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2ND INTERNATIONAL
SCIENTIFIC
CONFERENCE

**REGIONAL
DEVELOPMENT,
SPATIAL
PLANNING AND
STRATEGIC
GOVERNANCE**

Conference Proceedings

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CONTENTS

SESSION A

| | |
|--|-----|
| Miodrag Vujošević and Slavka Zeković RENEWAL OF STRATEGIC RESEARCH, THINKING AND GOVERNANCE IN SPATIAL DEVELOPMENT OF SERBIA: MID-TERM PRIORITIES..... | 13 |
| Marija Maksin, Saša Milijić and Nikola Krunić REGIONAL SPATIAL PLANNING IN SERBIA IN THE CONTEXT OF DYNAMIC CHANGES IN REGIONAL SPATIAL PLANNING IN THE EU..... | 43 |
| Jenny Atmanagara, Philip Crowe, Karen Foley and Johann Jessen MUNICIPALITIES AND RESILIENCE: STRATEGIC GOVERNANCE AND BUILDING COMMUNITY CAPITAL IN AN UNCERTAIN FUTURE..... | 69 |
| Janis Balodis BORDERLAND DEVELOPMENT POLICY COMPARISON BETWEEN CENTRAL EUROPE AND BALKAN REGION COUNTRIES..... | 83 |
| Enaya Banna-Jeries and Arza Churchman PROCEDURAL JUSTICE: TOWARDS NEW APPROACHES TO PUBLIC PARTICIPATION IN DECISION MAKING PROCESSES..... | 96 |
| Cristina E. Ciocoiu INFORMATION TECHNOLOGY SYSTEMS AND THE EUROPEAN UNION REGIONAL DEVELOPMENT POLICY: PAST, PRESENT AND WHAT THE FUTURE HAS IN STORE..... | 108 |
| Marija Cvetinović and Jean-Claude Bolay HOW TO TECHNOLOGIZE URBAN PLANNING PROCEDURES IN ORDER TO BOOST URBAN DEVELOPMENT..... | 119 |
| Jeremias Herberg EDUCATION FOR SUSTAINABLE DEVELOPMENT IN LEARNING REGIONS - AN INTERDISCIPLINARY CHALLENGE..... | 140 |
| Milutin Miljuš and Milica Vujošević RELATION TOWARDS BROWNFIELD SITES IN THE URBAN PLANNING STRATEGIES..... | 150 |
| Milica Pajkić, Marija Martinović and Mladen Pešić ARCHITECTURAL POLICY OF REPUBLIC OF SERBIA | 160 |
| Coheci Radu-Matei URBAN SPRAWL IN THE BRASOV METROPOLITAN AREA, ROMANIA – ENVIRONMENTAL IMPACT ASSESSMENT AND SOLUTIONS FOR A SUSTAINABLE METROPOLITAN DEVELOPMENT..... | 176 |
| Sara Reimann REVISITING COMMIN - THE ONLINE-DATABASE ON EUROPEAN SPATIAL PLANNING SYSTEMS AS AN EXAMPLE FOR THE LONG-TERM DEVELOPMENT OF PROCESS-ORIENTED INNOVATIONS..... | 188 |

| | |
|--|-----|
| Renzo Riboldazzi URBAN SPRAWL IN ITALY – ISSUES, CAUSES AND LAND POLICIES WITH A SPECIAL FOCUS ON THE MILAN AND LOMBARDY AREAS..... | 204 |
| Alcestis P. Rodi BEYOND COMPACTNESS: TRANSITIONS TOWARDS SUSTAINABLE NEIGHBOURHOODS OF PERI-URBAN ATHENS..... | 215 |
| Nataša Živaljević Luxor and Petar Mitković REGIONAL ACTIONS TO PROTECT THE ACCESSIBILITY RIGHT IN ACCORDANCE WITH EUROPEAN LEGISLATION..... | 244 |

SESSION B

| | |
|---|-----|
| Tamara Maričić, Jasna Petrić and Boško Josimović SOCIALIST LEGACY AND SOME CURRENT ISSUES OF ENVIRONMENT PROTECTION IN A EUROPEAN TRANSITIONAL SOCIETY: SERBIAN EXAMPLE..... | 256 |
| Vesna Popović and Jelena Živanović Miljković KEY ISSUES OF LAND POLICY IN SERBIA IN THE CONTEXT OF SPATIAL DEVELOPMENT - CASE STUDY OF DANUBE BASIN AREA | 271 |
| Stevan Stanković and Jelena Basarić IDENTIFICATION OF TOURISM DESTINATIONS AND THEIR POTENTIALS IN THE ĐERDAP NATIONAL PARK..... | 298 |
| Sofija Adžić THE INFLUENCE STRUCTURING OF PRODUCTION – ORGANIZATIONAL SYSTEM ON REGIONAL DEVELOPMENT – CASE OF SERBIA..... | 309 |
| Sónia Alves EVALUATION AND EVALUATING THE COMMUNITY INITIATIVE “URBAN”..... | 323 |
| Goran M. Babić and Aleksandar Videnović SERBIAN AND BULGARIAN VILLAGE AS A JOINT TOURISM BRAND OF “STARA PLANINA” MOUNTAIN..... | 341 |
| Iwona Cieślak, Małgorzata Gerus – Gościewska and Karol Szuniewicz THE APPLICATION OF GENETIC ALGORITHMS AS A TOOL FOR SUPPORTING THE PROCESSES OF ANALYSIS AND PREDICTING URBAN DEVELOPMENT..... | 350 |
| Marko Filipović, Marijana Pantić and Jelena Živanović Miljković URBAN-RURAL FUNCTIONS AND RELATIONSHIPS AT THE REGIONAL LEVEL - EXAMPLE OF THE CITY OF VALJEVO, MIONICA AND OSEČINA MUNICIPALITY...360 | 360 |
| Caterina Gallizioli RELATIONS DESIGN SPACES: VILLORESI CANAL AS OPPORTUNITY OF REDEVELOPMENT AND RECONNECTION OF OPEN PUBLIC SPACES..... | 374 |
| Fernando M. García Martín A METHODOLOGY TO STUDY THE RELATIONSHIP BETWEEN URBAN ACTIVITIES AND MORPHOLOGY IN THE CASE OF A TWENTIETH CENTURY SUBURB IN MADRID (SPAIN)..... | 386 |

| | |
|--|-----|
| Irina Grcheva THE IMPACT OF COPY-PASTE PLANNING: THE CASE OF THE STRATEGY FOR REGIONAL DEVELOPMENT OF REPUBLIC OF MACEDONIA 2009-2019..... | 401 |
| Miroljub Hadžić and Slavka Zeković EFFECTS OF THE PROCESS OF DEINDUSTRIALISATION AND THE CONCEPT OF A REINDUSTRIALISATION STRATEGY OF SERBIA..... | 410 |
| Dimitrios Kyrkilis and Simeon Semasis THE ROLE OF AGRICULTURE IN ECONOMIC GROWTH AND REGIONAL DEVELOPMENT IN GREECE..... | 422 |
| Aleksandar Lugonja SUSTAINABLE RURAL DEVELOPMENT IN THE MOUNTAIN AREAS OF BOSNIA AND HERZEGOVINA..... | 439 |
| Dijana Milašinović Marić MODERN ARCHITECTURE AND ITS SOCIAL AND REGIONAL ASPECTS AS TOOLS FOR MAKING STRATEGY FOR THE PRESENTATION OF CULTURAL AND HISTORICAL HERITAGE OF SERBIA..... | 449 |
| Tatjana Mrdenović and Danijela Milovanović Rodić TRAININGS AS A TOOL FOR CHANGE IN URBAN REGENERATION PRACTICE | 460 |
| Valentin Nemes THE ROLE OF SMALL TOWNS IN REGIONAL AND RURAL DEVELOPMENT IN ROMANIA..... | 470 |
| Marija Nevenić FUNCTIONAL URBAN REGION-THE INSTRUMENT OF POLYCENTRIC SPATIAL DEVELOPMENT OF SERBIA..... | 479 |
| Dragana Nikolić PROBLEMS IN THE IMPLEMENTATION OF PLANNING DOCUMENTS IN SERBIA... | 487 |
| Peter Nikolov A SURVEY OF BULGARIAN (NATIONAL) PLANNING AND REGULATION ACTS AND DOCUMENTS CONCERNING URBAN SPRAWL..... | 495 |
| Ana Perić INSTITUTIONAL COLLABORATION AS THE PILLAR OF SUSTAINABLE BROWNFIELD REGENERATION IN THE DANUBE MACRO-REGION..... | 506 |
| Rastko Petrović, Miloš Marjanović, Uroš Đurić, Vladimir Šušić, Biljana Abolmasov and Snežana Zečević STATISTICAL APPROACH IN LAND-USE SUITABILITY ANALYSIS OF THE BELGRADE CITY SUBURBS..... | 517 |
| Renata Pindžo, Goran Petković and Ana Vjetrov REVITALIZATION OF THE GOLUBAC FORTRESS IN ORDER TO ENSURE SUSTAINABLE USE OF THE NATURAL AND CULTURAL RESOURCES IN THE FUNCTION OF SOCIO- ECONOMIC VALORIZATION..... | 530 |
| Marcel Plejtte REGIONAL DEVELOPMENT BASED ON DIFFERENT TYPES OF VALUE CREATION AND BUSINESS MODELS..... | 544 |

| | |
|--|-----|
| Miodrag Ralević MONITORING IN THE FUNCTION OF OPEN (FLEXIBLE) PLANNING..... | 554 |
| Johann Rathke and Norbert Weber THE ROLE OF FORESTRY IN TRANSBORDER GOVERNANCE PROCESSES..... | 567 |
| Juan Luis de las Rivas Sanz and Mario Paris STRENGTHENING THE TERRITORIAL POSITION OF VALLADOLID THROUGH PLANNING STRATEGIES: NETWORKS, PATTERNS, CENTRALITIES..... | 578 |
| Ana Ruiz LOST CENTRALITY IN THE STRATEGIC PLANNING OF THE VALLADOLID REGION, SPAIN..... | 591 |
| Mileva Samardžić-Petrović, Branislav Bajat and Miloš Kovačević THE APPLICATION OF DIFFERENT KAPPA STATISTICS INDICES IN THE ASSESSMENT OF SIMILARITY BETWEEN PLANNED AND ACTUAL LAND USE MAPS..... | 605 |
| David Schnée A TRANSPORT-URBANISM STRATEGY BASED ON A NEW APPROACH OF CENTRALITY: AREAS OF MULTI-COMMUNE COHESION APPLIED TO THE GIRONDE'S COUNTY..... | 618 |
| Júlia Schuchmann NEW TRENDS OF SUBURBANIZATION PROCESSES IN THE BUDAPEST METROPOLITAN REGION..... | 634 |
| Dušica Srbović and Vojkan Gajović DETERMINATION AND DELINEATION OF FUNCTIONAL URBAN AREAS IN SERBIA..... | 649 |
| Viktória Szirmai EMERGENCE OF A NEW URBAN DEVELOPMENT MODEL? TRANSITION AND GLOBALISATION IN THE HUNGARIAN NEW TOWNS AND THEIR REGIONS..... | 666 |
| Paolo Tomasella HISTORIC PARKS AND GARDENS OF FRIULI VENEZIA GIULIA: CENSUS, CATALOGUING, PERSPECTIVE OF DEVELOPMENT IN THE REGIONAL SPATIAL PLANNING..... | 677 |
| Jacko A. van Ast TOWARDS INTERACTIVE FLOOD GOVERNANCE: CHANGING APPROACHES IN DUTCH FLOOD POLICY..... | 685 |
| Zsuzsanna Váradi and Levente Halász POTENTIALS, CONSTRAINTS AND CONFLICTS BETWEEN KAZINCBARCIKA AND GYÖNGYÖS, A HUNGARIAN NEW AND HISTORICAL TOWN AND THEIR SURROUNDINGS..... | 698 |
| Chengzhi Yin and Dongfeng Yang ANALYSIS OF THE DEVELOPMENT REGULATION IN CHINESE REGULATORY PLANNING TOWARDS THE MAIN FUNCTION ZONING STRATEGY..... | 714 |
| Zora Živanović and Dragica Gatarić INNER URBAN AREA OF BELGRADE..... | 725 |

SESSION C

Jelena Basarić and Jelena Stevanović Stojanović

ENHANCEMENT IN TOURISM AND PROTECTION OF THE LOWER DANUBE
BASIN TOURISM AREA.....738

Nikolaos Gavanas and Magda Pitsiava-Latinopoulou

METHODOLOGY FOR THE DEVELOPMENT OF AN INTEGRATED TRANSPORT
ACCESSIBILITY MODEL FOR THE WIDER BALKAN REGION.....749

Ana Mitić and Marija Martinović

MONITORING INTERNATIONAL COOPERATION IN PAN-EUROPEAN
TRANSPORTATION CORRIDOR 10.....761

Miodrag Ralević, Sanja Simeunčević Radulović and Branislav Antonić

DANUBE STRATEGY IN SERBIA: EDUCATION-BASED RESEARCH
OF THE POTENTIALS OF SERBIAN TOWNS ON THE DANUBE.....777

Marius Voica, Vasile Meita and Elena Stancu

DANUBE AREA SPATIAL INTEGRATION BY STIMULATING THE ROMANIAN
PORT CITIES REGENERATION.....791

SESSION D

Omiljena Dželebdžić, Dragana Bazik and Tijana Crnčević

VULNERABILITY OF NATURAL AND CULTURAL HERITAGE IN RELATION
TO CLIMATE CHANGE - NEW CHALLENGE FOR SPATIAL AND URBAN
PLANNING.....808

Igor Marić, Ana Niković and Božidar Manić

ENHANCEMENT OF URBAN STRUCTURE WITH THE AIM OF REDUCING THE
IMPACTS OF CLIMATE CHANGE ON THE EXAMPLE OF BELGRADE.....823

Marina Nenković-Riznić, Milena Stojković and Mila Pucar

KEY ISSUES OF ENVIRONMENTALLY SUSTAINABLE URBAN AND SPATIAL
DEVELOPMENT UNDER CLIMATE CHANGE CONDITIONS.....852

Dobrivoje Tošković, Branislava Kovačević and Tanja Bajić

SUSTAINABLE SPATIAL DEVELOPMENT UNDER THE CONDITIONS
OF DRY, HUMID AND MIXED CLIMATE ON THE EXAMPLES
OF SOME TROPICAL COUNTRIES.....871

Francesco Bonsinetto, Enzo Falco and Giuseppe Modica

REGIONS IN TRANSITION TO A LOW CARBON ECONOMY:
SOME FINDINGS FROM ESPON SIESTA PROJECT.....893

Matija Brković and Višnja Sretović

SMART SOLUTIONS FOR URBAN DEVELOPMENT: POTENTIAL
FOR APPLICATION IN SERBIA.....907

Liu Chengcheng, Sun Ling, Lu Li, An Shufang, Liu Shengli and Shi Huiling

IMPROVING ADAPTABILITY OF CLIMATE CHANGE – URBAN ECOLOGICAL
DEVELOPMENT STRATEGY.....920

| | |
|--|------|
| Mirjana Devetaković and Milan Radojević KNOWLEDGE ON CLIMATE CHANGES IN THE SEE REGION – INTEGRATION IN THE KNOWLEDGE BASE SUPPORTING THE PROJECT TR36035..... | 926 |
| Aleksandra Đukić and Milena Vukmirović IMPROVING THE PEDESTRIAN AND BICYCLING NETWORKS TOWARD CLIMATE FRIENDLY URBAN ENVIRONMENT. CASE STUDY: NEW BELGRADE..... | 938 |
| Darko Jaramaz, Veljko Perović, Snežana Belanović, Elmira Saljnikov, Dragan Čakmak, Vesna Mrvić and Ljubomir Životić THE ESA SENTINEL-2 MISSION VEGETATION VARIABLES FOR REMOTE SENSING OF PLANT MONITORING..... | 950 |
| Milica Jovanović Popović, Dušan Ignjatović and Nataša Ćuković Ignjatović RESIDENTIAL BUILDINGS TYPOLOGY IN SERBIA AND STRATEGIC ASPECTS OF SUSTAINABLE DEVELOPMENT..... | 962 |
| Ahmed Khaled Ahmed Elewa and Mahmoud Yousef M. Ghoneem A METHODOLOGY FOR MITIGATING THE EFFECTS OF THE MICROCLIMATE CHANGES RELATED TO THE URBANIZATION INSIDE DEVELOPING COUNTRIES MAIN CITIES "CAIRO AS A CASE STUDY"..... | 975 |
| Nada Kurtović Folić and Mirjana Sladić STRATEGY FOR PROTECTION OF CULTURAL HERITAGE EXPOSED TO THE NATURAL AND MAN-MADE ACTIVITY DISASTERS IN SERBIA..... | 990 |
| Marija Maruna CLIMATE CHANGE ADAPTATION STRATEGIES: URBAN PLANNING IN POST-SOCIALIST TRANSITION COUNTRIES IN BETWEEN VALUES AND INTERESTS..... | 1007 |
| Miloš Mihajlović RIVER FLOODS IN THE URBAN AREA, RESULT OF CHANGING CLIMATE - OBSERVATIONS..... | 1018 |
| Mira Milaković and Milena Vukmirović ANALYSING THE QUALITIES OF BEING ON FOOT: COMPARATIVE PILOT STUDY IN VRAČAR AND NEW BELGRADE..... | 1025 |
| Mirjana Miletić MEASURES AIMED AT IMPROVING THE ENERGY EFFICIENCY OF STATE PROTECTED BUILDINGS APPLYING INNOVATIVE MATERIALS ON BUILDING FRONTS..... | 1038 |
| Ana Mitić SMART ENERGY REGIONS AS A SUSTAINABLE DEVELOPMENT STRATEGY UNDER CLIMATE CHANGE CONDITIONS..... | 1048 |
| Miloš Nedić, Stefan Spasojević and Ana Radivojević TREATMENT OF CONSTRUCTION WASTE IN SERBIA AND THE LIFE CYCLE OF BUILDINGS..... | 1057 |
| Ana Nikezić and Nataša Janković (RE)CREATING URBAN LANDSCAPE: NEW BELGRADE RIVERFRONT..... | 1070 |

| | |
|--|------|
| Ksenija Pantović SUSTAINABILITY OF TEMPORARY STRUCTURE MODELS DESIGNED FOR HOUSING..... | 1081 |
| Ksenija Pantović and Vladimir Parežanin SUSTAINABLE TECHNOLOGY AESTHETICS..... | 1087 |
| Snežana M. Petrović and Mila Pucar INDICATORS OF SPATIAL SUSTAINABLE DEVELOPMENT AND CRITERIA OF LEED ND CERTIFICATION..... | 1094 |
| Elona Pojani and Perseta Grabova THE RISK OF NATURAL DISASTERS IN THE ECONOMY: THE CASE OF ALBANIA..... | 1104 |
| Ivan Simić and Tanja Bajić GREEN AND BLUE SPACES: INTEGRAL URBAN DESIGN AS A TOOLKIT FOR CLIMATE CHANGE ADAPTATION IN THE CASE OF SMALLER SETTLEMENTS IN VOJVODINA REGION..... | 1116 |
| Višnja Sretović and Matija Brković CONTEMPORARY APPROACH TO STORMWATER MANAGEMENT: POTENTIAL FOR APPLICATION IN SERBIA..... | 1126 |
| Milena Stojković, Dimitra Kyrkou and Boris Žerjav SUSTAINABILITY ASSESSMENT SYSTEMS – THE ISSUE OF SCALE IN SUSTAINABLE DESIGN..... | 1144 |
| Svetlana Vrečić and Branko AJ Turnšek ANALYSIS OF EXISTING CAPACITIES AND DEVELOPMENTAL NEEDS OF INDOOR SPORT FACILITIES IN THE AREA OF THE CITY OF NIŠ..... | 1158 |

SESSION A

**EUROPEAN DEVELOPMENT INITIATIVES AND
DOCUMENTS AND THEIR IMPACT ON
SUSTAINABLE SPATIAL DEVELOPMENT**

ENHANCEMENT OF URBAN STRUCTURE WITH THE AIM OF REDUCING THE IMPACTS OF CLIMATE CHANGE ON THE EXAMPLE OF BELGRADE

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1. INTRODUCTION

Urban areas and urban centers with high population density and different activities typical for industrial and post-industrial period and development processes that have brought about changes in the way of land use are the largest energy consumers, also responsible for approximately 75% of greenhouse gas emissions causing climate change (UN Habitat, 2011). At the same time, they are extremely vulnerable to climate change impacts, such as increase in heat waves and precipitation amount, as well as sea-level rise. Although coastal areas are jeopardized the most, modern definition of climate as a dynamic system of interconnected elements in which smaller and remote events cause essential changes, suggests that mitigation and adaptation strategies must be developed as an integral part of strategies and policies for urban planning regardless of geographical position of an urban area and direct or indirect exposure to natural disasters.

The task of architects and urban planners is to investigate urban structure at all levels taking into account specific characteristics of the area's climate. In this sense, analyses of urban and physical structure represent a model yielding the most comprehensive results in the investigation of the emergence and development of built structures and open spaces in urban environments. These analyses are a starting point in formulating the solutions and measures for the enhancement of urban structure with the aim to achieve a higher level of resilience to effects of global climate change. They imply maximum use of natural potential of a site, through the passive concepts of protection from global climate change, i.e. they are based on knowledge about the specific context of planning and design.

In contemporary literature, and within the investigation of the relationship between urban and physical structure and climate change, the notion of urban form is extended in its complexity and urban design concepts meeting the demands of sustainable development are also investigated. Accordingly, different models of urban forms that have developed based on these concepts are being proposed as a starting point in design and planning and, based on them, the guidelines leading to desirable state of the built environment are established. On the other hand, they can also be the criteria for evaluation of the existing or new urban forms. Concept of urban typology is being presented as a tool for adaptation of urban tissue to climate change. Simulation models are being developed with the aim to

predict impacts of the implementation of different urban typologies on climate change (Moon et al., 2009).

This paper uses the methodology developed by Jabaren (Jabareen, 2006) as a starting point for the urban form evaluation. Jabaren defines seven urban design concepts that are crucial for generating and evaluating the sustainable urban form. They include compactness, sustainable transport, density, mixed land uses, diversity, passive solar design, and greenery planting. The compactness is related to the quality of urban continuity, accessibility and availability. The most important objectives of urban form design and planning include the reduction of energy consumption, air pollution, solid waste volume and car use, the protection of public spaces and existing eco-systems, as well as social interaction. Table 1 shows the relationship between urban form design concepts and measures for achieving relevant sustainable development goals (SDGs).

Table 1. The relationship between urban form design concepts and measures for achieving relevant sustainable development goals

| Urban design concept | Reduction of energy consumption, air pollution and solid waste volume | Car use reduction | Protection of public spaces | Social interaction |
|-------------------------------|---|-------------------|-----------------------------|--------------------|
| Density | + | + | 0 | + |
| Diversity | 0 | 0 | 0 | + |
| Mixed land uses | + | + | 0 | + |
| Compactness | + | + | 0 | + |
| Sustainable transport | + | + | 0 | + |
| Passive solar design | + | 0 | 0 | 0 |
| Greenery planting – ecodesign | + | 0 | 0 | 0 |

2. OVERVIEW OF URBAN STRUCTURE TYPOLOGY IN BELGRADE IN THE CONTEXT OF SUSTAINABLE ENERGY CONCEPTS

This paper presents several main types of urban environments in Belgrade which differ by characteristics of urban structure, building typology, as well as by the time and prevailing paradigms in planning in the period in which they emerged. For the purpose of operationalizing the research and establishing a relatively consistent typology, only residential urban tissue has been considered taking into account that it covers the greatest

percentage within the buildable area of Belgrade¹, that it is exposed the most to transformation processes, which have to be considered as opportunities to develop cohesive responses in both mitigation and adaptation strategies in planning and designing to deal with climate change.

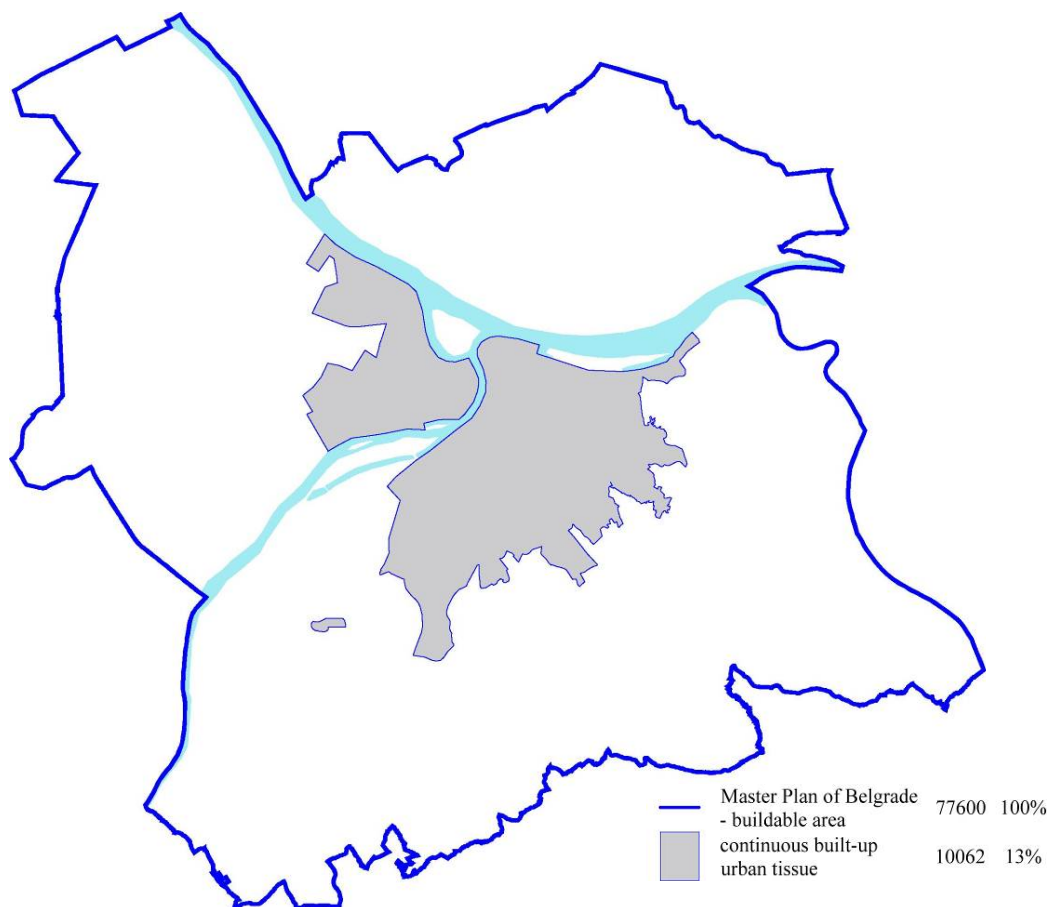


Figure 1. Continuous built-up urban tissue with relation to the boundary of the buildable area of Belgrade from the Master Plan of Belgrade 2021

¹ According to the Master Plan of Beolgrade 2021, the planned residential urban tissue accounts for approximately 18.22 % (14,141.9 hectares) of the area covered by the Plan (77,600 hectares), i.e. 64.3 % of the continuous built-up urban tissue (22000 ha) covering 30% of the area within the coverage of the Plan boundary. In this paper, for the purpose of investigations, the boundary of the Master Plan has been adopted as a referent framework, but the boundary of continuous built-up urban tissue has been modified based on the analysis of orthophoto images so that it covers the area (10,062 hectares) that is smaller than the one specified in the Master Plan due to omission of settlements having no urban character (Fig. 1).

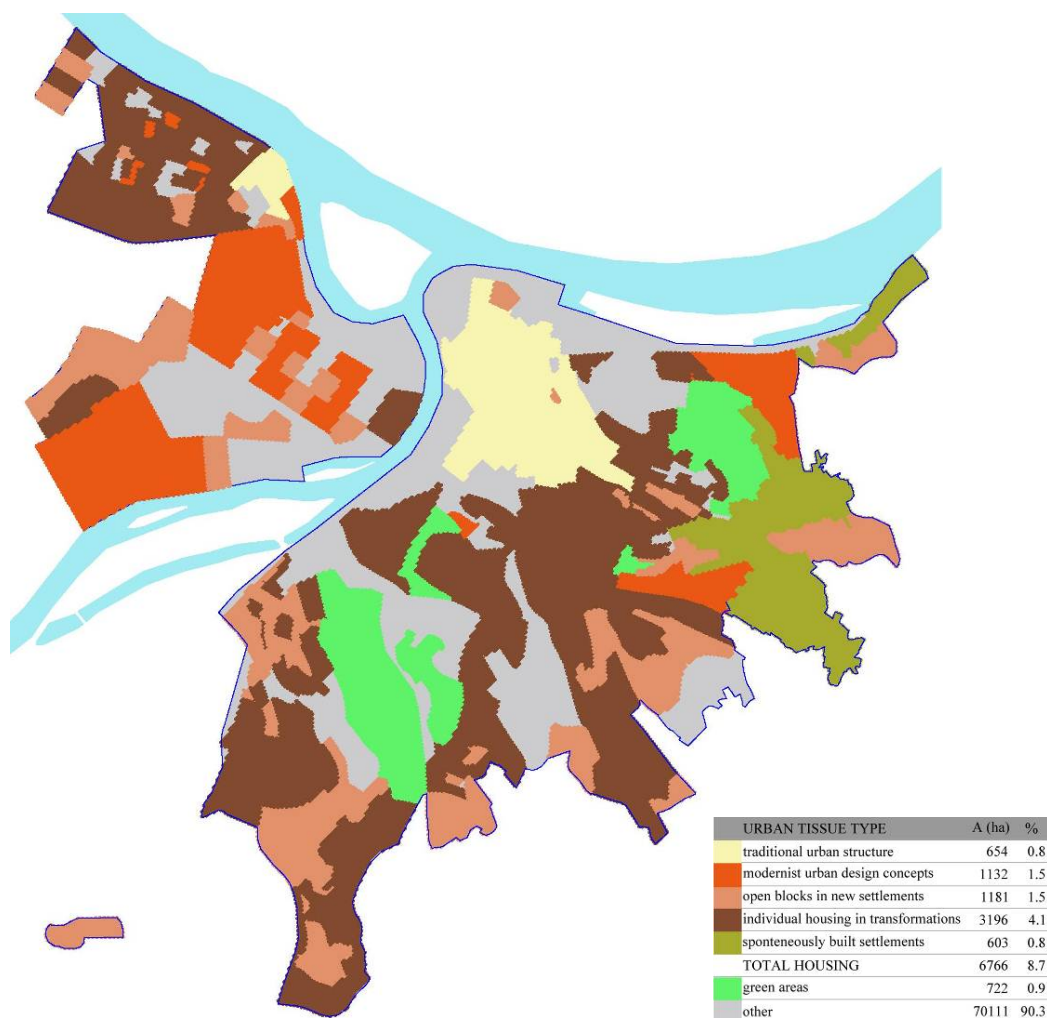


Figure 2. Representation of certain urban structure typologies within the continuous built-up urban tissue of Belgrade

The paper analyzes several examples of urban tissues with typical features of urban and physical structure in the context of conditions provided by architectural and urban compositions in terms of their adaptive capacity to climate impacts. Typical examples are grouped into four development periods. Figure 2 shows the distribution of observed typologies within the Belgrade continuous built-up urban tissue (Fig. 1).

Firstly, parts of the traditional historical tissue of Belgrade are shown, and then the urban and physical structure that emerged after the Second World War according to modern urban design concepts and architecture typical for these concepts. The third development

period emerged as a reaction against modern concepts in the time coinciding with international post-modern theory and practice in architecture and urban planning. The fourth period comprises contemporary architectural and urban planning practices, as well as development trends which mostly manifested themselves in the form of interpolations in the existing urban tissue, particularly in the part which is, in this paper, described as individual housing in transformation processes². Within each of the four periodizations, development processes and planning policies manifested themselves differently in different parts of the city. In its fourth part dealing with the current moment, the paper presents the trend of illegally, spontaneously built settlements that are the reality in the development of Belgrade and for which it is necessary to find solutions that would enable gradual introduction of modern urban standards in these settlements. Besides spontaneously built settlements, extensions and adding of new floors to the existing buildings is yet another, specific development trend. They are a special form of architectural activities which have marked transformation processes, particularly in the existing urban tissue where there is an increasing need for greater capacity of space.

2.1. Traditional Urban Structure

The traditional urban structure in the oldest, central part of Belgrade has developed gradually in physical framework of urban matrix which has obtained the current form in the period until the end of the Second World War (Fig. 3). It has developed spontaneously based on successive development on privately-owned plots, from original center which was in the first half of the 20th century situated along the today King Peter Street, then extended along the Terazije Ridge and King Alexander Boulevard in the longitudinal direction, also extending in transversal directions to river banks of the Save and the Danube. Thus developed urban matrix is characterized by a dense street network with closed compact blocks of different shapes which have, according to needs for expanding and by introducing the first planned street regulation, extended according to orthogonal block system (Blagojevic, 2009).

In the urban structure of the historical tissue of Belgrade, three types of blocks making up its structure can be noticed – small compact blocks on the Danube slope, big blocks on the Sava slope and elongated rectangular blocks on the Neimar and Vračar slopes (Perovic, 2008). In the oldest part of the city, on the Danube slope developed according to the Regulation Plan of Emilijan Josimović, there are relatively small compact blocks of

² In this paper, the term “individual housing in the transformation process” means a part of residential area in continuous built-up tissue of Belgrade which does not fall into the category of traditional urban structure of modern urban design concepts, open blocks in new settlements, with a clear concept of blocks and relationship between building types and types of grouping the buildings. Individual housing encompasses different building types – single-family houses, urban villas, *partajas*, multi-family homes usually built on own plots and in stages over time, and rarely according to the plan.

average size of 55x65m covering the area of approximately 0.4 hectares. On the Sava slope, the urban tissue of Belgrade is composed of big blocks of average size of 120x150m covering the area of approximately 1.8 hectares. On the slopes of Vračar and Neimar, exceptionally elongated blocks of small depths, approximate size of 40x340 m and area of 1.3 hectares, have been developed over time.

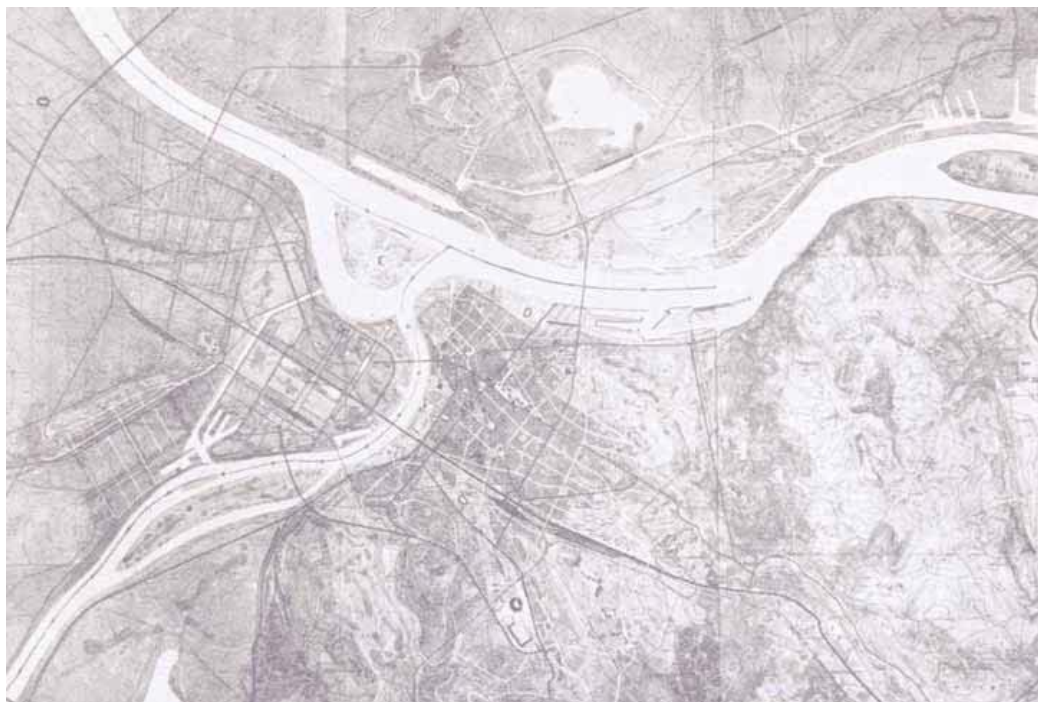


Figure 3. Master Plan of Belgrade from 1948. Clearly noticeable urban matrix of the traditional urban structure on the right bank of the Sava River. Outlines of New Belgrade are visible on the left bank of the Sava River. (Vukotić Lazar, 2008)

In this period, the row house building type has prevailed corresponding to the concept of closed block with buildings on its edge. The average height of buildings built before 1919 was GF+2F (from GF+1F to GF+3F), while in the period 1919-1945, the height of buildings was even up to GF+4F. Compact and non-compact building layouts of the area of 150-300 sq m with apartment's average surface area of approximately 95 sq m. are equally represented. Buildings were built according to the traditional, massive building system with individual, smaller and greater openings (Jovanovic Popovic et al., 2012). Facades were plastered over the load-bearing exterior walls and without thermal insulation given that regulations related to the construction physics did not exist in that period³.

³ The first regulations on thermal protection were adopted at the end of 60s of the 20th century (Krstic and Bogdanov, 2005).

The geomorphological position is characterized by a pronounced inclination of the terrain descending from the Terazije Ridge to the banks of the river Sava or to the banks of the river Danube⁴. On the other hand, urban structure of compact blocks with high percentage of plot usage contributes to the stabilization of the terrain. On the one hand, the inclination and exposure of the terrain contribute to better conditions regarding sunshine, aeration and views in blocks, taking into account negative effects of high densities that occur in such type of urban tissue. Despite the compact tissue, the inclined terrain provides more favorable micro-climatic conditions than in the case of the development on a flat terrain.



Figure 4. Presentation of urban blocks in continuous built-up urban tissue of Belgrade: a) blocks on the Sava slope; b) blocks on the Danube slope; c) blocks on the Neimar slope.

Figure 4 shows examples of blocks in the central part of the historical tissue of Belgrade (parts a and b) which is in the Master Plan of Belgrade included in the entity called the Old Belgrade (part in the Trench), while Figure 4 c shows the part of the urban structure of the wider center of Belgrade belonging to the Municipality of Neimar. These blocks are characterized by high percentage of plot usage and plot ratio, as well as high population density, which causes problems regarding bad micro-climatic conditions. In compact urban blocks in the city center, according to urban planning parameters from the Master Plan of Belgrade 2021, the maximum permitted percentage of plot usage is 40-60% , while plot ratio is 3.5, taking into account standards according to which each block should have 10% of green and uncovered areas, as well as that 0.7 – 1.1 parking spaces must be provided for each apartment, i.e. 1 parking space per each 80 sq m. The realization of all the above mentioned parameters is not possible in reality if the maximum use of the buildable plot potential is placed as priority, which is, indeed, the most frequent requirement of private investors. In addition to this, the percentage of plot usage on some buildable plots is even up to 100%, while plot ratio is up to 5. A great share of building stock in which such situation occurs is in the domain of the protection of architectural heritage, so that it is

⁴ The highest point above sea level of 128 m is on the Kalemegdan terrace, while the average water level of the Danube of 68 m is the lowest height above sea level. Such geomorphological position results in pronounced slopes and variable terrain exposition. Considering the high plot ratio, slopes are not hazardous (Faculty of Forestry of the University of Belgrade and IAUS, 2012).

difficult to undertake any interventions. Considering that it is the most complex and the most attractive part of the city, the traditional urban structure is exposed to permanent transformation processes, as described in their current form in the section 2.4.

2.1.1. Aspect of sustainable traditional urban structure – advantages and disadvantages

The traditional urban structure with compact type of blocks accounts for approximately 6.5% of the territory of continuous urban tissue of Belgrade. According to the previously mentioned concepts of sustainable urban form, its main characteristics include compactness, concentration and diversity of contents, as well as mixed purposes. From the aspect of sustainable development and resilience to climate change impacts, these characteristics are both good and bad. Compactness and concentration of contents are favorable characteristics because they enable rational use of infrastructure, transportation and energy. On the other hand, high density and concentration of contents, as well as the trend towards further increase in density and intensification of land use cause the deterioration of micro-climatic conditions. The greatest problem lies in the fact that physical structure transformations according to the increasing need for space in the city center are taking place in an unchanged street network. This leads to traffic overload and impossibility to accommodate additional infrastructure corridors into the existing street profiles according to the increasing land use intensity. Besides, street canyons - typical configuration of transversal street profiles, are formed in this way. They are characterized by a dominant ratio of building height to street width⁵. Tendency for the maximum use of the buildable plot potential further leads to the problem of insufficient percentage of greenery on the plot, as well as to the lack of parking space. It can be concluded that the traditional urban structure has a high potential for sustainable development, given that its urban form meets the criteria established by Jabaren, as mentioned above. However, the analysis of the current state shows numerous problems in the development, which need to be removed or mitigated by taking adequate measures. It is necessary to introduce instruments of planned control ensuring a balanced development. It is primarily necessary to protect open spaces on plots and in blocks from partial development. Furthermore, in defining the maximum development capacity it is necessary to consider permitted values not only at the level of the plot, but also at the level of the block, taking into account implications which an increase in development capacity have on the capacity of the existing street infrastructure.

⁵ Relationship between such urban configurations and microclimate and climate change are the subject of separate reserach studies. See: Hebbert, M., Jankovic, V., 2011.

2.1.2. Recommendations for Improvement

1) Aspects of Urban Planning

- Re-examining the standards for the number of parking spaces and amount of greenery according to real possibilities of sites in the city center;
- Providing the alternative design concepts where it is not possible to achieve standards set out by the plan, such as the formation of new public green spaces in sites of devastated blocks, reserving the space for greenery, i.e. exemption from the purpose of developing the plot; enabling the necessary amount of greenery on the plot, depending on its size, by planting the greenery on roofs and facades, as a partial compensation for the lack of greenery on ground;
- Defining the building-height-to-street-width ratio instead of defining the number of floors;
- Defining the maximum building outlines by defining the distance of buildings from boundaries of the plot and surrounding buildings, and not by defining the percentage of the plot usage;
- Defining the building volume as a resultant of the previous, and not on the basis of plot ratio;
- Introducing the passages and connections through blocks.

2) Design Aspects

- Reconstruction of the existing building stock along with introducing the energy efficiency measures;
- Replacement of individual buildings of poor energy performance with new ones designed according to principles of energy efficiency;
- Introducing technical solutions: solar panels, geothermal energy, green facades, thermal insulation, etc.

3) Organizational Aspects

- Re-examining the block size and form for the purpose of dividing or merging them aiming at achieving more rational use of space;
- Re-examining the pattern of land parceling and possibility of land parceling according to the planned development capacity and ownership status;
- Investigating the users of space for the purpose of redefining the standards;
- Investigating the possibilities for implementing an adequate model of public-private partnership in managing the space at the level of the entire block - planning, design, construction and maintenance.

2.2. Freestanding buildings and open blocks in modern urban design concepts

Modern urban design concepts emerged after the Second World War, i.e. after the adoption of planning documents envisaging the development of new settlements in Belgrade. Forms

of urban and physical structure typical for the Modernist period developed between 1945 and 1970 (Fig. 5,6,7). The tendencies that emerged in the period 1970-1980 were modern in their essential characteristics, but with elements of periods that followed and, therefore, classified into the Late Modern Period (Fig. 8). The new urban structure developed based on plans adopted by the State and under the system of open blocks built on the state-owned land. The implementation of the new type of development in new settlements in the city led to new design concepts of blocks. Depending on the size of territory earmarked for the new development, as well as on the type of buildings in terms of the way of construction and grouping of buildings, the urban structure is different in different parts of the city, as shown in Fig. 5,6,7.

The concept of open blocks was actually a reaction against the problems encountered in the development of central parts of the city⁶. New housing concept emphasized the importance of linking apartments directly with the open space. New settlements outside the historical tissue of the city center were conceived on, until then, undeveloped land in New Belgrade, Karaburma, Železnik, etc. Considering that these were mainly residential settlements, the priority was given to the creation of favorable conditions related to hygiene, cost effectiveness and comfort in housing. Planning and design on open terrains enabled the selection of forms, orientation and position of buildings and free spaces.

Compared to the previous periods in the development of Belgrade where the row house building type in a closed block prevailed, in this period new building typologies emerged, different both by the way of construction and by grouping of buildings. Both of these two aspects of building typology had impacts on micro-climatic conditions and, further, on climate change. Multi-family freestanding residential buildings in the form of tall residential towers and apartment blocks were the most represented building type in new settlements. They were characterized by the building height from GF+3F to GF+6F and, exceptionally, even greater height of residential towers. Relative to the previous period, the number of apartments in a building, as well as per floors in a building, increased, but their average surface area decreased to 50-60 sq m. Layouts were compact according to the requirements for land use rationalization. Buildings were first built according to the traditional, massive building system, while later, and with the development of new

⁶ Branko Maksimović writes about housing and urban planning problems which are becoming alarming with regard to the development of "unhygienic residential blocks", which implies poor conditions regarding sunlight, very small distances between buildings and high population density. In his opinion, the cause for this lies in "outdated and obsolete laws on construction which have put architectural and urban planning activity at the service of capital, rentals and speculations". As major drawbacks of urban structure of the central part of Belgrade, Maksimović quotes small, too densely built blocks with poor conditions related to sunlight and aeration, and with yard buildings. The situation is even worse due to small streets with noisy traffic and the lack of open spaces. He concludes that the image of the city is chaotic as a result of individual building construction, without general concept of urban and spatial planning (Maksimovic, 1957).

technologies, according to industrialized building system (IBS). With the implementation of pre-fabricated and industrialized building system, the number of openings also increased. They were either individual or in the form of ribbon (Jovanovic Popovic et al., 2012). Great number of buildings from this period does not have thermal insulation given that regulations on thermal protection were adopted only at the end of 60-ties of the 20th century (Krstic and Bogdanov, 2005). The buildings were built on a flat terrain, so that the terrain did not play important role when it comes to conditions related to sunshine, aeration and views.



**Figure 5. Types of buildings – pavilions in different parts of the city:
a) New Belgrade; b) Karaburma; c) Železnik**

Freestanding buildings nestled within greenery in open blocks were built on different locations and with different distribution of buildings within blocks. Pavilions in the street of Tošin bunar (Toša's Well) in New Belgrade (Fig. 5a) are built in the form of apartment blocks, the pavilions in Karaburma (Fig. 5b) are spot-like positioned buildings, while in Železnik (Fig. 5c) there is a spatial composition of different types of buildings. The gable position combined with the front, deeper set back, position of buildings enables grouping of apartment blocks with different types of housing units requiring different orientation. Thus, more complex forms of grouping have emerged, together with the creation of open spaces that are to a certain extent framed, thus forming separate entities. In this way, due to the need for N-E and E-W orientation of apartment blocks, the groups of apartment blocks in the new settlement of Železnik near Belgrade was realized (Maksimovic, 1957).



Figure 6. The first blocks of open type in New Belgrade: Block 7 and Block 21.

In addition to the fact that the first blocks in New Belgrade (Figure 6) were built taking into account the above described attitudes towards urban planning in local practice (Pucar and Nenkovic, 2006) in which different housing concepts emerged, as well as the fact that awareness about micro-climatic conditions in blocks increased, they were built in the spirit of ideology of the Modern Movement and Athens Character. In new settlements of this type, the size of residential blocks is 800x800m, and blocks are enclosed by wide roads designed primarily for automobile traffic. Pedestrians use separate independent paths distant from roadways and boulevards which run thorough center of blocks. Residential blocks are made up of long residential buildings, height of some 10 floors, and residential towers located at corners of blocks. Buildings of local community, schools and kindergartens, large undeveloped areas for children's playgrounds and sports grounds, as well as green areas, are located in center of blocks (Perovic, 2008).



Figure 7. New Belgrade blocks 45-70 and 61-64.

The buildings in blocks 45 to 70 and 61 to 64 (Fig. 7), located in direct contact with waterfront zone, are oriented so as to maximally use the southern orientation towards the river because of which the working title of this cluster of buildings was „The City of the Sun“. They are free apartment blocks using the principle the most favorable conditions for allowing plenty of sunshine in all apartments in apartment blocks or row buildings. Given that this are most frequently blocks with typical apartments, the conditions for orientation for all apartment blocks are the same, with equal distances required for allowing plenty of sunshine. By positioning apartment blocks in the same way with relation to the street, a group of parallel apartment blocks, i.e. a complex group of parallel row buildings, was obtained. Principle of allowing plenty of sunshine has had an important role in developing the modern urban planning and design, in which the priority has been given to functional characteristics. Another important factor is the orientation of housing units towards open spaces in blocks. Thus, the principle of equally allowing plenty of sunshine is linked to the principle of orienting the housing units towards gardens, children's playgrounds, and greenery in the block. By gable positioning of apartment blocks, streets have lost their previous firm framework and opened themselves towards free spaces in inner parts of blocks, thereby enabling better ventilation, the street microclimate has been refreshed, and street have become an integral part of open spaces outside them.



Figure 8. Residential settlements of Cerak (a) and Višnjička Banja (b)

At the end of the period 1970-1980, the settlements of Cerak and Višnjička Banja (Fig. 8 a and b) were formed under similar principles announcing the post-modern tendencies in architecture and urbanism. However, here, a more free grouping of buildings was implemented according to topography and proximity of natural elements, with the aim to achieve additional effects from the aspect of spatial experience of the built cluster of

buildings. In these settlements, the street was again introduced, but in a new way and not in the traditional form of a street corridor.

Open blocks were characterized by lower building density and more favorable ratio of open space to built-up area. However, this type of urban structure has also been exposed to processes of the land use intensification. According to urban parameters from the Master Plan of Belgrade 2021, the maximum permitted percentage of plot usage in an open urban block is 30-35%, while plot ratio is 2.2, also taking into account standards according to which green and uncovered areas should account for 30-40% of the area of the block, as well as the standard on 0.7 – 1.1 parking space per each apartment, or 1 nonresidential parking space per 80 sq m of commercial space. However, in the current architectural practice, through different mechanisms of speculation over land, these parameters are frequently exceeded in this type of blocks, as shown in the case study of the Block 16 in New Belgrade (Maric et al., 2010), where the difference between the competition design concept and the as-built design can be noticed by comparing the corresponding drawings (Fig. 9 a and b).



Figure 9 a and b. Block 16 in New Belgrade. Figure 9a shows the competition design concept, while Figure 9b shows as-built situation.

Furthermore, through comparative analyses of different concepts of urban structure it can be concluded that it is unrealistic to set out the same standards for parking in open blocks in New Belgrade, where the problem can also be solved by building the shared garages, and for parking in closed blocks in the city center.

2.2.1. Aspects of sustainability related to modern urban design concepts – advantages and disadvantages

New settlements that have emerged in Belgrade after the Second World War cover approximately 13.8% of the buildable area of Belgrade. The major characteristics of these

settlements include open mono-functional blocks, differentiation of functions per zones, freestanding multi-storey buildings and large undeveloped areas in blocks intended for greenery and playgrounds and sports grounds. Advantages of open block building type include more favorable microclimatic conditions related to sunshine, daylight and aeration due to large open spaces between buildings. Free positioning of buildings in blocks also allows the selection of the most favorable apartment's orientation. In addition, the street network consists of wide roads, so that in this type of settlements the street canyon problem does not exist. However, by comparing the characteristics of these settlements with criteria for sustainable form defined by Jabaren, it can be concluded that the only positive aspects are those of greenery planting and passive solar design. Other aspects, such as density, diversity, mixed purposes, compactness, and sustainable transport, cannot be positively evaluated. The infrastructure and transportation networks are over-stretched and not rational when compared to more compact patterns of development. Also, this type of settlements is suitable for the use of private cars which, to a great extent, contribute to increased greenhouse gas emissions. The increased private car use also necessitates new parking spaces in open blocks, often to the detriment of the greenery. The land use intensification in open blocks is a trend in the current practice. However, this practice has its negative aspects because, here, the private interests and tendency for using the buildable site potential neglecting the importance of open space and greenery are dominating, just like in the case of the traditional urban structure (Maric et al., 2010). It is necessary to introduce instruments of a planned control to direct the transformation of the existing urban structure to a more compact development taking into account principles of sustainable urban form.

2.2.2. Recommendations for Improvement

1) Aspects of Urban Planning

- Re-examining the standards for the number of parking spaces and amount of greenery according to the needs of users of space with the aim to exempt the open spaces in blocks from new development;
- Protection of open spaces in blocks from partial development through clearly defined zones where construction is not permitted;
- Defining the maximum outline of new buildings by defining the distance of buildings from block boundaries and neighboring buildings, as well as the possibility of implementing the standards for the number of parking spaces and amount of greenery;
- Defining the volume of buildings as a resultant of the previous one, and not on the basis of percentage of plot usage;
- Introducing the connections through blocks and demotivating the private car use.

2) Design Aspects

- Introducing technical solutions: solar panels, geothermal energy, green facades, thermal insulation, etc.
- Defining the types of buildings that can be built in open blocks and which take into account qualities of urban structure.

3) Organizational Aspects

- Investigate the possibilities of implementing appropriate models of public-private partnership in managing the space at the level of the entire block - planning, design, construction and maintenance.

2.3. Open blocks in new settlements – post-modern tendencies in architecture and urbanism of Belgrade

Open blocks in new settlements within the post-modern tendencies in architecture and urbanism of Belgrade emerged relatively late compared to international trends, actually in the period 1980-1990, following the urban planning and architectural design concepts from the previous period.

These design concepts are found on different locations in the city. They were based on the planning solutions and further elaboration of urban planning and architectural designs in which special attention was dedicated to characteristics of building and space shaping. The accent was placed on the open space structure, ambience and micro-ambience creation and gradation between public and private spaces by introducing small semi-private enclaves resembling the elements of traditional city, but in an open space. As the result, compositions blending the advantages of modern concepts with relation to the relationship between the built-up area and open space in the block were obtained, also taking into account needs of shaping. An imperative of linking the built-up areas and open spaces, as well as orienting the apartment towards green areas and playgrounds, is a common feature for all above mentioned concepts. In addition to favorable micro-climatic conditions, other positive effects were also achieved through the implementation of more free compositions and different way of construction in the mentioned examples marked as the post-modern period in architecture and urbanism. Different housing conditions satisfying different individual needs were provided, as well as the differentiation according to their functions and position in the city – the same principles resulted in different characteristics of urban structure in different parts of the city. Different population densities in certain parts of the city were achieved according to the need for space, at the same time retaining favorable micro-climatic conditions.



Figure 10 a,b,c. Block 24 (a) in New Belgrade, cluster of blocks along the street of Vojislava Ilića (b), new residential settlement in Mirijevo (c).

On the one hand, concepts of blocks (for example, block 24 in New Belgrade – Fig. 10a), cluster of blocks (for example, along the street of Vojislava Ilića – Fig. 10b) and residential settlements (for example, New Mirijevo – Fig. 10c) that emerged were by their geometry similar to the previously described design concepts of pavilions and modern design concepts. The difference was in the way of grouping the spaces which became closer to each other to form ambiances and distances which were by their dimensions appropriate to the perception and use of people.

Freestanding multi-storey residential buildings were a predominant building type. In addition to the possibility of achieving a rational population density together with favorable conditions regarding sunshine and aeration, with enough open space between buildings and building density not exceeding 20%, the population density reached 600 people per hectare, thus enabling the rational use of infrastructure systems. Layouts were either compact or non-compact, where non-compact layouts were often in the function of dimensioning of the form. Building height was from GF+3F to GF+6F, average surface area of apartments was 50-60 sq m. The buildings were built in the largest volume using the prefabricated system, with great number of openings (Jovanovic Popovic et al., 2012).

2.3.1. Aspects of sustainability related to open blocks in new settlements – advantages and disadvantages

The described urban structure accounts for approximately 9.7% of the buildable area of Belgrade. It is a modality of modern blocks retaining the principle of the relationship between the built-up area and open spaces taking into account the needs for direct sunshine, light and aeration. New typologies of built structure and new typologies of open spaces were implemented, where the formation of urban ambience is strived for through the relationship between the built-up area and open space. Major advantages and disadvantages of this type of urban structure are similar to those in modern concepts. The demands for satisfying elementary needs predominant in modern urban concepts, here

gave way to the demands for the humanization of space, as well as for taking into account social and psychological aspects. Out of this reason, the question arises as to what extent the formation of urban ambience would enable proper orientation of all housing units in this type of urban structure precisely due to the insistence on new building types and grouping of buildings.

2.3.2. Recommendations for Improvement

- 1) Aspects of urban planning
 - Re-examining the standards for the number of parking spaces and amount of greenery according to the needs of users of space with the aim to exempt the open spaces in blocks from new development;
 - Protection of open spaces in blocks from partial development through clearly defined zones where construction is not permitted;
 - Defining the maximum outline of new buildings by defining the distance of buildings from block boundaries and neighboring buildings, as well as the possibility of implementing the standards for the number of parking spaces and amount of greenery;
 - Defining the volume of buildings as a resultant of the previous one, and not on the basis of percentage of plot usage;
 - Introducing the connections through blocks and demotivating the private car use.
- 2) Design Aspects
 - Introducing technical solutions: solar panels, geothermal energy, green facades, thermal insulation, etc.
 - Defining the types of buildings that can be built in open blocks and which take into account qualities of urban structure.
- 3) Organizational Aspects
 - Investigate the possibilities of implementing appropriate models of public-private partnership in managing the space at the level of the entire block - planning, design, construction and maintenance.

2.4. Contemporary urban planning and architectural practices in Belgrade

The contemporary urban planning and architectural practices in Belgrade, which can roughly be analyzed from 90-ties of the 20-th century to date, is characterized by changes in the scale of construction. Instead of great undertakings, developing the entire residential settlements and blocks, which was typical characteristics of previous periods starting from the Second World War, the character of the development has been changing and turning towards the construction of individual buildings on private plots as a result of relying on private investments. The buildings from this period, as opposed to the previous period,

were built according to construction regulations related to urban physics. Most of them have the prescribed thermal insulation and openings of size meeting the housing standards.



Figure 11. New residential multi-storey buildings on sites of individual houses

Instead of freestanding buildings in open blocks, which was a typical urban planning and architectural design concept after the Second World War until 1990-ties, due to the change in the way of financing, as well as orientation towards the construction of individual buildings, the row buildings built in the existing urban blocks have become a prevailing building type. These interventions have most often been carried out in central parts of the city in the existing compact blocks as the replacement of the existing building stock. Individual buildings with smaller number of floors have been replaced with new multi-storey residential buildings. These changes motivated by the need for a greater number of apartments in these parts of the city, as well as the sites attractive for investors, have led to problems in functioning of the existing urban structure. Urban parameters have increased by many times within the spatial and physical framework which, according to infrastructure capacity, corresponded to considerably lower population and building density. Problems have manifested themselves in different ways, while in the context of impacts on city's micro-climate, the following negative consequences are particularly pronounced: decrease in green areas due to higher percentage of plot usage in blocks; reduced distances between buildings causing the effect of a canyon; street canyons occurring due to high buildings; increase in reflective surfaces; greater total energy consumption due to increasing number of consumers per the same surface area; increase of total heat emissions; and increase in areas absorbing radiation.

The planning solutions, first of all the regulation, leveling, percentage of plot usage and plot ratio, have to a great extent influenced the design concepts and have, directly or indirectly, been suitable for the implementation of certain shapes, thus shrinking the range

of architectural forms. The insistence by investors on the maximum use of permitted urban parameters has led to typical concept of the recent housing architecture. The types of roofs and front façade planes are some of the typical characteristics of recently built residential buildings (Fig. 11). As for roof shaping, the current construction practice shows that the priority in selecting the roof shape is given to barrel-shaped roofs as a variant of a mansard roof, considering that this type of roof ensures the maximum useful area in a building. Furthermore, the introduction of bay windows as an almost mandatory element and always in the shape using the maximum possibility of the plot is also the result of the tendency to achieve maximum permitted area in the interior of a building.

In the context of protection from climate change, it can be concluded that major problems occurring in this period have resulted from a partial development and, at the level of a block, have often led to the lack of greenery and the use of all available undeveloped area for parking spaces. A problem has also occurred in case of the design and development of entire blocks and residential settlements, such as in the example of the „Belvil“ settlement in New Belgrade and the „Stepa Stepanović“ settlement in Voždovac. Taking into account market conditions under which, due to economic crisis, interest in smaller apartments has been increasing, there is a tendency to design new buildings with a greater number of apartments of smaller surface area. In accordance with the prescribed standards for the required number of parking spaces on a plot, which increases with an increasing number of apartments, the space intended for green areas is mostly used for this purpose. Compared to the number of built parking spaces on a plot, the percentage of green space on the plot is not controlled in the procedure for issuance of building permits.

2.4.1. Problem of spontaneously and illegally built settlements

A specific, and not yet solved, problem of Belgrade lies in settlements spontaneously (illegally) built on the edge of the city area (Fig. 12). The buildings have been built illegally, and the streets have been cut through additionally, which has resulted in an irregular urban structure with streets improperly cut through and, most frequently, of insufficient dimensions to accept necessary infrastructure. In their initial form, these settlements have been built without infrastructure which has been introduced later when the authority has realized that this type of development should be accepted as reality.



Figure 12. Settlement of Mali Mokri Lug

The process of unplanned, illegal or, as in the current literature called *informal* construction (ETH Studio Basel, 2012), has for a long time been the case in the urban development of the city of Belgrade. In the period of 1990-2000, the growth of Belgrade was oriented towards the housing sector, while industry, commercial activities and public works stagnated under the conditions of international sanctions. Construction activities encouraging the transformations were mainly carried out on the edge of the city area owing to unclearly defined mechanisms of urban growth control which enabled private interests to dominate over public interests. Thus, instead of developing by expanding continuously in its area and by building construction, i.e. horizontal and vertical growth, the city has, over years and owing to illegal construction, expanded outside its boundaries, in the zone outside the city because of cheaper construction, while central parts remained undeveloped and neglected. Dubravka Stojanović emphasizes that the „issue of city district“ is a paradigmatic issue of Serbian history that also existed in previous periods of modernization and europeization, as well as that it is one of the most important hindering factors towards further development of Belgrade (Stojanovic, 2008). She also emphasizes that high prices of buildable land in Belgrade and high interest rates, as well as supply which has always been considerably smaller than demand, has enabled the owners of plots in the city to speculate, while, on the other hand, the quality of buildings has been maintained.

The urban structure developed in an unplanned way, by partial development, has the characteristics of an irregular formation of buildable plots and street regulation. The street

network has not resulted from a planning process and has not met the requirements of an urban settlement, but has made the street regulation and building of utility infrastructure, as a whole, more difficult. Furthermore, transportation and infrastructure networks have not been rationalized because their lengths have been adjusted to the fragmented construction. Referring to investigations carried out in 1995, Djukić and Stupar emphasize that only 20% of buildings built in peripheral zones of Belgrade were planned and/or regulated by some plan, while only 35% of them had some form of technical documentation. As an outcome, the majority of settlements did not have basic infrastructure. In the Kaluderica settlement, for example, 90% of houses had electricity, 65% of houses were connected to the public water supply system, approximately 20% were connected to the sewerage system and only 5% were connected to the heating system of the city (Djukic and Stupar, 2009).

The irrational infrastructure network, particularly of remote settlements not connected to the public transportation system, has additionally increased energy consumption and greenhouse gas emissions, considering that these households are often compelled to use only private cars. Furthermore, network of narrow streets and inappropriate buildings create poor hygienic conditions in settlements. Due to this, it is necessary to reexamine the possibilities for additionally regulating and rationalizing their utility infrastructure.

2.4.2. Transformations of the existing buildings by adding new floors

Adding new floors to the existing buildings is a special form of interventions in the development of the existing urban tissue of Belgrade. There are two typical forms of such interventions – adding new floors to the existing buildings – the replacement of the existing inclined roof or, frequently, the replacement of flat roofs with inclined roofs by adding new floors (Krstic and Bogdanov, 2005). Such type of interventions increases population density, additionally burdens infrastructure capacity which frequently remains unchanged, increases the number of users for which parking spaces are to be provided, requires an additional percentage of greenery and open spaces which is, indeed, impossible to provide, etc.

The buildings from the period between 1945 and 1970-ties were particularly subjected to interventions comprising the replacement of the existing roofs with new ones, most often with inclined roofs. Thus, a flat roof is one of the important stylistic determinants of modern architecture to which such buildings belong. Due to massive and unplanned construction, the physical problems have occurred, such as leaking and deterioration of such roofs due to poor and improperly executed structural joints. On the other hand, social problems, the need for an increased housing stock by passing the new development which is a longer and more expensive path to achieving this goal, have led to the decision on new construction which has, in local conditions, also further led to a change in design concept of roof, i.e. the replacement of flat roof with the inclined one (Ibid).

In addition, different types of extensions have emerged both in longitudinal and transversal direction according to the site conditions. The adaptation, understood as a procedure for the adaptation or adjustment of one or more parts of a building so that the entire building could fit in and meet the current needs of tenants, under current conditions undoubtedly also implies energy optimization as a desirable form of improving the existing housing stock and, more broadly, raising the quality of life in urban entities. Thus, the extension of buildings has sense and results in the creation of new architectural value where rules of the profession are observed, as well as where potentials of a building to which new floors are to be added are well recognized and improved (Cukovic Ignjatovic and Ignjatovic, 2005). Here, the following should also be added: as well as where effects which the extension has on immediate urban environment related to the relationship towards surrounding buildings, burdening of the existing infrastructure systems, and possibilities of providing enough free space and parking spaces for new beneficiaries.

2.4.3. Sustainability aspects in the analysis of urban structure transformations – advantages and disadvantages

The present paper identifies typologies common for urban structure of Belgrade corresponding to main periods of its development. The trend of the land use intensification has occurred in all types and has manifested itself in different ways. Transformations in the traditional urban structure have taken place in the unchanged urban matrix, thus leading to an overloaded transport network and infrastructure capacity, having negative effects of air pollution, as well as negative impacts on sustainable development and energy consumption. The balance between the built-up areas and open spaces is being disturbed within the closed urban blocks characterized by this type of urban structure, thus affecting the microclimatic conditions. In new settlements which have developed on the basis of modern and post-modern design concepts, there is also a trend of land use intensification, but here it manifests itself as a filling of open space not taking into account the relationship between the built-up areas and open spaces from the aspect of microclimatic conditions (Maric et al., 2010). The contemporary architectural practice is characterized by the principle of the domination of private interests, as well as by the maximum use of permitted urban parameters for the development on plots, which in combination with parking standards leads to the reduction or elimination of green areas. A special problem lies in illegally built settlements which are developing without any planned control and which require additional investments in the regulation and infrastructure. The attractiveness of sites in the city center leads to an additional increase in the buildable area through vertical and horizontal extensions.

The type of urban structure that emerged as a result of architectural practices over the past twenty years has resulted from interventions in the existing urban tissue of Belgrade. This type of interventions emerged mostly in the part of urban tissue designated in Figure 2 as

individual housing in the process of transformation, covering 31.8 % of the continuous built-up area of Belgrade. After this period in which priority in the planning solutions was given to the relationship between the built-up area and open space ensuring the safe and healthy environment, which resulted in characteristic typologies of built structure, the compact type of closed blocks and row buildings on the edge of the city area have again become the prevailing building type. Such building type may have its advantages if the capacity of infrastructure in street corridors is increased simultaneously with an increase in the capacity of the construction and if standards on required open areas, parking spaces and greenery are taken into account. Considering that these are individual, partial interventions, the accent has been placed on the maximum use of the buildable plot potential, where an appropriate percentage of free and green area at the level of both plot and block has not been achieved. The standard establishing the requirement for parking spaces additionally aggravates the achievement of the required percentage of greenery so that microclimatic conditions in urban compositions deteriorate. It is necessary to reexamine the capacity of both the site and street network in relation to the possibility of the existing urban tissue intensification and densification. Furthermore, it is also necessary to reexamine standards on the number of parking spaces taking into consideration needs of population and its social structure, also in the context of tendencies to sustainable forms of transportation – walking, bike, public transportation.

2.4.4. Recommendations for Improvement

1) Aspects of Urban Planning

- Defining the capacity of constructing new multi-family buildings on plots of former single-family houses according to the plot size, standards for the number of parking places and amount of greenery, relationship towards the neighboring buildings, as well as the existing infrastructure capacities;
- In cases where it is not possible to achieve planned capacities, it is necessary to reexamine the possibility of land parceling, standards for the number of parking spaces and amount of greenery, the possibility of the compensation of green and parking spaces on public spaces;
- Determining the height of buildings by defining the relationship between building height and distance from neighboring buildings and block boundaries;
- Defining the maximum building outline by defining the distance of buildings from block boundaries and neighboring buildings, as well as the possibility of achieving the required standards on the number of parking spaces and amount of greenery;
- Defining the volume of buildings as a resultant of the previous one, and not on the basis of plot ratio;
- Introducing the connections through blocks and demotivating the private car use.

2) Design Aspects

- Introducing technical solutions: solar panels, geothermal energy, green facades, thermal insulation, etc.
- Defining the types of buildings that can be built in open blocks and which take into account the qualities of urban structure.

3) Organizational Aspects

- Re-examining the block size and form for the purpose of dividing or merging blocks for achieving more rational use of space;
- Re-examining the pattern of land parceling and possibility of land parceling according to the planned development capacity and ownership status;
- Investigating the needs of the users of space for the purpose of redefining the standards;
- Investigate the possibilities of implementing appropriate models of public-private partnership in managing the space at the level of the entire block - planning, design, construction and maintenance.

3. CONCLUSIVE CONSIDERATIONS

The present paper analyzes the relationship between certain types of urban structure of Belgrade and the sustainable development and resilience to climate change impacts. Through investigating the urban structure typology, the following results have been obtained:

- The traditional urban structure that gradually developed in the period whose end coincided with the end of the Second World War had potentials for transformations in the direction of compact sustainable development. However, high densities, as well as tendencies towards further intensification and densification, led to the problem of excessive building densities and lack of green and uncovered areas, as well as to the impossibility to achieve all standards in design and planning of the new and reconstruction of the existing buildings. There was a lack of instruments for the planned control which would be used in the operationalization of recommendations for the improvement of such type of urban structure.
- Urban structure of open blocks emerging in the form of architectural and urban planning design concepts of the Modern Movement in the period of 1945-1970, Late-Modern in the period of 1970-1980 and Post-Modern in the period of 1980-1990, is favorable from the aspect of microclimatic conditions and protection from climate change, and owing to a favorable relationship between the built-up areas and green spaces, distances between buildings, and wide roads where the effect of street canyons is not pronounced. Such architectural and urban planning design concepts could be implemented in the system of centralized sustainable planning and management of land.

- Over the past two decades, the development and transformation forms that have occurred have not been harmonized with the principles of sustainable development.

These problems are tightly linked and have stemmed from general problems encountered in the current urban planning practices, as well as design and architectural practices in Belgrade. It is primarily the issue of partial development, domination of private interests, i.e. the neglect of public interests by using the maximum buildable plot potential not taking into account the necessary balance between different elements. This disbalance can be tracked at the level of block. Problem has derived from insufficiently developed mechanisms in regulating the relationships between private and public stakeholders in these processes.

To solve these problems, it is necessary to develop a methodology and instruments in the operationalization of design and planning from the aspect of urban planning and design, as well as from the organizational aspect - planning, design, construction and maintenance, as well as aspect of monitoring - implementation, realization and maintenance.

- From the aspect of urban planning, it is necessary to develop a methodological approach based on a complex analysis of the existing state of the built environment with the aim to affirm the quality of the existing spatial-functional organization.
- From the design aspect, it is necessary to introduce energy-efficiency measures in building design and construction new as well as reconstruction existing physical structure.
- From the organizational aspect, it is necessary to develop mechanisms in regulating the relationships between private and public stakeholders. It is also necessary to develop a methodology of planning and implementation of plans in which the future development would be planned and realized at the level of larger urban entities, primarily blocks, instead of partial development at the level of individual plots. This methodology should include the planning of blocks as basic planning units, as well as their maintenance in exploitation. The management of these procedures may be entrusted to the City which, through the Directorate as a public institution authorized for the city's land use management, can direct such type of development. Another possibility includes association of investors into interest groups which would be entrusted with the construction of block units – the joint venture system.

The main objective of this approach is to introduce the control in the zone in which the private interests dominate to the detriment of public interests. Hereby, we are faced with the described problems of insufficiently represented open and green spaces, insufficient distances between buildings, as well as buildings erected to a height in excess of the width of the street – where all this adversely affects microclimate conditions. This approach would enable the realization of common, public and semi-public spaces at the level of

blocks intended for greenery and recreational activities, which would otherwise be difficult to achieve through a partial approach.

The problem of insufficiently recognizing and differentiating the characteristics of urban structure in procedures of planning, design and construction is reflected in the environmental quality and possibility of sustainable development. Non-critical interventions in space, especially through partial development, disturb the balance of elements which should be involved in the architectural and urban planning design concepts - greenery, open spaces, the relationship towards the street, neighboring buildings and plot boundaries. The consequence of partial development is that private interests dominate in decision making related to the maximum use of the buildable plot potential. For solving the problem of partial development, it is necessary to offer models of planning based on synergy between private and public stakeholders. Only in this way, it would be possible to achieve and maintain the environmental quality consisting of a balanced relationship between the built and natural environments.

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SUMMARY

The enhancement of the existing urban structure aiming at reducing the impacts on climate change is a time consuming and complex task associated with planning, technology, building construction, economic mechanisms, education and modalities of the application through implementation. Belgrade is an exception model suitable for investigating this

issue because it has diverse urban tissue typology, from the city of 19th century through modern patterns to unplanned construction. On the other hand, its topography is very diverse, from plains to hills. Its microclimate is also diverse with relation to morphology and biological and hydrological characteristics.

The analysis of urban tissue and physical structure, with a view of the current strategies and planning documentation, was a research starting point which was followed by the valorization of different possibilities of implementing the instruments and technologies on typical parts of urban tissue of Belgrade. The outcome is a set of urban and planning, as well as production rules which could serve as a starting criteria for future plans for the urban tissue redevelopment, but also for the development of new parts of the city.

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