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LEARNING  
ARCHITECTURE

# PROCEEDINGS

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AND TECHNOLOGY IN THE DIGITAL AGE**

**CHAPTER 2 INNOVATION IN INFORMATION TECHNOLOGY –  
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**POSTER SESSION**

**ON ARCHITECTURE**  
**LEARNING ARCHITECTURE**  
**PROCEEDINGS**

Belgrade, Serbia  
2020

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- CHAPTER 1** Innovation in Art, Architecture, Science and Technology  
in The Digital Age
- CHAPTER 2** Innovation in Information Technology - Improved Use  
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**RESULTS OF SCIENTIFIC RESEARCH PROJECT „THE SPATIAL, ENVIRONMENTAL, ENERGY AND SOCIAL ASPECTS OF DEVELOPING SETTLEMENTS AND CLIMATE CHANGE – MUTUAL IMPACTS”- FACING THE CLIMATE CRISIS, PROPOSALS AND SOLUTIONS IN NEWER PLANNING PRACTICE IN SERBIA**

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**ABSTRACT**

The scientific research project entitled „*The Spatial, Environmental, Energy And Social Aspects of Developing Settlements And Climate Change – Mutual Impacts*”, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia in the period from 2011 to 2019, has gathered over 60 researchers from 6 scientific research institutes and faculties in Serbia. The Institute of Architecture and Urban & Spatial Planning of Serbia (IAUS) was a project coordinator. This paper shows the way of conducting the scientific research project and presents some of the results, but also the difficulties encountered by researchers over more than nine years of research work.

In addition to the official scientific research papers published within this Project (in the international and national journals and in the international and national congress proceedings), the results obtained in this Project have also found their direct implementation in drafting the planning documents in Serbia, as well as in the development of the specific web services/platforms for supporting the process of issuing the approvals on the environmental impact assessment studies and studies in the field related to the use of the solar power potential in urban areas. Added value of this scientific and wider community is the knowledge base established within the project with all relevant scientific and research contributions realized on the Project in the form of an online database that was and still is available to project participants and the entire scientific community in Serbia and worldwide. This paper presents the successfully made projects that have had a scientific research foothold in this Project.

**Keywords:** sustainable development, climate change, implementation of research results in the planning practice, the use of new technologies

## INTRODUCTION

The scientific research project entitled „Spatial, environmental, energy and social aspects of developing settlements and climate change – mutual impacts”, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia in the period from 2011 to 2019, has gathered over 60 researchers from 6 scientific research institutes and faculties in Serbia. The Institute of Architecture and Urban & Spatial Planning of Serbia (IAUS) is a project coordinator. The participants in the Project are: The Faculty of Architecture - University of Belgrade, The Faculty of Geography - University of Belgrade, The Faculty of Electrical Engineering - University of Belgrade, The Faculty of Natural Sciences and Mathematics - University of Nis, and the Institute of Technical Sciences of the Serbian Academy of Sciences and Art and from the Glasgow Caledonian University. In addition, a large number of doctoral students and scholarship holders of the Ministry, one researcher from abroad and several external associates participated in the project.

The Project is focused on various issues of actual climate changes and their impacts on urban development, combining a multidisciplinary knowledge of many disciplines involved directly and indirectly. The project explored the possibilities of innovative planning and construction and setting standards in accordance with the climate responsible attitude towards the environmental protection, which contributes to improving the quality of life, conserving resources, preserving the urban and natural environment and better management of settlement development and construction. This research offers solutions related to planning methodology, different types of plans, functional organization of settlements, treatment of open spaces and urban landscape, as well as standards for physical construction, replacement of the existing building fund with new ones that will be in line with environmental standards, i.e. climate-responsible design and construction. The research relates to the processes in the EU and is in line with the ongoing research efforts in other countries.

The construction fund in Serbia is of different quality and needs to be renewed. On the other hand, future construction will occupy undeveloped spaces inside and outside the existing tissue. The development of infrastructure that is the basis for the construction and reconstruction of new physical structures should adequately follow the development. Rationalization applied through planning and engineering procedures is necessary for the renovation of the old and the sustainable construction of the new urban space. The introduction of modern standards and technologies is necessary for further development within the set goals.

The problem of the poor, who often live in informal settlements located in areas at risk, is evident. Due to limited resources (that make it difficult for them to respond to changing conditions) this population is extremely vulnerable to climate change.

The project explored opportunities in the field of institutional building and climate change management instruments at all levels of governance, development of a responsible approach to planning and development management that contributes to change and improvement processes in the field of urban and spatial development planning systems, and directs redefining the role of all development actors in search of answers to operational questions, which are asked daily in the context of sustainable urban development of Serbia. The research results offered solutions for new institutional arrangements, creation and innovation of climate and environmentally responsible regulations, management instruments, norms and standards that enable efficient involvement in the decision-making process of climate-responsible spatial development at all levels of management.

Buildings consume about 50% of the total energy produced. Reduction of energy consumption in buildings can be achieved through energy efficient urban planning and design, application of bioclimatic principles and the use of renewable energy sources (RES). Within this project, research was done on the development of methods and tools for assessing the impact, vulnerability and adaptation to climate change, using indicators and criteria relevant to the spatial organization of the most modern technologies for the prevention of conflicts in space.

As part of the work on 3D urban information models, data collection and standardization were obtained (application of cityGML as an OGC standard for modeling, transmission and storage of geospatial data); as well as the development of the monitoring system and the architecture of the information system.

## RESEARCH OBJECTIVES

The goals set at the beginning of the research include: preparing and creating an information base; analysing and systematizing the input parameters for changing the planning patterns towards a climate-responsible model; analysing and systematizing the relevant elements of physical structure, linking to the climate-responsible approach; analysing the current legislation and proposals for its change in the domain of spatial

and urban planning; creating the knowledge base for linking it to the characteristic forms of knowledge created during the project and constant exchange of knowledge, both within the project and with wider researcher's and professional community; the promotion of young researchers and helping in PhD dissertation writing; the promotion of the researchers in editorial boards of international and national journals, organizational and scientific boards of international scientific conferences, review teams of national and international journals and conferences, national and international bodies, etc.

#### **SIGNIFICANCE OF RESEARCH**

Work on this project and research results are of great importance and are among the strategic priorities. The scientific contribution of this research is reflected in the creation of new bases for theoretical and methodological harmonization of the practice of planning and construction in Serbian cities. This project has created a basis for the development of new methods and techniques that will be responsible for climate change, the environment and the interest of citizens in a better life in cities. At the same time, within the project was created a knowledge fund (base) is created that enabled the establishment of effective communication with neighboring countries and EU countries, which will support the exchange of ideas, knowledge and experiences. The contribution of this research in the applied sense is reflected in the creation of scientifically based and practically validated material for the development of regulations, norms and standards of climate and especially CO<sub>2</sub> responsible development.

The importance of the research is reflected in the establishment of a typological classification of the existing building fund, as well as the forecast and recommendations, based on models, which should be used for urban planning and construction of buildings. Research contributes to the development of urban and technical parameters harmonized with European, adapted to technical, natural and social conditions in Serbia.

The scientific contribution of this research is reflected in the creation of new bases for further theoretical and conceptual redefinition of institutional and information support for urban and spatial planning, and the creation of bases for the development of new planning methods and techniques in Serbia.

In the field of energy efficiency, the scientific contribution was a great number of theoretical analyzes, which results can be applied to planning solutions that reduce the greenhouse effect. The results of this project applied in practice will have the effect of mitigating the effects of climate change in the current situation in Serbia.

The contribution of the research is reflected in the definition of the spatial organization of RES, especially wind farms in Serbia through the consideration of strategically significant impacts on the environment with special reference to the protection of ornithofauna in chiropteroфаuna. The contribution is also in defining the model of spatial organization of waste management systems at the regional and local level with the application of modern technologies of waste treatment and landfill gas exploitation.

The development of 3D city models enables the collection and integration of different data in different scales, the application of spatial and thematic queries as well as spatial analytical functions. 3D urban information models enable analyzes and simulations in order to find optimal urban solutions, in accordance with the established principles of energy efficiency and CO<sub>2</sub> emission reduction.

#### **ORGANIZATION OF PROJECT WORK**

The research is carried out within five subprojects: SP1: „Climate Change as the Factor in Spatial Development of Settlements“, SP2: „The technical and technological aspects of planning and designing the physical structures of settlements“, SP3: „Strengthening of Institutions, the Social and Institutional Aspects of Integrating the Climate-responsible Spatial Development“, SP4: „The Energy and Environmental Aspects of Spatial Planning and Climate Change“ and SP5: „Information Technologies, the Development of the System of Indicators and Monitoring, Geostimulation Modelling and Spatial Statistics as the Prerequisite for the Spatial Development of Settlements“. All subprojects had their own managers who coordinated the research within each subproject.

#### **RESEARCH DIFFICULTIES**

Most of the goals set at the beginning of the research have been met. The number of the planned goals were not fully achieved in certain time periods of research, so that they were to some extent modified and adapted to real conditions. The reasons for that primarily lay in the fact that the equipment that was counted on at the time the project was presented was not delivered, as well as that the funds for the DMC (Direct Material Costs), which made the field work and publishing of the monographs and leading international journals impossible. The researchers oriented themselves towards the theoretical work and published greater



number of theoretical papers than planned. Such research need to be partly carried out in field, actually in cooperation with local self-governments. However, the cooperation with local self-governments is difficult to realize. The project goals that were related to the field research were partially achieved, and the processing of the site survey data was partially carried out because the researchers often did not have appropriate equipment or access to the data which would provide the material for processing. The number of pilot projects for spatial analysis and implementation of research findings on concrete projects and concrete space was insufficient. As a compensation, an extensive research on good practices and experiences of other countries or certain research not depending on the field work was carried out.

## **RESEARCH RESULTS**

All planned activities were realized through the results in all categories. For total of 9 years, 740 results were planned, while 1524 were realized. The analysis of research results revealed that far greater number of results than planned was achieved. However, the structure of categories does not fully correspond to the planned one. There are almost no results on the project that were not achieved. Some planned results were not achieved, while other results were achieved, mostly those of higher category. An outstanding success was achieved by publishing as many as 122 papers in international journals. 20 papers were published in category - lectures at the invitation from international conferences. Most of the planned results were achieved. The doctoral theses were defended by 22 researchers. All researchers in the project participated with great number of papers in the international and national scientific conferences. Three monographs were published containing the results of research on the project, in which almost all researchers participated. In addition, a great number of international and national monographs, as well as chapters in monographs, were published as a result of the project. A concrete application of research on the project, where 85 technical solutions were achieved.

The results on the project are very significant and will have an impact on further research in this area in Serbia. Many researchers on the project have occupied very important positions in editorial boards of international and national journals, as well as in organizational and scientific boards of international scientific conferences, and they are reviewers of national and international journals and conferences, but also members of important national and international scientific bodies and associations.

## **Planning documents**

A significant part of the research was directly applied in practice through developing all levels of planning (spatial and regional planning, spatial plans of local self-government units; special purpose area spatial plans, urban plans, as well as strategic environmental assessments, strategies, studies, etc.).

One of the goals to investigate the links between climate change and spatial development of cities, the impact of climate change on further processes of urbanization, planning and construction, has been achieved. Through case studies, the following topics were explored on specific examples: promoting adaptation to climate change within urban planning; spatial plan implementation models - theoretical approach and case studies for spatial plans for the special purpose area; methodological framework for integrated planning of protection and development of natural resource areas in Serbia - spatial plans for special purpose areas for protected natural areas, as well as opportunities for development of tourist potentials in protected areas of water accumulations, for example spatial plans for special purpose areas in Serbia. Through the published works, recommendations are given that can be useful in the development of strategies, plans, projects and initiatives related to the impacts of climate change on the environmental aspects of settlement development.

The scientific contribution of this Project is reflected in the creation of new basis for theoretical and methodological coordination of the practices of planning and developing the cities in Serbia. The Project has created the basis for developing new methods and techniques that will be responsible towards climate change and the environment. The Project contribution in the applicative sense is reflected in the creation of the scientifically based and practically confirmed materials for developing the regulations, norms and standards for climate responsible development, and in particular relating to the CO<sub>2</sub> emissions. The project has also contributed to the creation of new basis for further theoretical and conceptual redefining of institutional and computer support to urban and spatial planning, as well as to the creation of a basis for developing new planning methods and techniques in Serbia considering the concept of new qualitatively improved computer basis. The applicability of the research in the field of sustainable climate responsible urban and spatial development, as well as spatial development in Serbia, is reflected in: -The identification of problems caused by climate change with an accent on urban environments and integration of institutional capacities for problem solving; -The identification of concepts, recommendations, programmes, methods and tools for the support at all levels of space management; -The creation of possibilities for institutional

building and strengthening of capacities for managing climate change and urban strategic projects in relation to the new demands of spatial development; -The creation of new approach that includes climate responsible planning and methodology for planning in relation to the different levels of planning, planning procedures and procedures for decision making; -The creation of conditions for the application of information and communication technologies in planning and participation of citizens, creation of social networks and their implementation in the practice of planning; -Examples of smart systems that can be a support to the environmental monitoring and detection of crisis areas; -The use of ICT tools to support urban development; -The structuring and creation of educational programmes oriented towards awareness raising, development of knowledge and skills at the local level; -The re-examination and application of research results in the practice, namely in urban environments most directly threatened by climate change; -The application of research results that contribute to reducing the greenhouse effect and increasing the energy efficiency; -The defining of spatial organization of RES, model of spatial organization of the waste management systems along with the application of modern technologies; -Efficient modelling of spatial information in urban environments in the field of energy, environment and fight against climate change (Urban Information Models, geoportals and remote detection sensors for collecting a large amounts of environmental data). The developed models and recommendations can have great practical application in building the smart city services and e-administration and creating the operating systems for environmental and climate impact monitoring.

Within the project, the results of the research were applied in projects and plans (often pilot projects), where new results and technological solutions were reached during the field work. Strengthening cross-sectoral cooperation and including climate change issues in sectoral priorities has certainly been one of the key preconditions for the efficient and complete implementation of systematic research.

The project explored the paradigms of development and construction of settlements based on the principles, criteria and standards of climate responsible development, the principles of climate responsible attitude towards space and the relationship it establishes towards the functional organization of settlements, urban organization and construction. A methodology for planning settlement development and construction has been established in accordance with the criteria of climate-responsible planning and CO<sub>2</sub> reduction. Models of sustainable development based on energy efficiency and the application of renewable energy sources (RES), as well as the possibility of applying planning settings and modern technologies in the prevention of conflicts in space, etc. were investigated.

#### **Development of specific web services**

The Project has worked on the establishment of a "smart" service based on the 3D Urban Information Model for sustainable urban planning and city management in accordance with the principles of energy efficiency and CO<sub>2</sub> reduction - a pilot project on a real case.

Results achieved in this project as well as the development of specific web services / platforms to support the process of issuing approvals for Environmental Impact Assessment Studies and in the field of using solar potential in urban areas.

Within the activities of the subproject dedicated to the use of geo-spatial modeling and information systems, a great contribution was made to the establishment and evaluation of eEnviPer and i-SCOPE services of "smart cities". Both systems were established and tested in the pilot area of the city of Indjija.

#### **"Smart Cities" Services**

In cooperation with the eEnviPer and i-SCOPE projects co-financed from the CIP-ICT-PSP program of the European Commission, two web-based services of "smart cities" were built in the pilot area of the city of Indjija. eEnviPer e-government service is intended to support the entire process of issuing approvals for environmental impact assessment as well as issuing integrated permits. The service is based on a unique multi-purpose platform based on Service Oriented Architecture (SOA) and tested and evaluated in a real-world environment over one year of pilot life. The system is designed to cover all aspects of e-government services: defining use cases and workflows defined according to the legislation of the Republic of Serbia, including GIS systems to provide the necessary information in the field of environmental management, Web 2.0 platform for citizen participation and knowledge management systems (KMS). The evaluation of the eEnviPer solution has shown significant advantages in establishing such e-government services in the field of environmental protection, primarily in the context of improved transparency of decision-making processes, better public involvement and visibility of spatial information used in these processes.

i-SCOPE "smart city" service provides information on the solar potential of roofs in Indjija. The service is built on the 3D Urban Information Model (UIM) which is based on the cityGML OGC (Open Geospatial

Consortium) standard. The 3D cityGML model is generated from the input data (Digital Terrain Model, Digital Roof Surface Model and Object Basics) in the novaFACTORY commercial software. Data on average solar radiation for each month during the year were calculated for each roof using the r.sun model of GRASS GIS open source software. In addition to technical, the service provides users with information related to the economic aspect of the use of solar energy, including the prices of solar panels, the necessary investments and the time of return on investment. Preliminary results of the evaluation show the great importance of accurate information on the potential use of solar energy in urban areas to raise citizens' interest in the exploitation of this renewable resource.

Research on pilot examples of eEnviPer and i-SCOPE services "smart cities" has shown the great importance of spatial models and Web-based geo-information systems in establishing a "smarter" attitude towards the environment and energy issues in urban areas, as well as raising public awareness and by changing social habits in these domains.

#### **Knowledge base**

The Knowledge Base should be emphasized as a special result (available at the address: <http://e-science.amres.ac.rs/TP36035/>). It also covers the research on the specificity of available knowledge about international influences on the development of settlements and climate change; the creation and use of knowledge base combined the knowledge about the problem, primarily produced within the proposed project, but in the broader social context.

The main ideas behind the presented Knowledge Base was to establish an efficient communication channel aimed at: - Sharing knowledge between the researchers - members of the Project TR 36035; - Highlighting external knowledge relevant to the Project TR36035; - Disseminating the knowledge created within the Project; - Connecting the knowledge created within the Project TR 36035 with other relevant knowledge bases - Being sustainable, in terms of maintaining contents during the Project and preserving it creation time after the Project conclusion.

Creating the proposed Knowledge Base we had in mind the following: Knowledge is information in action, so dealing with knowledge does not mean just systematizing information, but considering various sorts of related actions; Knowledge is dynamic, so it cannot be captured in a certain moment as absolute; Knowledge is social and in any kind of organization it goes through four characteristic states identified by Nonaka and Takeuchi as: socialization, externalization, combination and internalization and Finally, deciding to capture the observed knowledge it was our aim to increase the body of explicit knowledge on urban development.

The Knowledge Base is technically supported and hosted by Academic Network of Serbia - AMRES1, responsible also for the AMRES e-Learning platform2. For the purpose of creation of this particular resource, a new Web domain <http://e-science.amres.ac.rs> has been established, presuming that in the near future there might be more requirements for Web hosting by other research projects. Similarly with establishment of the AMRES e-Learning platform, this is regarded as a seed for a possible AMRES e-Science platform.

Having in mind the required functionalities of the future Knowledge Base, and limited funds allocated for purely technical and programming support, we have examined several content management systems (CMSs) against their capabilities to support the creation of KB. This examination included the MOODLE platform, already in use for the AMRES e-Learning Platform, and various CMSs available as open source or freeware solutions, including the Blogspot and WordPress.

Finally the WordPress has been chosen as a solution that could respond to the needs of this particular project. Main feature of the system that helped to make this decision was a double system of structuring the contents, by categories predefined by editors and by tags set by content contributors.

#### **Education, publications, round tables, cooperation with local communities**

In one part, the research was applied through the educational practice, i.e. the researchers active in teaching have integrated the research findings into teaching on subjects at the master's degree and PhD programmes. Researchers worked individually or in groups, depending on the topic, interests and scope of research. Where appropriate, consultations and meetings were organized at the level of sub-projects or the whole project, when the results achieved are presented. Project-level meetings were usually organized at the end of the research year when the results are summarized and the project report is prepared. After the project audit performed by the MPNTR expert every year, the project manager informed the researchers about the project evaluation, remarks and suggestions of the reviewer. This also influenced the further development

<sup>1</sup> AMRES – Academic Network of Serbia, <http://www.amres.ac.rs/> (accessed January 2013)

<sup>2</sup> AMRES e-Learning Platform, <http://elearning.amres.ac.rs/moodle/> (accessed January 2013)

and direction of research. Researchers were also allowed to present their results or give lectures that are directly recorded and transmitted (online) and are available through a knowledge base.

Occasionally, the Project team organized Round Tables with the aim to present the project activities and research results by subprojects as well as problems that researchers face and that affect and change the research plan. Researchers from other projects, stakeholders, partners who use research results through various projects (primarily urban and spatial plans), professional and scientific public, local self-government, etc. were also invited. It was obligatory to include young researchers, as well as doctoral students who were engaged in the project and who presented their research results that are relevant to their doctoral theses and the topic of the project.

In addition to participating in numerous national and international congresses, researchers held numerous lectures and workshops at various conferences, presented the results of the Project in media, intensively cooperated with the governmental and non-governmental sector dealing with climate change, built environment, energy, environment, etc. The project examined the methodological patterns of collaborative processes of formulating local sustainable solutions that will be responsible for climate change and the environment for specific local communities and in cooperation with its representatives. The goal of such processes, in addition to producing sustainable solutions (plans, policies, decisions), was to encourage communication and establish links and trust between different groups of actors within local communities.

## CONCLUSION

In the end, it can be concluded that the activities on the project were intensive, as evidenced by the total number of results achieved. A high level of goals has been achieved, which is largely the result of good planning, engagement and competence of researchers.

The aim of the project was also to give an answer to the professional and scientific public on how to face this challenge in specific local conditions, and how, to what extent and in what direction it is necessary to change policies, planning models and urban patterns that would be appropriate for Serbia, which could best meet the local circumstances and specifics.

Recommendations and standards of urban development planning and management practices were defined, especially in terms of formulating new instruments, methods and techniques. Work was done on the further development of curriculum and methodological tools in the education of professionals and the general public on the issue of climate change. Services of 'smart cities' based on urban information models (UIM) for combating climate change and environmental issues were investigated.

Additional research results in this area were summarized with reference to experiences and formulation of recommendations for overcoming obstacles. The Project has emphasized the modeling of climate change indicators as spatial layers from in situ data and remote sensing data. Work was done on further development of platforms for data collection in urban areas on crowdsourcing models. The state of urban vegetation was monitored using multitemporal data from the Sentinel-2 satellite mission. Large raster data management - use of raster databases (data cube). In the eighth year of the research, the Project continued maintaining the knowledge base, as well as created conditions for permanent storage of existing data even after the end of the project. Research continued in the field of action plans for adaptation to climate change (at the regional level) as well as in the field of application of BIM (Building Information Modeling) technology in the design of architectural structures. Current research on the TR36035 project is related to research on the international project COST CA16235 - Performance and Reliability of Photovoltaic Systems: Evaluations of Large-Scale Monitoring Data.

It can also be stated that the envisaged project objectives would have been met to a greater extent if there were no problems in delays and non-delivery of approved equipment and raw materials whose procurement is realized through the Project Management Unit (PIU). In addition, the implementation of the Law on Public Procurement has made it even more difficult for researchers to achieve their goals and implement projects, and it is necessary to initiate a procedure to give science a more favorable status in the public procurement procedure. There are also problems in cooperation with public companies (fragmented jurisdiction, unclearly defined responsibilities and procedures).

The scientific contribution of the research within the project is reflected in the creation of new bases for theoretical and methodological harmonization of the practice of planning and construction of cities in Serbia. This project creates a basis for the development of new methods and techniques that will be responsible for climate change, the environment and the interest of citizens for a better life in cities. At the same time, in this way, a knowledge fund is created that enables the establishment of effective communication with neighboring countries and EU countries, which will support the exchange of ideas, knowledge and experiences. The contribution of this research in the applied sense is reflected in the creation of scientifically based and practically validated material for the development of regulations, norms

and standards of climate and especially CO<sub>2</sub> responsible development. In the field of energy efficiency, the scientific contribution is represented by a large number of theoretical analyzes, the results of which have been applied to planning solutions, in order to reduce the greenhouse effect. An added value of the Project is the application of the results of research work in practice, at different spatial levels (from spatial plans and studies, to urban and architectural projects).

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