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BENEFITS OF SYNERGY OF URBAN GREEN INFRASTRUCTURE AND INTEGRATED STORMWATER MANAGEMENT APPROACHES: THEORETICAL PERSPECTIVE AND EXAMPLES FROM VIENNA

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Magdalena Vasilevska, Ljiljana Vasilevska

Faculty of Civil Engineering and Architecture University of Nis, Serbia

Abstract. *This paper deals with multiple benefits and outcomes at a lower spatial-functional city levels generated by the synergy of Urban Green Infrastructure approach and integrated stormwater management approaches, resulting from their simultaneous application in the process of urban planning and design. The conducted research examines and analyzes key characteristics of Green Infrastructure and integrated stormwater management approaches, as well as their relationship in terms of principles, spatial-functional forms, types and benefits of their implementation. Since both of them are based on supporting and mimicking the natural environment in urban conditions, which makes them environmentally friendly and allows a greater presence of nature in many urban circumstances, the focus is on investigation of two common main principles and benefits of their implementation - closer connection with nature and increase of biodiversity in urban environment. The research platform consists of selected examples from Vienna which represent different types of lower spatial-functional levels in which both approaches are applied, making them suitable for examining the effects of their synergy.*

Key words: *Urban Green Infrastructure, integrated stormwater management approaches, implementation, synergy, benefits, Vienna*

1. INTRODUCTION

Cities across the globe have been facing a lot of social, economic, spatial and environmental problems and challenges caused and shaped by various factors, among which the most significant are rapid urbanization, mass migration, climate changes and economic

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Corresponding author: Magdalena Vasilevska
Faculty of Civil Engineering and Architecture, Aleksandra Medvedeva 14, 18000 Niš, Serbia
E-mail: magdalena.vasilevska@gaf.ni.ac.rs

development, especially industrialization. In addition, cities face challenges related to public safety, public health, modernizing water and transportation infrastructure, improving urban design, feeding growing populations, including communicating urgent, but less visible sustainability problems to stakeholders [1]. In the attempt to find sustainable solutions and responses to the arising challenges, in the last decades, several concepts and approaches to urban design and planning have been developed on a theoretical level and applied through urban practice. The most known are New Urbanism, Smart Growth, Compact City, Transit Oriented Development, Ecological Urbanism etc. At the same time, in order to solve the problems related to water management, particularly stormwater, several integrated stormwater management approaches have also been developed. The best known 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 and Source Control in Canada [2][3]. In addition to solving the problems of flooding and the problems of quantity and quality of rainwater, in the meantime, the third basic goal of most of them became to replace and/or increase the capacity of the existing drainage system in urban catchments by mimicking the natural environment [4]. This conceptual shift also led to their synergy with the most contemporary urban approaches, especially those based on the importance of the natural environment and an ecological approach to the urban planning and design, such us Ecological Urbanism [5] and interrelated movement - Green Urbanism, Urban Green Infrastructure, Green-Blue Infrastructure, Landscape Urbanism, Sustainable Urbanism: Design with Nature, etc. [6][7][8][9], while simultaneously achieving the primary goals of contemporary urban planning and design process - improving the quality of life and the quality of the built environment [10].

This research considers and investigates multiple outcomes and benefits at lower spatial-functional city levels generated by the synergy of Urban Green Infrastructure (hereinafter UGI) and integrated stormwater management approaches (hereinafter ISMA), resulting from their simultaneous application in the process of urban planning and design. Since the UGI and ISMA are based on the supporting and mimicking the natural environment in urban conditions, that makes them environmentally friendly and, among others, allows a greater presence of nature in urban areas. In line with this, the research focus is on the analysis of two significant principles/outcomes which are common for both approaches: 1) closer connection with nature, and 2) increase of biodiversity in urban environment, in terms of its forms, types of spatial-functional organization and possibilities for improving a quality of everyday life, i.e. benefits of their implementation.

Accordingly, the main research goals are the following: 1) to analyze the relationship between UGI and ISMA in terms of goals, principles, spatial-functional forms and general benefits of their implementation; and 2) to scrutinize the synergy effects and benefits resulting from simultaneous application of both concepts/approaches at lower spatial-functional city level through analysis of selected examples, with the focus on benefits achieved from the closer connection with nature and increase of biodiversity in urban environment. The selected examples from Vienna, Austria represent the research platform.

2. METHODOLOGY

In analyzing the connection and relationship between the UGI and ISMA, as well as in exploring their relationship in terms of goals, principles, spatial-functional forms and benefits of their implementation, the methodological framework is based on an analytical approach which relies on description and analysis. Several examples from Vienna are chosen as a research platform to scrutinize the synergy effects and benefits resulting from simultaneous application of UGI and ISMA at lower spatial-functional city scale. They represent lower spatial-functional scales with different functions: 1) housing/neighborhoods, 2) recreation/parks and inner courtyards, and 3) commercial/spaces for retailing and other services. In each of them, both approaches are applied, making them suitable for examining the effects and benefits of their synergy. In this part of the research are applied methods of analysis and observation. The observation was conducted during the second half of July in 2016, 2017 and 2018. In addition to considering the basic characteristics of chosen examples, it included identification and assessment of the impact on the quality of everyday life of both soil-based and building-based urban and architectural forms which are achieved by applying the principle of closer connection with nature and increasing biodiversity.

3. URBAN GREEN INFRASTRUCTURE AND INTEGRATED STORMWATER MANAGEMENT APPROACHES - SETTING THE CONTEXT

In order to understand the connection and relationship between UGI and ISMA, as well as the synergy effects resulting from their simultaneous application in the process of urban planning and design, it is necessary to explain their basic characteristics.

3.1. Urban Green Infrastructure (UGI)

The concept of UGI became increasingly important and prominent in the last decade across the different scientific disciplines, development and urban policies, as well as urban planning and design. There are different, often convergent, definitions of this concept. It is understood as a strategic approach to develop “an interconnected network of green space that conserves natural ecosystem values and functions, and that provides associated benefits to human populations” [9]. At the pan-European scale, this approach can be crucial for achieving the 2020 biodiversity target [11][12]. According to the GREEN SURGE project [13] and MEA [14], UGI is seen as a planning approach aimed at creating networks of multifunctional green space in urban environments.

Despite differences, the following is common to all of them - UGI can contribute to a sustainable future for cities by addressing major urban challenges, such us land use conflicts, climate change, biodiversity conservation, demographic changes, a greener economy, and human health and wellbeing. Urban green spaces (in further text UGS), with various and diverse typological characteristics, are a key physical and functional urban form in the implementation of UGI in urban practice. They play multiple roles in making cities more sustainable, well-functioning and livable: 1) providing recreation in everyday life, at different city scales; 2) contributing to the conservation of biodiversity; 3) contributing to the cultural identity; 4) help maintaining and improving the environmental quality; and 5) bringing natural solutions to technical problems, for example sewage treatment or stormwater treatment [15].

In addition, the increasing interest in UGS is also driven by several other factors such us: 1) widespread concern for the decline in the quality and condition of many parks and other UGS due, in part, to their generally low priority in the political agenda at both national and local levels; 2) growing emphasis on the need for more intensive development in urban areas, focused around the Compact city concept as the model for future cities in Europe, raising questions about the role of green space in this model which is based on the densely populated and compact physical structure; 3) parallel emphasis on the development of brownfield rather than greenfield land, and a recognition that more intensive urban development may sometimes involve the sacrifice of existing areas of UGS [16][17].

Due to various ways to classify UGS, the different typologies are present. For example, Swanwick et al. [16] recognize 25 UGS types, divided into four main groups (amenity green space, functional green space, semi-natural habitats, and linear green space) and 10 subgroups, while Bell et al. [18] under UGS considered parks and gardens, natural and semi-natural spaces, green corridors, allotments, community gardens and urban farms, outdoor sport facilities, amenity green spaces, provision for children and young people, cemeteries, disused churchyards and other burial grounds, as well as other public spaces, such as squares, pedestrian areas or cycling areas. Other typologies are based on usage [19], dimensions of green spaces that are important for urban consolidation, i.e. size, naturalness, activity types etc. [20], or cover informal UGS [21].

Although there are still present knowledge gaps and doubts how exactly UGI and UGS can help address the moderation of climate change effects and produce sustainable urban solutions, there is a consensus that their basic purpose is urban ecosystem services provision. Research findings indicate that a wide range of ecosystem services is provided through different, already recognized and/or suggested types of UGS [17]. The main categories of urban ecosystem services, the modes and purpose of providing services, as well as a connection with different types of UGS are shown in Table 1. Additionally, it also indicates a close connection between UGI and ISMA, in terms of purpose/function and types of green spaces.

3.2. Integrated stormwater management approaches (ISMA)

Prerequisites for the development and later evolution of ISMA originated in the 1980s when the general shift happened from the concept of water as "urban and city life enemy" and "hidden elements behind pipes" to water as "an element that contributes to the quality of life" and "the location factor at the city level". New paradigm "living with water" was a part of a wider social discourse, established under the influence of the movement of Ecological Urbanism [6] [22] [23].

In addition to creating new approaches to stormwater management, these circumstances created opportunities for their integration into the urban planning and design process and, moreover, led to radical changes of the urban planning and design paradigm [24], primarily in terms of the evolution of the role of urban stormwater management in planning process, their conceptual and methodological framework and cumulative socio-economic effects.

New approaches to stormwater management are conceptually quite different from the traditional approach (Table 2). The basic intention of most of them is to establish a greater harmony between water as a key resource and the community, in a sustainable, socially rational and responsible way [25]. Consequently, close connection with nature and its involvement into the urban environment are at the core of paradigm shift which generated a new, ISMA.

Table 1 Urban ecosystem services provision as a basic role of Urban Green Infrastructure: Urban ecosystem services and accompanied types of urban green spaces

Main category of urban ecosystem services	Type of and purpose/role of ecosystems (ESs)	Type of urban green spaces and type of ESs
1. Provisioning services *The services that describe the material or energy outputs from ecosystems*	Raw materials (RM) *ESs provide a diversity of materials for fuel and construction* Fresh water (FW) *ESs regulate the flow and purification of water (vital role in the global hydrological cycle)* Food (F) *ESs provide the conditions for growing food* Medicinal resources (MR) *ESs provide plants used as traditional medicines and raw materials for the pharmaceutical industry*	Green roof (F, MR) Courtyard (F) Gardens (F) Community garden (F) Plot (F) Forest (F and RM) Lake, pond (F)
2. Regulating services *The services that ecosystems provide by acting as regulators*	Local climate and air quality (LCAQ) *ESs regulate air quality, provide shade and influence rainfall and water availability, removing pollutants from the atmosphere* Carbon sequestration and storage (CSS) *ESs store and sequester greenhouse gases, remove carbon dioxide from the atmosphere, improve the capacity to adapt to the effects of climate change* Moderation of extreme events (MEE) *ESs moderate extreme weather events or natural hazards, such us storms, tsunamis, floods, avalanches etc. ESs and living organisms create buffers against natural disasters* Waste-water treatment (WWT) *ESs filter both animal and human waste and act as a natural buffer to the surrounding environment*	Green wall (LCAQ) Green roof (LCAQ, MEE, WWT) Bioswale (MEE, WWT, LCAQ) Tree alley and street tree, hedge (LCAQ, CSS, MEE) House garden (CSS, LCAQ, MEE) Park, neighborhood park (LCAQ, CSS, MEE) Forest (LCAQ, CSS) Wetland (CSS,MEE, WWT)
3. Cultural services *The services which include the non-material, socio-ecological benefits (including psychological and cognitive benefits) people obtain from contact with the environment*	Recreation (R) *ESs provide physical and mental health, as well as socio-ecological and economic benefits* Tourism (T) *ESs provide physical and mental health, as well as socio-ecological and economic benefits* Aesthetic appreciation and inspiration for culture, art and design (AAD) *ESs provide physical and mental health, as well as socio-ecological and economic benefits* Spiritual experience and sense of place (SP) *ESs provide physical and mental health, as well as social and economic benefits*	Green roof (R, AAD) House garden (R, AAD, SP) Park (R, T, AAD) Neighborhood park (R, SP) Community garden (R, SP) Forest (R, T, AAD, SP) Lake, pond (R, T, SP)
4. Habitat and supporting services *The services which underpin almost all other services by providing living spaces*	Habitats for species (HfS) *ESs provide biodiversity and closer connection with nature* Maintenance of genetic diversity *ESs provide biodiversity and closer connection with nature*	Balcony (HfS) Green roof (HfS) Bioswale (HfS) Tree alley (HfS) Forest, park, garden, plot (HfS)

Source: Authors, based on EASAC [26] and TEEB [27] typology of urban ecosystem services

In line with this, ISMA offer a set of different technologies and treatment modes, which also represent evolution and innovation in relation to the traditional approach [28]. The following four basic modes of runoff treatment are recognized: 1) infiltration; 2) disposal; 3) storage; and/or 4) re-use [29]. They can be applied separately or in combination, where each of them implies implementation of different technical elements. Although the typology and significance of a particular element varies depending on the approach, in general, technical elements within them are similar and serve the same purpose. The most known technical elements are: 1) swales (dry or wet); 2) bioretetions; 3) trenches; 4) sand filters; 5) ponds and lakes; 6) porous paving; 7) wetlands; 8) rainwater tanks; 9) elements of landscape architecture (green walls, for example) etc. Green roofs are not a mandatory technical element, but their application proved to be very useful in the treatment of rainfall, so they became an unavoidable technical element of all modern stormwater approaches in many urban situations - the third most widely used technical element after bioretentions and porous paving.

Table 2 Integrated vs. traditional stormwater management

	Traditional stormwater management	Integrated stormwater management
Goal	Remove runoff quickly	Reduce runoff volume Maximize all watershed values
Approach	Engineering	Holistic
Scale	Sewer system	Watershed
Action	Reactive	Proactive

Source: Adapted by authors

Conceiving of modern approaches on the application of measures that imply or support the natural environment allows greater presence and involvement of nature in urban areas. Previously conducted research by the authors [30], which refers to the relationship between different types of technical elements and the expected elements of the natural environment that their application allows, indicate the following: 1) strong relationship between the most technical elements and the elements of nature environment; 2) application of one technical element often involves several elements of nature; and 3) beside the main characteristic of each technical element and its role in stormwater management approach, the intensity of connections between the technical element and certain elements of nature depends primarily on the design approach, climate conditions and spatial-functional capacity of a particular location. Consequently, each of the mentioned technical elements and accompanying elements of natural environment are actively involved in creating of usable and morphological potential of a particular location or urban area. As most of ISMA support environmentally friendly lifestyle, the synergy between technical elements and accompanying natural elements directly affects the quality of life, as well as the quality of the built environment. Each of the characteristics is accompanied by a set of measurable indicators. For example, ecological comfort can be evaluated through indicators such as: a) physical isolation from streets and other sources of noise and pollution, b) amount of greenery, c) disposition, form and type of greenery, d) biodiversity, etc. Safety and privacy, which are of great importance especially in residential areas, can be evaluated through indicators such as: a) applied construction materials for outdoor surfaces and communications, b) intensity of presence and types/forms of visual and physical protection and barriers, c) distance and size of the area that is isolated from access to the motor traffic, d) distance and size of the area that is isolated from access and views from the primary pedestrian communication, etc.

3.3. Relationship between Urban Green Infrastructure and integrated stormwater management approaches

Conducted analysis indicates a close connection and strong, multifunctional links between UGI and ISMA. The links can be recognized on the conceptual level and translated more obviously on the functional and technical level. Namely, both approaches serve to provide an ecological framework for social, economic and environmental health in the urban conditions. In this context, multifunctionality refers to the integration and interaction of different functions or activities on the same urban site, designed and covered by elements and forms of both approaches which support or mimic natural environment. In addition, one of the main role of UGI is stormwater management in urban circumstances and vice versa, UGI can be a component of WSUD, SuDS or SUDS, designed to manage water quality and quantity, while at the same time provide improvements related to biodiversity and amenity [31]. Elements of nature, including UGS, can be used within UGI to provide important ecological services for communities, simultaneously protecting them from flooding. The analysis of the typologies of UGS also confirms this, since the technical elements of ISMA (bioretension, wetland, etc.) are often identified as one of the key types of UGS [17].

The synergy of UGI approach and ISMA, resulting from their simultaneous application in the process of urban planning and design, can lead to many economic, ecological and social benefits. Some of them are thoroughly analyzed on the examples in the next section of this paper.

4. Synergy of Urban Green Infrastructure and Integrated Stormwater Management Approaches - Best Practice Examples from Vienna

As a model of sustainable urban development and best practice examples by many other cities, among others, Vienna applies UGI and ISMA in the current urban practice in a systematic and institutionally supported way, in order to achieve sustainable and efficient urban development that leads to a better quality of life. In a broader sense, both approaches are targeted as a part of The Smart City Wien framework strategy [32], adopted on 2014, which defines goals for the development of a city that assigns priority to, and interlinks, the issues of energy, mobility, buildings and infrastructure. The framework strategy defines one meta goal for 2050:"The best quality of life for all inhabitants of Vienna, while minimizing the consumption of resources. This will be realized through comprehensive innovation." In addition, the stormwater management is also targeted within several strategies, documents and guidelines adopted by the city of Vienna, such as Urban Heat Islands (UHI) - Strategieplan Wien [33], Integratives Regenwassermanagement – Motivenbericht, Beispielsammmlung [34], Regenwassermanagement. Nachhaltiger Umgang mit wertvollem Regenwasser [35], etc.

UGI and ISMA are applied at different spatial-functional levels across the city, both in newly developed areas and in those that are undergoing urban regeneration. The selected examples represent both cases on the lower spatial-functional city levels - neighbourhoods and sites. In addition to identification of elements and forms of nature made by applying both approaches, shaped by planning framework, site conditions, implemented measures, and urban, landscape and architectural design, the multiple benefits of the simultaneous application of both approaches are considered.

4.1. Autofreie Mustersiedlung

Experimental building, often in form of 'theme-oriented' estates with topics pre-determined by the city, has a major share in the qualitative development of Vienna social housing in the 1990-es. The largest of this kind in Europe, with building lot size approx. 11.400m^2, is the Autofreie Mustersiedlung (car-free model estate), planned in 1994 by architects Schindler, Szedenik, Lautner and Scheifinger, completed in 1999/2000 (Fig. 1a). This neighborhood transferred the means needed normally for the construction of car parks into an environmentally friendly infrastructure that include greened roof-gardens, parking lots for bicycles, internet-cafe, meeting rooms, children's day-care centre, etc. A comprehensive ecological concept was realized: low energy consumption level, use of solar energy, a loading station for electric cars, heat recovery from waste water, a grey water system, runoff treatment, green areas with humid biotopes and intensive planting, including pond green walls (Fig. 1b and 1d).

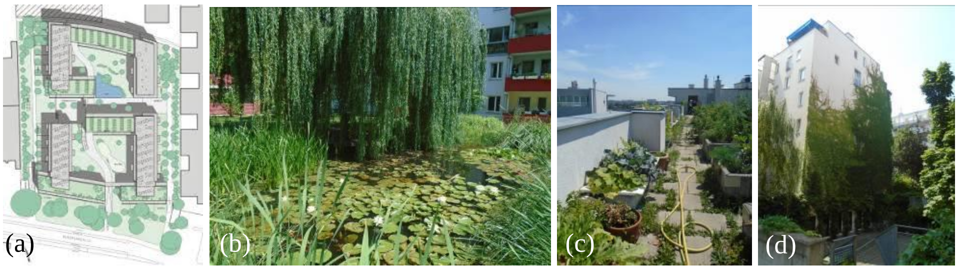

Fig. 1 Autofreie Mustersiedlung. (a) Plan. (b) Pond and surrounding greenery in the inner courtyard. (c) Green roof - rooftop farming. (d) Green wall. Sources: (a) http://www.gewog-wohnen.at/media/1044/af_broschure.pdf.; (b), (c) and (d) Authors

The main technical element for stormwater treatment is a green roof. Three roofs are intensively planted for the general use, two roofs are with raised beds and intensively landscaped, while two roofs on which solar panels are attached are designed as gravel roofs (Fig. 1c). At the same time, greened roof-gardens provide additional, multiple benefits - possibilities for urban agriculture (Fig. 1c), children education, social interactions, they improve ecological comfort/microclimate and create healthy and pleasant urban environment. The decorative pond is in a focus point in one of two courtyards within the housing area (Fig. 1a and 1b). The feeding of the decorative pond as well as the irrigation takes place via a water well, the water is cleaned by UV irradiation. The pond has a seepage pit for the excess water bellow.

4.2. Hagedornweg

Hagedornweg is as social housing neighborhood built-up in twenty-second Vienna's district, designed by Göth and Guttmann (DonauConsult KT), completed in 1996. Building lot size is approx. 26.000m^2. The greenery and biotope pond, with total size approx. 2600m^2, are in the focus of the central courtyard (Fig. 2a), as well as of the whole urban composition (2a, 2b and 2c). The feeding of the biotope pond as well as the irrigation takes place via a water well, while the water is cleaned by UV irradiation. The pond has a seepage pit for the excess water bellow (with circulation pumping system).

The original intention to discharge the roof rainwater into the biotope pond was not realized due to the long-term planning and relatively dense buildings accumulating the water, which led to large water level fluctuations in the pond. Extreme rainfall and excess water infiltration takes place in a swale adjacent to the pond. However, as the most important element that mimics the natural environment, pond provides additional benefits such as a healthy and pleasant environment, close connection with nature, improves biodiversity, mitigates urban heat island, provides diversification of use (recreation, leisure) and provides a powerful aesthetic experience (Fig. 2a and 2b).

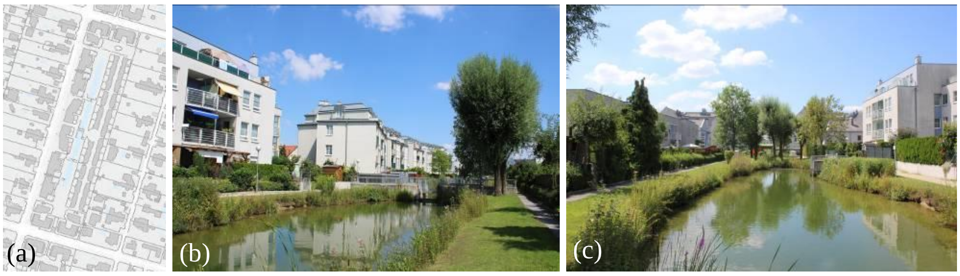

Fig. 2 Hagedornweg. (a) Plan. (b) and (c) Pond/Biotope and surrounding greenery in inner courtyard. Sources: (a) Stadt Wien – Vienna GIS. www.wien.gv.at/viennagis/; (b) and (c) Authors

4.3. Spar Supermarket, Engerthstrasse

Spar Supermarket in Engerthstrasse was built in 2010 within an existing park in the densely built-up housing and mix-use area in the second district. It is an example of good practice that utilizes a green roof as a type of UGS and as a technical element of stormwater management in order to compensate for greenery in the limited spatial conditions, as well as to maintain the existing ratio between built and green areas within the residential area (Fig. 3a). Building lot size is 2.526m^2. Plant size is approx. 1500m^2, where the green roof surface participates with 921m^2, and the area under slopes with 629 m². The supermarket is built mostly under a gently rising artificial hill (Fig. 3b). The roof area and the slopes were planted with waves form of lavender and grass leaking into the adjacent green area (Fig. 3a and 3c). Multiple use and ecological benefits are recognized in the following: more public open space in limited urban conditions, more greenery, quality landscape design which supports the natural environment, improvement of microclimate, improvement of air quality, improvement of biodiversity, creating possibilities for recreation, leisure and social interaction, and reduction of energy demand.

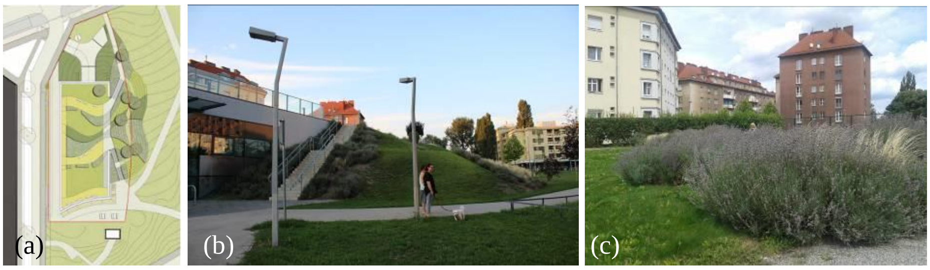

Fig. 3 Spar Supermarket in Engerthstrasse. (a) Plan. (b) and (c) Intensive green roof. Sources: (a) K. Grimm; (b) and (c) Authors

4.4. Boutiquehotel Stadthalle

Boutiquehotel Stadthalle was built in 2009 in a densely built-up housing and mix-use area in the fifteenth district (Fig. 4a). It is designed as a passive house and represent the first city hotel with a zero-energy balance, which is made possible by the use of solar panels, photovoltaic panels (Fig. 4b and 4d), water-heat pump as well as LED and light bulbs. Environmental friendliness and sustainable tourism are also supported by implementation of 145m^2 intensive green roof "Lavendeldach" (Fig. 4b), 140m^2 extensive green roof, courtyard garden, as well as green walls, both from the street side and inner courtyard (Fig. 4c and 4d), providing the natural cooling. For the contributions to the CO_2 emission reduction, the hotel has already been awarded numerous prizes.

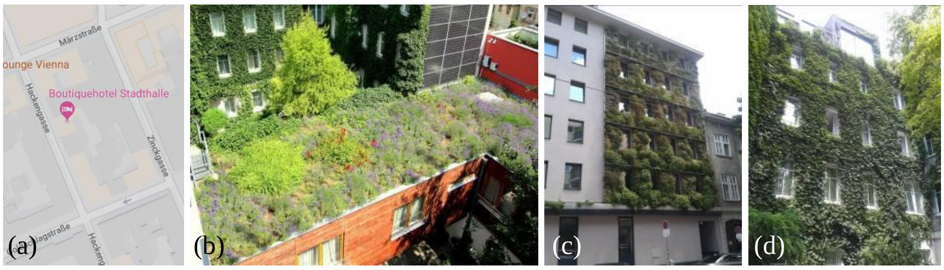

Fig. 4 Boutiquehotel Stadhalle. (a) Plan. (b) Extensive green roof - *Lavanderdach*, green wall and photovoltaic panels. (c) Green wall - street facade. (d) Green wall - inner courtyard. Sources: (a) and (b) https://www.google.com/maps, (c) and (d) Authors

4.5. Synergetic effects and benefits resulting from simultaneous application of Urban Green Infrastructure and integrated stormwater management approaches in the chosen best practice examples

An analysis of a chosen best practice examples provides an opportunity to assess the impact of the application of the principles of closer connection with nature and the increasing biodiversity, which is common to UGI and ISMA, as well as the effects of their simultaneous application in the process of urban planning and design. In addition to the closer connection with nature and the increase of biodiversity, which was achieved in all observed examples by applying the appropriate UGI and ISMA technical elements and forms (green roofs, green walls, bioswales, ponds), the conducted analysis also indicates additionally economic, ecological and social benefits, both in newly developed areas (Autofreie Mustersiedlung, Hagedornweg) and in those that are undergoing urban regeneration (Spar Supermarket in Engerthstrasse, Boutiquehotel Stadhalle). The following benefits are recognized: more public open space in the limited urban conditions, more greenery, quality landscape design, improvement of microclimate, improvement of air quality, creating possibilities for recreation, leisure and social interaction, creating possibilities for new jobs, and reduction of energy demand.

5. Conclusion

In relation to the first research goal - *to analyze the relationship between UGI and ISMA*, the conducted research indicates a strong relationship between approaches on the conceptual, functional, organizational, implementation and technical level, since both approaches serve the same broad goal - to provide an ecological framework for social, economic and environmental health in the urban conditions. The research also indicated a high degree of their compatibility, since one of the main purposes of UGI is to manage stormwater, just as UGI is often seen as a component of WSUD, SuDS or SUDS.

In relation to the second research goal - *to scrutinize the synergy effects and benefits resulting from simultaneous application of both concepts/approaches at lower spatial-functional city level in the process of urban planning and design*, conducted analysis of selected examples in Vienna indicates a strong synergy effects and benefits. As the most significant can be recognized the following: 1) creating a healthy and pleasant urban environment; 2) providing a close relationship with nature; 3) improving biodiversity; 4) improving air quality; 5) mitigating urban heat island; 6) improving the usability of the site in limited urban conditions; 7) providing diversification of use - recreation, leisure, education, urban agriculture etc., 8) creating opportunities for social interaction, and 9) creating economic benefits.

The research also points out that the multiple benefits of simultaneous application of UGI and ISMA can be most efficiently generated within the process of urban planning and design, as well as urban regeneration, since they simultaneously serve main goals - improving the quality of life and quality of the built environment in altered urban conditions. The main purpose of integration of UGI and ISMA in the process of urban planning and design is to create an attractive, functional and "environmentally-friendly" urban structure whose physical and functional substructures would be adapted to future challenges caused by rapid urbanization, environmental protection and climate changes. However, research indicates that the application of UGI and ISMA is possible only in conditions when urban planning framework is based on the shift in the urban planning processes based on radical changes of the urban planning and design paradigm, primarily in terms of the evolution of the role of urban greenery and urban stormwater management in planning process, their conceptual and methodological framework and cumulative socio-economic effects. Namely, the principles of traditional urban planning and the accompanying methodological framework are often based on sectoral and *ex post* consideration of the urban green infrastructure and stormwater management issues, which causes in practice many conflicts and does not allow the realization of wide range of UGI and ISMA potentials. In order to contribute to a sustainable future for cities by addressing major urban challenges in a sustainable, socially rational and responsible way, the new urban planning and design framework must be both conceptually and methodologically more *ex ante* "green and water sensitive". In line with this, future research will address the investigation and elaboration of models and methodology of implementation of UGI and ISMA in urban planning and design processes, in an attempt to find an answers how exactly UGI and ISMA, as a part of urban planning, could produce sustainable urban solutions and help solve the problems of rapid urbanization and climate change.

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KORISTI SINERGIJE URBANE ZELENE INFRASTRUKTURE I INTEGRISANIH PRISTUPA UPRAVLJANJU KIŠNIM OTICAJEM: TEORETSKI OSVRT I PRIMERI IZ BEČA

Rad se bavi višestrukim koristima sinergije koncepta Urbane zelene infrastrukture i integrisanih pristupa upravljanja kišnim oticajem na nižim prostorno- funkcionalnim nivoima organizacije grada, generisanim njihovom istovremenom primenom u procesu urbanističkog planiranja i projektovanja. U okviru sprovedenog istraživanja se analiziraju njihove ključne karakteristike i ispituju međusobni odnosi sa aspekta principa, prostorno-funkcionalnih formi, tipova i koristi njihove primene. Budući da se oba pristupa zasnivaju na podržavanju i oponašanju prirodnog okruženja u urbanim uslovima, što ih čini ekološki prijateljskim i omogućava veće prisustvo prirode u urbanoj sredini, fokus istraživanja je na koristima primene dva zajednička principa - bliže povezanosti sa prirodom i povećanja biodiverziteta. Istraživačku platformu čine selektovani primeri iz Beča koji reprezentuju različite tipovi nižih prostorno-funkcionalnih nivoa, što ih čini pogodnim za ispitivanje efekata sinergije.

Ključne reči: *Urbana zelena infrastruktura, integrisani pristupi upravljanju kišnim oticajem, primena, sinergija, koristi, Beč*