"Water Sensitive City" Within City as A Strategy for Activate Polluted Urban Areas

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Abstract. The paper deals with the possibilities of urban and architectural design to benefit human condition, which encompasses physical well-being, environmental quality of life in big cities during the Climate Change era. Cities are dependent on the ecosystems beyond the city limits, but also benefit from internal urban ecosystems. This paper focuses on issues relevant for urban areas, the attention is on direct and locally generated services relevant for Szczecin. The first part of the paper depicts what the term "water sensitive city" means in urban design as a way to encapsulate a fuzzy concepts of an ideal relationship between people, governance, built environment, infrastructure, living ecosystems, resource use (e.g. energy) and water. This section also includes the example of project North Harbour, Northern Europe’s largest new urban development area in Copenhagen where this concept is implemented. The second part of the paper presents the results of the research for the Łasztownia Island in Szczecin by Jakub Golebiewski and Tomasz Sachanowicz team (West Pomeranian University of Technology in Szczecin). Currently, the Łasztownia Island remains as a degraded and polluted area in Szczecin's inner city. In conclusion, the paper emphasizes the implementation the concept "water sensitive city" is the desired strategy for reactivation this urban area. This also allows the ecosystems close to the city centre to be linked with larger ecosystems outside of the city.

1. Introduction

Humanity is rapidly urbanizing, and by 2030 more than 60% of the world population is expected to live in cities [1]. But even if humanity is increasingly urban, we are still as dependent on Nature as before. Nowadays, the "green" principles in urban design are well known and implemented in many cities around the world [2]. These principles integrate various techniques to minimize emission of greenhouse gases, the usage of water, energy and materials. They take into account above other public use green spaces and green architecture or water management. As the world’s cities continue to grow, continuing to value green space in cities is vital: but is also a challenge, particularly in developing nations where there is pressure for space, resources and development. The 21st century is already known for unprecedented changes and new ways of thinking on the climate change, global economics, migration and population growth. The following study is an application of an experimental approach to urban and architectural design in recently re-opened discussion on possibility of creating a systemic solution to resolve the problem of activate polluted urban areas in big cities. The presented urban design for the area of Łasztownia Island in Szczecin deals with this problem through the concept "water sensitive city" oriented urban design. This proposed novel nature strategy is informed by urban ecology, landscape and water management collaborates systematically in "designed experiments" with urban landscape architecture practice.
2. What the term "water sensitive city" means in urban design

In the first decade of 21st century the term ‘water sensitive cities’ (WSC’s) has emerged as a useful way to encapsulate the still somewhat fuzzy concepts of an ideal relationship between people, governance, built environment, infrastructure, living ecosystems, resource use (e.g. energy) and water. It potentially serves a practical purpose – allowing people to share and compare their understanding about emerging water strategies in a way that can help to orient and integrate disparate efforts to deal with new challenges. The explicit focus on an urban context is due to cities housing most of the world’s people and being the origin of significant impacts on the natural environment [3].

Planning and architecture went through a paradigm shift at the turn of the 20th century. The industrialized cities of the 19th century grew at a tremendous rate. It has arisen from concerns for health and maintaining wellbeing through averting diseases and illnesses associated with overcrowding, poor sanitation, and exposure to environmental pollution. Urban design is about making connections between people and places, movement and urban form, Nature and the built fabric or management of public space. The ecosystem concept was introduced in ecology originally to solve problems associated with theories of succession and ecological communities. The "water sensitive city" (WSC) concept is common for professionals in all these disciplines to practice in urban planning and urban design. It suggests a cross-disciplinary research into the built environment and water management. Research in this emerging field is now being undertaken by several sectors including medical, health promotion, recreational studies, urban studies and planning and transport planning research. There is a growing body of research showing a connection between human health and wellbeing and the design and structure of towns, cities and regions.

2.1. Urban ecosystems and the "water sensitive city" (WSC) oriented design

The study on urban ecosystems is a relatively new pursuit in ecology, dating to the middle 1970's. An ecosystem can be defined as “a set of interacting species and their local, non-biological environment functioning together to sustain life” [4]. Ecosystems in the cities are dynamic systems that have similar interactions and behaviours as natural ecosystems. The urban environment, it is both possible to define the city as one single ecosystem or to see the city as composed of several individual ecosystems, e.g. parks, lakes rivers and sea. In the built environment it can be identified several different urban ecosystems which we call natural, even if almost all areas in cities are manipulated and managed by man. The contemporary ecological paradigm recognizes that humans can be, and often are, parts of ecosystems [4]. Urban ecosystems are a hybrid of humans, natural and man-made elements whose interactions are affected not only by the natural environment, but also culture, personal behaviour, politics, economics and social organisation. Multidisciplinary in nature, urban ecosystem management requires a composite of social, environmental, economic and decision making tools and institutions that are flexible and can adapt quickly to changes in one or more systems. For example, prepared in 1995 the Bo01 high-density mixed-use development in Malmö, Sweden, was based on innovative planning procedures and products. A very broad definition of sustainability and ecosystems required new approaches in collaboration by the city, developers, planners, and designers. The outcomes of the project included outstanding aesthetics in the plan and the individual elements, as well as spaces that foster social interactions at the city, neighbourhood, and block scales. A density of 26 residential dwelling units per gross acre balances the 50% open space dedication. Comprehensive planning for energy, water, and waste systems resulted in significant improvements, especially in energy production (100% is from renewable sources) and solid waste management. A wind turbine provides most of the electricity while a district-wide system supplied by a geothermal storage network provides almost all of the heating and cooling resources [5].

In 2010, the Stockholm City Council decided that Stockholm Royal Seaport would be designated an area with an environmental profile with the mandate to determine what is possible in the current situation and push the boundaries where possible, to become a model of sustainable urban development and the "water sensitive city" oriented urban design. One of the prerequisites for the development of Stockholm
Roy al Seaport is broad political support and the aspiration that Stockholm should continue to be a leader in sustainable urban development. One of the City’s strategies is to work with areas with an environmental profile to test what is currently feasible and to push the boundaries of what is possible [6].

2.2. The "water sensitive city" oriented urban design - the North Harbour in Copenhagen

North Harbour, Northern Europe’s largest new urban development area, is the best example of the "water sensitive city" oriented urban design for future sustainable postindustrial urban areas in Copenhagen. With 200 ha, Copenhagen’s Northern harbor is today used as harbor, but expected to be transformed into a new Copenhagen neighborhood within the next 40 to 50 years. Danish Architects COBE, in collaboration with Sleth Modernism, Polyform and Rambøll, are currently developing the largest urban transformation project in Scandinavia. Their vision is that North Harbour with its potential 40,000 inhabitants and 40,000 work places will at least be carbon neutral in the energy area – and in time, export sustainable energy to the rest of Copenhagen. With the post industrial landscape as a starting point and guideline, a series of new canals are dug out. While respecting the cultural heritage of the harbour, the canals add new qualities to the plan in several areas: they improve liveability as well as commercial value, they act as a tool for feasible phasing, and they give a sense of place in the vast Nordhavnen area. The resulting islets will become individual neighbourhoods, each with own identities and qualities. The islets will all have mixed programmes of housing, offices, commerce, culture, sports etc. The project has a distinct emphasis on the south facing quays. Multiplied by the addition of new canals, each one holds significant qualities and potentials. All quaysides will be publically accessible, and in terms of greenery and landscaping graduate from dense and urban in the south, to wide and wild in the north [7].

In the long term, the district energy infrastructure and connected heat storage will ensure that the North Harbour will be able to use the future's most appropriate sustainable technologies and sources of energy, for instance solar energy, wind energy and geothermal heat extracted from the ground deep below North Harbour. Also groundwater and are planned to be used for cooling purposes. Power consumption in the North Harbour will be kept at a minimum through the building design and the integration of information technology to control and monitoring. Building and infrastructure will be subject to environmental impact assessment and will be designed on the basis of principles aimed at keeping resource consumption, waste production and negative environmental impact to a minimum. The electricity required will be generated by wind turbines and, in the long term, also by solar cells. The future city district of the North Harbour will be a world leader in the use of sustainable technologies. The energy system for the North Harbour is to demonstrate future sustainable energy systems, which, combined with other green initiatives, should position Copenhagen as a centre of green growth and a display
window for green technologies. Currently, the water partnership between the City of Copenhagen, City and Harbour, Copenhagen Energy and the partnership "Water in urban areas" are working together with the Development of Nordhavn. Faced with climate change as a result of modern way of life, the urban development of such vast territories implies great responsibilities on the makers of new cities. As an urban development project, the North Harbour shows how cities can be both environmentally and economically sustainable without losing out on quality of life or welfare.

3. Research for implementation of the water sensitive city within Łasztownia Island

The main aim of this research was to demonstrate possibilities of application the „water sensitive city” theory as a strategy in revitalisation of polluted urban areas, on the example of the Łasztownia Island in Szczecin. The undertaking of this research was a response to the international architectural competition under the title „Lasztownia – the new heart of the city”. The architectural and urban design competition for the preparation of a conceptual plan for the area of Międzyodrze, including the area of Łasztownia in Szczecin” conducted by the Szczecin’s authorities. The purpose of the competition set out in the regulations was to make Szczecin's vision of the future known as „floating garden 2050 project” a reality. This concept is based on the use of the geographic potential of the city, which has many water bodies and natural greenery. In “Floating Garden” concept the city is a people- and environment-friendly place connected with its natural surroundings. In order to realize the assumptions of the floating gardens design in our spatial concept, we have set the following research problems before us. What ideals should be met by an environmentally friendly inner-city district in the waterfront context? How should we respond to the challenges of climate change in the aquatic environment? How should the transformation of degraded and polluted post-port areas should be carried out?

In the first part of the research the main characteristics of Międzyodrze area was given. It was important to study and understand the environmental conditions of the project. The development area is a part of a very valuable ecosystem that requires protection and reasonable management, which should be included in the planning process. An important aspect in this context are the geological conditions of the area and its location in the flood zone in the context of climate warming and increasing level of waters. In the second part of the research, an analysis of spatial development and the current development of the urbanized part of Międzyodrze was carried out. As a result of the conducted studies, this part of the area has been diagnosed as extensively built-up, degraded and contaminated as a result of many years of use for industrial purposes. It was also found that the historical spatial structure of the area has been broken up and distorted. In this context, a radical transformation of the Łasztownia island was proposed. The third part of the research goes on to attempt to solve the research problems through the implementation of “water sensitive city” theory. The studied examples show that the assumptions of this theory can be widely used in the spatial planning process of contemporary cities, taking into account issues of flood protection, rational use of water in the built environment and proper functioning of water ecosystems.

4. Result and discussions

Szczecin is located in the Lower Odra Valley, 65 km from the Baltic Sea coastline. As much as 41.6% of the city's area is green, and 23.9% is water. Within the city limits there is Dąbie Lake (the third largest lake in Poland) and two arms of the Odra River with numerous tributaries and canals, which are only a part of a much larger area of the Odra estuary. To the south of the city stretches wide Odra Valley, that is 30 km long, extending from Widuchowa. The geographical name of this area, located between Western Odra and Eastern Odra (Regalica) is Międzyodrze (figure 2). The area of Międzyodrze consists of many islands including reed communities, swamp alder woods, willow-poplar gallery forests, oxbow lakes, lowland hay meadows, small fragments of elm-ash forests and old river beds. In this valuable natural area, a total of 16 plant communities, 168 species of occurring birds and 286 plant species have been identified. The average terrain level in Międzyodrze area ranges from 0.3 to 0.5 m a.m.s., which means that it is a flood plain [8].
The islands of Międzyodrze, located within the city limits, form an integral part of this ecosystem. Most of them have kept their natural character to this day. The largest transformations have been made to the islands adjacent to the city center. Since the Middle Ages Łasztownia was an economic suburb of Szczecin. However, the landscape of Międzyodrze in this area, have changed scarcely at the turn of the 19th and 20th centuries, when the construction of a modern port was made here. Some of the natural riverbeds were buried, and new canals and port basins were dug through the islands. These investments significantly disturbed the natural character of the area in its part. As a result of this process Łasztownia and Kępa Parnicka were built with low-standard residential buildings adjacent to industrial facilities, harbor warehouses and storage yards, which survived virtually unchanged until World War II.

The war and the post-war period brought further significant changes in the landscape of Międzyodrze. The buildings existing on the island have been destroyed in 75%, and the historical urban plan has been rebuilt. Residential buildings were virtually eliminated from the area, for port and industrial functions [9]. At the turn of the 20th and 21st centuries, the city was affected by deindustrialisation, and part of the port area has ceased to be useful. As a result, a new role of post-industrial areas in the city structure was sought. However numerous spatial concepts, that have arisen over the years have not resulted in a
final decision, regarding the shape of the Lasztownia development. Finally, the city authorities decided to organize an international urban competition for the development of Międzyodrze and Łasztownia in 2017.

4.1. “Water sensitive urban planning” for Międzyodrze area

The project developed at the West Pomeranian University of Technology in Szczecin was one of the proposals awarded in the competition [10]. Our approach was based on the concept of a new balance between the natural environment and the built environment. We had opportunity to define Międzyodrze urban plan, responding to climate change issues and sustainability issues. A special place in our design proposal was taken by the concept of a “water sensitive city”. In the context of Szczecin's geographical location, this choice seems to be obvious. Despite the fact that Szczecin does not lie by the sea, we can rank it in the category of coastal cities [11]. The city is exposed to the occurrence of floods as a result of pushing sea water into the land through the strong winds. This phenomenon along with other threats related to climate change, makes rational water management one of the significant challenges that city authorities have to face. The concept of “water sensitive city” provides us with answers how to deal with such a threats. In research conducted by Cooperative Research Centre for Water Sensitive Cities in Australia the most important goals of WSC’s have been formulated:

- provide the water security essential for economic prosperity through efficient use of diverse available resources;
- enhance and protect the health of waterways and wetlands, the river basins that surround them, and the coast and bays;
- mitigate flood risk and damage; and
- create public spaces that collect, clean, and recycle water [12].

Responding to the WSC’s postulates in our concept we strived for the maximum protection of the natural landscape and the restoration of ecosystems within the urbanized parts of Międzyodrze area. The aim of the competition was to design an urban plan for the four islands of Międzyodrze. While the Łasztownia Island and Kępa Parnicka is a degraded post-industrial area, the Grodzka Island and Green Island maintained mostly their natural character. This distinction decided to introduce two different strategies to the area. Design decisions regarding Łasztownia and Kępa have focused on improving ecological efficiency, while in the case of the Green and Grodzka Islands, the most important goal was a protection of existing landscape values and minimalization of urban interference.

Figure 4. View from the Grodzka Island to the Chrobry’s Embankments. The current character of the island as a park and recreation area is mostly maintained in the project. Photo: J. Golebiewski.

We decided to keep the existing primeval forest on the Green Island, because any investments in this area would result in the destruction of the natural ecosystem and water relations. In the case of Grodzka Island, which is now used for recreation and as a allotment gardens (figure 4), we decided to do a little interference by introducing a low-intensity residential development surrounded by park-like greenery. Floating houses and houses on stilts were designed here, so there was no need to raise the level of the island and interfere in its marshy nature. As a result, the building's resistance to flood conditions was
also obtained. The shores of the island have preserved their natural character, allowing further vegetation at the junction of water and land.

Figure 5. Scheme of spatial transformations of the Łasztownia urban plan. Drawing: J. Golebiewski

In the case of Łasztownia and Kępa, we wanted to reconcile the city's expectations, aimed at creating a new, intense downtown district with the challenges of the “water sensitive city theory”. Detailed solutions in this case are presented for Łasztownia Island. The project was inspired by analysis of the historical development of the island. The original urban structure of Łasztownia was based on narrow plots adjacent to the main road and to the quays (figure 5). The front parts of the plot were built, while in the depths of it gardens and breeding farms were placed. In later centuries this rural landscape was destroyed by industrial revolution, and the island become a strictly built-up, unhealthy place to live. In our concept, we reinterpret the idea of the coexistence of nature with the built environment, by adapting the identified values to contemporary conditions (figure 6).

Figure 6. Jakub Golebiewski, Tomasz Sachanowicz, the urban plan for Łasztownia and Wyspa Grodzka, shows the balance between buildings and green areas. Drawing, 2017
4.2. The strategy for Lasztownia Island

In the design concept, we refer to the balance between buildings and greenery, as well as to the strip layout of buildings. This action aims to optimize the area of the biologically active and water-permeable surface in the island. This system can be defined as “50/50” - 50% of buildings and 50% of greenery. The limited building intensity is compensated by its height to keep investment profitable. Land conditions at Międzyodrze are very difficult so even ground-floor, relatively light objects require piling foundations [8]. Therefore, limiting the building area with the simultaneous increase in its height is economically rational. To ensure the free flow of high groundwater, it was decided to place garages in the ground floor. Simultaneously the roofs of the garage parts have been designed as a green surface, maximizing the biologically active area.

An important element which shapes the urban layout is the flow of rainwater and the way it is managed. Some rainwater is used for irrigation of green roofs, while water from cohesive roofs is imported into raingardens. Plants filter and purify rainwater that partially evaporates into the atmosphere, and in a part flows freely into the river as biologically purified. This is possible due to the formation of “green strips” in a perpendicular manner to the shoreline. As a result, partly contaminated rainwater does not burden the sewage system, which in the face of heavy rainfall becomes inefficient.

The proximity of natural water sources makes us aware of the importance of this life-giving resource. The urban plan of Lasztownia Island is closely related to the coastline. The perpendicular relation of the “building strips” to the shore allows all residents to have eye contact with water ecosystem. Each of the “green strips” reaches the shore by creating a small ecosystem associated with the river. Here, the naturally formed slopes are preferred instead of reinforced quays. By those corridors, fauna and flora from neighboring islands can penetrate into urban space, and restore the balance of the whole
Międzyodrze ecosystem. This connection between the built environment and the natural environment allows residents to understand the need of water resources protection and their rational use (figure 8).

**Figure 8.** Jakub Gołebiewski, Tomasz Sachanowicz, The concept of “sponge city”, showing the circulation and reuse of rainwater on Łasztownia Island, 2017

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**Figure 9.** Jakub Gołebiewski, Tomasz Sachanowicz, Residential buildings on the waterfront, refer in form to old granaries. Between them we can see the “green strips”, visualisation: A. Pukalski, 2017

Another important role played by “green strips” is protection against flooding. Biologically active surface is favourable for the proper water circulation, in the urban environment. Excess water can be removed in this case through application of riparian ‘Sponge’ concept [12]. In the event of drastic climate changes and a steady increase in the level of water in the oceans, living in Łasztownia will be still possible. Properly designed structure of the ground floor and elimination of residential function from this part of the building will enable its adaptation to the new conditions. In this case, a system of channels and “building strips” will be created with green areas, located on the roofs of the flooded storey. The adopted solutions ensure that the Łasztownia’s urban plan meets not only the current challenges of climate change but also the possible future.
5. Conclusions
In the era of climate change, we need to plan new districts responsibly, anticipating potential weather hazards. In the presented transformation project of the Łasztownia Island three important issues have been addressed: the proper water circulation in an urbanized environment; limitation of flood hazard; as well as maintaining the continuity of the natural ecosystem of the Międzyodrze islands. The essence of the project, corresponding to these issues are „green strips”.
In the first place they maintain the proper circulation of water. The biological surface naturally absorbs rainwater using it for irrigation and cooling urban spaces. Its excess is purified biologically and discharged into the aquatic environment. They can also absorb excess water during heavy storms and prevent local flooding. In addition, the urban plan based on „green strips” and „green corridors” promotes continuity in the ecosystem structure of the entire Międzyodrze area. Thanks to this, the new district is environmentally friendly and transforms the industrial area into a modern ecological habitat. This is also facilitated by the re-naturalization of the quays that have lost their current port function. The island which since the industrial revolution was a foreign body in the area of Międzyodrze, producing pollution and using the entire surface for human activity is partially restored to the environment. In this way, the vision of a „water sensitive city” is realized. This is a city that draws from the advantages of its location on the water, at the same time eliminating the negative impact of the urbanized area on the aquatic environment.

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