Climate Change Management

Walter Leal Filho
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Climate Change Adaptation in Eastern Europe

Managing Risks and Building Resilience to Climate Change

Springer

Climate Change Management

Series editor

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The aim of this book series is to provide an authoritative source of information on climate change management, with an emphasis on projects, case studies and practical initiatives—all of which may help to address a problem with a global scope, but the impacts of which are mostly local. As the world actively seeks ways to cope with the effects of climate change and global warming, such as floods, droughts, rising sea levels and landscape changes, there is a vital need for reliable information and data to support the efforts pursued by local governments, NGOs and other organizations to address the problems associated with climate change. This series welcomes monographs and contributed volumes written for an academic and professional audience, as well as peer-reviewed conference proceedings. Relevant topics include but are not limited to water conservation, disaster prevention and management, and agriculture, as well as regional studies and documentation of trends. Thanks to its interdisciplinary focus, the series aims to concretely contribute to a better understanding of the state-of-the-art of climate change adaptation, and of the tools with which it can be implemented on the ground.

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Preface

Climate change affects countries in Eastern Europe, i.e. the Western Balkans and Southeast Europe in a variety of ways. Apart from severe floods, there are records of decreasing water reserves in the southern part and of gradual changes in biodiversity and agricultural production. In the South Caucasus area, for instance, climate change models project a decline in precipitation by the end of the century and suggest that it will continue to become drier this century.

Many Eastern European countries, especially the non-EU ones, are characterized by the fact that national climate policies on the one hand and transboundary collaboration on the other are rather weak and by the fact that the engagement of the general public on matters related to climate change is still rather limited. Climate change thus poses a serious threat to the economic stability and development of many Eastern European countries and to the sustainable development of the region.

The above state of affairs illustrates the need for a better understanding of how climate change influences Eastern Europe and for the identification of processes, methods and tools which may help the countries and the communities in the region to adapt. There is also a perceived need to showcase successful examples of how to cope with the social, economic and political problems posed by floods/droughts in the region, especially the ways of increasing the resilience of agricultural systems and of communities.

It is against this background that this book has been prepared. It contains a set of papers presented at the "International Scientific Conference on Climate Change Adaptation in Eastern Europe" being organized by the University of Banja Luka, University of Belgrade, the Research and Transfer Centre "Sustainable Development and Climate Change Management" of the Hamburg University of Applied Sciences (Germany), the International Climate Change Information Programme (ICCIP), Fund for Environmental Protection and Energy Efficiency of the Republika Srpska and Center for Climatic Research (CCR Banja Luka), as well as additional contributions. The book is a very interdisciplinary piece, mobilizing scholars, social movements, practitioners and members of governmental agencies, undertaking research and/or executing projects focusing on climate change in Eastern Europe.

Thanks to its scope, the book will serve the purpose of showcasing experiences from research, field projects and best practice to foster climate change adaptation among countries in the region, which may be useful or implemented elsewhere.

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Contents

Towards Resilient Cities in Serbia

Branko Protić, Velimir Šećerov, Bogdan Lukić and Marija Jeftić

Abstract The problems of climate change and the concepts of resilient cities and resilience to climate change have gained considerable attention and interest in Serbia over recent years, especially after the catastrophic floods that hit Serbia in 2014. Now the improvement of resilience in the face of natural, socioeconomic, and political uncertainty and risks has captured the attention of researchers and decision-makers in almost all disciplines and sectors. This paper, through an analysis of the literature on climate change, with a special focus on Serbia, as well as Serbian legal regulations, strategies and planning documents, will show the awareness and understanding of resilience in the Serbian planning policy arena. Special attention is paid to local governments and the issue of climate change, and the problem of how planners, planning policy and decision-makers take into account or deal with the risks that it presents.

Keywords Climate change · Serbia · Resilience · Urban and spatial planning Local government

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1 Introduction

The population of cities is increasing annually. According to a United Nations estimate, the number of residents in cities will grow from 3.6 billion in 2011 to 6.3 billion by 2050. Most people will live in large cities, while the population of medium-sized towns will increase by about 40% of this number (UN 2014). Also, urban areas are global economic hubs, as a result of which many assets are exposed to climate change hazards (Satterthwaite 2007; Rosenzweig et al. 2011; Revi et al. 2014; Doherty et al. 2016). This trend is also present in Serbia, where the urban population as a share of the total population is constantly on the rise.

However, data by the Intergovernmental Panel on Climate Change (IPCC) show that developed countries are among the largest polluters of the environment and the largest emitters of greenhouse gases, which contributes to the acceleration of climate change (IPCC 2014), while at the same time, cities in developing countries are most at risk of climate change due to poverty, a degraded environment, poor infrastructure, limited resources and limited capacities (Jabareen 2013). These changes have a devastating effect on the environment and economy, and particularly on people (Folke et al. 2010). Disasters most often affect developing countries, since they are the most vulnerable and poorly equipped to deal with them. The lack of capacity and resources is the most common reason why, especially in less developed countries, adaptation measures are not systematically, strategically and preventively implemented prior to dramatic experiences with extreme climatic events (Kern and Alber 2008; Fünfgeld 2010). Almost all countries in the region of the Western Balkans, where Serbia is located, are quite threatened and have similar problems caused by climate change (Spasov et al. 2008; Trbić et al. 2018).

Research results indicate that cities are creating a very significant and ever-growing amount of greenhouse gases—GHG. Consequently, we can expect a manifold increase in the number of extreme climatic events, such as drought, floods and hurricanes (IPCC 2014).

According to a general definition, climate change adaptation involves predicting when and where the consequences of global warming will happen, developing adaptation strategies, and applying definite measures to reduce any vulnerability to the effects of climate change. These measures can range from those that are technical, institutional, legal and educational to those that encourage a change in behavior (Füssel 2007: 267).

Climate change greatly affects urban activities, including town planning, general mobility, construction, the energy sector, public health, waste management and food safety (Đukic and Antonic 2016). Failure in one part can have a domino effect in others, thereby creating further economic losses (Torres 2013). Managers and city leaders understand that climate change is a priority—but many cities are facing what they view as conflicting priorities (Zottis 2014).

However, the resilience and the ability of people and places to withstand these effects and recover quickly are still present. Resilience is defined as the ability of a system, community or society exposed to danger to resist, absorb, adapt and recover in a timely and efficient manner from the consequences of an event, including the preservation and restoration of essential basic structures and functions (UNISDR 2009). Similarly, the resilience of cities refers to the ability of urban systems and all their integral socio-ecological and socio-technical elements and connections to maintain or quickly restore the desired functions to their previous state in the event of certain severe weather and spatial phenomena, i.e. disasters, and to adapt to these new conditions and to transform (Meerow et al. 2015).

The term resilience originates from ecology, and it was created in the 1970s with the goal of explaining the capacity of a system to maintain or restore functionality in stress situations or under the influence of negative factors (Holling 1973). The popularity of "resilience" has exploded in both academic and policy discourse. Resilience theory provides insight into complex socio-ecological systems and their sustainable management (Folke 2006; Pickett et al. 2013), especially with respect to climate change (Leichenko 2011; Pierce et al. 2011; Solecki et al. 2011; Zimmerman and Faris 2011; Meerow et al. 2015).

Resilience is especially important for urban areas. Rapid urbanization threatens urban security through sudden disasters such as floods, heat, and food shortages. It also threatens urban security through slow changes which endanger both the environment and society. Examples of such changes are urban sprawl, lack of urban infrastructure, climate change and loss of biodiversity. Urban areas are especially vulnerable to both acute disasters and the slow effects of development (Falleth 2013). This makes urban planning, as a collective response to urban threats, an important means of improving urban resilience. The academic focus is especially on resilience related to climate change, environmental threats, natural disasters and terrorism (Falleth 2013; Coaffee 2008; Pickett et al. 2004). Unfortunately, very few urban planning tools are being considered by national and local policymakers in the redeployment of resources in a climate change era. It is time to suggest a research and policy paradigm to craft better urban planning systems in response to climate change (Blakely 2007).

In spatial and urban planning, social, environmental and technical resilience is observed in different ways: as a tool for assessing the possibilities and abilities of a system to change, as a conceptual framework for understanding how to achieve sustainable transformation of the system in the event of a major weather disaster, as a mechanism for introducing new directions in thinking, and as a rich source of innovations (Crowe et al. 2016).

The local level is critical for overcoming climate-generated challenges and making environmentally responsible decisions (Albrito 2012; Measham et al. 2011). This is the level at which all factors of significance for climate change are either present or emerging. If the aim is to contribute to the global endeavor to make inhabited areas, and particularly cities, healthier, more sustainable and safer, then major changes should occur at the local level (Bajić-Brković 2013). Planning, and especially local planning, plays an important part in creating change through the transformation of work methods and the implementation of environmentally responsible spatial solutions (Nordgren et al. 2016). Weak and poorly staffed local self-governments that lack the capacity and expertise to invest, and which do not participate in strategic urban and spatial planning on behalf of their low income citizens living in illegally built settlements, will not meet the challenge of resilience, but will instead increase the vulnerability of the majority of the urban population (Lukic and Šecerov 2017). The need for climate change adaptation requires the enhanced control and monitoring of changes in indicators, research into different aspects of climate change, the development of forecasting models, the development of scenarios, economic analyses, monitoring the impact of extreme temperature changes, the modification of existing adaptation strategies and measures, and the inclusion of stakeholders (Carter 2007).

2 Methodology

Starting from the premise that cities and local self-governments are of key importance for facing the challenges that climate change brings, in combination with an increase in the population of potentially endangered/vulnerable areas, the aim of this paper is to draw attention to the possibility of increasing the resilience of Serbian cities to disasters and the importance of acting locally, that is, to point out actions that primarily the state, but also cities, i.e. local communities, can initiate and apply in order to prevent, and in cases when this is not possible, to solve and deal with problems.

The research conducted for this paper covers the period from 2000 until the adoption of key spatial plans in Serbia (2010–2012), and it contains a review of the current situation in Serbian cities. Since the adoption of a set of laws on the environment (Law on Strategic Environmental Impact Assessment, Law on Environmental Protection, Law on Communal Activities, etc., 2003 and 2004) and the merging of several planning and construction laws into one (Law on Planning and Construction), which until 2003 covered the planning, design, construction and maintenance of buildings, the connection between spatial and urban planning and the environment and nature has strengthened formally, too. Simultaneously with this process, the awareness of the significant impact of climate change on space as a whole has grown through, among other things, an increasing number of segments on this subject in spatial plans, but also through a set of sectoral and thematic strategies at the national and local level (between 40 and 50 at the state level). The subject of resilient cities, particularly with an emphasis on climate change resilience, is still new in Serbia. A theoretical understanding of the issue exists and numerous scientific conferences have been held, but the practice and implementation of rare planning guidelines related to urban resilience are almost non-existent. For this reason, this paper represents an attempt to show the objective state and the genesis of the visibility of this phenomenon, as well as the direction in which the future methodological framework of Serbian planning fund will go.

3 Results and Analysis

3.1 Serbia in the Light of Climate Change

Serbia faces severe economic difficulties: the standard of living is lower than in the EU; unemployment rates are high; and economic growth is relatively modest. The acceleration of economic reforms is a huge challenge, but at the same time it can be seen as an opportune moment to integrate climate change aspects into the newly drafted national development plans (REC 2011).

Serbia is increasingly involved in numerous European projects and programs related to sustainable development, resilience and climate change. Because of the turbulent events that Serbia experienced in the 1990s and 2000s, there have been significant delays, Serbia's progress has been slowed down at all levels, and the country is still poor (Pucar et al. 2013). This is best reflected in the average gross domestic product per capita, which amounts to just $5280.[1] A large number of highly educated people are leaving Serbia and this trend is not slowing down. The political situation is not stable and one of the biggest problems is that there are constant changes within the ministries, due to which, with each new government, the responsibility for dealing not only with climate change, but also spatial planning, is being shifted from one ministry to another. Serbia has become an EU membership candidate, which means that many requirements for this sector will have to be met.

The process of adaptation and improvement in the resilience to climate change in Serbia has been backed up by very modest and not fully adequate activities. There is no *National Adaptation Strategy for Climate Change*, neither is there a *National Strategy for Reducing Greenhouse Gas Emissions*, and there are no laws regulating this issue. As a consequence, there is a lack of a clear and synchronized national policy primarily focusing on adapting to climate change. When it comes to assessing vulnerability to climate change, there is no national strategic document to define this area, although, during the ongoing process of joining the EU, a set of laws and bylaws focused on mitigating climate change has been adopted. A constant lack of funds in the state budget prevents the practical application of the measures established so far (Spasov et al. 2008; Pucar et al. 2013).

The Law on the Spatial Plan of the Republic of Serbia, i.e. the Spatial Plan of the Republic of Serbia (SPRS), deals with the issue of climate change and its impact on the built and natural environment, as well as the issue of renewable energy sources and energy efficiency (SPRS 2010).

A large number of non-governmental organizations, whose primary focus is the protection of the environment, deal with this issue, but their influence on politics and practice is insufficient. The construction fund in Serbia is of varied quality and needs to be restored. On the other hand, future construction will take up unoccupied spaces in the existing fabric of cities and beyond. The development of infrastructure, which is the basis for the construction and reconstruction of new physical structures, should

[1] In 2018 according to http://www.doingbusiness.org/data/exploreeconomies/serbia/.

adequately accompany this development. “The rationalization applied through planning and engineering procedures is necessary for the purpose of sustainability of the restoration of old and the construction of new urban space. The introduction of modern standards and technologies is necessary for further development within set goals” (Pucar et al. 2013: 16).

“The topic that gets a lot of attention in Europe and the world, but is almost completely neglected in Serbia, is the promotion of innovation through the cooperation of universities and institutes with the economy by linking research with practice. One of the key problems is the stagnation of the Serbian economy and its slow recovery” (Pucar et al. 2013: 16). Many researchers in Serbia are engaged in research in various areas of climate change (biodiversity, water, air, land, agriculture, forestry, urban and rural areas, cultural heritage, legislation etc.) by taking part in projects financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia. The majority of research in this area is theoretical and is published in international and national journals, while its practical application is sporadic and insufficient. The problem of science in Serbia is the lack of equipment, which causes a big delay and results in research being insufficient and incomplete. There are not enough funds for field research, which additionally makes the situation more difficult.

3.2 From National Policies to Local Plans—The Legislative Framework for Achieving Resilience to Climate Change

Many countries deal with the issue of climate change mostly at the national level and this results in various political decisions, state policies and normative solutions (Table 1). At the same time, the issue does not receive a lot of attention, if any, at the local level. However, the real impact of any strategy or spatial planning action is most obvious precisely at the local level. Bajić-Brković (2013) points out that this is where it starts and finishes, and that it is where the results can be seen and experienced. The situation in Serbia in this area is similar to the situation in other countries. On one hand, the state undertakes and implements numerous policies and projects, but on the other hand, the situation in the local communities is such that they are generally lagging behind and are less “progressive” because they do not treat this issue as a priority.

In Serbia, as in many other countries, energy production and consumption present the main threat that causes climate change. The energy sector is therefore the focus of every debate on climate change and it is the manner in which this problem needs to be addressed, and much discussion needs to take place as to what to do in order to improve the current state of affairs.

The state is generally considered as the body with the greatest responsibility for resolving this issue, which is in line with the hierarchical management model (top-down) still dominant in Serbia. “Placing the focus on the highest state level is not

Table 1 National legal and strategic framework related to climate change

Kyoto Protocol
The Paris Agreement
Spatial Plan of the Republic of Serbia 2010–2020
Law on Planning and Construction ("Official Gazette of the Republic of Serbia", No. 72/2009, 81/2009-correction, 64/2010-CC, 24/2011, 121/2012, 42/2013-CC, 50/2013-CC, 98/2013-CC, 132/2014 and 145/2014)
Law on Environmental Protection ("Official Gazette of the Republic of Serbia", No. 135/2004, 36/2009, 43/2011-CC and 14/2016)
Law on Strategic Environmental Impact Assessment ("Official Gazette of the Republic of Serbia", No. 135/2004 and 88/2010)
Law on Environmental Impact Assessment ("Official Gazette of the Republic of Serbia", No. 135/2004 and 36/2009)
Law on Air Protection ("Official Gazette of the Republic of Serbia", No. 36/2009 and 10/2013)
National Strategy for Sustainable Development ("Official Gazette of the Republic of Serbia", No. 57/2008)
National Strategy for Sustainable Use of Natural Goods and Resources ("Official Gazette of the Republic of Serbia", No. 33/2012)
National Program of Environmental Protection ("Official Gazette of the Republic of Serbia", No. 12/2010)
Biodiversity Strategy of the Republic of Serbia for the period 2011–2018 ("Official Gazette of the Republic of Serbia", No. 13/2011)
Energy Sector Development Strategy of the Republic of Serbia for the period up to 2025 with projections up to 2030 ("Official Gazette of the Republic of Serbia", No. 101/2015)
Strategy of Agriculture and Rural development for the period 2014–2024. ("Official Gazette of the Republic of Serbia", No. 85/2014)
Strategy and Policy of industrial development of the Republic of Serbia 2011–2020 ("Official Gazette of the Republic of Serbia", No. 55/2011)

only a reflection of the belief that the state should and must react at the highest level, but also of the inertia in the line of responsibility, as well as the assumption that local communities have necessary capacities and are capable of implementing policies and measures in local practice, where this is needed" (Bajić-Brković 2013: 42). However, many communities do not implement these policies and measures, although some (mostly urban) communities are interested in them. The reasons lie partially in their inefficient management, but also in the traditional understanding of spatial planning, which primarily focuses on the land use, infrastructure systems and physical features of the development, as well as on the lack of available resources, effective enforcement measures and professional capacities.

3.2.1 The National Level

Since energy is the main factor contributing to climate change in Serbia, all activities so far have been directed towards the energy sector and the areas with the highest energy consumption. The state administration deals with this problem through its various departments and agencies, as well as with the help of various political decisions, policies, normative solutions and strategies designed and adopted so far. Serbia signed and ratified the Kyoto Protocol, and the Ministry of Environmental Protection became the focal point of the UN Framework Convention on Climate Change (UNFCCC). The Department of Climate Change was established as a part of the Sector for Nature Protection and Climate Change at the Ministry of Environmental Protection. The Department is authorized to initiate and coordinate activities related to climate change such as: implementation of the UN Framework Convention on Climate Change and related protocols, the monitoring, reporting and coordination of activities on meeting the obligations arising from membership in the UN Framework Convention, cooperation with the Secretariat of the UN Framework Convention, cooperation with other state bodies and institutions, promoting the UN Framework Convention, project approval and monitoring, drafting strategic documents, etc.[2] Serbia is one of the countries not required by the Kyoto Protocol to participate in the quantitative reduction of global greenhouse gas (GHG) emissions. However, Serbia participates in the program through the Clean Development Mechanism, which means that other countries can invest in the production of green electricity (green energy) in Serbia with the aim of reducing greenhouse gas emissions for their own territories.

A project called the Climate Change Strategy and Action Plan, financed by the European Union through its Instrument for Pre-Accession Assistance (IPA II funds), was launched in 2016. The goal of this project is for the Ministry of Environmental Protection to develop a national intersectoral Climate Change Strategy with an Action Plan. The adoption of a national intersectoral *Climate Change Strategy* with *an Action Plan* will help Serbia establish a national strategic and legislative framework for combating climate change (mitigation and adaptation) in line with the international obligations and goals of reducing greenhouse gas emissions (the Paris Agreement and joining the EU).

The Climate Change Strategy and Action Plan will identify priority measures for reducing greenhouse gas (GHG) emissions (mitigation) and identify the institutions in charge of implementing certain options, as well as the timeframe for the implementation and the total financial resources needed. The creation of transparent scenarios will help identify and assess the potential for a cost-effective and long-term reduction of GHG emissions in relevant economic sectors in Serbia by 2020, 2025, 2030 and 2050. These scenarios will provide information on the contribution to reducing emissions and achieving the global target by 2070. The Strategy will also provide a framework for the policy of adapting to altered climatic conditions, with priorities

[2]The Ministry of Environmental Protection of the Republic of Serbia—http://www.ekologija.gov.rs/organizacija/nadleznost/.

being the agriculture, forestry and water management sectors. In addition to helping Serbia meet its goals in the area of combating climate change, the strategy will also contribute to the advancement of the Serbian economy by providing clear guidelines for future investors (in the areas of infrastructure and development) and by creating conditions for improving the competitiveness of the economy (The Climate Strategy and Action Plan 2016).

This issue has also been elaborated in detail by means of relevant recommendations in the Spatial Plan of the Republic of Serbia 2010–2020. The Plan focuses on the relationship between energy and climate change and this relationship is presented as one of the key factors of urban development and an important factor in determining the critical components of spatial availability, communication and the quality of urban life. This has given a new dimension to the role that local communities can have and opened up new opportunities for local spatial planning (SPRS 2010).

3.2.2 The Local Level

Urban and spatial planning is regulated primarily by the Law on Planning and Construction adopted in 2009, but it is also the subject of several other laws and bylaws. There are two categories of plans: spatial plans and urban plans. The first group includes the Spatial Plan of the Republic of Serbia (SPRS), Regional Spatial Plans (RSP), Spatial Plans for Special Purposes (SPSP), which are intended for specific activities or areas (such as protected natural and cultural areas, areas of infrastructure corridors, etc.) and the Spatial Plan for Local Self-government (municipalities and cities) (SPLS), which is the most important plan when it comes to the issue in question. The second group includes several urban development plans, such as the General Urban Plan (GUP), General (GRP) or Detailed Regulation Plan (DRP) and urban plans (Law on Planning and Construction 2009).

The Republic, or rather the state administration, formally initiates spatial plans (SPRS, RSP and SPSP), whereas the state government or the National Assembly/Assembly of the Autonomous Province/Assembly of City of Belgrade are in charge of their adoption. Their preparation can also be initiated by local communities or numerous public institutions. Local self-government units can also initiate and adopt urban plans. When it comes to the City of Belgrade, which consists of 17 municipalities, these responsibilities lie with the City administration. In the case of the General Urban Plan, due to its strategic character and greater importance, the final approval is given by the competent ministry.

In a conceptual and methodological sense, the planning system represents a mixture of the traditional “top-down” approach and some aspects of the “bottom-up” model. There are no explicit requirements with regard to the process and the planning methods themselves, because they are considered to be dependent on the context and can be changed from one plan to another, as well as from one city to another (Bajić-Brković 2012, 2013). The content is defined by the law for each type of plan. Spatial planning regulates land use, road networks, transport and infrastructure corridors, and the use and development of natural and cultural resources; it identifies and protects sensitive areas, and ecological and natural habitats; and it identifies areas for which more detailed plans have to be developed, including urban areas designated for detailed planning. Planning solutions describe and graphically represent the area they occupy, along with a set of proposals for their implementation or more detailed planning. A section concerning energy issues is a mandatory component of each plan, as defined by the Law on Planning and Construction.

The General Urban Plan (GUP), whose function is to guide and control development at the local level, contains general instructions on the use of land, traffic and the development of infrastructure, green areas and outdoor recreation areas, protected areas and areas designated for urban renewal. The GUP must also take into consideration the issues of energy efficiency, issues of sources and the use of renewable energy, as well as the possible impacts of climate change. However, there is no formal requirement for devising energy-responsible planning solutions in terms of land use or transport, nor are these plans obliged to provide solutions which would take into account resilience to climate change.

Both the GRP and DRP focus on the use of land, areas designated for construction, local traffic and infrastructure. However, both plans are required to establish rules for development and construction which would be applied in each spatial section/sector, and whose implementation would be subject to careful monitoring (Šećerov 2012). Additionally, all local plans must provide and guarantee solutions related to energy conservation, the rational use of energy and the use of renewable energy sources. In this area, local planning has many opportunities at its disposal for developing solutions and recommendations for an energy-responsible urban environment and an urban environment sensitive to the implications of climate change. Unfortunately, few communities and planning teams use these opportunities in order to change the situation and make the issue of resilience to climate change relevant to urban development.

The Law on Planning and Construction (2009) envisages a clear division of responsibilities between state authorities at the republic level and local self-government units. Cities/local self-governments have the responsibility to initiate, develop and adopt urban plans and strategies, as well as to implement plans and present actions taken. Furthermore, all local self-governments are obliged to participate in planning and making decisions on the development of larger spatial units, since they are a part of them (Lukic and Šecerov 2017). According to the laws and bylaws regulating spatial and urban planning in Serbia, it is obvious that there are countless possibilities for cities and local communities to change their environments and make them sustainable and environmentally responsible, on their own initiative and in line with the estimated situation and available possibilities. According to Bajić-Brković (2012, 2013) several options are available to cities and local self-governments:

– Developing strategies of spatial development, with the aim of providing the basis for environmentally responsible development;
– Developing sectoral strategies (e.g. in the area of transport, preservation of natural environment and other areas) of local importance;

- Developing and making urban plans that integrate environmentally responsible parameters, criteria and standards, taking into consideration already existing state policies and measures that encourage this;
- Introducing legislation on local construction and providing technical assistance for its implementation;
- Developing urban projects that integrate parameters of resilience to climate change, as well as those aimed at reducing greenhouse gas emissions;
- Supporting education in the area of environmentally responsible behavior;
- Supporting citizens' initiatives, action groups and non-governmental organizations;
- Starting pilot projects, learning from good examples and establishing cooperation with those with more experience who are already successful in implementing changes in their communities.

Despite the numerous possibilities, the response of cities in Serbia is weak and very few local communities are using any of these options. Key constraints are reflected in the lack of knowledge of the law, legislation, techniques and technology, and financial resources. Bajić-Brković (2012) points out that the gap between the actions of the state government and the situation at the local level is obvious and it requires consideration and urgent action.

4 Conclusion

The Republic of Serbia has established an important component of the institutional and legal framework to fight climate change. At the same time, there is still a need for improvement, as well as capacity building, and a need for responsible and competent institutions at the national level to have greater knowledge.

Although the significance of climate change issues, in particular the need for increased resilience and the need for a change of practice in spatial development issues in Serbia, has been recognized, not much has been done at the local level so far. The current state shows us how slow this process is, and that there are a small number of local communities that care about making their environment, in spatial and physical terms, climate-responsible and resilient. The current practice of dealing with spatial development issues is still unchanged because it is based on a deeply rooted traditional approach both in realizing and understanding relevant issues, as well as in terms of working practice and possible outcomes. The issues of climate change and resilience are both very low on the list of priorities of many communities in Serbia. Although the issues of developing infrastructure, transport, housing and urban services and social infrastructure have the highest priority in local development, they are rarely, if ever, linked to the issue of climate change.

There are many opportunities in Serbia to change the understanding of how important climate change is for local development and to change how it is dealt with. Realizing these opportunities is a priority task and a commitment for local communities.

The state has already fulfilled most of its obligations, and relevant ministries should act in compliance with those measures, so it can be expected that their activity in this domain will continue to grow. However, certain steps have to be undertaken by cities, local authorities and local interest groups in order to take advantage of this favorable moment and to achieve a positive shift.

It seems, however, that the importance of climate change and resilience issues is insufficiently recognized by urban and spatial planners. Although there are plenty of opportunities to work differently, planning practice remains unchanged and continues to rely on a pattern that has long since been established. However, redefining the existing planning model and moving towards a more sensitive model of resilience to climate change—which are now key issues of global development—are the primary task for experts in Serbia.

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Projected Changes in Multi-day Extreme Precipitation Over the Western Balkan Region

Vladimir Djurdjevic, Goran Trbić, Aleksandra Krzic and Danijela Bozanic

Abstract Based on climate change projections, specifically scenarios without ambitious mitigation, climate change can be expected to continue in the Western Balkan region in the future. Even if the international Paris agreement achieves its goals and the mean global temperature increase remains well below 2 °C, we will face at least one more degree of warming and corresponding changes in other climate variables. Climate change projections show that for the Western Balkan region possible changes in the mean annual temperature, in relation to the period 1971–2000, range from 2 to 5.5 °C, depending on the scenario selected and the part of the region analyzed. Projections results shows that mean annual rainfall decrease can be up to −40%, compared to the reference period 1917–2000, and that most of the territory has negative anomaly. On the other side, many studies identify possible increases in the intensity and frequency of extreme precipitation in warmer climates. In addition, it is interesting that there will be a future change in multi-day episodes with extreme precipitation accumulations. In this paper, changes in the number of episodes with five-day accumulated precipitation over 60 mm and the overall accumulated precipitation during these episodes are analyzed for the Western Balkan region, using dynamically downscaled climate projections with a non-hydrostatic climate model that has an 8 km horizontal resolution.

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Keywords Climate change · Heavy precipitation · Dynamical downscaling
Climate projections

1 Introduction

Continuous anthropogenic emissions of greenhouse gases since the industrial revolution have led to an increase in the global mean surface air temperature, which has caused different changes in the Earth's climate system (IPCC 2014). In addition to the changes in the mean states of different climate variables, of specific importance are the changes in extreme weather and climate events, since these events unavoidably lead to high economic losses and even losses to human lives. If modern society continues to emit greenhouse gases, then the changes in the Earth's climate system in the future will be even more dramatic, and the risks of possible negative consequences for socio-economic sectors and natural systems will increase significantly. To determine these risks on a regional level, dynamical downscaling of global projections of possible future climate change has become a common practice over the past few decades.

The Western Balkans are part of South Eastern Europe (Fig. 1), and the majority of the region has a temperate or continental climate, which belongs to the C or D group of the Köppen climate classification. Like the rest of the world, the region has experienced changes in key climate variables over the past few decades. The linear positive trend in the mean annual temperature, calculated since 1960, is statistically significant for the whole region and ranges from 0.2 to 0.3 °C/decade. On the other hand, the average annual precipitation across the region had a generally negative trend since 1960, but it has not been significant (Kurnik et al. 2017). In addition to the changes in key climate variables over the past few decades, an increase in the frequency and amplitude of different extreme events, such as extreme temperatures, heat waves, droughts and extreme precipitation, have been observed (Marx et al. 2017; Stagge et al. 2017; Stadtherr et al. 2016; Spinoni et al. 2014). In the future, according to climate projections, the region could face further significant changes in the climate especially considering that the Western Balkan area is a part of the wider Mediterranean region, which has been identified as a climate change hotspot (Giorgi 2006). Based on the results of different impact studies for multiple sectors and on climate change projections for scenarios that do not include significant mitigation, the area can be considered highly vulnerable in comparison to most of the European continent (Lung and Hilden 2017).

Recently, most attention has been devoted to the analysis of extreme precipitation in the region, especially because of a series of high impact events, one of which occurred in May 2014 (EC 2014). Based on observations, multi-day precipitation accumulation has a statistically significant positive trend especially for the high quantiles relevant to flooding events (Stadtherr et al. 2016). On the other hand, projections have shown that for the high emission scenarios, such as the RCP 8.5 defined for the fifth assessment report of the Intergovernmental Panel on Climate

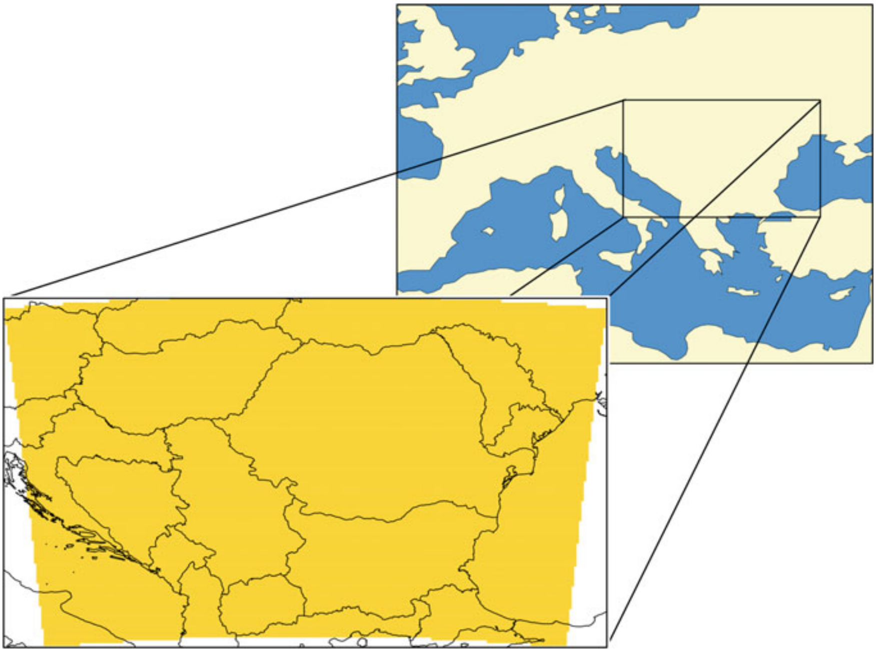

Fig. 1 NMMB model domain (front rectangular yellow area) over the Western Balkan region

Change (Riahi et al. 2011), in the future, we can expect further increases in extreme daily precipitation accumulations for almost all of Europe (Jacob et al. 2014). This increase in extreme precipitation events is even expected for the regions where climate projections show a decrease in annual mean accumulations (Polade et al. 2017). One of the reasons for this result is the well-known fact that based on the Clausius—Clapeyron relation warmer air is capable of holding more water vapor. Based on this relation and different analyses, one degree of temperature increase is associated with an approximately 7% increase in extreme precipitation (Lehmann et al. 2015; Trenberth 2011). On the other hand, it has also been shown that changes in large-scale hemispheric circulation can additionally contribute to the increase in extreme precipitation beyond 7% (Stadtherr et al. 2016). In this paper, we will examine the changes in multi-day episodes of extreme precipitation, using regional climate projections obtained from the regional non-hydrostatic high-resolution climate model.

2 Regional Climate Model and Experiments Setup

The NMMB is a Non-hydrostatic Multi-scale Model defined on the Arakawa B grid (Janjic and Gall 2012; Janjic et al. 2011, 2013). This model was developed at the United States National Centers for Environmental Prediction (NCEP). The model can be run both as a global and regional model. Dynamical core preserves many important properties of differential operators and conserves a variety of basic and derived quantities including energy and enstrophy (Janjic and Gall 2012), and a novel implementation of the nonhydrostatic dynamics is also applied (Janjic et al. 2001; Janjic 2003). For vertical coordinate models use sigma p-hybrid coordinate. For grid-scale convection parameterization, the Betts-Miller-Janjic scheme is implemented (Betts and Miller 1986; Janjic 1994), and for turbulence, the Mellor-Yamada-Janjic turbulence closure sub-model is used (Mellor and Yamada 1982; Janjic 1990). For radiation, a user can choose between two radiation schemes, the Rapid Radiative Transfer Model (RRTM) (Mlawer et al. 1997) and Geophysical fluid dynamics laboratory radiation (GFDL) model (Fels and Schwarzkopf 1975). Additionally, two land surface packages are available, the NOAH land surface model (Ek et al. 2003) and the Land Ice Seas Surface (LISS) model (Vukovic et al. 2010). Finally, for cloud microphysics, two packages are available as well, the cloud microphysics scheme of Ferrier et al. (2002) and microphysics from Zhao and Carr (1997). The regional version of the NMMB recently replaced the WRF NMM as the main NCEP operational short-range forecasting model for North America (NAM). In recent years, the model has also been used for a number of operational and research applications in Serbia (Djurdjevic et al. 2013).

In this paper, we will present the results of three model integrations. The first integration involves downscaling the reanalysis data set over the period 1971–2000. The second and third integrations involve downscaling of the results of a global climate model for a historical run and a scenario run. The downscaling of the historical run was conducted for the same period as the downscaling of the reanalysis, 1971–2000, and the downscaling of the RCP 8.5 scenario was conducted for the period 2011–2100. During the historical run, the concentrations of greenhouse gases were established to correspond to the observed values, and for the scenario run, the concentrations were established to correspond to the RCP 8.5 scenario (Riahi et al. 2011). The model domain that was used in all three experiments is presented in Fig. 1, and the model horizontal resolution was 8 km.

3 Model Verification Over the Period 1971–2000

The period 1971–2000 was used for model verification, and for this period, two downscaling experiments were conducted. For the first experiment, the experiment with a perfect boundary condition, the ERA40 reanalysis (Uppala et al. 2005), was used for the initial and lateral boundary conditions for the NMMB model (NMMB-E40 experiment). For the second experiment, for the initial and boundary conditions, outputs from the historical integration of the CMCC-CM global climate model (Scoccimarro et al. 2011) were used (NMMB-CMCC experiment). The model results over this period were verified using available observed values of the corresponding key climate variables and gridded data sets.

Table 1 Average scores of daily and monthly mean temperature and precipitation for the NMMB-E40 experiment

Temperature				
Score	BIAS (°C)	MAE (°C)	RMSE (°C)	CC
Daily	0.06	1.7	2.2	0.98
Monthly	0.06	1.0	1.2	0.99

Precipitation			
Score	BIAS (mm)	BIAS (%)	CC
Daily	−0.08	−4.6	0.53
Monthly	−2.5	−4.6	0.86

BIAS bias score, *MAE* mean absolute error, *RMSE* root mean square error, *CC* correlation coefficient

In Table 1, verification scores for daily and monthly mean temperatures and daily and monthly accumulated precipitation for the NMMB-E40 experiment over the territory of Serbia are presented. To calculate scores the observations from 46 stations that are part of the national observational network were used. Presented scores for temperatures are calculated as the mean difference between the model results and observations, averaged over a period of 30 years, or for precipitation as a ratio of the difference and the long-term mean of the corresponding observation that is presented as the percent of deviation. We can see that for both daily and monthly temperatures the correlation coefficients are very high, 0.98 and 0.99, respectively. On the other hand, the bias scores are very low with values of 0.06 °C for both the daily and monthly temperatures. For both, daily and monthly precipitation, bias is −4.6%, and for monthly precipitation correlation coefficient is 0.86 and can be considered high for this kind of experiment.

Model results for the annual mean temperature and annual mean precipitation from the NMMB-E40 experiment, are piloted on Fig. 2. Additional two panels of Fig. 2 are EOBS and CARPATCLIM data sets, which are gridded observations. The EOBS gridded climatology (Haylock et al. 2008) with a horizontal resolution of 25 km is used for the mean annual temperature plot, and CARPATCLIM data (Spinoni et al. 2014), with a horizontal resolution of 10 km, are for the annual accumulated precipitation plot. CARPATCLIM data have been selected for precipitation, because this data set has better spatial resolution and because more meteorological stations were used in the gridding process in comparison to EOBS data (Djurdjevic and Krzic 2013). As we can observe, model biases can be higher locally then the one noted in Table 1, but still model results capture the main spatial characteristics of both fields. The presented results show that the model is capable of reproducing observed climate characteristics at a level comparable to the results of other similar experiments performed with state-of-the-art regional climate models (Heikkilä et al. 2010; Soares et al. 2012).

Finally, the advantage of the high horizontal resolution of the regional model is presented in Fig. 3, that shows distributions of the daily precipitation accumulations

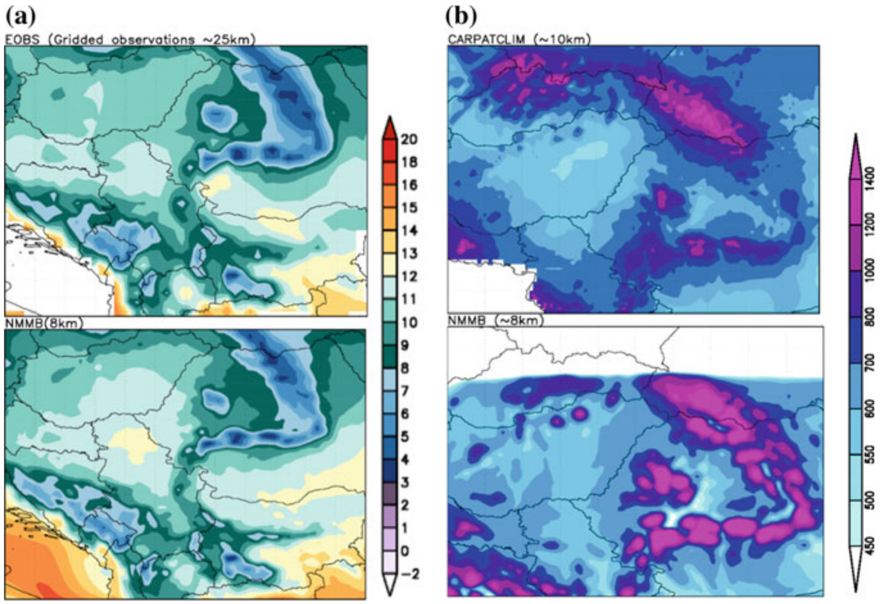

Fig. 2 **a** Annual mean temperature for the period 1971–2000 from EOBS data (upper panel) and dynamical downscaling of ERA40 reanalysis with the NMMB model (lower panel). **b** Annual mean precipitation for the period 1971–2000 from CARPATCLIM data (upper panel) and dynamical downscaling of ERA40 reanalysis with the NMMB model (lower panel)

over Serbia for the summer months (June–July–August). As we can see, the results from the experiment with the NMMB model with an 8 km horizontal resolution are closer to the observations, in comparison to driving data set ERA40, especially for high daily precipitation accumulations with values above 20 mm/day. The reason for this result is probably due to the fact that high resolution non-hydrostatic models are capable of better representing convective processes during the summer months (Djurdjevic and Krzic 2015), which are the main contributors to summer precipitation in the region (Tošić and Unkašević 2012). Additional details about the verification of the NMMB-E40 experiment can be found in Djurdjevic and Krzic (2013, 2014, 2015).

The left panel in Fig. 4 depicts the annual cycle of monthly mean temperatures from the NMMB-CMCC experiment and the observations obtained from the Serbian national meteorological observation network from 1971–2000. The monthly mean temperatures are calculated as averages over the whole territory of Serbia. The annual cycle is well represented but has a negative bias of 1 to approximately 3 °C throughout the entire year for all the months. The bias is lower for the summer months in comparison to the winter months. Similarly, the monthly means are calculated for the mean accumulated precipitation (right panel) for the same period.

Precipitation has a positive bias from January to May and November and December, and a negative bias was found for June, August and September. For July and