MODERN STORMWATER MANAGEMENT APPROACHES IN URBAN REGENERATION

Magdalena Vasilevska [1]
Ljiljana Vasilevska [2]
UDK: 551.578.1:711.4
DOI: 10.14415/konferencijaGFS2018.052
Summary: *In response to climate change, the negative effects of urbanization and industrialization, as well as numerous socio-economic, physical and environmental changes in urban areas and urban catchments, developed countries have generated and implemented several integrated stormwater management approaches. They are based on the principle of longer and safe stormwater retention in the urban catchment, which is achieved through the application of a number of systemic measures and technical elements designed to have minimal influence on the natural hydrological cycle. The benefits of their applications are multiple, as indicated by the experience of countries that enabled the integration modern stormwater management approaches into the process of urban planning and design, through defining the appropriate legal and institutional framework.*

Keywords: *modern stormwater management approach, urban planning, urban design, urban regeneration, integration*

1. INTRODUCTION

In the last decades a several modern stormwater management approaches have been developed. Scientific thought has dealt with various aspects of this issue, such as the role and significance of modern approaches [1] [2], the relationship between modern approaches and urban planning and design [3], as well as recommendations for the application of individual measures and technical elements [3]. However, as current planning theory and practice made a significant shift towards implementation of modern approaches, moreover to their integration into the urban planning and design process, research of this type is important and necessary.
In the unbuilt/newly-planned areas, the measures and elements of modern stormwater management approaches are selected and applied according to the characteristics of natural conditions, while in the urban environment the character and the possibility of their application are additionally dependent on the characteristics of the existing physical structures. In the second case, when the upgrading and/or reconstruction of the existing system is performed, the planning and design tasks are much more complex, due to the

[1] Magdalena Vasilevska, mast.inž.arh., Građevinsko-arhitektonski fakultet Univerziteta u Nišu, e-mail: magdalena.vasilevska@gaf.ni.ac.rs
[2] Dr Ljiljana Vasilevska, red.prof., Građevinsko-arhitektonski fakultet Univerziteta u Nišu, e-mail: ljiljana.vasilevska@gaf.ni.ac.rs

complexity of the practical options for solving the problems related to the quantity and quality of stormwater in the built environment, as well as the fact that activities related to the reconstruction of the existing system are most often realized within the framework of urban regeneration projects, which is even more complex process according to the goals and structure.

In addition to the general characteristics of modern stormwater management approaches, the main goal of this paper is the analysis of the genesis and development of the conceptual framework for integrating modern approaches into the urban planning and design process, as well as the benefits that arise from this. The focus of the research is on urban regeneration, as one of the key methods and tool of urban planning and design.

2. METHODOLOGY

In analyzing the basic characteristics and possibilities of applying modern stormwater management approaches and exploring the methodological and conceptual framework of their integration into the process of urban planning and design, the methodological framework is based on an analytical approach which relies on description and analysis.

3. ORIGIN AND BASIC CHARACTERISTICS OF MODERN STORMWATER MANAGEMENT APPROACHES

Modern stormwater management approaches have been created as a result of the need to find answers to the global changes and the problems that human society has been facing for the last few decades, such as: 1) rapid urbanization; 2) industrialization; and 3) climate change. Some UN projections indicate that the potential risks of global climate change are: a) an increase in the average temperature by 3° C by 2070; b) reduction of average rainfall amounts by 20-40% by 2070; c) increasing the sea level in cooperation with storm events; and d) an increase in the frequency and intensity of the storm periods, where there are some countries and regions with varying degrees of vulnerability.

Rapid urbanization, which reflects in the fact that in 2007, for the first time on a global scale, the number of urban population equaled the number of rural population and that since then, it has steadily increased by an average of about 1.5 million inhabitants every week, that by 2025. there will be about 40 cities with a population of more than 10 million, or that since 1990, the number of people living in slums increased by 33%, disrupted the natural water cycle and influenced major imbalances in the urban water cycle.

Unlike the natural environment, where over 50% of the rainwater infiltrates through the soil (25% shallow and 25% deep infiltration), about 40% is regulated by evapotranspiration, while only about 10% of the rainwater is retained on the surface, in the urban environment the situation is quite different. Namely, due to the high participation of non-porous surfaces, only about 15% of the rainwater is infiltrated (10% shallow and only 5% deep infiltration), evapotranspiration participates with about 30%, while more than half of the total rainfall is about 55% . In the central, densely built urban areas, the share of surface rainfall ranges from 80% to as much as 100%, ie there is no possibility of infiltration or it is reduced to a minimum. Numerous studies indicate a direct connection between the intensity of the urbanization process (expressed by increasing population density and greater participation of impermeable surfaces) with an increase in the amount of rainfall that is retained on the surface (Figure 1).

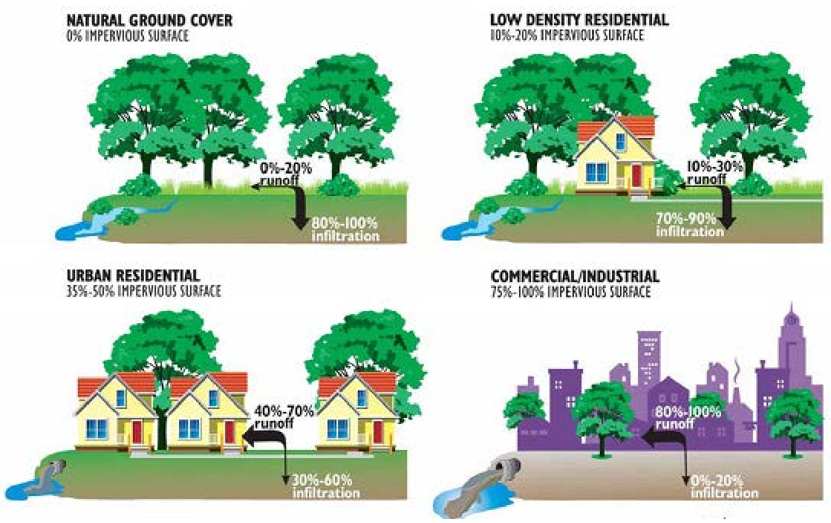

Figure 1. Influence of the intensity of urbanization on the increase of surface rainfall [4]

The need to streamline the solutions to problems and challenges arising from the process of rapid urbanization in a socially sustainable way, and to adapt urban areas to climate change such as increasing the frequency and intensity of storm events, is directly related to the need to establish and implement an effective, new stormwater management approaches. In line with that, in the last decades, several new, innovative approaches and principles of stormwater management have been developed, e.g. the drainage of rain and stormwater in urban areas, which are conceptually based in a completely different way compared to traditional atmospheric water management systems. The following basic goals of new approaches are defined [2]: 1) replace and/or increase the capacity of the existing drainage system in urban catchments by mimicking nature environment; 2) solve the flooding problems; 3) solve the problems associated with stormwater quantity and quality.

Although the initial researches and patterns of stormwater management were initially motivated by the specific characteristics and problems of the country in which they were created, today most of them have an integrated approach to the problem, through the tendency to deviate from the natural hydrological cycle and the conditions that are present in the urban catchment. Under the paradigm of sustainable development, modern approaches are based on additional common goals, which are simultaneously in synergy with the primary goals of urban planning and design, such as: 1) improving the characteristics of the built environment - increasing the quality of life; 2) improving the quality of water resources; 3) reduction of negative impacts of stormwaters and risk management; and 4) the preservation and improvement of urban ecosystem.

The most recognized and prominent modern stormwater approaches are *Water Sensitive Urban Design* (WSUD) in Australia, *Sustainable Drainage System* (SuDS) and *Sustainable Urban Drainage System* (SUDS) in Great Britain and Scotland, *Best Management Practices* (BMPs) and *Low Impact Development* (LID) in the United States, *Alternative techniques* (ATs) in French speaking countries, *Source Control* in Canada, etc. [5].

For example, *Sustainable Drainage System* (SuDS) is an stormwater management approach that takes into account the amount of water (flooding), water quality (pollution) and questions of affection, while in technical terms it presents a set of management practices, control facilities and strategies designed to efficiently and effectively drain surface water, while reducing pollution to the smallest possible extent and managing the impact of quality on local water bodies. On the other hand, WSUD is an approach based on the integration of stormwater management into the process of urban planning and design in order to reduce environmental degradation and improve its sustainability and attractiveness [6]. However, regardless of specificity and certain differences, all approaches are commonly based on the same conceptual definition (Figure 2) - replacement of the existing drainage system in urban basins or creating new drainage systems using measures and elements that imitate or support the natural environment [1].

1 Figure 2. Evolution in stormwater management [7]

Also, all approaches offer a set of different technologies and ways of treating rainfall. There are four basic treatments, which are applied in modern approaches, separately or in combination, and which are also representative of the evolution of contemporary approaches in relation to the traditional approach (Figure 3). These are: 1) infiltration; 2) disposal; 3) storage; and/or 4) re-use of atmospheric water. Each of the treatment modes involves the application of different systemic measures and technical elements.

Depending on the approach, the elements are differently defined, although in general they have the same function.

2 *Figure 3. Traditional vs. modern stormwater management approach [8]*

Thus, WSUD recognizes the following elements: 1) swales (dry or wet); 2) filter trenches; 3) sand filters; 4) bioretension systems; 5) porous paving; 6) infiltration channels; 7) infiltration basins; 8) rainwater tanks; and 9) elements of landscape architecture. In the framework of SuDS, the division of elements is as follows: 1) porous paving (pedestrian communication and other surfaces); 2) filter belts; 3) filter and infiltration trenches; 4) swales (dry or wet); 5) retention ponds; 6) underground rainwater storage tanks; 7) swamps; and 8) little water surface - lakes (Figure 4).

Figure 4. Technical elements of SuDS integrated in the process of urban regeneration in residential ares of Augustenborg, Malmo [9]

Infiltrationbased elements are primarily designed to dispose atmospheric water into the ground, with its complete removal through the drainage system from the atmospheric sewage, which also requires the use of porous substrates. Storage-based elements retain part of the flow but have limited capacity (when it reaches, excess water goes into atmospheric sewage). Some of the elements, such as bioretensions, can provide both, while many approaches offer a combination of infiltration and storage by the application and incorporation of a set of technical elements into the whole system.
In addition to the above, other technical elements, such as sedimentary basins - basins for collecting deposits, tampon systems, elements for the treatment of street timber, are possible, and also the use of green roofs (Figure 4). It should be noted that green roofs are not a compulsory technical element of contemporary approaches, since adequate rainwater treatment can be realized without them. However, the green roofs are recognized through practice as an important technical and aesthetic element in the integrated stormwater management approach, which, in addition to turning and channeling the drainage from the combined sewage system to the green areas with infiltration systems (1), and the transfer of atmospheric waters from the traffic surfaces through shallow greened liner bioretentions in the lakes or dry depression in the open space (2), became the third, most well-known and applied measure in time (Figure 4).

4. BENEFITS OF INTEGRATING MODERN STORMWATER MANAGEMENT APPROACHES IN THE PROCESS OF URBAN REGENERATION

Preconditions for the development of modern approaches and their subsequent integration into the urban planning and design process originated in the 1980s. Under the paradigm of "living with water", there was a general departure from the concept of water as “urban and city life enemy” and “hidden element behind pipes and taps”, to an “element that contributes to the quality of life”. In addition to providing an opportunity to integrate modern approaches into the process of urban planning and design, these circumstances also favored a radical change in the urban development paradigm [10], primarily in terms of the evolution of the role of urban water cycle management, its conceptual framework integration and cumulative socio-economic factors (Figure 5).
The basic intention of the new conceptual framework is to establish a greater harmony between water as a key resource and the social community through a process of urban planning and design in a sustainable, socially rational and responsible way. Accordingly, the goals of integrating modern approaches in the conceptual and methodological framework of urban planning and design, including urban regeneration, is to create an attractive, functional and "environmentally-friendly" urban environment. In that term, with its physical and functional structure, this environment would be adapted to future challenges of urbanization, environmental protection and climate changes.
This determination certainly involves the transformation of a traditional urban approach, whose principles of planning and design and the accompanying methodological framework are often based on sectoral and *ex post* consideration of the problem of channeling stormwaters. Instead, a modern urban approach has been established, which is both conceptually and methodologicaly *ex ante* "water sensitive", which can have

numerous benefits for the utilization and design potential of urban spaces and its ecological characteristics (Figure 6).

Figure 5. Relations between the evolution of stormwater management, cumulative socio-political drivers, urban planning and design process and transformation of the city [10]

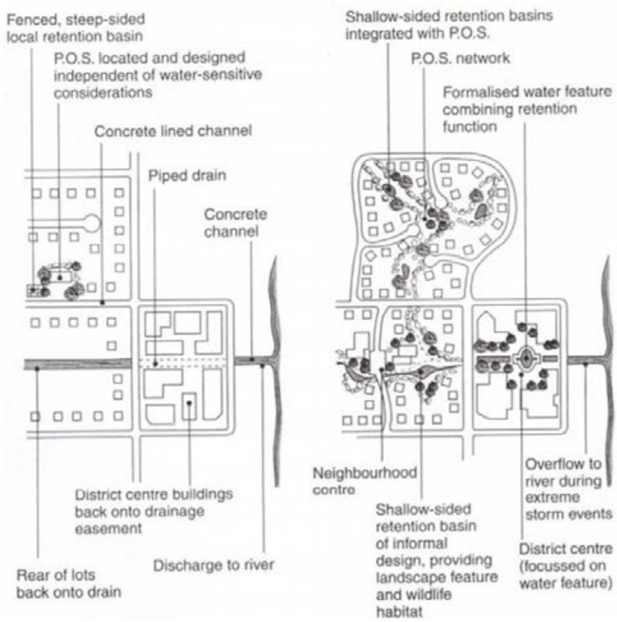

Figure 6. Difference between traditional and modern approach and their influence on characteristics of urban areas in urban design and regeneration process [11]

On the other hand, modern approaches, in contrast to the traditional ones, offer the possibility, in addition to reducing the amount of surface waters and flooding of the area, to form or increase the degree of utilization and design potential of the urban environment, both newly planned and already existing (Figure 4). In this way, the principles of modern approaches are in correlation with the principles of current theoretical approaches to urban development and urban planning and design, such as *New Urbanism*, *Smarth Growth* and *TOD - Transit Oriented Development*. Modern approaches are also in close correlation with the *European 2020 Strategy* (EU 2020), the *Green Infrastructure* and *Green Urbanism*. Modern approaches have thus become important as a conceptual framework and as a methodological tool of urban planning and design which leads to: improving recreation and housing features, creating quality open spaces/multifunctional open spaces, increasing the level of biodiversity in the urban areas, allowing closer contact with nature, reducing the effects of the thermal island or re-use of rainwater.

In addition to practical solutions related to the management of quantity and quality of stormwater, modern approaches provide a whole set of planning and design solutions and possibilities in the development of newly-planned and/or regenerated inherited sites. Because they are based on the application of measures and elements that imitate or support the natural environment, contemporary approaches provide the possibility of applying a wide range of different elements in forming or improving the usable and design potential of urban spaces, since each technical element has its own specific use and design characteristics (Figure 4). The experiences of the countries that have integrated modern stormwater management approaches in the process of urban regeneration indicate that the effects of applying their principles, measures and technical elements (at different spatial and functional levels of the organization of the urban environment) influenced a higher degree of its: 1) sustainability; 2) flexibility and adaptability; 3) the ability to respond to climate change; and 4) ecological comfort and sense of comfort [12].

The application of modern approaches, either through comprehensive or partial coverage, is particularly important in housing areas. The approaches are of particular importance for the treatment of public, semi-public and private open spaces within these areas, since the quality of life depends largely on the types of organization, typological structure, use and design potential. As most approaches support "environmentally friendly" housing and lifestyle, the previously mentioned technical elements (green roofs, bioretensions, rain gardens, porous paving, etc.) are in direct relation to the degree of usable and design quality of open spaces an its key characteristic: 1) ecological comfort, which is evaluated through indicators, such as physical isolation in relation to streets (a), percentage of green areas, their position and form/type (b), and percentage of increase in biodiversity (c); 2) diversification of contents and forms of open spaces; 3) the level of safety and privacy, which is evaluated through indicators, such as implemented materials for construction of open spaces surfaces and communications (a) [13], various forms of visual and physical protection and barriers (b), spatial distance and size of the area that is isolated from access to the motor traffic or communications access and views of the pedestrian communication (c) and other physical dimensions and urban and architectural design arrangements (d); 4) social sustainability.

When it comes to the relations between modern approaches and landscape architecture, it is possible to identify three dominant design approaches: 1) traditional; 2) integrated;

and 3) artful. The traditional approach does not have any additional benefits for shaping the space and quality of life in the urban environment, since the stormwater is directly driven into the separate sewage system. An integrated approach is based on incorporation of technical elements of modern approaches into the process of planning and design of open space. Artful rainwater design refers not only to channeling the stormwater, but also to the transformation of space and the creation of its identity, based on the benefits and design possibilities of the technical elements of modern approaches.
Examples of good practice suggest that modern stormwater management approaches have found their adequate application within the process of urban regeneration as one of the key methods in the urban planning process and design of inherited urban structures.

5. CONCLUSION

Most modern approaches are in full synergy with urban regeneration as one of the key methods of a sustainable and socially rational process of urban planning and design. Based on the conducted analysis, it can be concluded that environmental improvements, improvement of the built environment and empowerment of the local community are recognized as key benefits of implementing the modern stormwater management approaches in urban regeneration process. The analysis of current theoretical and practical experiences has shown that the benefits of applying modern approaches within urban regeneration are numerous and, among others, include: 1) reducing the risks and incidents of floods; 2) improving usage and morphologic characteristics of urban areas, especially the open spaces; 3) providing ways to supplement the water supply systems in areas that are under stress; 4) efficient rainwater treatment, 5) improving biodiversity, 6) reducing the impact of urban heat island. All these represent a contribution to mitigating the expected negative impacts of climate change.

REFERENCES

[1] Gordon-Walker, S., Harle, T., & Naismith, I.: Using science to create a better place. Cost-benefit of SUDS retrofit in urban areas, **2007**., Science Report – SC060024, Environmental Agency, Bristol
[2] https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=139, download 03.05.2018.
[3] Wong, T. H. F.: An Overview of Water Sensitive Urban Design Practices in Australia. *Water Practice & Technology*, **2006**., vol 1, № 1, p.p.
[4] http://greatlakesresilience.org/case-studies/infrastructure/resilient-stormwater-planning-takes-time-and-pays, download 05.03.2018.
[5] Fletcher, T. D. Shuster, William, H., William F. A., Richard. Butler, D., Arthur, S., Trowsdale, S., Barraud, S., Semadeni-Davies, A., Bertrand-Krajewski, J., Steen Mikkelsen, P., Rivard, G., Uhl, M., Dagenais, D., Viklander, M.: SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage. *Urban Water Journal*, **2015**, vol.12, № 7, p.p. 525–542
[6] http://www.rms.nsw.gov.au/documents/projects/planning-principles/urban-design/water-sensitive-urban-design-guideline.pdf, download 20.11.2017.

[7] https://www.slideshare.net/KatiePekarek/stormwater-and-water-quality-trading-from-10000-feet download 20.11.2017.
[8] https://inhabitat.com/pierces-park-combines-art-play-and-stormwater-management-into-a-stunning-urban-oasis-in-baltimore/pierces-park-by-mahan-rykiel-23/, download 20.11.2017.
[9] http://www.malmo.se/English/Sustainable-City-Development/Augustenborg-Eco-City.html, download 20.11.2017.
[10] Brown P., Keath H., Wong T.: Transitioning to Water Sensitive Cities: Historical, Current and Future Transition States, 11th International Conference on Urban Drainage, **2008**, Edinburgh, Scotland, UK
[11] https://www.sa.gov.au/__data/assets/pdf_file/0003/21756/WSUD_chapter_2.pdf, download 20.11.2017.
[12] Vasilevska, Lj., Blagojević, B., Vasilevska, M.: Linijski tehnički elementi u integrisanim pristupima upravljanju atmosferskim otpadnim vodama, *Zbornik radova Građevinsko-arhitektonskog fakulteta*, **2014**, № 29, p.p. 27-43
[13] Vasilevska, M., Vasilevska, Lj.: Porous concrete as a technical element of modern stormwater managament approaches: usable and morphologic potential in the process of urban design, *Zbornik radova III Medjunarodna naučno-stručna konferencija Tehnologija betona SFERA*, **2017**, p.p. 136-141

САВРЕМЕНИ ПРИСТУПИ КАНАЛИСАЊА КИШНОГ ОТИЦАЈА У УРБАНОЈ РЕГЕНЕРАЦИЈИ

Резиме: *Као одговор на климатске промене, негативне ефекте урбанизације и индустријализације, као и бројне социо-економске, физичке и енвајронменталне промене у урбаним срединама и урбаним сливовима, у развијеним земљама су у последњих неколико деценија генерисани и имплементирани интегрисани приступи канализања кишног отицаја, односно управљања атмосферским водама. Они се заснивају на принципу дужег а безбедног задржавања кишнице у урбаном сливу, што се постиже применом низа системских мера и техничких елемената осмишљених тако да што мање утичу на природни хидролошки циклус. Користи њихове примене су вишеструке, на шта указује искуство земаља које су кроз дефинисање одговарајућег законског и институционалног оквира омогућиле интеграцију примене савремених приступа канализању кишног отицаја у процес урбанистичког планирања и пројектовања.*

Кључне речи: *савремени приступи каналтисања кишног отицаја, урбанистичко планирање, урбанистичко пројектовање, урбана регенерација, интегрисање*