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REGIONAL DEVELOPMENT, SPATIAL PLANNING AND STRATEGIC GOVERNANCE

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GREEN AND BLUE SPACES: INTEGRAL URBAN DESIGN AS A TOOLKIT FOR CLIMATE CHANGE ADAPTATION IN THE CASE OF SMALLER SETTLEMENTS IN VOJVODINA REGION

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1. INTRODUCTION

The consequences brought along with urbanization processes are vital for the functioning of the ecosystem and its basic features. The main adverse effects on the environment are being shown through pollution of waterways, loss of biodiversity and climate change (Alberti, 1999). Climate change is causing urban heat island effect and disruption of natural water flows, thereby compromising the quality of life and use of public and private open space of the city. Traditional urban design approach with its principles of place making and choice supporting has not brought up the issues of sustainability, especially the ones concerning impact on environment and climate. Ecological paradigm is bringing new goals to urban design: resilience, comfort, resource efficiency, conservation, and biodiversity. Therefore, we will consider urban design within the concept of integral urbanism and its ecological principles of permeable membranes, permeability and "go with the flow" principle.

The aim of this paper is to suggest that urban design toolkit for adaptation to climate change could be developed by establishing relations between compatible elements of the built form and those of the green infrastructure.

We suggest that urban design toolkit for adaptation to climate change could be developed by establishing relations between elements of the built form and those of green and blue infrastructure, based on the principles of integrity and permeability, as well as complementarities of their spatial scales. In this way, urban design toolkit can be integrated into a wide range of strategies and plans for adaptation to climate change.

As part of the research presented in the paper we used a method of case studies of several smaller settlements in Vojvodina, because of their inherited plan-based urban layout and specific infrastructure related to rural ecosystems which have the potential to be successfully 'remodeled'.

2. INTEGRAL APPROACH

Urban design has not inherited the continuity of ecological knowledge that is required for full understanding of living systems. We ought to remember that the founder of town planning, Patrick Geddes, developed his ideas using an approach that was fundamentally multi-disciplinary and recognizably ecological in its examination of the phenomenon of the city.

It is necessary to bring urban design within a framework that supports the development of cities in appropriate environmental and social context (see Cowan, Van der Ryn, Boyden, Register, in Dowton, 2009). If we understand ecology as the study of relationships between living things and their environment, then urban design can find its place within the disciplines of urban ecology, landscape ecology and urbanism. These disciplines provide the scientific basis for an integrated approach of urban design strategies.

2.1. Adaptive Urban Design

Attributes "ecological" or "sustainable" are not inherent principles of urban design, primarily due to a lengthy break with ecological values initiated during the industrial revolution, which lasted until the end of modernism. Ecological paradigm was re-established during the 70-ies, when the oil crisis arouses awareness of limited energy resources and negative effects of human activities on the environment.

Adaptability as the quality of the built environment is first mentioned by Lynch and Rodwin. In their incisive article "A Theory of Urban Form," they developed analytical categories to explore the relationships between elements of form and basic values such as health, survival, growth, and adaptability (Alberti, 1999).

It is interesting to compare Lynch's concept of "learning ecology" and adaptability of urban form with contemporary concept of resilience of urban system and its adaptive capacity. From this point of view it is more appropriate to use attributes "adaptive" and "regenerative" than "sustainable" urban design. Adaptation implies capacity to achieve state which fits to the given purpose, capacity to evolve, which is not sustainability in a sense of simple maintaining but also regenerating those ecosystems that have been compromised or destroyed by human endeavors (Bergman, 2012).

Adaptive urban design has to be capable to restore climate resilient urban system. This also refers to social systems management, planning, economy and community. Resilience of such systems is based on the following characteristics: redundancy, flexibility, capacity to reorganize and capacity to learn (Raven, 2012).

This paper will consider adaptation as response to macro-environmentally changing physical conditions, i.e. to climate change.

3. GREEN AND BLUE INFRASTRUCTURE WITHIN URBAN DESIGN

Architects and urban planners of modern era emphasized linking indoors with outdoors including Aldo van Eyck, Frank Lloyd Wright, and Nikolas Pevsner. Buckminster Fuller proposed intelligent membranes for cities that can adapt in response to the environmental changes. Today, these mega-technological solutions from modernism era are criticized as non-realistic. Planners and architects of the new generation of tend to establish their urban design strategies on the potentials of nature and characteristics of ecosystems that should be utilized for strengthening the resilience of cities and their adaptability to climate change. Planners and architects of the new generation base their design strategy on the theoretical groundings of urban planner Kevin Lynch and environmentalist Ian McHarg. Lynch classified cities as celestial, mechanical and organic, and allowed that the organic type could be considered to have the characteristics of an organism, rather than, for instance, a machine (Lynch, 1981). New generation represented by van Ryn and Cowan (1996, x) maintain this idea " It is time to stop designing in the image of the machine and start designing a way that honors the complexity of life itself . . . . we must mirror nature's deep interconnections in our own epistemology of design". Downton sets urbanism and architecture in the context of urban ecology: "... making of architecture and cities has to be understood on a theoretical basis that unifies the living and inanimate worlds and that urban ecology provides the means to do this" (Downton, 2009). In doing so, urban designers have been learning from ecosystems studies about efficiency, conservation, biodiversity, resilience, self-adjusting feedback mechanisms, and the value of permeable membranes and "going with the flow".

As Raven suggests, this could be achieved "through a systematic, interconnected public realm to achieve reduced energy loads, cleaner air and enhanced civic life" (Raven, 2012). Nan Ellin states that integral urbanism is largely inspired by ecosystems and derives inspiration from thresholds, ecotones, tentacles, rhizomes (Nan, 2006). These allegations are directing the practice of urban design towards the solutions that are based on the technology of nature that could be realized in the form of green infrastructure. In this way green and blue infrastructure[1] form a kind of "armature" for the implementation of urban design in the strategies and measures to adapt to climate change.

By linking urban design toolkit to green and blue infrastructure, the goals related to adaptation to climate change and improving the quality of life in the city could be achieved. Moreover, many adaptation strategies contribute to wider policy objectives and

[1] Green and blue infrastructure refers to a strategically planned and managed network of green and water spaces and other environmental features vital to the sustainability of any urban area (England Green Infrastructure Guidance, 2009).

the creation of a quality public realm.[2] The imperative to manage high temperatures and reduce flood and drought impacts can justify the creation and maintenance of green infrastructure. In turn, a linked network of open spaces that can be used by a range of people contributes to quality of life and health. It also has a crucial role in maintaining and improving air quality, flood and surface water management and biodiversity. Green and blue infrastructure is associated with all spatial levels, for all types of land use, the private and the public, the quality of public open space and ecosystem services.

3.1. Key Principles

Elements of green and blue infrastructure can be classified by spatial scale criteria - to referent regional, city, neighborhood, or building scale. Based on the same criteria, it is possible to classify the elements of urban form (see Jenks, 2010). These two groups of elements and their inter-relations constitute a good basis for the creation of adaptive urban design strategies. They are both complementary and based on the theory of hierarchy and dynamism of ecosystems that operate at several spatial scales (Wu and Qi, 2000). Since the elements are arranged at complementary spatial scales, it is possible to establish the inter-relationship between elements of green infrastructure and urban form. Urban form is closely related to the spatial scale and can be described as a "morphological attributes of an urban area at all scales" (Williams et al, in Jenks, 2010). At the city level urban form refers to the type of housing, type of street and their spatial arrangement, or form. At the neighborhood level, urban design refers to architecture, facade, materialization etc.
Since the intention is to establish urban design tools based on its relationship to green infrastructure, it is necessary to understand multi-scalar dimension of the city, within a dynamic system that is in constant interaction with its direct and indirect green environment. This approach seeks to establish these relationships and methods that are consistent with the paradigm of integral urbanism elaborated by Nan Ellin: "[...] integral urbanism demonstrates functional, social, disciplinary and professional re-integration; permeable membranes rather that modernists attempt to remove spatial boundaries or postmodernists fortification, and design for movement through space and time via circulation, dynamism and flexibility".

In contrast to modernist attempt to eliminate traditional boundaries and the postmodern tendency to ignore or alternatively fortify them, an integral urbanism seeks to demonstrate porosity trough permeable membranes. By allowing diversity of people, activities, and building types to thrive along these membranes, this approach seeks to re-integrate natural and human component of city.

[2] Benefits of green and blue infrastructure include improving liveability, multifunctionality, sustainable transport, cooling effect, reducing flood risk, biodiversity, soil erosion and urban agriculture.

The level of integration of urban form and green space is defined by relations between permeability and connectivity, using the elements of green and blue infrastructure. By changing the spatial scale (from region to building scale) permeability and connectivity are increasing.

4. THE POTENTIALS FOR THE DEVELOPMENT OF GREEN AND BLUE INFRASTRUCTURE IN SMALL SETTLEMENTS IN VOJVODINA

As a part of the Austro-Hungarian Empire, Vojvodina became an area of multi-cultural and multi-ethnical co-existence. This formed a unique background for the development of specific architecture. With the introduction of cadastre, the conditions for planned reorganization of settlements were established. According to its characteristics, this urban matrix belonged to the "ideal city" concept which existed in the late seventeenth and the beginning of the eighteenth century in Western Europe (Kojić, 1973).

Settlements are conceived as compact forms, an orthogonal matrix defined by two major axes, narrow and deep lots, wide streets and drainage canals. Dimensions of the blocks depend on the depth of the lots ranging between 200 and 300 meters in width and 200 and 500 meters in length, as it is realized in Torak settlement (Figure 01).

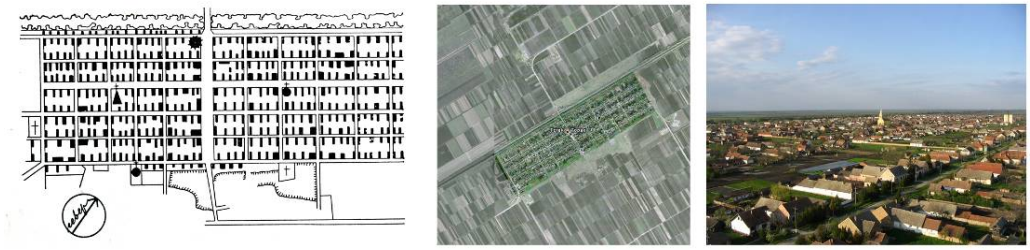

Figure 01. Torak - standardized planned settlement in Vojvodina (source: Kojić, 1973; Google Earth).

Planning of small settlements in Vojvodina was the result of natural conditions-flooding of the terrain and difficult supply of drinking water. The plans from the eighteenth century were aimed at establishing a regional irrigation system, which will support future large-scale agricultural production. Therefore, in old Austro-Hungarian plans can be seen watercourses and canals that have been implemented and are now in the same position (Kojić, 178). Settlements in Vojvodina are planned primarily to establish a regulated system of settlements with distinctly agricultural character and activities.
The potential for the development of green and blue infrastructure in Vojvodina's settlements are enabled by planning that had regional dimensions. Urban development is considered also in the broader strategy of systemic organization of Vojvodina as an

agricultural region. Standardized plan of smaller settlements consists of residential areas with network of streets and plots, and the wider agricultural land. These areas were planned at the same time to optimize basic agricultural functions of the settlements. Agricultural land was usually planned and divided into a number of cooperative agricultural units. These cooperative areas are re-actualized in the context of adaptation to climate change. They could become an important element of future network of green and blue spaces, as they can be transformed into a cooperative forests or controlled marshland ecosystems that may have an economic function of the fish pond (Figure 02).

The potential of green infrastructure is based on a standardized system of street profiles equipped with channels for collecting rain water (main streets are 34-38 meters wide, while local streets have a width of 11-16 meters). This provides opportunities for the development of public space, while large blocks facilitate a green infill.

The streets were equipped with drainage channels that collect storm water (Figure 03). Profile of the street contains a space for tree-alleys with natural water-absorbent land cover. This area is directly related to the courtyard area of the plot, so it makes a continuous natural land cover that has an important role in providing connected and permeable elements of green infrastructure.

The street matrix contained and specialized roads which had a primary function of connecting households with agricultural land. In addition to the primary road network, some settlements had a network of secondary roads that were located in the background of plot row, and that had function of connecting households to the fields.

These elements of urban matrix, that are integrally planned with agricultural systems, irrigation canals and roads in function of agricultural production, are compatible with today's needs for adaptation to climate change, and new conditions and activities of people living in the smaller settlements of Vojvodina. Integrated planning approach of street matrix, land and infrastructure intended for irrigation and drainage allows connected and permeable network of green and blue infrastructure.

4.1. Scale Relations

The question of scale in urban design is a key issue because it influences the integration of green infrastructure and ecosystem services that it provides. Urban design interventions usually take place on the scale of individual plots and private property. The result is a small garden of decorative nature that fails to integrate with nature and wider ecosystems on neighborhood, city and region scale. Although changes in policy and practice at a regional scale are essential to address many environmental problems, it is equally important to practice environmentally responsible design at a building and plot scale, where changes can accumulate to produce neighborhood scale patterns over time. This is

the scale at which most architects and urban designers practice - and it is also the scale that must respond to and implement environmentally responsive design (Johnson and Hill, 2002).

Regional scale - the urban fringe is more clearly separated from the surrounding natural ecosystems of the region - forests, steppes, marshes and rivers, and rural agricultural areas and village greens, as it is shown in the example of fish pond near Sakule (Figure 02). These elements of green infrastructure form urban green belt, natural background which can be put into the service for adaptation to climate change strategies, particularly for temperature regulation and flood control, but also as one of the measures of urban sprawl prevention.

Settlement scale - essential elements of green infrastructure are "green fingers", corridors and canals that are a key element of integration with its surrounding natural ecosystems. They are intertwined with patterns of urban form, passing through the full range of urban: peri-urban, sub-urban, wider central and central city areas. Linked on other types of green infrastructure (fields, parks, outdoor sports facilities, urban canals), they are becoming increasingly porous while interacting with the surrounding urban forms. On this level a different layout developments, urban patterns as well as densities should be considered in order to provide usable space and deliver meaningful opportunities for multiple green infrastructure functions as can be seen in Torak (Figure 03).

Neighborhood scale is the most immediate level of interaction between people and the open public space. It can best be described by criteria of liveability which, from the ecological approach followed in this chapter, is a statement about the relationship between a subject (an organism, a person or a community) and the environment. Proximity to the green open spaces and housing is one of the most important prerequisites for high liveability (van Dorst, 2012). Neighborhood scale integrity may be reached by focusing on the creation of medium density housing, including separate medium-size green spaces, well connected by a dense network of green corridors that provide accessibility by sustainable transport to green spaces and to other urban activities. Elements of green infrastructure at this level are community gardens, private gardens, urban parks, street trees and drainage bioswales like those in street network in Sakule (Figure 04).

Building scale erases the boundaries between building and its environment, in order to create an architecture that integrates the animate and inanimate world. Boundaries between green space as infrastructure and architecture as superstructure disappear on buildings with green roofs and façades and passive and active systems of energy efficiency as it is shown in th example of house in Klek (Figure 05).

Green roofs are not only good for diversity of plant and animal species within urban areas but vegetated roofs will decrease and slow down the amount of rainwater and will reduce

local floods. The green roof protects the roof underneath from ultra-violet light and frost, reduces costs of air-conditioning during hot weather and reduces the heat island effect in urban areas.

Vertical greening of façades has more potential to impact the area per building then for example a green roof (i.e., greening of a building façade can encompass more than four times the area of the roof). A variety of different systems are also available for greening of vertical walls.

These elements of green infrastructure, distributed by the different spatial scales, make a linked network of well-irrigated open spaces with tempered microclimate that can be used by a range of people, which has additional ecological, recreational, cooling and flood storage beneits.

Figure 02. Regional scale - Fish pond near Sakule (source: Google Earth).

Figure 03. Settlement scale - Torak (source: Google Earth).

Figure 04. Neighborhood scale - Street in Sakule (source: Google Earth).

Figure 05. Building scale - House in green, Klek (source: Google Earth).

5. CONCLUSION

The aim of this paper is to suggest that urban design toolkit for adaptation to climate change could be developed by establishing relations between compatible elements of the built form and those of the green infrastructure. We set urban design into a framework of ecological paradigm which brings new values and goals: resilience, comfort, resource efficiency, conservation, and biodiversity. Therefore, we consider urban design within the concept of integral urbanism and its ecological principles of permeable membranes, permeability and "going with the flow". In order to estimate relationship between the elements of green and blue infrastructure and the elements of built form, we examined them principles of inter-connection and permeability. Special attention was given to the complementarities of their spatial scales. We categorized benefits of green infrastructure on the key urban scales and related them to complementary elements of urban form.
The identified level of integration and permeability between elements of green and blue infrastructure and built form showed tendency to increase from regional and city toward neighborhood and building scale. A new symbiosis between these green and urban form entities could certainly become a useful framework for further understanding of integrated design and sustainable development, but the outcome has yet to be tested, evaluated and confirmed.

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SUMMARY

The urban environment which we inhabit is not built with the intention of being environmentally sustainable and climate responsible. Rather, it facilitates most of the activities that cause climate change. Therefore, integrated urban design takes an increasingly important role in the strategies and actions of climate change adaptation in the built environment.
As part of the research we used a method of case studies of several smaller settlements in Vojvodina, because of their inherited plan-based urban layout and specific infrastructure related to rural ecosystems which have the potential to be successfully 'remodeled'.
This research deals with the special importance and role of green and blue infrastructure as an integral part of the urban design toolkit for climate change adaptation. Sustainable urban design integrates green and blue spaces into a living environment and utilizes them for cooling, protection against solar radiation, maintaining the water supply and the collection of surface water. The main task of the paper is to identify the ways of using green and blue infrastructure when adapting the different elements of urban form (neighborhood, public space, house and lot) to climate change.