New “Revolution” - Green Solutions in Urban Design

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Abstract. The urban environment is constantly changing, which results in the depreciation of its natural elements. Progressing urbanization means that a person ceases to perceive larger cities as an attractive place to live or relax, while the city becomes first and foremost a place of work or an economic center. The thing that may change the attitude of the inhabitants to the attractiveness of the environment is green infrastructure. Greenery in the city space plays biological, recreational and aesthetic functions. What is more, it is a habitat for animal life, increases biodiversity, improves air quality and reduces the effects of climate change. Certainly, the preservation of open spaces and greenery is justified, because of the numerous advantages. That is why innovative solutions are applied for the identification, assessment, and planning as well as management of greenery in cities. A relatively new concept, used by the authors during the research, which relates the design and management of green areas to the needs of a better life of inhabitants, is "green livability". Thus, ecological solutions appear in space based on balancing the expected economic effects in relation to the growing social and environmental needs. The revolution in planning is also increasingly associated with climate change and the migration of the population to a previously unknown scale. This paper presents selected design trends in Poland, Slovakia, and Lithuania, covering green solutions in small scale – including roof gardens, vertical vegetation, rain gardens, community and pocket gardens in cities. In the countries analyzed, there is increasing recognition of the need to change the way of thinking about planning, which results solely from economic or aesthetic needs, towards ecological planning with the participation of society.

1. Introduction
The standard approach to planning of the public and private space in towns and villages has changed over the centuries. It was most often associated with diverse spatial and cultural conditions, and with design and artistic tendencies as well as social development. For several years, a new trend has been increasingly visible, including comprehensive thinking about environmental urban planning. Accordingly the concept of environmental urban planning is related to one of sustainable development dimensions of urban area. Environmental urban planning is also closely related to concepts like green or ecological solutions, green infrastructure or green places. Some of them explore the place based
approach, and architectural solutions, some requires managerial decision making as well as economic evaluations. Furthermore environmental urban planning considers various innovations which make living conditions and environment more attractive to residents. Thus, ecological solutions appear in space based on balancing the expected economic effects in relation to the growing social and environmental needs. The revolution in planning is also increasingly associated with climate change and the migration of population to a previously unknown scale. This paper presents selected design trends covering green solutions in cities and rural areas. There are pro-ecological solutions in small scale, including roofs gardens, vertical vegetation, rain gardens and community/pocket gardens presented. These mentioned pro-ecological solutions are a part of green infrastructure and their significance has become recognized and gradually introduced by numerous cities as formal (top-down) and informal (bottom-up) initiatives [1], depending on local specificities of urban area and the socio-economic context. This is why, as Cilliers [2] state, the environmental considerations have recently become an integral part of developmental thinking and green-environment decision-making.

Multi-functionality is a key characteristic of green infrastructure planning [3] so the analyzed pro-ecological solutions are related to connectivity process which highlights the potential of green infrastructure to combine various social and ecological functions. This multifunctional approach means that green spaces in general can be perceived as a luxury or even basic services in the urban level, because most urban areas have insufficient green spaces due to increasing urbanization placing pressure on space for development [2]. As Kabisch and Haase [4] stated the term urban green space usually encompasses all areas of vegetation found within a city including parks, allotments, residential gardens or roadside trees. So the analysed green solutions of this article can be assumed as innovations for urban residents and visitors comparing them with traditional green spaces.

Hansen and Pauleit [5] explored that the main principles of green infrastructure planning are related to green structure (integration, connectivity, multi-scale and multi-object approach, multi-functionality) and governance processes (strategic approach, social inclusion, transdisciplinarity).

The idea of green infrastructure comes from two basic concepts. The first is to connect green spaces in such a way as to provide benefits to society. The second one underlines the combination of green areas is conducive to preserving biodiversity and preventing habitat fragmentation. All the situations and concepts had influence on the current shape of green infrastructure. Green infrastructure includes a number of components, and their identification largely depends on the used definition. The context and criteria for assessing green infrastructure are also important. For larger green areas in cities in the form of green rings, forests, ecological corridors, diverse areas with different functions, including parks, squares, aquatic greeneries, recreational greeneries, or city gardens, the most important are the issues of recognizing them as a special good affecting livability. It is important to protect, maintain and care for existing areas and, where possible, establish new green areas. A slightly different situation is in the case of compactly built-up space, e.g. in the center or space of a housing estate, where it is not possible to introduce larger forms of greeneries. That is why the essence of our considerations is quite recent, seemingly revolutionary approach to tightly built-up space in cities, namely the use of elements of green infrastructure on a micro scale e.g. green roofs, vertical greeneries, as well as elements impacting the natural environment e.g. rain gardens, or social environment e.g. community gardens, or pocket gardens. Importantly, we selected 3 countries from Central and Eastern Europe for analysis, where the above-mentioned design solutions have been used for only a few years, so relatively recently compared with examples from the world or even Western Europe.

Green infrastructure has gradually become an integral part of urban development, new planning/design strategies and related to the resilience of cities targeting sustainable development. Furthermore green infrastructure provides environmental services [6] as well green infrastructure affect human well-being in the context of an integrated socio-ecological system of the urban areas.
Simic et al. [7] define green infrastructure also as an interconnected network of green spaces which conserves values and functions of a natural ecosystem, providing associated benefits for human population. So in this context, green solutions are becoming an important factor forming living and working style of urban residents, especially for those who prefer urban lifestyles over nature.

2. Methods and area of research

The research focused on the assessment of the current state of green infrastructure and green solutions, including green roofs, green walls, rain gardens and community/pocket gardens in three countries Poland, Slovakia and Lithuania.

The used comparison method enables to explore the examples of good practices or cases how, in different selected countries, green solutions are implemented or developed. The analysis mainly took into account particular assessment criteria (table 1).

| Assessment criterion                     | Its purpose                                                                 |
|------------------------------------------|-----------------------------------------------------------------------------|
| Biological and environmental meaning     | To explore the impact on the nearest built-up, urban, suburban environment  |
| Architectural and aesthetic marking      | To identify the impact on the object, improving the reception of the aesthetics of buildings, or common space, public places |
| Social and educational meaning           | To explore the impact on interpersonal, neighborly, social relations, cognitive values, issues of empathizing space |
| Different functions of facilities and areas | To identify the importance from public, through semi-public or private approaches |
| Location                                 | To disclose existence of green solutions - large cities, medium and small cities, suburban areas |

Own elaboration

The green solutions of selected towns and urban areas were studied using online sources from web pages, literary sources, planning documents, and by on-site research visits.

3. Results and discussion

Green solutions in the regions include differences in terms of function, location and scale examples.

2.1. Vertical greenery – green walls

Vertical greenery is usually established at public or commercial facilities, e.g. shopping centers or hotels (table 2). Multi-species green walls are less often found on private buildings, and if they are already present in single-family or multi-family housing, they are a classic climber covering (there are no new solutions). In the case of public available facilities serving the inhabitants of the analyzed cities, more developed technologies are encountered in the form of extended panels or pocket constructions with plants placed in them. Certain restrictions on the use of various types of panels or structures are also associated with the need of adaptation of the vegetation to habitat and climate conditions. This situation is particularly evident in examples from Poland and Lithuania, and to a lesser extent Slovakia. A good solution in this case is an experimental approach, i.e. one that allows observation of the growth and development of plant species recognized as native or acclimated on special constructions (example from Olsztyn, table 2). The importance of green walls in the concept of green livability is invaluable. Despite the mostly small scale, they affect the health and well-being...
of users, as well as the microclimate. They are of great importance in raising the aesthetics of architecture and the environment.

### Table 2. Vertical Green Walls – examples from selected countries.

| Country  | Town   | Description – greenery | Description – function | Impact on environment | Impact on people |
|----------|--------|------------------------|------------------------|-----------------------|------------------|
| Poland   | Warsaw | The five main climbing species | Building of Foundation for Polish Sciences, front facade | Insulation of the building and good impact on the microclimate inside | The selection and arrangement were designed to make the wall attractive all year round |
| Poland   | Olsztyn | Plants, mainly perennials, placed in pockets – pots made of synthetic felt | Vertical wall - experimental panel in the University Campus Kortowo | In a micro scale, a few set panels can have a significant impact on improving the environmental conditions | Educational values for students and other people, an experimental facility, a place for hortitherapy |
| Lithuania | Vilnius | Plant walls from various species of flowers and various other plants, herbs; a special material is placed on the plastic panel to plant the plants | Office in Vilnius, hotel | Air cleaning, saving horizontal spaces and creation of vertical, big attention is given to collection of excess water in advance | Attention to living and working environment, forming of relaxation zones, soothing of emotions, it gives to the spaces the uniqueness and creates a shelter of nature in enclosed spaces |
| Lithuania | Palanga | This wall is made mostly with a variety of climbing plants | Hotel with leisure hall | Air cleaning, no need for “live” flowers, saving of water – the sewage pipes can be connected to the city sewage network | Helps visitors to enjoy the greenery in hotel, brings man closer to nature, working place is more attractive to hotel workers, place to relax |
| Slovakia | Bratislava | Climbing plants on steel cable construction | Car parking House Aupark | Air cleaning, shading, impact on microclimate | Additional aesthetic effect in interior for the users and in exterior for passersby |
| Slovakia | Bratislava | Mainly perennials, in a pot wall system | Café in the park Jama | Impact on microclimate | Aesthetic effect in the exterior spaces for the visitors |

Own elaboration

### 2.1. Green roofs

Green roofs are not a new green solution, they are successfully used in the world and in Europe for several years but the technology of their planning has changed. However, in the analyzed countries their number is still relatively small. They occur most often in large cities, in Warsaw, Bratislava, Vilnius, there are also assumptions in smaller centers.

Green roofs increase the biologically active area, they are using the area not used so far, and from the point of view of usability and the so-called “green livability” allow users commune with nature beyond the classic green areas, especially where these areas are missing. The analyzed examples (table 3) show a large diversity of roof gardens. As in the case of green walls, some of them are publicly available (garden in the library in Warsaw, shopping center in Bratislava), semi-private (hotel in Vilnius), few of them are private (e.g. roof integrated in the environment in Książnice). These
gardens favor the integration of residents or users, as well as have an educational or cognitive character. They are often green oases in urban space.

Table 3. Green roofs – examples from selected countries.

| Country | Town | Description – greenery | Description – function | Impact on environment | Impact on people |
|---------|------|-------------------------|------------------------|-----------------------|------------------|
| Poland  | Książnice (near Warsaw) | Natural greenery, grassy surface cut from a natural space | Private building, modern construction | Harmonized with the surrounding landscape, introduction of additional green surface | Direct impact on the health of the residents of the house |
| Poland  | Warsaw | Composed greenery, flowering and green shrubs (colors sign different parts of garden), the composition is ramed by miniature apple trees | Garden on the roof of the University of Warsaw Library, public use, for concerts, happenings, summer cinema, and urban games | Huge impact on urban and build environment, “green oasis”, panoramic view of the Vistula River | Resting place for students, residents of Warsaw, and tourists |
| Lithuania | Vilnius | Planted sward, several components were used which with the plants create suitable conditions for sward growing, assure the prosperity of plants | Swardy roof – terraces on the hotel business centre, school’s sports hall, office in the nature | Bioplots are created, returned to the city, better thermal features, saves energy, reduces and clean air pollution | Strengthen people relation with nature, protect people from big noise, health strengthening, promote attractiveness of workplace |
| Lithuania | Vilnius | Lot with an oasis of green trees and shrubs | Vilnius university botanical garden | Implementation and test of new technologies when planting and taking care of plants | For educational activities, being in a different natural environment, innovation for visitors |
| Slovakia | Bratislava | Extensive plants, mostly Sedum, low vegetation | Senior Home Archa, extensive green roof, sustainable rainwater management, renovation of old building roof | The vegetation roof has a cooling effect and is an effective measure in supporting sustainable rainwater management | Improvement of living conditions of elderly |
| Slovakia | Bratislava | Extensive and intensive roof plants, flowering plants, grasses and shrubs | Shopping Center “Centrál” – with offices, hotel, medicine center, spa and green roof park | Introduction of biodiversity in build environment | Despite the commercial function, the place influences social contacts |

Own elaboration

2.1. Rain gardens
A rain garden is the garden that is best able to take advantage of rainfall and even heavy rainfall, so a special design must be developed and adapted and only plants that are adapted to humid growth conditions must be selected. Usually it is a small garden designed to withstand extreme conditions -
constant humidity and high concentrations and accumulation of certain substances, especially nitrogen and phosphorus (found in the study of heavy rainfall water). So implementation of these gardens is related to nature conservation and saving of water. For people the rain garden looks like a charming garden, attracting birds and butterflies, complementing the “formal” landscape with a pleasing eye-view. For the rain garden, appropriate soil should be selected and only plants that love moisture should be planted. The garden is like a tiny bio-retention medium, which is used to purify the rainwater and reduce the volume of water as soon as rainwater enters the formed gutters.

Among the new solutions including the form of water gardens with hydro-technical elements including a balanced drainage system, rain gardens can be distinguished. Simply put, rain gardens collect rainwater gradually giving it back to the ecosystem. Establishing rain gardens is particularly important in Poland, because there is a visible problem with water management. In addition to large investments, there is a lack of small retention places, as in other countries. For example, the creation of rain gardens has been indicated as one of the blue-green infrastructure solutions in plans for adaptation to climate change, which are emerging in 44 Polish cities. In addition to technical and hydrological significance, these gardens use specific vegetation, including hygrophytes, and are excellent habitats for animals. From the point of view of green livability, rain gardens are a meeting place for residents and local communities, they are often created by residents themselves with the help of specialists (example of rain gardens in Gdańsk, table 4). They affect well-being and health improvement, and also fulfill the function of active green therapy (so-called hortitherapy).

2.1. Community gardens

The last group of analyzed green solutions is social – community gardens. Sometimes they occupy small spaces; therefore for the purposes of this work the so-called pocket gardens were included. The idea of community gardens is to share space and share responsibility for the environment. There are many studies dealing with the social benefits of community gardens mostly including functions like social group integration and reduction of social alienation, strengthening social relations among different generations, development of work skills, and knowledge on agricultural activity, etc. Community gardening has become a growing movement in cities all over the world, where these diverse collectively managed spaces provide various economic, ecological, and social benefits for urban residents. Community gardens provide not only locally-produced food for urban residents [8, 9], but also benefits such as education, community development, new experiences inherent to democratic forms of governance, ecosystem services, green infrastructure, or space for recreation.

These places fit perfectly into our definition of green livability. In addition to ecological and biological role, it is in the case of these forms of greenery that the social function aiming at intergenerational or social integration is most visible. In most of the cases analyzed, the essence of a garden is to work in it and grow fruits and vegetables on a small scale. Users use separate plots or a common area, organize meetings, and prepare meals together. The basis of all activities is broadly understood integration (the example of Antakalniečiai garden in Vilnius, table 5). Environmental education is also of great importance.
Table 4. Rain gardens – examples from selected countries.

| Country | Town                       | Description – greenery | Description – function | Impact on environment | Impact on people |
|---------|----------------------------|------------------------|------------------------|-----------------------|------------------|
| Poland  | Gdańsk, several rain gardens | Hydrophytic vegetation: Caltha palustris, Lythrum salicaria, Symphytum officinale, Eupatorium cannabinum, Acorus calamus | Six rain gardens, three mini retention parks and troughs area of 20 ha, some with mainly drainage functions, others with recreational, social and educational functions | Retention with mini treatment plant, gardens affect the environment on a small or larger scale, draining the area and storing water, i.e. in the Matarnia district during heavy rains water is taken from the streets, other – the oldest garden at the flood control, store water for irrigating plants | Co-creation of gardens, social factor - participation of residents in the design process, shared responsibility for gardens, educational function, e.g. activities of school and kindergarten students in planting |
| Poland  | Łódź, rain installations | Hydrogenic vegetation intended for pots and boxes | 8 rain installations as part of the pilot project “Łódź rain gardens”, these are spatially small installations at cultural and social assistance centers | Impact on micro-space, the environment at the buildings in the city, by using rainwater to irrigate plants in pots, boxes | Educational function by learning how to create and care for green rainwater installations, increasing public awareness of water management during periods of drought and during heavy rain |
| Lithuania | Vilnius, Visoriai gardens | Garden with special design and only selected plants adjusted to wet growth conditions | Spaces for living, relaxation and self-grown food growing | Best experiences to use rainfall, moisture control on the ground, big attention to grown plants, can change terrain or even landscape | Bringing people closer to nature, self-grown food, way to eat what you grow, relaxation and stress relief, for people living there can cause problems due to excessive humidity |
| Slovakia | Štiavnické Bane | Rain garden with perennials, hygrophilous plants | Primary school and kindergarten of Maximilián Hell - retention pond for rain water from roofs | Improvement of rainwater management, microclimate improvement | Significant education effect |
| Slovakia | Zvolen | Rain garden with hygrophilous plants in the area of retention pond | Technical University of Zvolen – rain water fountain and a retention pond | Improvement of rainwater management, microclimate improvement | Attractive relaxation place for students, education effect |

Own elaboration
Table 5. Community gardens/pocket gardens – examples from selected countries.

| Country   | Town     | Description – greenery                                    | Description – function                  | Impact on environment                                                                 | Impact on people                                                                 |
|-----------|----------|-----------------------------------------------------------|----------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Poland    | Cracow   | Shrubs, perennials, decorative plants, vegetation to consume | Community Garden Macierzanki, local initiative, educational | Use of undeveloped space, increasing the number of occurring species, impact on biodiversity | Common care of the common space, the integration of residents, the integration between the generations, education of children, youth and adults |
| Poland    | Sobolew  | Honey plants, *Lavatera thuringiaca* L.                    | Social apiary, Monar association        | Increasing of honeybee population, insects contribute to increased pollination of plants in the immediate area (wild plants, home gardens, agricultural crops), popularization of bees | Activation of homeless and poorest people. There is also a strong need to fight social exclusion and integrate the local community |
| Lithuania | Vilnius  | The first gardens were planted and the flower beds were arranged | Community Antakalniečiai garden, initiative based garden for local community, renewed greenhouse | Dispose of abandoned plots, promoting environmental protection, promotion of natural plants growth | The main principle is - together to grow, maintain the garden and share the harvested crop; join members of community, education/cognition function for children and youth, promote local food (from garden to table) |
| Lithuania | Aukštelkė | People who live and work in the care home created garden, planted vegetables | Aukstelke social care home, Social care home community initiative based garden for care home residents | Environmental protection, promoting the natural grown up food | Promotes communication and inclusion, strengthening feeling of nature, a sense of community, soothing stress, strengthening capabilities of vulnerable people |
| Slovakia | Bratislava | Elevated beds for growing vegetables and fruits and a herb garden | Water-management community garden, permaculture garden, there is also an old but functional greenhouse and couple of beehives | Permaculture gardening is “the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems.” Permaculture is essentially mimicking natural ecologies in the garden. | High impact on local community, educational function, learning to live in harmony with nature and production from nature |
| Slovakia | Nitra   | Beds for growing vegetables, herbs, fruits, flowers        | Community garden Hidepark               | Use of abandoned plots, promoting environmental protection, permaculture and local food production and plant growing | Strengthening social contacts of local community, connection with nature |

Own elaboration
4. Conclusions
In the era of rapid environmental and climate changes, it is necessary to change the approach to planning and managing public and semi-public spaces. The responsibilities of designers and, consequently, of users for the planning and use of private space should also be increased. These changes include new pro-ecological solutions in the urban structure, as well as a new look at greenery planning in the so-called micro-scale by maximizing the use of space, e.g. roof gardens, vertical walls, rain gardens, or community pocket gardens. Especially in densely built-up areas, where it is not possible to plan a larger area of greenery. Therefore, in the strategies for developing green infrastructure in cities, a large role is attributed to the use of modern technologies and design trends. In the Polish, Slovak and Lithuanian examples, we have presented the green solutions characteristic for the cities in Eastern and Central Europe. In the countries analyzed, there is increasing recognition of the need to change the way of thinking about planning, which results solely from economic or aesthetic needs, towards ecological planning with the participation of society. A large role is also attributed to broadly understood ecological education of urban residents. A well-planned public space should affect the use of common places, as well as the way people feel these places, in accordance with the principle of "green livability".

Acknowledgments
The research was supported by the project APVV SK-PL-18-0022 “LIVA - The Concept of livability in the context of small towns” funded by NAWA – Polish National Agency for Academic Exchange and SRDA - Slovak Research and Development Agency. The authors would like to acknowledge networking support by the COST Action CA13177 Circular City - Implementing nature based solutions for creating a resourceful circular city.

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