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Water sensitive design potentials in Paris, Berlin, and Budapest revisited

Analiza potencjału rozwiązań wrażliwych na wodę w Paryżu, Berlinie i Budapeszcie

Abstract

Impacts of extreme weather events are increasing due to ongoing climate change. Floods in the urban areas not just damage properties but also threat human life. Coping with these challenges in metropolises of old Europe is difficult as the ex-istent building structures and combined rainwater and sewage systems originating from the 19th century. We compare three old European capital cities (Berlin, Budapest and Paris) regarding rainwater management concepts. We identify important spatial land use types of blue-green infrastructure and corresponding measures for the implementation towards a more water sensitive management by using the case study approach.

Keywords: urban rainwater management, sustainable planning, european metropolises

Streszczenie

Obecnie, w rezultacie postępującej zmiany klimatu, obserwuje się coraz więcej skutków ekstremalnych zjawisk pogodowych. Podtopienia w obszarach miejskich prowadzą nie tylko do szkód materialnych, ale też zagrażają ludzkiemu życiu. W europejskich metropoliach problem ten stanowi prawdziwe wyzwanie, ponieważ znajdujące się tam budowle i sieci kanalizacji burzowej i sanitarnej wybudowano jeszcze w XIX wieku. W artykule porównano trzy europejskie stolice (Berlin, Budapeszt i Paryż) pod względem zastosowanych tam rozwiązań dotyczących zagospodarowania wody deszczowej. Zidentyfikowano istotne sposoby zagospodarowania przestrzennego zielonej infrastruktury oraz odpowiednie środki zorientowane na zarządzanie wrażliwe na wodę na podstawie analizy przypadku

Słowa kluczowe: zagospodarowanie wody deszczowej, zrównoważone planowanie, europejskie metropolie

1. Introduction

The frequencies and duration of stormwater events and floods are increasing in Central Europe (e.g. Fig. 1). Socio-economic impacts are projected to increase by two hundred percent (Alferi et al. 2015) [1]. Floods in vulnerable and densely populated urban areas not just damage properties but also threat human life. In our ongoing urbanized world, these threats affect more people in the future, as urban dwellers will likely account for 86 per cent of the population in 2050 [2].

The old European metropolises have a similar historical and structural development and a common heirship of traditional water infrastructure. This traditional water infrastructures are unlikely to adapt to the increasingly unpredictable extreme weather events [3], imply tremendous operation and maintenance costs, and contradict sustainable use of resources and possible ecological and aesthetical advantages of integrating blue infrastructure into the urban life.

The Water Sensitive City approach aims on a more sustainable water management and includes normative values regarding environment repair and protection, supply security, flood control, public health, amenity, livability and economic sustainability and thus includes aspects beyond the traditional functions of water supply, draining and sewage [6]. The integration of green and blue urban infrastructure (e.g. Blue-Green City Approaches, Lundy & Wade, 2011; Rozos et al., 2013; Lawson et al., 2014) will also fostering multifunctionality and sustainability of urban infrastructure. Up to date certain efforts have been done to implement an alternative approach on urban water services in new built up areas whereas the transformation of existing

Fig. 1. The summer flood 2013 of Danube River caused costs of over ten Mio. Euro for Budapest, Hungary [4]. At 17th of August 2013 96 mm of rain fall within one hour– an amount equivalent to the average of one month. Consequently, the canal system could not cope with the runoff and on some streets flow more than one meter high water.[5]

housing areas remains understudied. Thus, in this paper we compare three old European capital cities (Berlin, Budapest and Paris) regarding water relevant natural features, existing urban structure and rainwater management concepts. We identify important spatial land use types of blue-green infrastructure and corresponding measures for the implementation towards a more water sensitive city. We analyzed geographical information, land use maps, and other cartographic data. Successfully implemented methods and measures will be identified from city development plans, water strategies, climate adaptation plans and from the KURAS database (see www.kuras-projekt.de). The measures will be illustrated with realized projects from our focus cities. Finally we attempt to define a set of potential strategies and measures for Budapest, which could be used in order to foster transition from the existing towards a more sustainable rainwater management system in the capital of Hungary.

Sustainable urban stormwater management (SUWM) appeared in Europe at first in the 80ies often related to brownfields and poor water quality. New draining solutions and restored retention basins reduced costs through using of smaller diameter drainage pipes [7]. Nowadays sustainable measures takes part of planning principles in European countries. Especially the European Water Framework Directive fostered the implementation of laws, directives and supporting programs towards a more sustainable water management. Metropolises, which are substantial affected in extreme weather events and rising see level (e.g. Copenhagen or Rotterdam) creates long-range climate adaptation plans or water city plans with complex measurements for the next decades.

2. Results

2.1. Natural and structural features relevant for water infrastructure

Climate, geology and hydrology determine basically the natural features of an area and thus frame conditions of blue-green infrastructure. Table 1 summarizes relevant features. In general, the cities show similarities in major climatic parameters and also in the riverside location. Special soil types of floodplains with good permeability are dominating. Some city specific features modify the main character.

Table 1. Water relevant natural features of three old European capital cities (Berlin, Budapest and Paris)[1]

	PARIS	BERLIN	BUDAPEST
Climate	oceanic	oceanic-continental	continental
Annual precipitation	641 mm	581 mm	533 mm
Area	105 km^2	525 km^2	892 km^2
Population	2,2 mio	3,5 mio	1,7 mio

[1] Data sources: Institut national de la statistique et des études économiques; Amt für Statistik Brandenburg; Központi Statisztikai Hivatal.

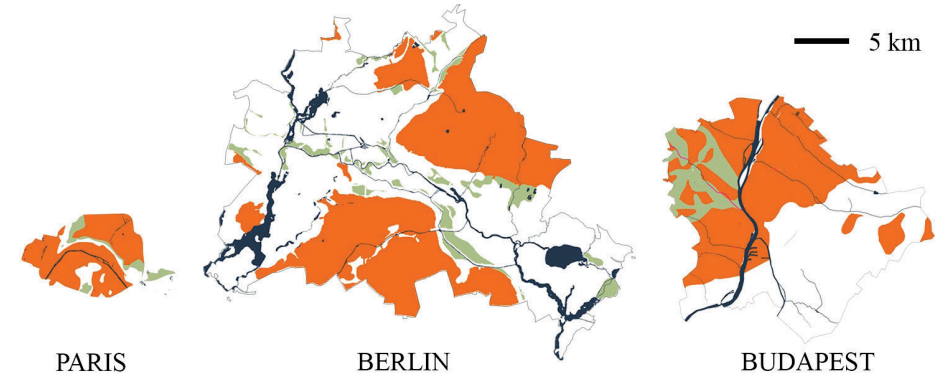

Fig. 2. Soil types of Paris, Berlin and Budapest

Paris with large, evenly dispersed annual precipitation and narrow temperature range has the most balanced climate [8]. The main river Seine of the city´s blue infrastructure has highly changeable water level which threatens the city permanently with flooding. Infiltration of rain is often obstructed by watertight soil such as claim or granite (Fig. 2).

The big city renovations of 19th centuries turned the blue infrastructure into simple constructed utilities. Many creeks were canalized and carried under the earth. The creek Biévre had been completely underdrained. Thus, a revitalization of water courses towards nature near riverbanks appear ambitious.

Berlin´s climate is a transition between oceanic and continental climate with warm temperate, massive humidity and colder summers [9] Numerous lakes, canals and rivers of Berlin help to cool the city and buffer the changes of water level. The Berlin rivers (Spree, Havel and Dahme) have a low water volume, the water surface is large. Berlin is dominated by sand and turf soil, high groundwater level implies limits for infiltration in many parts of the city.

Budapest is situated easternmost – summer droughts with 35°C are increasing. The city similarly to Paris is dominated by one big river, the Danube. The Danube has fifteen times bigger water volume, than the all main rivers of Berlin together, but the water surface is just third. The east side of the city has mostly permeable soil types as sand and gravel, the western Buda side is mainly constructed on limestone

Climate change will strongly affect climate of European metropolises. Main effects will be expectedly similar in the three cities: distribution of precipitation will be shifted from summer to winter, summer droughts will enhance frequency of heat waves and extreme weather events will cause bigger surface runoff [10].

The structure of old European Metropolis had been developed till the middle of 19th century in a similar way and was supplemented or modified during the last century (Fig. 3).

Hausmann´s renovation formed Paris into a looser structure, but the density of historical tenement housing dominates as 2.2 mio inhabitants live in an area that is fifth of Budapest. In some places of the old city structure just the street trees can help the vaporization and infiltration. In the dense structure of Paris there are few possibilities for rainwater infiltration.

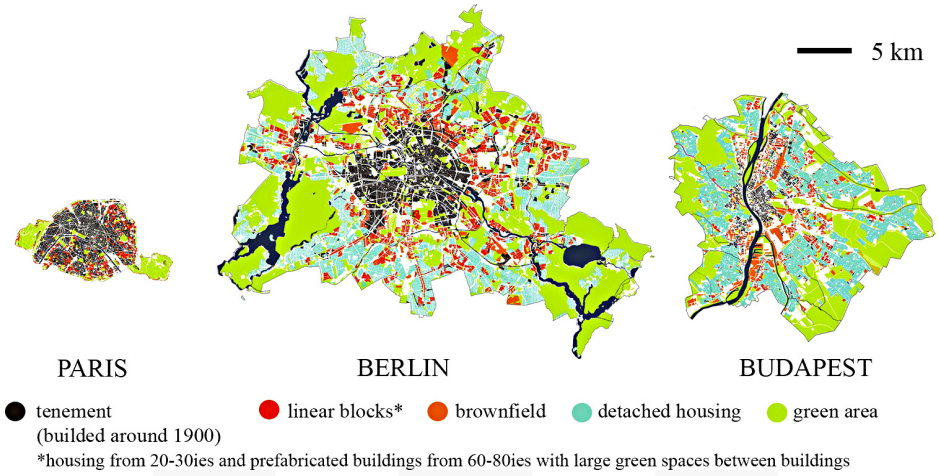

Fig. 3. Land use types of Paris, Berlin and Budapest

The combined sewage system transports the stormwater into the river increasing the flood wave. Heat island effect is also a common challenge in the city: the temperature difference between Paris and the outer suburbs is able to reach over 8°C difference at night [11].

Berlin´s building inventory suffered in World War II huge damages – the historical city center was mainly perished. Today's city structure is loose, 44% of the urban surface is green area and City center is characterized by a high proportion of new buildings. Berlin has some special housing types with high green area ratio: linear blocks of 20-30ies and the 50-60ies (Zeilenbau) and prefabricated buildings from 60-80ies (Plattenbau and Großsiedlungen) are surrounded by extended green areas in common use. Away from the center the most common type is low density housing with private gardens. Built-in areas are connected with a multifunctional network of creeks, rivers, lakes, canals, green corridors and recreational areas. This blue-green grid turns Berlin into a green and livable city. Budapest's compact city center with tenement is framed by looser zones of prefabricated building estates and low density housing. Parks of the inner city and the larger green areas near to the city border are poorly connected. In the last 20 years the green area ratio of Budapest has been decreased 4% [12]. The city structure lacks of green ways which could provide ecological transfer zones and healthy recreational areas for the citizens.

As the analysis of city structures shows, while Berlin has a large similarity in younger housing types to Budapest, Paris can be used as an example to cope with flooding and challenges of dense tenement housing.

2.2. Best Practise toward a new water infrastructure for old European metropolises

Paris synthetized goals and measures of sustainable water management in the urban water strategy **"Livre Bleu"** (Blue Book) to cope the challenges of climate change. The main measures selected as part of this policy are the improving of evaporation, infiltration

of rainwater and restricted flow rejection in the network [11]. Implementation are reviewed by instruments as city gardens, small green areas, green roofs, and the lake "Lac Inférieur". Small sized city gardens and pocket parks have a great importance for recreation and cooling in the dense tenement housing of Paris. These green islands are supplemented with numerous small green areas such as swales along pedestrian ways. However lack of green space is partially compensated by the use of planters and rooftop vegetable gardens – a frequent and beloved type of green roofs in Paris. Riverside projects in Paris can be hardly implementing due to the lack of space and the traffic routes along the river. Local government tries to find nevertheless new connections between the Seine and the city: inźthe project named "Paris Plages" the wharfs are closed for the weekend for traffic and opened for the citizens as a promenade [13] (Fig. 4). The "Lac Inférieur" is a retention pond of the place Colombie integrated into the historical park Bois de Bolougne. A wetland between lake and road was constructed to protect the highly sensitive aquatic environment of the lake from the direct polluted runoff of neigbouring streets.

Fig. 4. Project Paris-Plages [13]

Fig. 5. Visualization of the project "Panke 2015" [14]

Development and climate adaptation plan of Berlin focuses on the action zones of historical city center and watercourses. Street trees, permeable pavement, green roofs and green walls are defined as most relevant measures in the historical districts. Pedestrian ways and parking lots are huge potential infiltration surfaces – Berlin's typical micro cube stone pavement can infiltrate more rainwater as grass. Applicability of green roofs and green walls depends mainly on building structure [10]. Ecological pilot project **Block 103 Kreuzberg** was one of the first experiments for transformation existing housing into an energy and water efficient, climate friendly environment. Green area ratio was increased from 2% to 39% with measures as court greening, green roofs, green walls. Rainwater collection permitted graywater reuse for irrigation and toilet flushing [15].

Improving of water quality is an important goal of the city since two decades. Emission reduction and riverside restorations helped to reach such a betterment for today, that newest city concept **"Flussbad Berlin"** is considering to transform the banks of the Spree River and Spree Canal into a bath area and new meeting place for urban society [16]. Water quality is however just one required factor of a diverse biocoenosis. Revitalisation project of creek Panke aims the restoration of natural meandering river form and configuration of new habitats and flood zones (Fig. 5) The naturalized stretches with widened and meandering river section and new river forks make step stones for species of flora and fauna [14].

The **Park Am Gleisdreieck** was constructed with the transformation of a former marshaling yard partly as green area compensation for dense building development of Potsdamer Platz. Larger paved areas are permeable and the stormwater goes from the ways to the grass surfaces. The park has a special area with temporary water filled swales and hills, where children and young people can experience nature [17]. The larger green areas between linear blocks permit the application of SUWM measures such as swales, rain gardens or retention ponds. Building structure is ideal for green roofs and green walls. Some tree species are unequal to the increasing summer droughts. Gradual change of plants into climate adaptive species is therefore an important goal of the city [10].

The concept of SUWM has appeared only recently in urban planning practice of Hungary, nevertheless several projects have been realized within the last ten years used the approach of water sensitive planning. An early example from the 90ies was the radical **reconstruction of the district Ferencváros.** Demolition of numerous building annexes resulted an airier tenement structure with large gardens inside the blocks.[18] **Rehabilitation of the Károly-körút**, a section of the small boulevard, created a new broad grass stripe, two tree rows and more fountains to improve the microclimate in the hearth of the city [19] (Fig. 6). Revitalisation of Kopaszi dam in 2007 was the first big successful riverside project. Cleaning the bank of the former harbor bay and forming surroundings into a multifunctional green space turned the area into one of the most popular public parks of the city [20] (Fig. 7).

Fig. 6. Rehabilitation of Károly-körút [21]

Fig. 7. Kopaszi-dam [20]

Revealing priority action fields, we took a closer examination on urban structure of Budapest (Fig. 8). 47% of the city surface is covered by plants, two-thirds made up of forests and field lands [12]. In the built-in area most green spaces can be found on private house grounds. This research is engaged in transitioning of public urban areas, doesn't examine therefore the three aforementioned categories (forests, fields and private gardens).

We classified **5 action zones** of sustainable urban rainwater management according to their different use, features and spatial position, illustrated on the Figure 9.

Historical **tenement housing** with combined sewage system has the biggest lack of green spaces and impervious surfaces – often not just the streets and squares but also the courtyards are totally paved. These surfaces are mainly covered with low albedo asphalt,

Fig. 8. Green intensity analysis of Budapest [22]

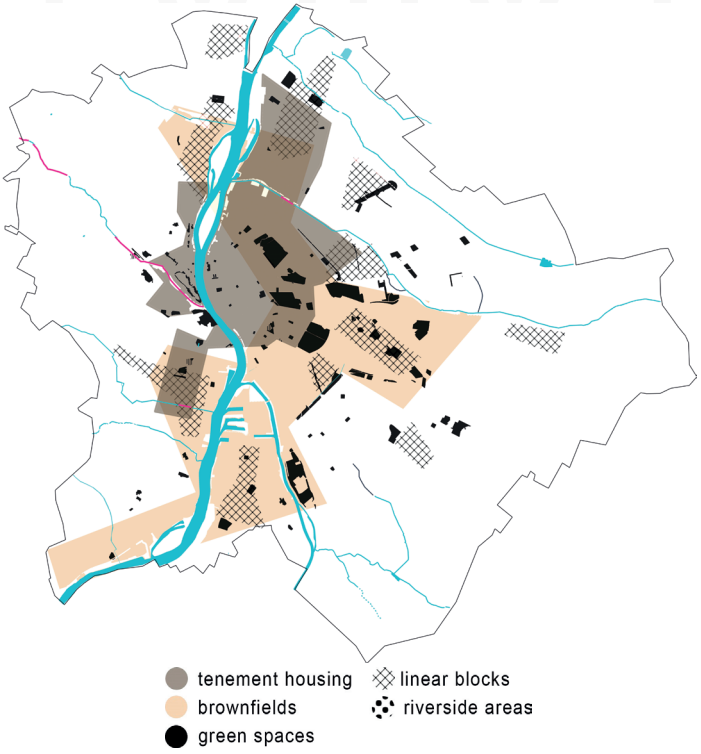

Fig. 9. The five action zones of SWUM

which causes fast runoff and amplifies urban heat island effect. Historical facades permit limited application of green roofs and green facades. A new tree line demands therefore Tree planting costs oftentimes multiple as a usual green space establishment because of the dense underground public utility system.

Linear blocks in extended public green space are represented by prefabricated modernist buildings of 60-80ies (Plattenbau) and social realist linear and perimeter blocks of the 50ies. The grounds are owned and generally maintained by the local government and used as a public park with good plant condition. Building structure favors for green roofs and green facades.

There are mainly two big possibilities for larger extension of retention areas in the old city structure. **Brownfield areas** cover more than 1200 ha in Budapest [23]. These ancient industrial and railway areas intersected with riverside zones (e.g. the Csepel Island or the Rákosrendezö marshalling yard) are particularly valuable for blue infrastructure development. **Riverside areas** along the Danube and smaller creeks can provide new green connections. Canalization of watercourses prohibited the direct contact with the city. Along the rivers flooding zones are built-up in many places, but outside of the city center river a natural riverbed revitalization is still possible [24].

The performance of **public parks** in the blue-green infrastructure is strongly influenced by the plant condition. Condition of less drought-tolerant species decays year by year – application of adaptive species and retention of rainwater or infiltration into the groundwater has an essential importance to retain ecosystem services. In contrast with Paris and Berlin Budapest has a lack of small city gardens and linear green spaces, which would have an important role in urban recreation and also in decentralized rainwater management in the dense urban structure.

3. Conclusion

Climate change and the heritage of old urban structure rise common challenges for the European metropolises. Different spatial situations of extent housing need adopted planning solutions. Best practice and realized projects shows broad possibilities of acting.

Most challenging areas are city centers with dense tenement housing. Application of permeable pavement, green roofs and green walls allowing for the traditional facades and roof-forms would provide reduced runoff and higher evaporation. Surrounding of 20th linear or prefabricated block buildings are suitable for even for measures with larger area demand like swales, retention ponds or rain gardens. Brownfields and riverside areas have the highest potential for new green space establishment and can also provide important linear elements of the blue-green infrastructure. Preserving of green space condition needs nevertheless providing good maintenance and the plant use adoption to the climate change.

Old European metropolises was designed to exploit the natural sources – transitioning extent housing into a water sensitive city needs radically new approaches and customized smart solutions. Our mentality has to be changed from consuming into adopting – the blue-green infrastructure is our tool for cheaper, safer and more livable cities.

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