Chapter 17
Update, Conclusions, and Recommendations for "Water Resources Management in Balkan Countries"

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Abstract This chapter presents the update of the topic of water management in Balkan countries, main conclusions, and recommendations of the chapters presented in the book. Reliable information about the state and trends of a country's water resources—surface water, waters in an unsaturated zone and ground water—about amounts and quality, are assessed for several purposes, such as, for example: evaluating the potential sources and potential for storage of present and foreseeable demand. The protection of people and property against dangerous associations with water. Planning, designing and operating water projects and monitoring the off-take of water units for anthropogenic impacts, variability and climate change and for other environmental factors. Recommendations for future research is pointed out to direct the future research towards sustainability of water resources management in Balkan countries.

17.1 Introduction

The management and assessment of water resources, including studies on floods, droughts and desertification and hydrological predictions, should be based on the preservation of the relevant scientific principles depending on the technology of

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their implementation. Research and development activities should, therefore, be based on strategic analysis of the needs of the country. They should take into consideration and strengthen national expertise. This book presents topical issues in water resources management in Balkan countries.

The assessment of water resources is determining the amount, quality and availability of water resources, on which an evaluation of the possibilities of sustaining their development, management and control is established. The assessment of water resources offers the basis for a broad scale of activities related to water. Without such an assessment it is impossible to plan, design, administer, operate and sustain projects for irrigation and drainage, ameliorating floods, industrial and household supplying of water, urban drainage, the production of energy (including hydropower), health, agriculture, fishing, moderating drought and preserving water-based ecosystems and littoral waters.

The nature of decisions based on information on the assessment of water resources may include large capital investments with a potentially massive impact on the environment. This demonstrates the value of the assessment of water resources and its tangible and intangible benefits. For ensuring sustainable development in the future, appropriate government policies and programs are needed. Therefore, greater knowledge regarding the amount and quality of surface and groundwater is needed, and extensive monitoring, which would direct the management of these resources, is required.

This conclusion chapter presents a summary of the water management in Balkan countries, essential findings and conclusions of the studies on water quality and the quantity related to climate change. A set of recommendations extracted from all contributions are presented to help academicians, practitioners, scientists, and decision-makers to go forward towards sustainable management of water resources in Balkan.

17.2 Update

Integrated monitoring and information systems should be established, and data should be collected and preserved on all aspects of water resources management which are necessary for complete understanding of the nature of these sources and their sustainable development. Information includes not only hydrological data but also associated geological, climatological, hydrobiological and topographical data and data on types of soil, the use of soil, desertification and deforestation as well as information about subjects such as the using and reusing of water, wastewater treatment, point and exceptional sources of pollution and runoff into the seas and oceans. This includes the installation of observation networks and other mechanisms for gathering data determined for the monitoring of various climatic and topographical regimes and for the development of tools for storing data. In places where on the national, regional and international levels information related to water with the number of information systems is managed, it is important that these systems be coordinated.

Those who plan, design and operate water projects and those who deal with the protection of life, property and the environment, especially from natural catastrophes, should have access to the information related to water necessary for their work. They should be informed about the availability of such information and should be capable of obtaining it in a form which is suitable for their use, including the free mutual exchange of data necessary for ameliorating natural catastrophes. Commercialization of information associated with water should not prevent its complete use, and distribution of information associated with water should be based on a non-profit basis.

The Balkans region has always constituted an area with multiple geographic and historical valences. The social issues that have characterized this area over the history, whose reminiscences are still felt today, have had a significant impact on the management of natural resources. As a result, water resources have suffered, in the sense that the anthropic impact has been markedly at the level of the natural environment through landscape changes due to armed conflicts. At the same time, the natural conditions (climatic, geological and geomorphological) that characterize this area must be taken into account. The influences of the Mediterranean climate, with rainfall in the cold season and with severe manifestations of hydrologic droughts during the hot season require a translation of water volumes from one season to another. To this is added the geological and geomorphological characteristics of the area where the limestone rock dominates and the mountain relief restricts the accumulation of water on the surface and favors its accumulation in the underground. In the absence of an efficient water storage mechanism at the surface, human communities have focused on capitalizing on underground water resources. This has had significant consequences on the quality and quantity of groundwater (see the situation in Slovenia, Croatia and Greece) where uncontrolled exploitation has led to critical situations. Apparently, in the last decades, the demand for the exploitation of good quality water has become more and more increasingly. Water supply systems developed to satisfy the growing demand for tourism and agriculture have put pressure on water resources. In this sense, new solutions are sought to reduce the anthropogenic impact or recycle the most efficient water used in various fields (agriculture, industry, tourism).

This volume includes a series of general and particular analyzes on the management of water resources in the Balkans region which can be extrapolated to socially, historically and geographically similar regions in Europe or elsewhere in the world. An approach to capitalizing on the Balkans' water resources could not refer to the largest aquatic ecosystem in this part of the world. Even if it is somewhere in a peripheral area of the Balkans, the Danube River is the main collector of the northern Balkans region. In this sense, a volume dedicated to the management of water resources in the Balkans could not be started without reference to the Danube Delta area and the water quality of this biosphere reserve. The ever-increasing anthropic impact of the last decades, imposed by a series of political mechanisms in the communist period (until 1989), has diminished the quality of life and water in this reserve. The socialist "five years' period" that concerned agricultural development and industrial valorization of natural resources have left their

mark on water quality that has significantly decreased (Gâștescu and Știucă 2008; Gâștescu 2017). Improvement hopes stem from the decline in industrial activities and pollutants discharged into the delta area. However, the Danube as the main wastewater collector in Central and South-Eastern Europe brings water volumes with questionable chemical properties that pose problems in terms of quality water and the future of this reservation. (Brețcan et al. 2009; Romanescu et al. 2016a, b) in the conditions of anthropogenic impact and climate change increase (Bîrsan et al. 2014; Croitoru and Minea 2015; Sfică et al. 2017; Prăvălie et al. 2019).

Gradually the volume introduces us to the issue of water resource management at the level of each country. Slovenia, for example, although from a hydrological point of view it is a country with high hydrological potential, it is currently facing problems with the volumes of water exploited and their quality. The problems lie in the increasing frequency of hydrological droughts (Frantar 2008; Zorn and Komac 2011; Vertačnik et al. 2018) and the quantities of polluted wastewater entering the hydrographic and underground network (Steinman and Banovec 2000). However, it is trying to find solutions (Kopač et al. 2017) to reduce the anthropogenic impact on water resources, especially underground ones (as presented by Kopač and Vremec in the chapter *Induced riverbank filtration (IRBF) for managed artificial groundwater recharge (MAR) in Slovenia*).

Much more extensive is the issue of water management in Croatia. Despite its spatial dimensions and geographical heterogeneity, Croatia is ranked third on the European level as regards Total Renewable Water Resources per capita. Through the gradual implementation of the EU Water Framework Directive, Croatia is slowly changing management practice towards more environmentally friendly solutions. A particular emphasis was placed on the surface water quality analysis (in the chapter *Water quality status of Croatian surface water resources written by* Tadić et al.) and those from underground (in the chapter Groundwater resources in Croatia written by Orešić, and Čanjevac). Water quality analysis of different Croatian rivers and lakes (natural and artificial) shows an critical influence of the catchment area including geographical features, hydrological regime, land use, population, etc.

In some cases, it was challenging to define the dominant sources of pollution but the recorded data shows an improvement of the most analysed parameters (Tomas et al. 2011; Repac et al. 2015). In Croatian karst region, the main groundwater reserves are tied to prevailing highly permeable carbonate rocks. Concerning underground water resources, Croatia has an estimated reserve of 22,430 million m^3/year. The total water withdrawal in Croatia amounts to about 1 billion m^3 of water annually, some 40% of it being groundwater withdrawal, mostly for the public water supply. The groundwater reserves are in general not overused. However, most essential aquifers are vulnerable, and locally under environmental pressure (Bačani et al. 2010). Nevertheless, groundwater reserves are still mostly in good condition regarding their quantity and quality, dar în anumite areale apar semne care indică un declin al nivelului hidrogeologic (Vujević and Posavec 2018).

Much more synthetic is the analysis of Bosnia and Herzegovina's water resources because there is no clear organized structure for water management at the

state level. This is undoubtedly a major challenge since the entities in this state have their separate constitutions and separate legislation, including water management legislation. But, in some areas, there are signs indicating a decline in the hydrogeological level. The relative annual availability of water resources per capita rank Bosnia and Hertegovina in the countries of "average water availability" is between 5.000–10.000 m^3/capita; the rivers from this state are characterized by high gradients and relatively high flow rate (22 l/s/ km^2). At the level of the water resource management, essential steps are taken regarding the unification of the analytical methodologies at the level of the various state entities and the implementation of the European legislation.

The management of water resources in Serbia faces specific problems as it is maintained in the chapter *Water resources of Serbia and its utilization* written by Blagojević et al. The transit waters account for 90% of the total water volume in the territory of Serbia. This has a major impact on both the way and volume of water consumption and utilization. The entire country is well into finding solutions in the regional water supply systems to enable a more reliable water supply for the population (Djordjević 2014). It is assessed a stable water supply in the future would require about 4 billions m^3 of water annually. This is several times more than the current drinking water delivery. At the same time, it is necessary to take into account the evolution of climatic parameters, especially since the area of Serbia is increasingly affected by the frequent flood and drought episodes (as specified in the chapter *Precipitation and drought analysis in Serbia for the period 1946–2017,* written by Gocic et al. 2014). The north part of Serbia is the area with the least amount of precipitation and the south, and the southeast part have the moderate precipitation regime, while the west part is the wettest part. According to the applied analysis, it is evident that the stations in the western part of Serbia have the significant increasing trend in annual precipitation with an impact in the volume of surface water transported by rivers (Gocic and Trajkovic 2013; Gocic and Trajkovic). It is also worth mentioning the issues related to surface water pollution in Serbia used in irrigations that have an impact on food safety (analyzed in chapter *Microbial Quality of Irrigation Water in Serbia: Risks to Food Safety* written by Rudić et al.). In Serbia, all surface water resources (canals and rivers) are polluted to some extent, which becomes obvious particularly during the growing season. The presence of *Escherichia coli*, *E. coli O157: H7*, *L. monocytogenes*, *Salmonella spp*. on different kind of fresh vegetables become a potential risk for food safety.

Bulgaria's water resources are limited and unevenly distributed within its territory. 15% of the population has problems with providing the necessary water resources (approximately 500 settlements with about 1.17 million inhabitants). The water consumption per person per day is 120 l with a tendency to decrease due to the increased water price and improved accuracy of the measurements (drinking water losses for the country are about 52%). 70% of the water supply in Bulgaria comes from surface water, and 30% comes from groundwater. These include the impact of climate change that is conducive to the occurrence of long-lasting hydrological droughts (Chilikova-Lubomirova 2016) (as specified in the chapter

River Systems under the Anthropogenic and Climate Change Impacts: Bulgarian Case written by Chilikova-Lubomirova).

North Macedonia has significant water resources but unequally distributed. All of the 10 largest water springs are located in the western part of the country, spring area of river Vardar and river Crni Drim basin. The eastern part is much dryer, poor in spring waters and predominantly depends on the accumulated water in the dams. The more organized managing of water resources started in the post-war period in the 20th century with establishing the Water Management Authority. With this public body largest irrigation systems were created and more than 300 dams were built to keep the water obtained in the wet period and use it in the dry period of the year. The water volume stored in these dams is mainly used for water supply of population, industry and agriculture.

Various sources of pollution seriously endanger the waters in the major rivers in the Republic of North Macedonia, but the primary point sources are household waste, industry and mining. The problematic sources of pollution such as agriculture and wastewater from the dispersed population are also a problem. The data that as many as 40% of the total number of dwellings are not equipped with installations for discharging wastewater from the households into public sewage system show that little care is taken in the Republic of North Macedonia for protection of the environment from household wastewater (Dimitrovska et al. 2012; Blöschl et al. 2017).

The dry-warm climate of Greece, with wet winters and dry summers, leads to the need for irrigation in many crops in order to achieve satisfactory production and income. Private systems are based on boreholes drilled by the farmers. Since there are several illegal boreholes in addition to legal ones, this led to situations of over-pumping and high pressure in aquifers. Given that Greece is a coastal country (more than 16.500 km of coastline), the phenomenon of sea intrusion is intense and it is the biggest problem caused by agriculture to the environment (even greater than that of agrochemicals). These problems were analysed by Nicholas Dercas in the chapter *Water management in the agricultural sector in Greece*.

Finally, we can draw some major conclusions and recommendations on the management of water resources in the Balkans.region. Firstly, surface water resources are insufficient (in the case of Bulgaria, Serbia and Greece) and unevenly distributed spatially (for Croatia, Serbia, Bulgaria and North Macedonia). This has led to a series of adaptations in the management of these resources through the construction of reservoirs (Northern Macedonia, Bulgaria, Serbia, Slovenia) and the increasingly intensive use of underground water (in Bulgaria, Greece, Croatia and Slovenia). As a result, groundwater pollution (in Slovenia and Croatia) or underground water intrusion occurred in coastal areas (in Greece). Against the backdrop of increasing and more pronounced climate changes in this area (with effects on increasing the frequency and duration of hydrological droughts) it is necessary to take managerial measures as efficiently as possible by increasing the sewage treatment capacity and its reuse in various economic fields (Slovenia, Croatia, Serbia and Bulgaria) and the identification of new sources of water supply to the population (Bulgaria).

17.3 Conclusions

In the next sections, the conclusions extracted from the chapters in this volume of the Environmental Earth Science are presented.

1. The Danube Delta in Romania is a complex, open and interactive system that revolves around two major components—water circulation and human intervention. The greatest significance in the pollution with nutrients compounds have agriculture sources, some of them entered into the delta as pollutants in the Danube River.
2. Slovenia has an above-average quantity of water. However, because of droughts, pollution, and problems with the drinking water supply, over the past decades' issues concerning the available quantity of water first attracted the attention of the professional community and soon after that also the attention of the Slovenian public.
3. Managed artificial groundwater recharge systems coupled with induced riverbank filtration have proven itself as an irreplaceable contributor in the protection of the pumping station Vrbanski Plato and pumping stations Podgrad and Segovci on Apače field in Slovenia.
4. Water resources management has a rather long history in Croatia and is still mainly led by the civil engineering sector. That is reflected in technically oriented (grey) solutions for flood protection and, even more in river regulations, which have been proved to be inadequate in many European countries.
5. The proposed analysis of Croatian surface water quality status made on the basis of the recorded data shows improvement of the most analysed parameters. They are the result of the implementation of the Water Framework Directive, the Nitrate Directive and improvement of the sewage water system by the construction of wastewater treatment plants. However, there are still some improvements which can be done, mainly during dry hydrological conditions.
6. Groundwater resources in Croatia are still mostly in good condition regarding their quantity and quality although it can be concluded that the most important inland aquifers are under environmental pressure.
7. In Bosnia and Herzegovina significant issue is the development of the institutional framework for water management sector. Due to the complexity of governance, the management capacities of the responsible authorities in the water resources management are limited, especially the capacities of public authorities at the state level.
8. Water resources in Serbia are diversified both in water quality and quantity and characterized by an uneven temporal and areal distribution. The most industrially developed and populated, northern part of the country is scarce in domicile waters, while all transit waters are concentrated in it.
9. In Serbia all surface water resources (canals and rivers) are polluted to some extent. Even the quality of shallow groundwater occasionally exhibits the levels of faecal indicator bacteria that exceed the limits proposed by international standards for irrigation water quality.

10. Spatial distribution of annual mean precipitation in Serbia showed that the north part of Serbia is the area with the least amount of precipitation, while the west part is the wettest part. Analysing of precipitation is very important for water resources planning and management of irrigation systems.
11. Bulgaria's water resources are limited and unevenly distributed within its territory. Water is a precious, vital resource for Bulgaria. It provides vital needs for the population. This natural renewal wealth should be reasonably used, stored and preserved. This is in the interest of the people of Bulgaria and not only.
12. Bulgaria is a country with a dense river systems network, resulting in the topological specifics of the territory. Rivers are characterized with periods of spring floods and summer and winter low flows, formed with regard to the precipitations and groundwater recharge. In Bulgaria both floods and drought events occur; they are irregularly distributed in space and time, showing various grades and emerging significant impacts.
13. There are significant water resources in North Macedonia but unequally distributed. The western part of the country is five times richer in precipitation than the central part of the country. The eastern part is much dryer, poor in spring waters and predominantly depends on the accumulated water in the dams.
14. Various sources of pollution seriously endanger the waters in the major rivers in the Republic of North Macedonia, but the primary point sources are household waste, industry and mining. The problematic sources of pollution such as agriculture and wastewater from the dispersed population are also a problem.
15. Agriculture is a big consumer of water and at the same time a big polluter, and therefore there is an urgent need for a radical improvement of irrigation water management.

17.4 Recommendations

The following recommendations are mainly extracted from the chapters presented in this volume:

1. Water level dynamics is an important factor in shaping numerous processes in river systems and wetlands. Therefore, more research effort should be concentrated on links between the main pressures like heavy metals pollution or eutrophication under different water levels.
2. Danube's transnational character makes the conservation and the protection of the Danube Delta Biosphere Reserve in Romania to be a major environmental concern for all of Central and Eastern Europe. Interdisciplinary researches are needed to bring together stakeholders, politics, ecology, hydrology, social sciences.

3. To date, the aspects have primarily been at the forefront of studying waters in Slovenia, such as their use for generating power, regulation, and flood protection, because it has been unimaginable that the problem of insufficient water supply, which is common in many places around the world, could also exist in Slovenia.
4. Today the fact that climate change is a reality suggests that one of the effects of this change is also a change in the quantity of water.
5. To get all the benefits of managed induced riverbank filtration and managed artificial groundwater recharge systems versus recent current practice this should now be upgraded to the appropriate Decision Support System based on remote data acquisition and transmission, including GIS physically based fully distributed numerical modeling to continuously monitor and manage well fields, reducing costs and human-operated activities.
6. The Decision Support System combining and integrating all needed measurements and the modelling environment can give operators of these systems an alert system about the scheme performance and reaching limits of infiltration rates against cost-effectiveness or water quality indices.
7. Accession to the EU encourages Croatia and the water resource management system to accept new paradigms and approaches, which will lead to integral and sustainable management of water resources.
8. Scientific cooperation, interdisciplinary and stakeholder participation is a challenge which Croatia's water management sector should accept in order to improve and manage fragile water resources in a more sustainable way.
9. Besides the action plans and measures defined by water management strategies, it is necessary to continue the development of established water quality monitoring programmes not only in Croatia.
10. Frequency of sampling and accuracy of observed data cannot assure reliable water quality categorization, especially on small and medium rivers in the karst region of the Adriatic Sea Basin. Although widening of existing water quality monitoring network will take time and other resources, it certainly will contribute to the final goal—having safe and clear surface water.
11. In order to manage groundwater reserves in a sustainable way it is highly important to protect and preserve them as karst waters can be easily polluted, and the natural auto purification is very poor in the absence of clastic rocks acting as filters.
12. Vulnerability of the aquifers and their water resources should take into the account that a considerable portion of the groundwater resources is shared with neighbouring countries.
13. In order to improve the state of governance in the water sector authorities in Bosnia and Herzegovina, it should be focused on strengthening the institutional framework, preparation of strategic, planning and legal documents at the state level; improving cross-sectoral cooperation and coordination at all levels of government; harmonization of water legislation and planning documents with EU policies and legislation; improving water management infrastructure and

develop adequate economic and financial instruments in the management of water resources.

14. Well water resource management should be a priority in the development plans of each country.
15. There are several significant opportunities for water resources utilization in Serbia, including the navigation in rivers and canal network, spa tourism, and hydropower production.
16. While the legal, regulatory and institutional framework for further development and progress in the water resources utilization sector is laid out within the integral water resources management approach, it is estimated that time, investments, and human resources are the key factors in achieving long term strategic goal of the Republic of Serbia.
17. Due to expected water scarcity, the availability of good-quality water for irrigation will be affected, and irrigated agriculture will be challenged. Therefore, a sufficient resource for quality water for irrigation is crucial for sustainable agricultural production.
18. Water is a very effective vector of the transmission of human pathogen to plants, so microbiologically safe water has a special role in safe food production.
19. Drought policy must be based on the proactive approach and associated with the preparedness plans. Furthermore, the productivity risk assessment of arable land should be the first step in defining the strategy for mitigating the impacts of climate change on the soil.
20. Drought management plan stands out of all plans both as an administrative tool and additional planning document for the enforcement of preventive measures and measures for mitigation drought consequence aiming to mitigate the impact of drought and to improve drought resilience.
21. A major problem is the deterioration of freshwater quality due to the disposal of industrial and domestic wastewater. A large part of Bulgaria's waters, especially the rivers, are heavily polluted by wastewater and sewage waters of the settlements. The construction of water treatment plants, the multiple uses of water, the reduction of leakage from watercourses, etc. are necessary.
22. As a result of the pollution of the running waters, there is already an acute shortage of drinking water in a number of areas of the country, and especially during the warm half-year the settlements pass into a water supply regime. This is particularly true for the regions of Northwestern Bulgaria. Stringent measures are needed for the rational and full use of water and its conservation.
23. To mitigate extreme events—floods and droughts—various legislative and practical measures are implemented in practice. One of them is providing specific water management measures, including ecosystems protection, briefly presented within the Bulgarian site.

24. Another extreme events mitigation is the initiation and performance of additional activities, based on the particular river basins studies and characterization. This course of interconnected implementation of legislative, theoretical and practical developments is the only way to guarantee the best results are obtaining.
25. The basic recommendations in the North Macedonia water management are complementary with the Organization for Economic Cooperation and Development, where main topics of managing of water quantity, improving water quality, success in managing of water risks and disasters, ensuring good water governance, sustainable financing and pricing of water services.
26. Improving the system of water resources management in North Macedonia includes gathering information about water resources in the country, higher water sector funding, employment of adequate professional human resources in water management sector, building new water structures.
27. The appropriate measures that would improve ecological status in the major watercourses in the Republic of North Macedonia are increasing percentage of the population connected to sewer systems and providing a high percentage of purification of the urban wastewaters.
28. The water quality in North Macedonia will also be improving by providing a strict level of control and prevention from polluting and contaminating the watercourses from the industry and by controlled use of the mineral fertilizers and pesticides.
29. An effort to improve irrigation water management should start with a detailed inventory of the current state of the networks with regard to the following parameters: operation, exploitation and maintenance of collective networks; technical support for irrigation to the farmers; studies and scheduling of complementary projects where necessary; commercial, administrative and financial management.
30. Concrete measures need to be taken to reverse the current situation in irrigation water management in Greece: Involvement of agencies able to carry out water management successfully; rehabilitation of the existing networks and planning for new projects; effective technical support.

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