impact at the watershed scale and at the neighborhood scale.

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