Boian Koulov · Georgi Zhelezov *Editors*

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Editors
Boian Koulov
National Institute of Geophysics, Geodesy, and Geography
Bulgarian Academy of Sciences
Sofia, Bulgaria

Georgi Zhelezov
National Institute of Geophysics, Geodesy, and Geography
Bulgarian Academy of Sciences
Sofia, Bulgaria

ISBN 978-3-319-27903-9 ISBN 978-3-319-27905-3 (eBook)
DOI 10.1007/978-3-319-27905-3

Library of Congress Control Number: 2016932306

Printed on acid-free paper

This Springer imprint is published by SpringerNature
The registered company is Springer International Publishing AG Switzerland.

Preface: Sustainability of Europe's Mountains

This book is a call from South-eastern Europe and certainly not the first one. The idea of a Balkan Convention on Sustainable Mountain Regions has been raised in 2009, and even then not for the first time, at the international conference on this issue, organized by the Institute of Geography at the Bulgarian Academy of Sciences and sponsored by the Federal Ministry of Science and Research of Austria, which took place in Borovets, Bulgaria. An international scientific network – Southeast European Mountain Research (SEEmore) – was also launched at that conference. This network organizes bi-yearly international conferences in different states of the region, disseminates recommendations, rallies support, and builds a sound scientific foundation for a future Balkan Convention. Here are the places and organizers of the SEEmore conferences that followed:

- 2010: Second SEEmore Meeting in Timisoara, Romania – The West University of Timisoara in cooperation with the Mountain Research Initiative in Berne, Switzerland, and the Institute for Mountain Research at the Austrian Academy of Sciences;
- 2012: Third SEEmore Meeting in Ankara, Turkey – the Centre for Environmental Studies at Ankara University and Mountain Research Initiative in Berne, Switzerland;
- 2013: Fourth SEEmore Meeting in Sofia, Bulgaria – The Center of Excellence in Humanities at Sofia University "St. Kliment Ohridski", and the National Institute of Geophysics, Geodesy and Geography, funded by the National Research Fund of the Bulgarian Ministry of Education and Science;
- 2015: Fifth SEEmore Meeting in Borovets, Bulgaria – The Center of Excellence in Humanities at Sofia University "St. Kliment Ohridski", and the National Institute of Geophysics, Geodesy and Geography, funded by the National Research Fund of the Bulgarian Ministry of Education and Science.

The last conference brought together 79 presenters from 14 countries, the majority of them from outside the host country. In addition to scholars and Ph.D. students from South-eastern Europe, scientists from Russia, Germany, Switzerland, Italy, and Georgia also presented their research. Strong scholarly support for the conference topic – Sustainable Mountain Regions: Make Them Work – provided SEEmore's partners, among them, the National Center for Regional Development of Bulgaria, the Bulgarian Geographical Society, the Association for Development of Mountain Municipalities of Republic of Bulgaria, the Faculty of and Geology and Geography at Sofia University "St. Kliment Ohridski", and the Bulgarian Association for Alternative Tourism. The conference statement reiterated the need for all countries of Southeast Europe (including three EU Member States – Bulgaria, Croatia, and Greece) to be included in a convention on Integrated Sustainable Governance of Mountain Regions.

The conference agreed with the conclusion that the EU needs a regional development strategy, which prioritizes mountainous areas. An issue, particularly relevant in South-east Europe, which contains the most sizeable parts of EU's 'deepest' periphery (NUTS 3 level regions, which produce below 30 % of the average EU GDP per inhabitant, measured in purchasing power standard for 2011). Significantly lower standard of living, depopulation and aging, immigration pressures, unsustainable land use practices, lack of institutional capacity, and absent or insufficient trans-border environmental cooperation are disproportionally concentrated in South-east European mountains. The trans-border status of most mountains in the region further intensifies their peripheral characteristics. The territorial overlap of peripheries at different scale and nature (economic, demographic, political, and social) creates a vulnerable zone at the politically sensitive external borders of the EU, which requires Union-level action. A special EU policy for sustainable development of mountain regions should motivate and support South-east European states to join an expanded Carpathian Convention or form a new, area specific, agreement (e.g., Carpathian – Balkan or Balkan Convention) that would expand and fortify the basis for territorial cooperation and partnership initiatives.

Sustainable governance cannot be achieved within any given geographic area. Mountains, river catchments, sea basins or coasts, only whole geographic systems can develop sustainably and policy making gradually adapts. The EU Cohesion policy package (2014–2020) and the related EU regulations, which outline the conditions for investing in Europe's growth, use a new, macro-regional approach, based, very generally, on the catchment areas of Europe's continental seas. Geographers probably applaud the adoption of the new macro-regions, since they at least offer policy makers the opportunity to be more region-specific and closer to people's problems. In all fairness, this author recommended and endorsed a sea catchment area-based approach to sustainable management in an article published in 2012.

This method, however, naturally uses mountainous regions as boundaries in order to delineate the new macro-regions. The approach allows significant flexibility, since relatively large areas can fall in two macro-regions. Nevertheless, a sea catchment-based approach appears quite at odds with the vision of a mountainous region-based policy instrument, like the above mentioned Balkan Convention. Indeed, mountains are largely overlooked in the Danube Transnational Cooperation Program (2014–2020) and only the Carpathians are recognized in passing in the EU Strategy for the Danube Region (2010). The situation with the policy documents regarding the other two macro-regions, which address these very mountainous southern and southeastern areas of Europe, is quite similar. Initiatives for cooperation among macro-regions will hardly provide the needed level of integration.

The problem is certainly not rooted in the new EU Commission delineation approach. It is, rather, in the perception that the old approach can be completely abandoned. The three new macro-regions (Adriatic-Ionian, Balkan-Mediterranean, and Danube) should not necessarily replace the South East Europe Region of the 2007–2013 period. They should rather be used in parallel with that Region, depending on the scale of the geographic systems that are targets of the respective policy making. Whatever the vision of Europe's future, policy making should be taking place at all scales, in close correspondence to the characteristics of the area of governance.

Europe has a lot to gain from a "sustainable mountain" policy. The Alpine Convention (1991) Member States and, particularly mountain inhabitants, will receive an added impetus from a sister convention in a neighboring part of the Europe. The Carpathian Convention countries can achieve even more, chiefly in the area of integrated sustainable regional development. An EU-wide framework convention on mountain regions is also among the possible benefits of the proposed initiative.

Positive signals are present and opportunities exist. Albeit an informal arrangement at present, in 2015, Bulgaria, Romania, and Serbia announced the Craiova Group, which sets an example of cooperation in the Balkan area. The majority of the EU cross-border cooperation programs in the 2014–2020 period focus, in the vast majority of cases, on mountain areas which serve as state boundaries. In Bulgaria, after years of ardent advocacy by the scientific community, the Bulgarian government program (2014–2018) devoted a third of its regional policy priorities solely to mountain regions.

In his 2015 book, entitled "Why the Sustainable Development Goals Matter", Jeffry Sachs ardently re-emphasizes the centrality of sustainable development as a "central concept for our age" and points to its double – analytical and normative – potential. He calls it "a method for solving global problems". This collection of chapters, selected by an international reviewers' committee, has more modest goals: to present multiple pieces of evidence that sustainable mountain regions in Southeast Europe can work and demonstrate that sustainability principles should be employed at every geographic scale of geo-spatial planning.

Boian Koulov

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Contributors

Nazan An Institute of Environmental Sciences, Bogazici University, Bebek, Istanbul, Turkey

Assen Assenov Landscapes and Environmental Protection Department, Faculty of Geology and Geography, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

Mariana Assenova Geography of Tourism Department, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

Daniela Avetisyan Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

Bilyana Borisova Department of Landscape Ecology and Environmental Protection, Sofia University, Sofia, Bulgaria

Kremena Boyanova Department of Geography, National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Sofia, Bulgaria

Benjamin Burkhard Institute for Natural Resource Conservation, University of Kiel, Kiel, Germany

Mihaela Triglav Čekada Geodetic Institute of Slovenia, Ljubljana, Slovenia

Renato R. Colucci Department of Earth System Science and Environmental Technology, National Research Council, Marine Science Institute, Trieste, Italy

Osman Cenk Demiroglu School of Tourism and Hospitality, Istanbul Bilgi University, Istanbul, Turkey

Petar Dimitrov Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

Elka Dogramadjieva Geography of Tourism Department, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

Mihai Doroftei Danube Delta National Institute, Tulcea, Romania

Alexander Dountchev University of Forestry, Sofia, Bulgaria

Carmen-Sofia Dragotă Institute of Geography, Romanian Academy, Bucharest, Romania

Monica Dumitraşcu Institute of Geography, Romanian Academy, Bucharest, Romania

Alexander Gikov Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

Ines Grigorescu Institute of Geography, Romanian Academy, Bucharest, Romania

Borislav Grigorov Faculty of Geology and Geography, University of Sofia "St. Kliment Ohridski", Sofia, Bulgaria

Christian Hoffmann Institute for Regional Development and Location Management, European Academy of Bozen/Bolzano (EURAC Research), Bolzano, Italy

Ekaterina Ivanova Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

Zita Izakovičová Institute of Landscape Ecology, Slovak Academy of Sciences, Bratislava, Slovakia

Sara Stanić Jovanović Faculty of Geography, University of Belgrade, Belgrade, Serbia

Dimitris Kaliampakos Metsovion Interdisciplinary Research Center, National Technical University of Athens, Zographou, Greece

Laboratory of Mining & Environmental Technology, School of Mining and Metallurgical Engineering, National Technical University of Athens, Zographou, Greece

Boian Koulov National Institute of Geophysics, Geodesy, and Geography, Bulgarian Academy of Sciences, Sofia, Bulgaria

Gheorghe Kucsicsa Institute of Geography, Romanian Academy, Bucharest, Romania

Mehmet Levent Kurnaz Department of Physics, Bogazici University, Bebek, Istanbul, Turkey

Vasil Marinov Geography of Tourism Department, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

László Miklós Institute of Landscape Ecology, Slovak Academy of Sciences, Bratislava, Slovakia

Ivica Milevski Institute of Geography, Faculty of Sciences, University Ss Cyril and Methodius, Skopje, Republic of Macedonia

Loukas-Moysis Misthos Metsovion Interdisciplinary Research Center, National Technical University of Athens, Zographou, Greece

Mihaela Năstase Protected Areas Department, National Forest Administration – Romsilva, Bucharest, Romania

Lora Naydenova Forest Research Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

Roumen Nedkov Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

Stoyan Nedkov Department of Geography, National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Sofia, Bulgaria

Mariyana Nikolova National Institute of Geophysics, Geodesy and Geography, Sofia, Bulgaria

Tugba Ozturk Department of Physics, Isik University, Sile, Istanbul, Turkey

George Panagiotopoulos Metsovion Interdisciplinary Research Center, National Technical University of Athens, Zographou, Greece

Momchil Panayotov University of Forestry, Sofia, Bulgaria

Sanja Pavlović Faculty of Geography, University of Belgrade, Belgrade, Serbia

Barbora Šatalová Institute of Landscape Ecology, Slovak Academy of Sciences, Bratislava, Slovakia

Mehmet Somuncu Department of Geography, Ankara University, Ankara, Turkey

Snežana Štetić College of Tourism, Belgrade, Serbia

Thomas Streifeneder Institute for Regional Development and Location Management, European Academy of Bozen/Bolzano (EURAC Research), Bolzano, Italy

Nickolay Tsvetanov University of Forestry, Sofia, Bulgaria

Mustafa Tufan Turp Institute of Environmental Sciences, Bogazici University, Bebek, Istanbul, Turkey

Urs Wagenseil Institute of Tourism (ITW), Lucerne University of Applied Sciences and Arts, Lucerne, Switzerland

Miriam L. Weiß Institute for Regional Development and Location Management, European Academy of Bozen/Bolzano (EURAC Research), Bolzano, Italy

Stefan Yurukov University of Forestry, Sofia, Bulgaria

Myrta Zemp Institute of Tourism (ITW), Lucerne University of Applied Sciences and Arts, Lucerne, Switzerland

Petar Zhelev University of Forestry, Sofia, Bulgaria

Georgi Zhelezov National Institute of Geophysics, Geodesy, and Geography, Bulgarian Academy of Sciences, Sofia, Bulgaria

Miglena Zhiyanski Forest Research Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

Matija Zorn Research Centre of the Slovenian Academy of Sciences and Arts, Anton Melik Geographical Institute, Ljubljana, Slovenia

Part I
Sustainable Policies in Mountain Regions

Chapter 1
Mountain Development Policies in Bulgaria: Practices and Challenges

Boian Koulov, Mariyana Nikolova, and Georgi Zhelezov

Abstract The main goal of this research is to analyze the regulatory framework and related geographic problems of regional development policies that concern Bulgarian mountains in the post-socialist period. Based on the need to establish and implement a state policy for integrated sustainable governance of mountain regions in this country, the investigation identifies and structures the challenges to regional development policy making.

At the European Union (EU) scale, the most important challenge is related to the absence of territorial policy integration and inept priority setting of regional development. Mountain areas of Southeastern Europe need to become a special focus of EU policy making because they make up the most sizeable parts of the Union's "deepest" periphery. In these areas, the overlap of peripheries of different geographic scales and diverse nature (physical geography limitations, depopulation and aging, severely lagging economies, and increasing political insecurity at the external EU borders) additionally intensifies their unfavorable characteristics.

At the state scale, identification of the territorial units eligible for assistance from the hilly belt presents the most socially and politically sensitive challenge for both geographers and regional policy makers. Policy instability, the inadequate scale of territorial governance of mountainous regions, and significant deficiencies in territorial policy integration are also among the challenges to sustainable mountain development policies in Bulgaria.

Keywords Regional development • Mountainous areas • Regulatory framework • Integrated governance • Territorial policy integration

B. Koulov (✉) • G. Zhelezov
National Institute of Geophysics, Geodesy, and Geography,
Bulgarian Academy of Sciences, Sofia, Bulgaria
e-mail: bkoulov@gmail.com; gzhelezov@abv.bg

M. Nikolova
National Institute of Geophysics, Geodesy and Geography,
Acad. Georgi Bonchev Str., bl. 3, 1113 Sofia, Bulgaria
e-mail: mkn_08@yahoo.com

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_1

1.1 Analysis of the Regulatory Framework of Mountain Areas Development

Mountains occupy a significant share of Bulgarian geographic, historic, economic, and cultural space. State policies have specifically targeted their development at least since the beginning of the twentieth century. As early as 1910, the newly liberated Bulgarian state founded a Fruit-Growing Nursery Garden in the Town of Troyan of the Balkan Mountains Range. Currently, this is the main Agricultural Academy unit concerned with theoretical and practical issues of mountain agriculture, including environmental protection of mountain agricultural ecosystems (Институт по планинско животновъдство и земеделие/Institute of Mountain Stockbreeding and Land Cultivation 2015).

Mountain areas have always featured quite high on the public agenda, and the state has demonstrated political and policy attention to them: from only 1960 to 1995, the Council of Ministers adopted 15 decrees aimed at improvement of the living and working conditions in these regions (Geshev 1995). In the early 1980s, the Bulgarian state introduced the “Strandja-Sakar” Program, aimed at turning the low mountain and hilly border areas in Southeastern Bulgaria, which were affected by severe aging and depopulation, into a “Republic of Youth.” Albeit unsuccessful, this has been one of the largest attempts at lagging regions development. State-funded scientific research produced the largest so far and most informative two-volume study of the natural, demographic, and socioeconomic potential of the Bulgarian mountains (Mishev 1989, 1990).

Public attention toward development of mountainous regions continued unabated in post-socialist Bulgaria, despite the prolonged and extremely strenuous transition to a market economy. A special Temporary Parliamentary Commission for Development of Mountainous Regions was set up in 1992, based on Article 20 of the new Constitution, which invokes the state obligation to create “conditions for balanced development of the different regions of the country and assist the territorial bodies and activities through its fiscal, credit, and investment policies.” (Constitution 1991). The results from the most extensive public hearing held on the issue in Bulgaria prompted the Commission to propose, the following year, legal and program provisions for the development of the mountain territories in the country.

In 1995, the People’s Assembly, a.k.a. the Parliament, upgraded the status of the Commission to “standing,” in view of the continued public interest in the issue and as a result of the sustained efforts of a number of parliamentary members, local authorities, scientific institutions, and nongovernmental organizations (NGOs). To further increase public support for the topic, the Parliament also widened the geographic scope of the Commission’s object of work to include the development problems of the hilly, or in the Bulgarian public parlance “semi-mountainous,” and border territories. The parliamentarians proposed a number of helpful resolutions, most importantly the preparation of the first law on development of the mountainous, semi-mountainous, and border regions in Bulgaria.

Political instability, a constant companion of Bulgaria's transition to capitalism, and the very deep financial and economic crisis of 1996, did not allow the Parliament to finish its full term and sharply affected the political priorities of the country. The draft law on mountainous, semi-mountainous, and border regions did not make the next Parliament's agenda. Bozhkova, Chief Expert at the Ministry of Regional Development and Public Works, noted that "targeted policy towards development, protection, and spatial planning of mountainous areas (in the context of its European understanding) is missing" (2000). In 2015, despite continued public pressure, especially from local authorities and national NGOs, the situation is still largely unchanged.

Some of the reasons for this state of affairs are apparently rooted in the "volatility" of the Bulgarian legislation, and particularly the regional development legislation and the accompanying regulations. The country began the process of harmonization of its statutory framework with that of the EU even before the country's accession in 2007. Between 1999 and 2008, the Parliament passed three separate regional development laws (Закон/Law 1999, 2004, 2008). By 2015, the last version only was amended and supplemented eight times, and the ninth amendment is in progress.

The first Regional Development Law (Закон/Law 1999) provided an important instrument for institutionalization and application of a coordinated policy toward Bulgaria's socioeconomic periphery. The Law's Additional Provisions (Paragraph 1.6) indicate that the "Regions with Specific Problems and Priorities" include mountainous regions, which the National Plan for Regional Development targets for assistance. However, in the now-defunct Ordinance (Наредба/Ordinance 1999), issued the same year, which specifies the criteria for definition of the territorial scope of the "Regions with Specific Problems and Priorities," mountainous territories have been dropped, despite the ample evidence for their dire socioeconomic situation and the accumulated legal and policy experience.

The next Regional Development Law (Закон/Law 2004, Article 7.4.5) also lists mountainous regions among the Regions for Targeted Impact. In a further step to bring Bulgarian regional development legislation closer to that of the EU, this Law also introduces Planning Regions. Hereby, the Regions for Targeted Impact, mountainous regions included, became parts of the Planning Regions (Article 7.1), and next year's amendment delegated the responsibility to determine their territorial boundaries to the Regional Plans for Development (Article 7.4.6).

In its only mention of the term "mountainous," the much-amended Regional Development Law (Закон/Law 2008, Article 7 c. (4) 6), still in operation in 2015, also delegates the definition of special "Zones of Geographic Specifics – mountainous, coastal, and border" to the Regional, rather than the National, Scheme for Spatial Development. The purpose of these zones is not yet specified, and neither is their relationship to the just introduced by the same document "Regions for Targeted Assistance," which are to be conceived as parts of the NUTS 3 regions.

In respect to sustainable mountain policies, the comparison of the three regional development laws (1999 through 2008) shows significant positive changes from one law to the next. First, the inclusion of the mountainous regions in the regional development legislation, in 1999, signifies recognition of their specifics, as well as their prioritization of their problems. Second, it demonstrates understanding that such regions require a specific type of management, within the regional development decision-making framework. The next two laws not only designate mountainous regions for targeted impact, but, more importantly, incorporate their formation within the Regional Plans for Development.

Thus, positive influences, mostly related to the EU policy agenda and experience, have gradually started to affect Bulgarian policy making. Nevertheless, the analysis of the lower-level regional policy regulations – the Council of Ministers and other ministerial ordinances that are concerned with establishment of territorial boundaries of the mountainous regions targeted for state assistance – shows mixed results. Thus, the 2004 Ordinance for Establishment of the Indicators for Differentiation of Types of Regions for Targeted Impact (Наредба/Ordinance 2004), which replaced the defunct 1999 Ordinance on the same issue, represents a largely successful attempt for a more integrative and inclusive approach to the development of lagging territories. The Ordinance includes mountainous and border areas among the types of regions targeted for special measures, including state assistance. Albeit limited, some devolution of power to regional and local authorities has been institutionalized in terms of active participation of the so-called Regional Councils for Development, a NUTS 2 level stakeholders assembly, in the identification of the boundaries of the Regions for Targeted Impact, while the municipalities retain the right to appeal before the foregoing Councils and the National Statistical Institute.

Sectoral policies, however, continue to be produced, despite the prescriptions for coordination and integration in the regional development legislation. This is especially relevant for the regulatory framework, issued by the Ministry of Agriculture and Forestry for the specific purposes of providing state support to farmers. Too often, the documents do not even attempt at regional integration, as evidenced by Ordinance 14 of 2003, which determines the settlements in the agricultural and mountainous regions (Наредба/Ordinance 2003). On the one hand, such policies sustain the monoculture structure of mountain economies, and on the other, assistance does not reach local people engaged in "not supported" economic activities.

Another such example is the Ordinance for Determination of the Criteria for Less-favored Regions and their Territorial Scope) (Наредба/Ordinance 2008). Its Article 2 clearly states its sectoral goal, pursuant to the Farmers' Assistance Law. True to its purpose, the document does not even relate to the Regions for Targeted Impact (Наредба/Ordinance 2004), among which prominently feature the "lagging mountainous" and "lagging rural" categories. Rather, the Ministry of Agriculture and Forestry institutes its own single-function territorial units, called "Less-favored Regions" and divides them in two types: (a) mountainous regions and (b) regions with limitations, other than mountainous. The latter are defined as the land areas, "zemlishta," of settlements that have agricultural land of low productivity (Наредба/Ordinance 2008, Article 4).

The document analysis shows that the classification criteria for identification of the two types of Regions for Targeted Impact (Наредба/Ordinance 2008) are not mutually exclusive, because agricultural land of lower productivity is also typically characteristic of mountain regions. Further, a legal document of higher level, the Regional Development Law, has already introduced "Zones of Geographic Specifics" (Закон/Law 2008, Article 7 c.(4)6), which explicitly include the mountainous regions category. Efficient regional governance necessitates the construction of these regions according to the purposes of farmers' assistance and their integration with the other regional development goals. Third, even the physical geography criteria and the indicators used to identify mountainous regions and their territorial scope differ substantially from those in the legal documents, pursuant to the Regional Development Law. In addition, they seem to be changing too often even within the same sector (Наредба/Ordinance 1999, 2003, 2008). A higher level of coordination and cooperation between the state administration and the state-funded scientific community in Bulgaria would avoid such discrepancies and raise the effectiveness and efficiency of decision making in the regional policy sector.

Last, but not least, the territorial scope of the mountainous regions, according to the discussed Ordinance, is based on the so-called zemlishta, territorial units at approximately LAU 2 level. This overly centralized administration and the related sectoral type of regionalization, practiced by the Ministry of Agriculture and Forestry, excludes local authorities and other local stakeholders from participation in the decision-making process, creates dependence on the center, and, in fact, increases the "distance" between central authorities and the supported and controlled actual producers on the ground, thereby diminishing governance efficiency.

As far as regional programs are concerned, the new millennium has not changed the notoriety of the Bulgarian government for troubled implementation of legal and other strategic policy documentation. Despite the ambitious promises, the Program for Development of Alternative Agriculture in the Rhodope Region (2003), the Program for Development of Agriculture and Rural Regions in Strandja–Sakar (2005), and the Program for Realization of Activities in the Regions for Targeted Support (2010–2013) did not demonstrate much success. Among the reasons for these regional development policy failures, Troeva (2015) points out lack of finances, but also the hasty change of policies and lack of consistency in policy implementation.

1.2 Geographic Problems of Policy Formation for Mountain Development: The Bulgarian Experience

The identification of mountainous regions for regional development purposes is a typical geographic problem, that of regionalization, which usually stands before regional development policy makers. Among the most important related tasks are the definition of a mountain and delineation of the territory that possesses such characteristics. The geography of the country, where this process takes place, affects the formulation of criteria and selection of indicators used in the regionalization process.

In fact, two different types of regionalization are carried out in the process of establishment of the scheme of mountain regions. The first determines the area that possesses mountain qualities. This part of the task falls within the field of physical geography, which studies the qualities of mountains as physical elements of the Earth's surface, their genesis and dynamics. The physical geography regionalization results in delineation of regions with physical limitations to human development.

On that basis, the second type of regionalization takes place, which actually determines the regions eligible for assistance. Human geography criteria – demographic, economic, social, environmental, and political – and respective indicators have the major role at this stage. Geographically, this type of regionalization is salient mostly for the lower mountain elevations, the zone of contact between mountainous and non-mountainous territory. This is also the zone in which regionalization results are likely to be most disputed and, therefore, socially and politically most sensitive.

Two significant circumstances about the delineation of mountainous regions attribute to the sensitivity just mentioned. The first is valid for any physical geography regionalization: rather than lines, dynamic zones of transition separate one type of territory from another. For the purposes of regional development policy however, the policy subjects, that is, regions eligible for assistance, have to be unambiguously identifiable and stable within the time period of the particular instrument. Furthermore, their social and political sensitivity has to be accounted for in this process.

The second condition has to do with the fact that there are no universally accepted definitions of a mountain (Gerrard 1990). The British Ordnance Survey abandoned its definition of a mountain in the 1920s and the U.S. Board on Geographic Names did the same in the early 1970s (What… 2015). Currently, some definitions of mountain also include local perceptions and generally differ widely across communities, countries, and even between regions in the same country. For example, although in most countries the line of distinction between mountainous and "non-mountainous" territories passes between mountains and hills, Bulgarian policy makers have recently added the vernacular "semi-mountainous" (poluplaninski) to the mountainous regions that have been targeted for assistance (Програма/Program 2015, p. 109). This new category only increases the complexity even further: in the Bulgarian language, its meaning is between a mountain and a hill, but, in contrast to these two categories, the "semi-mountainous" terrain has not have been scientifically "distinguished" by any established morphometric characteristics.

In addition to the concept of mountain, physical geographers also use "mountain territory," which Nikolova (2015) defines as a "landscape-ecological territorial system that includes mountains, situated in the respective region's low, medium, and high mountain hypsometric belt." The UNEP World Conservation Monitoring Center, an IGO, which handles biodiversity assessment and policy implementation, prefers the use of "mountainous environment" (Blyth et al. 2002). Another and more holistic concept, mountain landscape, appears to be more appropriate for the purposes of integrated sustainable development policy making in mountain areas. It assumes greater focus on nature–society relationships and emphasizes the fact that all elements of the mountain system relate to human development. In the case of regional policy making in mountain areas, these interdependencies denote overcoming, to the extent possible, the natural limitations that restrict socioeconomic development, in terms of difficulties in access to resources and landscape services, increased risk of natural hazards and sensitivity to global change, restrictive climate (to both human habitation and agriculture), and shallower and less fertile soils. As Borisova (2013) notes, the landscape approach facilitates the integrative and adaptive management of resources and maintains the landscape potential (landscape services) from the point of view of its multi-functionality and sustainability.

Regional development policy making and other state institutions have produced a number of regionalization schemes, which determine the borders of mountain regions in Bulgaria (Проектозакон/Bill 1995; Наредба/Ordinance 1999, 2003, 2004, 2008; Закон/Law 2004). Because relief is the main Earth surface factor that influences the other natural components (climate, water, vegetation, soil, etc.), it also has a decisive impact on the living conditions, social and technical infrastructure, and nature of economic activities in the mountains. Thus, terrain morphology and morphometry occupy the primary role in the selection criteria and indicators in all attempts for differentiation of mountainous areas.

The analysis of the regulation documentation reviewed here (Table 1.1) shows that the elevation criterion is necessarily present in all regionalization schemes. Moreover, in all cases but one, it is considered sufficient for the purpose, in the cases where the value of the indicator is above 600 m. Apparently, this is the most effective and, consequently, the leading, universally used criterion for determining the boundaries of mountain areas.

Despite the absence of a universally accepted definition of mountain, Bulgarian scientific opinions differ on the issue of the height of the lowest contour of the mountain hypsometric belt for this country. Nevertheless, although this value varies between 500 and 700 m in the different documents, most agree that at an elevation of about 600 m "the transition between mountainous and plain-hilly territorial characteristics" is most abrupt (Geshev 1995). The contour line that limits the areas with an average slope gradient of 10° also coincides to a much larger extent with the 600-m isohypse; the horizontal segmentation above this elevation in most mountains of Bulgaria is more than 1–1.5 km/km^2, and the vertical segmentation is more than 100 m/km^2 (Mihaylov 1982). For example, the tectonic boundary between the Danube Plain and the Predbalkan is marked throughout by the increase of the average degree of relief segmentation: for horizontal segmentation, on average from 0.5 to 1.0 km/km^2, for the vertical, on average from 50 to 150 m/km^2, and for the average slope gradient, from 3° to 7° (Simeonov and Totsev 1997).

Under this assumption, the distribution of the country's territory (a total of 110 987.8 km^2) in the respective hypsometric zones is as follows: lowland (0–200 m), 31.4 % of the area; hilly (200–600 m), 41 %; low mountain (600–1000 m), 15.3 %; medium mountain (1000–1600 m), 9.8 %; and high mountain (above 1600 m), 2.5 % (Stefanov 2002). According to this distribution, 27.6 % of the country's area undisputedly qualifies as mountainous, whereas the hilly belt, which has the largest share of the territory, is the object of scientific and public policy discussion related

Table 1.1 Criteria and indicators in Bulgarian legislation for determining the territorial scope of the mountain regions

Regulations/criteria and indicators	Measurement unit	1995 draft law for mountain areas	2003 regulation	2004 regulation	2005 amendment to the regional development law (2004)	2008 regulation
Object of definition		Settlements in mountain regions	Settlements in mountain regions	Regions for targeted impact	Regions for targeted impact	Less-favored regions
Elevation	m	>600	>600	>600	>500 average above sea level	>700 average above sea
Slope gradient	°/%	>12°	–	–	–	>20 % average
Vertical segmentation	m/km^2	>200	–	–	–	–
Horizontal segmentation	km/km^2	>2	–	–	–	–
Additional criteria and indicators		Elevation >600 m plus at least one from the other three indicators or elevation <600 m plus at least two of the other indicators	Elevation <600 m and vertical segmentation >200, horizontal segmentation >2, and slope >12	Average elevation <600 m and average vertical segmentation >200, average horizontal segmentation >2, and average slope >10°	Average elevation <500 m and average vertical segmentation >150, average horizontal segmentation >1, 5, and average slope >7°	Average elevation >500 m and average slope >15 %

to the extent to which the nature of the relief has an adverse impact on the socioeconomic development of the territory. This belt serves as testing ground for the efficacy of the additional criteria used for classifying the hilly land into less-favored regions, respectively, regions for targeted assistance (Table 1.1).

In the majority of the regulations studied here, the sole use of the elevation criterion is not considered sufficient in the cases where its value is less than 600 m. Thus, more criteria are used, which in Bulgaria are most often limited to (average) slope gradient, (average) horizontal, and (average) vertical segmentation of the relief, or combinations thereof. The use of the slope criterion is more practical, because by its definition it largely incorporates the results from the horizontal and vertical segmentation of the relief. According to Simeonov and Totsev (1997)), the actual or average values of these indicators vary as follows: slope gradient between 12° and 7°, vertical segmentation between 200 and 150 m/km^2, and horizontal segmentation between 2 and 1.5 km/km^2. Socioeconomic criteria facilitate this process.

The purpose of the regional policy regulations, which establish the territorial scope of mountainous and other disadvantaged regions, is the most important factor determining the selection of particular regionalization criteria and indicators. This choice establishes the actual municipalities and settlements, which are subject to the targeted regional policy of the state. Historical analysis of the changes in the regulatory documents reveals a tendency to boost the number of the municipalities, recognized as mountainous, from 138 municipalities (Regulation 14/2003) to 144 municipalities (Regulation 30/2008). A part of this increase is the result of the usual demographic, economic, and administrative transformations in a country in transition. However, the noteworthy decrease in the minimum values of all indicators (Table 1.1) in the 2005 amendment of the Regional Development Law (2004) leads to the conclusion that another reason for the enlargement of the area of mountainous regions, and particularly the increasing inclusion of hilly lands, can certainly be attributed to Bulgaria's preparation to join the European Union (2007) and the related expectations to use the possibilities offered by its Structural Investment and Cohesion funds.

1.3 Challenges to Mountain Policy in Bulgaria

This investigation identified two types of challenges in relationship to mountain development policy in Bulgaria. The challenges to geography are mainly related to the definition of mountain in the conditions of this country, as well as the criteria and indicators for mountainous territory delineation for investment purposes. The practical question of exactly which territorial units in the zone of contact between mountainous and non-mountainous territory, particularly from the hilly belt, will be selected as eligible for assistance features as the most socially and politically sensitive challenge for both scientists and policy makers. This question will come up consistently with each regional plan, given the normal changes in the local socioeconomic indicators.

The second type of challenges specifically targets mountain development policy makers. Despite explicit public approval of institutionalization of a special policy to this respect, the political instability and economic crisis that accompanied Bulgaria's transition to a market economy prevented the adoption of the draft Law for Mountain Territories in 1995. Since then, attempts at structuring a policy framework for sustainable development of mountainous areas have continued, but a coherent, stable, and all-encompassing state policy is still not in place. Thus, the challenges before mountain policy making in Bulgaria are structured simultaneously at several geographic scales.

At the supranational, European Union scale, the relatively high level of recognition of the salience of mountains for sustainable development has not yet materialized in a respective EU-wide policy, nor has appropriate attention been paid to its very important regional dimension. Mountain areas make up a large and increasing part of the EU periphery, particularly in Southeastern Europe (Koulov 2016). At the same time, the European Southeast contains the most sizeable parts of EU's 'deepest' periphery, that is, areas where multiple peripheries of different nature and scale coincide and peripheral qualities are most intensive (23–27 % of EU-28 average GDP measured by PPS, 2011). This type of periphery, located at EU's increasingly politically sensitive eastern and southeastern borders (with Russia, Ukraine, Belarus, Moldova, and Turkey), closely ties sustainable regional development and territorial planning to security and neighborhood policies. Instead of targeting mountain areas in Southeast Europe as a priority of EU regional development policy, the Union supports two conventions for sustainable mountain development, the Alpine Convention (1991) and the Carpathian Convention (2003), which do not include three EU Member States (Bulgaria, Croatia, and Greece) and a number of other countries in the Balkan region (namely, Albania, Bosnia and Herzegovina, Macedonia, Montenegro, and Kosovo), all of which have a significant share of transboundary mountain areas. This part of EU decision making certainly presents a challenge, not just for the EU but also on a national level, and Bulgaria is not an exception.

At the state level, since 1989, Bulgaria has been instituting dramatic simultaneous changes in its politics, economy, society, and culture. Such fundamental transition cannot but complicate, even hinder, optimization of the statutory framework in a particular sector, especially if it is not prioritized in that period. The transformations brought about one of the major challenges of Bulgarian regional development legislation, policy instability with the accompanying impact on the sector as a whole. Three regional development laws during a period of 10 years, while at the same time adopting amendments or supplements on average every year, cannot possibly create a stable and predictable working environment in any aspect of regional development, including sustainable mountain regions. An unsustainable statutory framework can hardly produce sustainable results.

Another notable challenge for Bulgarian mountain policy relates to the scale of governance of mountainous regions. In the general case, their incorporation within the Regional Plans for Development at the NUTS 2 scale is a positive development and its rationale is understandable: The EU NUTS (nomenclature of territorial units for statistics) classification system has designated this scale for framing and application of EU regional policies (NUTS 2015). At the same time, however, essential differences exist between mountainous and, for example, rural regions, which are based in the inherent differences of their physical geographic nature, structure, and functions. In the first regional development law (Закон/Law 1999), as well as in the latest (Закон/Law 2008), mountain regions are classified in the “Regions with Specific Problems and Priorities” and “Zones of Geographic Specifics” categories, respectively, the result exactly of their specific limitations. For example, mountains are much more often used as interstate borders, and therefore their territorial scope seldom conforms even to national, not to speak of NUTS 2 regional, boundaries. Some of the most important aspects of the geographic specificity of the mountainous zones are their supranational- and national-level functions, for example, provision of landscape services, such as nature conservation and protection and water supply. Both human habitation and the economy are exposed to much higher risks of natural hazards (Koulov 2013; Nikolova 2011, 2001). Climate change in mountain regions also requires the application of special policies for adaptation to the changing conditions.

Therefore, regions with geographic specifics have to be governed with particular attention to their specificity, including their scale. For mountain regions, similar to large river basins and coastal zones, the challenge is rooted in devising specific policy instruments, conceived at the “whole mountain” scale, within the boundaries of the entire mountain geographic system. Furthermore, Bulgarian mountainous and border areas, as a rule, are lagging in socioeconomic development, which poses yet another argument that necessitates planning and assistance at the national, rather than regional, level. Moreover, most of these regions, including the Bulgarian coastal zone, represent particularly sensitive parts of the EU border and therefore also require increasingly urgent attention at the EU scale (Koulov 2016). The 2015 governmental investment program targeted towards mountain, semi-mountain, and border regions, including the Strandja and the Rhodope Mountains (Програма/Program 2015), is yet another chance to realize a fully integrated sustainable mountain governance policy in Bulgaria.

Deficiencies in territorial policy integration in mountain areas present another state-level challenge to their sustainable development. Agriculture and forestry are among the main economic activities in mountainous regions and, as such, are vital elements in the development of these regions. Central government ministries have one and the same purpose in any region and, without integration of their territorial policies, this purpose is being compromised. The boundaries of mountain regions cannot depend on a particular ministry, and variances in this respect produce territorial discrepancies and conflicts, rather than being conducive to improving regional welfare. In view of this, decentralization of power to regional and local authorities, one of the most important instruments of territorial policy integration, is not being applied with sufficient political will.

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Chapter 2
Cooperation Models and Pluri-Activity to Exhaust Value-Added Potentials in Mountain Regions

Miriam L. Weiß, Christian Hoffmann, and Thomas Streifeneder

Abstract Unfavorable site conditions, short vegetation periods, low accessibility, and market pressure are the issues with which small structured farms in the Alps must cope. Horizontal and vertical cooperation and a pluri-activity business model to best exploit their economic possibilities is their response. Manifold and beneficial interlinkages between farms and accommodations are quite common in the Alps to sustain farming activities. In explorative studies in South Tyrol, Italy's northernmost province, various forms of cooperative approaches were investigated to point out diverging expectations of demand and supply as well as factors favoring and hindering cooperation. For sustaining mutual respect, accommodations have to be aware that typical regional products from a valley have a limited quantity because of season or limited production capacities. Hence, they lack planning security. Coping with these circumstances requires a proper regional food cooperation scheme with sophisticated logistical and organizational solutions, with innovative approaches of trustable entrepreneurs to promote these certified and high-quality regional food products, and the valley's authenticity as a unique selling point. Distinctive menus, authentic people, and untouched nature are in themselves ambassadors of the valley. Successful integration of South Tyrolean food cooperative systems in touristic packages has strengthened the market position of accommodations and resulted in meaningful side and multiplier effects along the whole value-added chain in the region.

Keywords Regional food systems • Rural added value chains • South Tyrol • Agricultural products • Mountain agriculture

M.L. Weiß (✉) • C. Hoffmann • T. Streifeneder
Institute for Regional Development and Location Management, European Academy of Bozen/Bolzano (EURAC Research), Viale Druso1, 39100 Bolzano, Italy
e-mail: miriam.weiss@eurac.edu

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_2

2.1 Introduction

In large agglomeration centers in the plain, society is still largely catered by the vast food and agricultural industries, but in the European Alpine area, traditional forms of small-structured agriculture dominate on the regional food market. To uphold their competitive advantage on the regional level, farms are required to continuously specialize their production on the one hand and to diversify their activities on the other hand, despite often unfavorable location conditions such as sloped fields or extreme weather conditions at different altitudes (Groier 2007; Streifeneder 2010; Südtiroler Bauernbund 2014). In addition, limited production capacities naturally constrain agricultural production. For farmers it thus becomes increasingly economically motivating and crucial for survival to cooperate horizontally, that is, with other farmers, or vertically, with other economic branches such as accommodations on a regional level. It allows farmers to supply products in a more demand-driven way, to diversify sales channels, to increase the sale of their products, and eventually realize more income. The accommodations branch, and here these are usually upscale or luxury hotels, residences, and similar venues, is comparably motivated to become involved. To satisfy the increasing demand for local, homegrown quality products on the part of tourists, a demand trend expected to continue for another decade and longer,[1] and to better differentiate from others, these accommodations attempt to render their gastronomic offerings more authentic and regional.

The valorization of local products is often considered an important factor for the regional development of rural areas (Knox and Mayer 2008). By means of vertical value-added chains between agriculture and tourism, farms and hotels can establish cooperation schemes enabling them to balance supply and demand of regional products so that both parties can achieve economic benefits and contribute to an increased regional value added. This classic regional economy approach, based on Hirschman (1958), is observed at regional production along the preceding and subsequent steps in a vertical value-added chain. By identifying gaps in the chain and investigating how nearby suppliers can bridge these, it seeks to complete the value-added chains through strategic interlinking of service providers at different levels (Hirschman 1958; Hahne 2009). This approach can thus also bring other contributors onto the scene in a strategic role, such as a delivery enterprise or as a local wholesale trader, in case a logistics partner is necessary to collect, invoice, and deliver the agricultural products. Vertical value-added cooperation is imaginable also among other touristic service providers, such as tourist offices, local hiking guides, and farmers who aim at drawing tourists to farms. For example, such cooperation networks are established to enable visitors to get to know contemporary and traditional farm life and to obtain first-hand information on agricultural production methods as well as other farming activities that contribute to safeguarding the cultural landscape.

Accommodations and farms can mutually benefit in many ways. Generally, most tourists appreciate staying in a landscape with heterogeneous patterns of cultivated

[1] Cf. DLG 2011; Warschun et al. 2013.

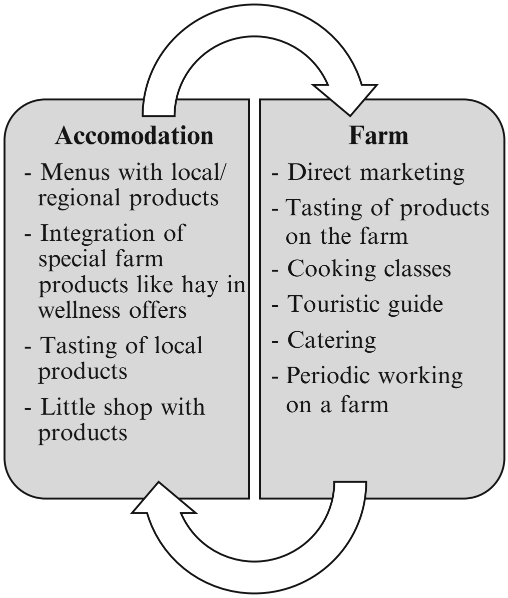

Fig. 2.1 Interlinkages between accommodation and farms (Own illustration)

agricultural land and active farms.[2] However, landscape perception differs strongly between groups of people according to age, educational background, and former onsite experiences (Hunziker 2000). The farmers benefit from the touristic presence because the demand for infrastructure facilities and services opens new job opportunities. However, it is also possible that conflicts may arise if agricultural practices result in noise, smell, and health-related disturbances, or, from the farmer's point of view, the result is rising land prices or the consumption of agricultural land. The focus should thus be on the manifold beneficial interlinkages between accommodations and farms (Fig. 2.1). Following the social trend toward regionality and authenticity, it is likely that in future the farmer's presence in accommodations, in the framework of tasting sessions, or in other services, will become more frequent and attractive. Vice versa, tourists may wish to be integrated in the work, daily life, and cultural traditions of farmers by participating in cooking classes and tasting sessions in a rural environment.

Different factors may constrain these positive mutual benefits (Fig. 2.2). Farmers might not produce a sufficient supply of high-quality foods as requested by the accommodations because of seasonality of the products and the limited agricultural areas available in mountainous regions. Additionally, hoteliers often demand certified and labeled products to be in line with hygienic and quality standards and standards requested by demanding tourists. Certain groups may be used to

[2] Farming activities generally fulfill important tasks that have a broad societal and environmental dimension: farming preserves rural areas, safeguards the cultural landscape, and cultivates traditions and customs, with that contributing to creating and maintaining decentralized workplaces, eventually increasing local value added (Südtiroler Bauernbund 2014).

Factors constraining linkages between agriculture and tourism

- Supply and production-related factors (quantity, quality and seasonality)
- Demand-related factors (food preferences, negative stereotypes of local/regional products, training and nationality of hotel and restaurant chefs, expectation that supply of agricultural products is unlimited)
- Market-related factors (low revenues, collaboration with intermediaries, supplier monopolies, bureaucracy, mutual mistrust, infrastructural limitations, transport facilities)

Fig. 2.2 Factors constraining interlinkages between agriculture and tourism (Based on Torres 2003)

intercontinental food, a major constraint to the promotion of local products and the gain of higher prices. It may also be difficult for a cook to adapt the week's menu at short notice in response to seasonally unavailable agricultural products or to process all the pieces of locally slaughtered cattle, sheep, or goat. Finally, various market-related factors such as established commercial collaborations between hoteliers and suppliers, mistrust, and logistic obstacles can be decisive in setting up separate collaborations among farms and accommodations.

Generally, cooperation models such as the aforementioned require time to take shape and mature. They can emerge with difficulty in rural regions with little tradition in intersectoral cooperation. Against this background, in this chapter we investigate the framework conditions for cooperation schemes to function between agriculture and accommodations. Which factors favor and which hinder cooperation? What are possible cooperation schemes? How can logistics be organized? We advance the hypothesis that successful cooperation of agriculture and accommodations results in positive economic benefits on both parts and increases the regional value added. Furthermore, we assert that to close the product gap from the seasonal availability of agricultural products, the farmers in a region are required to cooperate horizontally and hotels (i.e., their chefs) need to adjust to limited product offers.

2.2 Data and Methods

We followed an explorative approach, in which qualitative and context-sensitive research methods are used, and context-specific factors (e.g., location conditions and existing forms of cooperation and institutions) are considered.[3] The chosen qualitative and context-sensitive research method is a case study analysis. The case study area comprises the municipalities of the Passeier Valley and adjacent boroughs, seven municipalities overall, located in Italy's northernmost province, South Tyrol. This intermunicipal approach was chosen under the presumption that

[3] Cf. Lamnek (2010)

common potentials can be used more efficiently in functional areas, in which adjacent municipalities work together independent of administrative borders.[4] The research focused on the specific cooperation situation and its challenges among the three economic branches of agriculture, accommodations, and wholesale trade across the municipalities to understand expectations, perceptions, and processes favoring or hindering cooperation.

First, we evaluated available data, past and current project initiatives as well as practice examples from other regions in the cooperation triangle of agriculture, accommodations, and wholesale trade. An empirical survey was carried out (exclusively by telephone) among 28 direct marketers[5] in the municipalities, of which 22 provided comprehensive information that was utilizable in the further process. With a standardized questionnaire, we gained an overview of the type and the processing degree, price, seasonality, available quantities, and delivery conditions of agricultural products from said marketers. We held the interviews from December 2012 to January 2013.

Following a community-led local development (CLLD) approach,[6] we simultaneously organized four working group meetings with a local coordinator engaged in agri-touristic activities. Local entrepreneurs,[7] municipal stakeholders, and experts for regional product marketing, food quality, and logistics participated in the working group meetings or were consulted. We undertook site visits to single farms, wholesale traders, and accommodations. Overall, 45 people were involved in the data collection, interview, and consultation process. A workshop was dedicated to discuss and document strengths, weaknesses, opportunities, and threats of regional logistics systems, food quality, and food certification, and documented in SWOT profiles. The workshop served also to inform about and further sensitize for the cooperation topic among accommodation owners, farmers, and wholesale traders.

2.3 Research Findings

The survey among direct marketers provided an overview of the available agricultural products, quantities, expected prices, and willingness to engage in cooperation with the accommodations and wholesale trading branch. The survey as well as the workshop with farmers, accommodation owners, wholesale traders, and tourist

[4] Application document of the project "Zukunft 2030" (nr. 2/26/2012) funded by the European Social Fund.

[5] The list of direct marketers was provided by the South Tyrol Farmers' Association (*Südtiroler Bauernbund*).

[6] The CLLD approach support persons in rural areas to develop bottom-up projects that build on recognizing endogenous regional potentials and reacting to current and future territorial problems. CLLD encourages citizens to take responsibility for their own territory and future, to actively engage in recognizing and developing unused potentials and foster the regional innovation potential. It is a way to directly involve citizens in implementing EU objectives (EC 2014).

[7] Cheese production, wholesale trade, organic farming, fish farming.

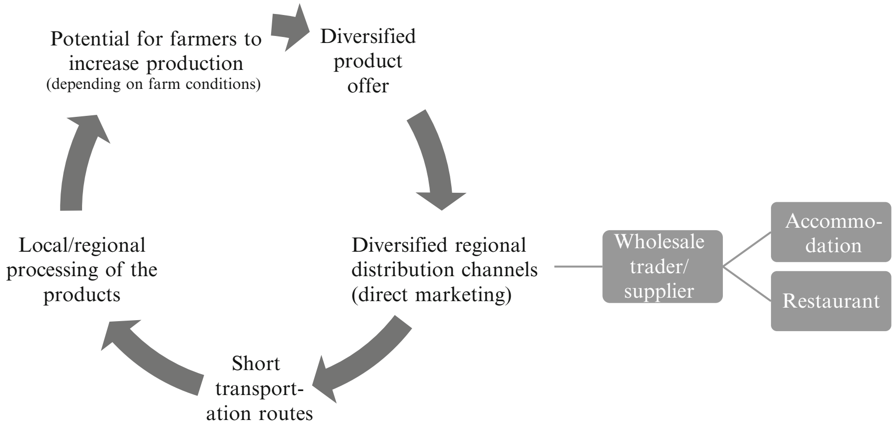

Fig. 2.3 Aspired/expected multiplier effect (Own illustration)

representatives have conveyed an impression of the current situation, the challenges to cooperation, and shown a general openness to collaborate. Among all participants and across all branches, an interest prevails in a strengthened cooperation of agriculture, tourism, and trade. The sustainable development of all three sectors through closing regional economic cycles (Fig. 2.3) is perceived as a major strength of a vertical and horizontal cooperation scheme.

Particularly, participants see advantages in a diversified range of regional products[8] that a cooperation can offer. In conversations with the local wholesale trade, it became evident that the product range largely corresponds to the demand of those restaurants and hotels that offer regional products, for example, for selected buffets (such as breakfast or cheese buffets). Single-accommodation establishments also consider in-house food presentations by a farmer to be an authentic and attractive idea to introduce guests to the local farms and products. Of particular interest are selected specialties, that is, niche products, which are produced only in limited quantities and provided only by a few farms. Additionally, the study showed that participants perceive also aspects, which constrain cooperation between agriculture and tourism. Primarily, these regard the certification and quality of agricultural foods as well as the logistics aspect (i.e., collecting, delivering, accounting, and marketing). The factors are related to production and to supply, demand, or market.

[8] In the Passeier Valley, the agricultural product offer ranges from unprocessed vegetables, fruits, milk, and meat to processed foodstuffs such as fruit and vegetable chutneys, jams and juices, ice cream, wheat and flour, sausage specialties, dairy products (yoghurt, butter, cheese), fish, herbal teas, and non-food herb products.

2.4 Certification of Food Products

Universal definitions and standards for regional products are missing, although demand and supply are increasing, and this lack raises uncertainty among some workshop participants. On the European, national, and regional level, efforts are made to develop standards, definitions, and labels, but these do not have binding character (e.g., *Regionalfenster* in Germany, *Pro Montagna* of Coop in Switzerland, or the geographic indications PDO/Protected Designation of Origin and PGI/ Protected Geographical Indication in the European Union). Some producers certify their products with regional labels such as the "Quality South Tyrol" label or the "Red Rooster" (*Roter Hahn*)[9] certification. Both are examples of food certification allowing producers to attest their products' high quality and origin (traceability), to profit from a large sales network in South Tyrol and beyond, and to access new markets in the higher price segment. However, some producers and hoteliers criticize product certification because quality controls can be inconsequent and damaging to the credibility of certified products. Some farmers are also unable to manage the bureaucratic efforts required to certify products. Other farmers state that, for direct marketing activities (e.g., farmers' markets, catering, farmgate sales, farm visits), products do not necessarily have to be certified to be sold. A reason for this could be that in direct marketing, a basis of trust prevails between customer and farmer as it allows both to interact personally, permitting values to be 'lived and sold,' rendering certification unnecessary. As stated by a participant, it would be far more important that a stronger basis of trust be created among producers, suppliers, and consumers, based on personal contacts, stories, and shared values. For farmers, thus, who cannot or do not want to meet the standards certification requires, it is important and would be sufficient to mark their products with a basic label, indicating the ingredients and the best-before date, to sell them on the regional market.

2.5 Food Quality and Quality Products

Discussion on the quality of regional products directly relates to and resembles that on certification. In both cases, proving and reiterating a product's origin, ingredients, and its quality are at the center of debate. In this sense, product quality is equally disputable as certification as there is yet no universal, reliable standardization and labeling regime. That said, the major discussion points on food quality regard the diverging perceptions of regional products by accommodation establishments and producers (demand-related), the challenges encountered from seasonality of products (related to supply and production), and the role of communication between producers, clients, and consumers of regional products (market related).

[9] For Red Rooster products, a minimum of 75 % of the raw materials must come from the family farm. Small quantities can be bought from another South Tyrolean farm. The products are regularly blind tasted and have to be positively evaluated by an independent commission to guarantee their constant high quality.

The discussion shows a divergence in the perception of regional products. For accommodation establishments it is important, for example, that products are principally available and deliverable, independent of season. Generally, establishments need to be able to rely on producers or traders in that ordered products are delivered according to contracted agreements. Regional products, however, are subject to seasonal variations, which can influence available quantities, quality, and prices negatively or positively. Some chefs consider the lack of a certain product a guarantor for quality and are willing to pay a higher price for a regionally produced (livestock) product. Most, however, consider regional products only supplementary to conventional ones. Farmers thus demand chefs to become more flexible, for example, in the processing, presentation, and combination of products to cope with unexpected bottlenecks. Practically, this would mean chefs need to become more creative in processing all parts of an animal, vegetable, or fruit instead of using the 'prime cuts' only, adapt their menu, and be more flexible in planning and anticipating product acquisition. It may also mean adapting storage space and temperature because a fresh regional product has a shorter shelf life. Similarly, depending on the chef's training and own taste, further training may be required to become acquainted with regional products and traditional and innovative preparation methods. Eventually, this may result in higher financial expenditures on the part of chefs. These are demand- and supply-related factors that can constrain cooperation between agriculture and tourism.

2.6 Logistics Cooperation

Generally, the workshop and survey participants consider it a positive effect of logistics cooperation to close regional economic cycles, foster the identification of the involved actors with the products and the region, and contribute to a positive image of the region. Farmers see that by cooperating with a logistics partner, who (collects and) delivers their products, they are able to concentrate on their farming business, allowing them to diversify their agricultural income and maintain workplaces in agriculture. In turn, logistic partners can diversify their range of products and become more attractive for clients in and potentially outside the region. Thus, in terms of logistics, all participants expect advantages from collecting and delivering products within an organized regional logistics network.

However, market-related factors are perceived that can make cooperation with a logistic partner costly and strenuous. If traders realize only very low margins while facing high costs, for example, for transportation, storage, and accounting, a functioning logistic chain of producer–trader–customer can be jeopardized. In turn, this may put price pressure on farmers, increasing competition between them. Customers (hoteliers, chefs) may also turn away if financial and administrative efforts are higher when buying from a trader than buying directly from the farmer. Similarly, logistic chains are less attractive for farmers if direct marketing generates much higher prices than selling via a wholesale trader. Finally, from an organizational point of view, according to the workshop participants, lacking a responsible agent who takes the project leadership and continuously accompanies the logistics cooperation initiative through implementation is a decisively weak point.

2.7 Discussion

Regional food/logistics systems between farmers and accommodations as well as between farmers, wholesale traders, and accommodations are widespread (EC DG AGRI 2012). Various local food systems have emerged, offering farmers alternative sales channels and responding to the increasing consumer demand for regional products (EC DG AGRI 2012; Warschun et al. 2013). Looking at the literature and good practice examples,[10] regional value-added cooperation schemes are largely promoted as a leverage for regional development (RKW Kompetenzzentrum 2009; EC DG AGRI 2012). It remains scientifically disputable, however, whether the aspired multiplier effects and benefits of closed regional economic cycles (as depicted in Fig. 2.3) can be realized and empirically proven (Kullmann 2004; Fernández Sánchez 2009). Still, Beck, and Knox and Mayer, emphasize the cultural and social relevance of regional food for regional economic systems (Beck 1997; Knox and Mayer 2008). In fast-moving busy societies and open markets, knowledge about the provenience, cultivation, and processing of products is slowly disappearing because almost any product is available at any time of the year and day from anywhere in the world, such as through online shopping. It is again favorable to regionalize local products, says Beck, as it becomes more important again for consumers to know where and how the products they consume are being cultivated and processed (Beck 1997). To uphold and pass on knowledge and traditions implies that in fact a strong basis of trust is needed among producers, suppliers, and consumers, based on personal contacts, stories, and shared values. Marsden et al. (2000, p. 425) follow that "a key characteristic of short supply chains is their capacity to re-socialize or re-spatialize food" and that they "seek to redefine the producer–consumer relation." 'Buy local' campaigns, farmers' markets, farm tours such as the *Höfe-Tour*[11] in South Tyrol, and similar producer–consumer alliances representing short supply chains are reactions in line with this trend to regionalize food systems and the economy (Knox and Mayer 2008, p. 141).

[10] Regionalbuffet Steigerwald-Süd, http://www.steigerwald-info.de; Regionalbuffet Romantisches Franken, http://www.regionalbuffet.de; Heimat aufm Teller e. V., www.heimat-aufm-teller.de; Natürlich von hier http://www.natuerlich-von-hier.de.

[11] The *Höfe-Tour* aims at valorizing the particular construction method, architecture, and farming activities of traditional mountain farms in the Ultimo Valley by developing a tour targeted at tourists and the local population as well as a specialist public (architects, designers, technicians, entrepreneurs, university students). Participants are invited to taste (and purchase) agricultural products. This approach contributes to preserving the traditional way of processing farm products and constructing farmhouses and, with that, to safeguarding the cultural landscape. Local hiking guides, providing information about the valley's history, traditions, and nature, accompany the guests.

2.7.1 Factors Favoring and Hindering Cooperation

Regional food cooperation systems can function well if certain circumstances are given, as argued by Cavelti and Kopainsky based on a case studies analysis in Switzerland[12] (Cavelti and Kopainsky 2008). Innovation strategies such as regional food cooperation systems in rural areas are successful if a high level of professionalism in the demand structure and marketing and market proximity are given. For cooperation in agriculture and tourism, this means it is decisive to clarify and debate early on doubts and possible advantages, for example, regarding quality standards, marketing, and logistics for the involved parties. Together they need to create planning security by means of clear organizational and sales processes because producers, deliverers, and consumers need to be able to rely on each other according to concluded agreements (ibid.). Diverging perceptions of the significance, use, and seasonal availability of regional products need to be discussed to arrive at a common understanding and long-term cooperation objective. A high degree of willingness and networking of the different parties involved is indispensable as a trust basis for an innovative strategy to function well before reaping the first noticeable benefits. Actors have to meet, discuss, possibly found an association, and agree on one person or a group of persons to drive the cooperation.

Because the demand for regional products is expected to continue for about another decade,[13] setting targeted action at strategic points in the regional economic structure, that is, between accommodations, wholesale traders, and farms, to further develop respective value chains, can lead to considerable revenues for the involved parties (DLG 2011; Hahne 2009). Through consistent focus on regional production, the value added in the region can be increased many times over, argues Hahne (2009). Product certification or labeling is advantageous but not necessarily required for this effort. It seems tough that the market for 'classic' regional products, such as regular fruit jams, is saturated. Chefs and consumers ask for new, unusual, unconventional products, for traditionally grown fruits, vegetables, and meat, as well as creative combinations and packages or portions to establish niche markets (EC DG AGRI 2012; cf. practice examples[9]). Similarly, alternative ways to present regional products and introduce producers to consumers, for example, with in-house food presentations or farm visits such as the *Höfe-Tour*[11] must need to become standard in hotels. At best, they are organized jointly by accommodations, farmers, and tourist associations.

Regional food cooperation systems can also have difficulties if constraining factors of supply, demand, or market prevail. A case study by Kohl (2008) in Austria

[12] Primarily, their research focused on innovation in areas with little potential in Switzerland. However, generally their findings are valid also for areas where potentials are more tangible but are not yet perceived as such and thus not exploited.

[13] Expectations for Germany according to DLG (2011).

revealed that culinary experiences increasingly form an important part of guests' motivation for a holiday. At the same time, the guest's consumer behavior is characterized by increased health consciousness, decreasing fault tolerance, and high standards of ambience, service, and product (ibid.). A missing strategic positioning on the market of a hotel or an unauthentic offer can thus damage its image. To be authentic, a hotel needs to consider the entire customer journey from check-in to food, to the wellness area, to the rooms, etc. Additionally, an increased number of competitors offering gastronomic services, such as *Buschenschanken*,[14] but also shopping malls or club bars, challenge the gastronomy. Without a concrete gastronomic profile taking into consideration current food trends, hotels and restaurants risk being more easily interchangeable (ibid.).

Cooperation projects also emerge with difficulty if participants do not invest enough time, opinions are too divergent, and benefits are not immediately visible or comprehensive. Expectations of some involved partners are often too high (e.g., related to available quantities, quality, and product prices). Cooperation may thus be more successful if started on a small scale with few partners and few products, slowly expanding partnership and product range.[15] Increasing costs resulting from hygiene requirements or other legal obligations make it additionally difficult for producers, wholesale traders, and accommodations to sell or buy just any agricultural product (ibid.). Practice examples show that a promoter is needed who fully supports the project, takes the lead, and drives the cooperation involving all partners – a crucial shortcoming pointed out also by the workshop participants in the Passeier Valley case study. Valuable is also an institutional framework that allows benefiting from varied expert knowledge in food research, marketing and production, project management, and monitoring. This structure could help farmers to better position their products and communicate information on the value added of the product (provenance, identity, cultural integrity) (EC DG AGRI 2012).

[14] *Buschenschanken* have a long tradition in South Tyrol but also in other Alpine regions (e.g., *Heuriger* in Austria, *Straußen-*, *Hecken-*, or *Besenwirtschaft* in Germany). Law No. 7, 19 September 2008, Arts. 2, 4, 6 of the Autonomous Province of South Tyrol, regulates the operation of a *Buschenschank*: serving food and drinks in a *Buschenschank* is limited to the wine-growing areas that are defined by the Provincial Department for Agriculture. For this activity, wine must be produced from the locale's own grapes; other wine that is served has to stem from the surrounding area. The maximal opening time for *Buschenschank* activities is 180 days per year. Opening times can vary from one *Buschenschank* to the other. Typically, however, it is open after the new wine is produced (between mid-September and mid-December) and in the first half of the year (mid-January to May). Nevertheless, some open also during the summer months.

[15] Cooperation schemes should strive for a diversified range for regional products, possibly under an own regional trademark or under an existing regionally established umbrella brand to be able to cater to the needs of accommodation establishments (Kohl 2008).

2.7.2 Regional Food Cooperation Schemes: Examples from South Tyrol and Common Characteristics

In South Tyrol, small- and medium-sized trading companies such as *Biokistl*[16] and *Pur Südtirol*[17] sell in stores and deliver regional products to private homes, offices, restaurants, and hotels. They purchase their products from more than 140 producers (*Biokistl* > 50 producers; *Pur Südtirol* ca. 250 producers), with whom they conclude individual delivery contracts. Some producers deliver to both companies. *Biokistl* arranges from a warehouse and its own logistics center. It sells foodstuffs from organic farms in South Tyrol, the Lake Garda region, as well as other organic food companies from South Tyrol, other Italian regions, and Germany. *Pur Südtirol* sells only products produced in South Tyrol, both online and in its three flagship stores in South Tyrol. One supplier is the ‘Red Rooster’ trademark for high-quality South Tyrolean farmers’ products, developed from within the South Tyrol Farmers’ Association. *Ahrntal Natur*, a former private distribution network aimed at introducing farmers’ products to regional supermarkets, hotels, and restaurants, initiated and cofounded in 1998 by an organic farmer, was recently integrated into the *Pur Südtirol* company. Another supplier of regional foodstuffs, *Gastrofresh*, caters to almost 80 % of South Tyrolean hotels and restaurants.[18] It also sells quality products from South Tyrol, which are mainly industrially produced (in contrast to small quantities from regional producers/suppliers). Personnel involved in regional food cooperation schemes in South Tyrol have recognized the societal, cultural, and innovation benefits of these cooperation forms as identified also by a study of the European Commission as major benefits of local food systems and short supply chains (EC DG AGRI 2012). These benefits are, among others, sustainable community development, support of biodiversity and cultural tradition, revitalized relationships between rural and urban areas, and reduced need for transportation and refrigeration to minimize greenhouse gas emissions as well.

In synthesis, four cooperation models seem to be common to establish between farms, wholesale traders, and accommodations (models M 1, 2, 3) or between farms and accommodations (M 4) to organize the collection and delivery of agricultural foods (Figs. 2.4 and 2.5).

Farmers can directly deliver to one or more wholesale traders, which in turn deliver to accommodations (Model M 1). Invoicing takes place between the individual farmer and the wholesale trader and the wholesale trader and the accommodation. To better respond to demand of accommodations and be able to deliver also in bottleneck situations, supply needs to be jointly coordinated by the farmers together with the wholesale traders. In terms of logistics, alternatively, a local wholesale trader can pick up the products from the farms (M 2) or from a collection point (M 3) and deliver them to the accommodations. M 2 foresees that the trading

[16] http://www.biokistl.it

[17] http://www.pursuedtirol.com

[18] http://www.gastrofresh.it/de/frischespezialist/logistik.html

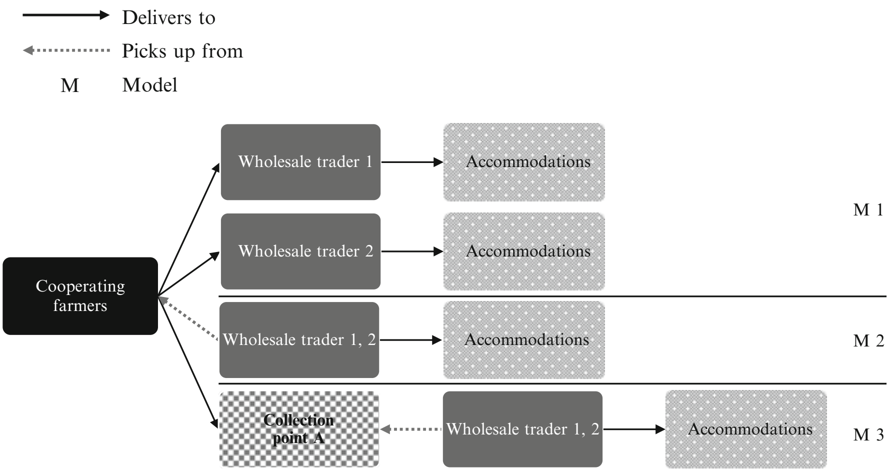

Fig. 2.4 Delivery and pick-up models between farmers, wholesale traders, and accommodations (Own illustration)

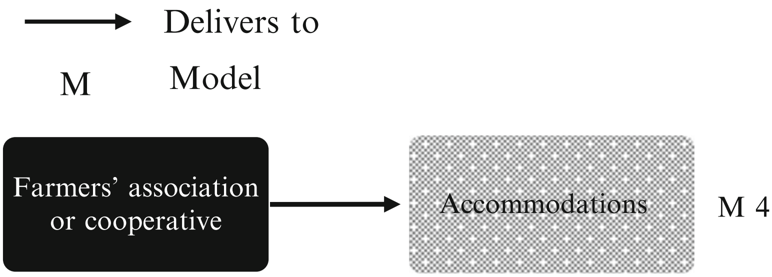

Fig. 2.5 Delivery and pick-up model between farmers and accommodations (Own illustration)

company is willing to pick up products from single farms whereas M 3 foresees that farmers are willing to deliver to an agreed collection point. In these models, the trading partner uses a professional software for sales coordination to systematically document client data, products, deliveries, and invoices. As an alternative to a local wholesale trader, a delivery enterprise specialized in regional/agricultural products can be engaged or newly founded with the added value of specialized expertise and competences in the regional food sector regarding product quality, marketing, food certification, and perhaps even online shopping.

In model 4, farmers are self-organized in an association or a cooperative. They themselves jointly plan the pickup and coordinate the delivery (e.g., alternation of drivers) to accommodations. Depending on the number of participating farms and hotels, the sales coordination can be simple (e.g., online with an open software spreadsheet or a bulletin board/website) or more elaborate (professional software to systematically document client data, products, deliveries, invoices, etc.). The invoicing takes place between the farmer and the accommodation or between the cooperative and the accommodation. It is useful that essential levels of the value chain or food system to be developed are present or newly established in the region to increase regional valued added (Schubert and Bühler 2008).

2.8 Conclusion

Regional food cooperation systems are varied and widespread as response to the increased demand of people for food cultivated in immediate proximity and their need for authenticity and quality products. Accommodations in tourist regions are well advised to cater to this demand by increasing the share of regional products on their menu. To acquire regional products, accommodation establishments seek out farmers as their primary supply source. This aim becomes time intensive and complex, however, as the product range of individual farmers is limited and one needs to contact various farmers for different products and to secure sufficient quantities. A major challenge to cooperation is thus to match and guarantee supply and demand, as evidenced also in the Passeier Valley case study. Regional food cooperation systems are a useful tool to oversee and manage the local regional product market. At best, farmers cooperate horizontally and collaborate with local wholesale traders or specialized delivery companies to cater to this demand. This method allows them to close product gaps caused by seasonal availability of agricultural products and other supply bottlenecks. It is disputable whether and at what point in time involved parties profit economically from regional food cooperation systems. Including a wholesale trader seems especially valuable but also challenging as the margins for this economic branch can be low whereas their expenditures are high (transportation, storage, accounting). By contrast, social, cultural, and innovation benefits are perceived more likely, or they are the motif for cooperation in the first place as hotels and restaurants are conscious of their region's potential and the values and are motivated to participate to strengthen their own position in the region, to contribute to preserving the cultural landscape, and to benefit from the regional unique selling proposition (USP) that is being established.

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Part II
Natural Resources and Ecosystem Services: Adaptation to Climate Change

Chapter 3
Applications of GIS-Based Hydrological Models in Mountain Areas in Bulgaria for Ecosystem Services Assessment: Issues and Advantages

Kremena Boyanova, Stoyan Nedkov, and Benjamin Burkhard

Abstract The application of hydrological models for the assessment of ecosystem services provides multiple opportunities for their quantitative analysis. Furthermore, Geographic Information System (GIS)-based models provide the possibility for spatially explicit analyses of model outputs and their representation in maps. A broadly applied and freely available hydrological model is the Soil and Water Assessment Tool (SWAT). The tool for its application in ArcGIS is ArcSWAT. The application of the model in mountain areas in Bulgaria can provide better understanding of the supply of ecosystem services and especially the water-related services, considering the large landscape diversity and climate differences within mountain watersheds. Still, data characteristics and limitations in Bulgaria can be restrictive for the quality of the model outputs.

ArcSWAT is created and actively supported by the United States Department of Agriculture (USDA). Consequently, the soil and land cover typologies and their respective lookup tables that are built into the model database are based on freely available USA datasets. The climate database integrated in the model is from stations throughout the United States and does not cover other countries, which makes the application of the model outside the United States more complicated.

For Bulgaria, the most detailed soil and land cover datasets use Bulgarian typologies, which have rarely been correlated to European or global types, and no correlation with US typologies have been found in the literature. Additionally, vegetation information within the different natural and semi-natural land cover classes is not

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K. Boyanova (✉) • S. Nedkov
Department of Geography, National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Akad. G. Bonchev Str. bl. 3, 1113 Sofia, Bulgaria
e-mail: kbboyanova@gmail.com

B. Burkhard
Institute for Natural Resource Conservation, University of Kiel, Olshausenstr. 40, 24098 Kiel, Germany

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_3

freely available. The access to daily climate data is also limited, especially for solar radiation, relative humidity, and wind speed, which are harder to collect than temperature and precipitation.

In this study we show how the application of the SWAT hydrological model in mountain watersheds in Bulgaria is possible, even with the existent data limitations. The test watershed used for that purpose is the Upper Ogosta watershed. The benefits of running the model for understanding of the hydrological cycle and the supply of ecosystem services within the area are discussed, as well as the issues and restrictions resulting from data limitations.

Keywords Ecosystem services • SWAT • Data • Mountain areas • Bulgaria

3.1 Introduction

The assessment of ecosystem services (ES) has gained broad recognition in the management of natural resources in EU member states, especially after the European Commission (EC) accepted, in 2011, the Biodiversity Strategy 2020.[1] The headlines of the Strategy are these:

> *Halting the loss of biodiversity and the degradation of* ***ecosystem services*** *in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss.*

Furthermore, ***Target 2: Maintain and Restore Ecosystems and Their Services*** – *Action 5: Improve knowledge of* ***ecosystems and their services*** *in the EU* of the Strategy requires that:

> *Member States, with the assistance of the Commission, will* ***map and assess the state of ecosystems and their services*** *in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020.*

Up to now, to support the Member States in this initiative, basic guidelines on the methodologies for mapping and assessment of ecosystems and ES have been provided by the MAES working group (Mapping and Assessment of Ecosystem Services).[2] ES mapping and assessment activities are further supported by EU projects such as OpenNESS, OPERAs, MESEU, or ESMERALDA.

The assessment methodologies can vary significantly, depending on the ES of interest, data availability, or accuracy demand. A broadly applied method is expert-based assessment, which does not require quantitative data sources and relies on experts' knowledge and understanding of the ecosystems within an area. This factor makes the method applicable in all EU member states with minimum resources.

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0244&from=EN%20.

[2] http://biodiversity.europa.eu/maes.

The quantification of ES is another assessment method that has been acknowledged for its relevance (de Groot et al. 2010; Burkhard et al. 2012a). It is based on the analysis of biophysical data and it is mostly applicable for regulating and provisioning ES. Very often, the analyses are made through the application of computer models, which are able to calculate variables that have not been or could not be measured. Still, significant amounts of data are needed to run and calibrate such models, which complicates the quantification of ES, especially in data-scarce areas.

In this study, the SWAT (Soil and Water Assessment Tool) hydrological model has been chosen as the source of quantitative data for the assessment of ES in the Ogosta watershed in Bulgaria. The model is developed in the USA and uses data that are available for free in this country. However, the soil and land use typologies integrated within the model differ from those available in Bulgaria. The various input climate data with high temporal resolution needed to run the model are also not available within the study area.

This chapter discusses the possible solutions of the data-related issues faced during the application of the hydrological model in a case study in Bulgaria.

3.1.1 Hydrological Modeling

Hydrological models are simplified mathematical representations of the environment, aiming to simulate the water cycle in a computer environment. They integrate different aspects of physical science in the effort to understand key hydrological processes and how these are being influenced by anthropogenic and other changes.

In the present work, the SWAT hydrological model was applied. The model was created by the USDA Agricultural Research Service (ARS) (Arnold et al. 1998). SWAT simulates a number of physical processes to predict the impact of land management practices on water, sediment, and agricultural chemical yields, considering the varying soil, land use, and management conditions, the topography, and climate conditions in large complex watersheds over long periods of time (Neitsch et al. 2011).

3.1.2 Mountain Ecosystems and Their Services

Mountain regions are of high relevance for their high intrinsic natural values and for the ecosystem goods and services they supply to human society. Mountain regions provide clusters of regulating ES (such as water regulation and purification, erosion control, climate regulation, natural hazard protection), provisioning services (e.g., timber, wood fuel, freshwater, fodder, livestock, wild foods), and cultural services (e.g., landscape aesthetics, recreation, inspiration). Human-induced land cover change, land use intensification, and climate change can cause significant alterations in mountain ecosystem structures (including biodiversity) and functions. ES

Fig. 3.1 Location of the upper Ogosta watershed

supply is based on functioning ecosystems, and changes will feed back to the society. Therefore, ES have become a major issue in ongoing research and decision making.

A practical ES assessment framework with respective indicators and tools that are applicable in mountain landscape management is needed. It should quantify and visualize ES appropriately to understand, indicate, and map stocks, demands, and flows of ecosystem services on different spatial and temporal scales. Maps and spatially explicit models allow the assignment of ES supply and demand data to particular multifunctional landscape units. Both are good models of real conditions and powerful tools to process the complex data of interdisciplinary research into sound information that is relatively easy to understand.

3.2 Materials and Methods

3.2.1 Case Study Area

The study area is the watershed of Upper Ogosta River in northwest Bulgaria, upstream from the hydrometric station at the village of Gavril Genovo (Fig. 3.1). The watershed has a area of 51,798.5 ha. Its elevation varies between 202 and 2009 m; one third of the watershed is within an elevation below 600 m and the other two thirds are above 600 m. The climate is temperate-continental. The average annual temperature varies between 4 °C and 11 °C. The average annual precipitation is between 600 and 1000 mm, depending on elevation, with a spring/summer maximum and a winter minimum.

3.2.2 Application of Hydrological Models for ES Assessments

The application of hydrological models for the quantification of ES is growing in popularity among scientists (Boyanova et al. 2014; Stürk et al. 2014; Nedkov and Burkhard 2012). Hydrological models provide quantitative output variables that can be used as indicators for the quantification of multiple ES. Depending on the model, the outputs may be in different spatial and temporal scales.

The common basis for all hydrological models is the water balance, which is a result of the processes in the watershed. SWAT is also able to predict the movement of pesticides, sediments, or nutrients. However, these ecosystem processes were not used in the present research. Only the variables that characterize the hydrological cycle have been calibrated and used for the analysis.

The spatial differentiation performed by the model within the analyzed watershed is on two levels: first, the subbasins were delineated, and second, the different hydrological response units (HRUs) within each subbasin were derived. Each HRU is a unique combination of land cover, soil, and slope. The climate variables required by SWAT are on a daily basis.

The simulation provides outputs of daily or monthly temporal scale for every HRU and average values for the subbasins. Results with such temporal and spatial resolution allow thorough quantitative analyses of multiple ES that can be indicated by the output variables. Moreover, the application of hydrological models for the quantification of ES can provide better understanding of impacts of climate change and management scenarios on future ES flows to the society.

3.2.3 GIS-Based Hydrological Modeling: ArcSWAT

The SWAT model can be applied in ArcGIS using the ArcSWAT extension, a graphical user interface that provides a user-friendly environment for GIS (Winchell et al. 2013). This is a big advantage for multiple spatial analyses and visualization options in GIS environments. Furthermore, the post-processing of the output results also demands a spatially explicit environment such as ArcGIS.

3.2.4 Data Requirements and Specification: Advantages and Issues

One of the main advantages of the SWAT hydrological model and specifically of ArcSWAT, besides its functionality, is that it uses freely available data as input data. Still, this is only valid for watersheds located in the USA, because the integrated land cover and soil typologies are those used within the USA. Also, the integrated climate data, needed for the simulation, come from weather stations throughout the country. For Europe, and more precisely Bulgaria, the typologies of the available land cover and soil data should be adapted to the one integrated in ArcSWAT. Also, the availability of weather stations and data records is much more limited in Bulgaria than in the USA.

3.2.4.1 Land Use, Soils, and Topography

The HRUs within the different subbasins are unique combinations of land use, soil type, and slope. The land use/land cover (LULC) and soil data are required in ESRI GRID, shapefile, or feature class format. The digital elevation model (DEM) is required in ESRI GRID format. This is not a problem for the Bulgarian case study, where data in the respective file formats are available. Issues are related to the required typologies.

Land Cover/Land Use

If the LULC categories in the map used need to be reclassified into SWAT land cover/plant types, the user has two main options (ArcSWAT documentation; Winchell et al. 2013):

- To use a LULC lookup table that is built into the ArcSWAT interface, which includes USGS LULC, NLCD 1992, and 2001/2009 lookup tables;
- To create a user lookup table that identifies the 4-letter SWAT land use/plant code for the different classes on the user's map.

The first option is not applicable in Bulgaria, because data with such classifications are not available within the country. The SWAT land use/plant classes are in two general groups, urban and crop: there are 9 different urban classes and 118 crop classes. Most of the crop classes are established agricultural plants and, if such data are available within a watershed, the model can be used to assess the influence of specific plants and the respective agricultural practices on the water resources in the area. If such information is lacking, there is also a general class for agricultural areas, that is, agricultural land–generic, which is the one used for the agricultural lands in the case study.

For the Upper Ogosta watershed, the available LULC maps were derived from the CORINE land cover dataset and the physical blocks of the area, provided by the Bulgarian Ministry of Agriculture and Food (MAF). A physical block is a continuous area of land bounded by enduring topographic elements. The spatial comparison between the MAF physical blocks and CORINE land cover shows that CORINE provides more detailed information on the different forest types (deciduous, coniferous, mixed) whereas the physical blocks provide more detailed information on the agricultural and urban areas. For that reason, both datasets were overlaid and reclassified to the CORINE typology. This step provided a more detailed CORINE land cover map of the area. Still, neither of the datasets provided information on the land cover that corresponds to the SWAT land cover/plant classes. For that purpose, the CORINE classes were also reclassified, which led to additional spatial generalization in some areas and made the analyses of the influence of different agricultural practices in some areas impossible. Table 3.1 shows the two steps of reclassification.

Soils

The soil categories included in the model come from the US soils databases [State Soil Geographic (STATSGO) and Soil Survey Geographic (SSURGO)] only. Both classifications are unavailable in Bulgaria, and no translation between those typologies and the one available for the research area could be found in the literature.

The soil map available in the Upper Ogosta watershed was extracted from the digital soil map of the Executive Agency for Soil Resources (EASR) at the Bulgarian Ministry of Agriculture and Foods (MAF). The digital map is based on the soil maps of the Scientific Research Institute of Soil Science and Agroecology (SRISSA) on the scale 1:25,000. The typology of the soil map is based on the current Bulgarian soil classification, which is drawn on the genetic concept of the Russian soil science school. The available Bulgarian typology of the available digital soil map was reclassified to the international FAO typology during previous research (Ninov 2000; Penkov 1996).

The FAO international soil classification is not integrated in the ArcSWAT model. A reclassification of the FAO soil typology to the US soil typology is very laborious, demanding soil specialists' expert knowledge because of the large number and variety of parameters for the different soil types. For that reason, a lookup table from the MWSWAT Microsoft Access database was copied and integrated in the ArcSWAT Microsoft Access database. MWSWAT is an extension for the application of the SWAT model in the open source GIS software MapWindow. By this, the FAO soil classification with the respective parameters of the different soil types was integrated in ArcSWAT and could be applied for the case study.

Slope

The slope values were extracted from the DEM used for the delineation of the watershed. The user can still choose between two different options for spatial slope discretization. The first option would be to use a single slope. In this case, an average slope for the subbasin would be used. The second option is to use multiple slopes, in which case the user can define from one to five different slope classes.

For the Upper Ogosta watershed, the slopes were differentiated into four classes (Table 3.2).

Table 3.1 Reclassification of available land use/land cover (LULC) data and the Soil & Water Assessment Tool (SWAT) land cover/plant dataset

Physical blocks (Ministry of Agriculture and Food, MAF)		CORINE		SWAT	
Code	Class	Code	Class	Code	Class
030	Cities	112	Discontinuous urban fabric	URML	Residential-Med/Low Density
031	Gardens	112	Discontinuous urban fabric	URML	Residential-Med/Low Density
032	Suburbs	112	Discontinuous urban fabric	URML	Residential-Med/Low Density
300	Urban areas	112	Discontinuous urban fabric	URML	Residential-Med/Low Density
302	Buildings outside cities	112	Discontinuous urban fabric	URML	Residential-Med/Low Density
103	Black roads	122	Road and rail network and associated land	UTRN	Transportation
600	Transportation	122	Road and rail network and associated land	UTRN	Transportation
601	Asphalt roads and adjacent areas	122	Road and rail network and associated land	UTRN	Transportation
602	Railroads and adjacent areas	122	Road and rail network and associated land	UTRN	Transportation
501	Mines and open pits	131	Mineral extraction sites	UTRN	Transportation
502	Waste	132	Dump sites	UIDU	Industrial
303	Sport and leisure areas	142	Sport and leisure facilities	UCOM	Commercial
010	Arable land	211	Non-irrigated arable land	AGRL	Agricultural Land-Generic
021	Vineyards	221	Vineyards	GRAP	Vineyard
020	Perennial plants	222	Fruit trees and berry plantations	AGRL	Agricultural Land-Generic
022	Fruit trees	222	Fruit trees and berry plantations	AGRL	Agricultural Land-Generic
023	Other perennial plants	222	Fruit trees and berry plantations	AGRL	Agricultural Land-Generic
040	Pastures and grasslands	231	Pasture	PAST	Rasture
042	Pastures and grasslands in arable land	231	Pasture	PAST	Rasture
060	Other agricultural area	242	Complex cultivation patterns	AGRL	Agricultural Land-Generic

(continued)

Table 3.1 (continued)

Physical blocks (Ministry of Agriculture and Food, MAF)		CORINE		SWAT	
Code	Class	Code	Class	Code	Class
100	Uncultivated areas	242	Complex cultivation patterns	AGRL	Agricultural Land-Generic
801	Undersized uncultivated areas	242	Complex cultivation patterns	AGRL	Agricultural Land-Generic
900	Areas for other (non-agricultural) use	242	Complex cultivation patterns	AGRL	Agricultural Land-Generic
050	Mixed land use	243	Land principally occupied by agriculture	AGRL	Agricultural Land-Generic
200	Forests	311	Broad-leaved forest	FRSD	Forest-Deciduous
–	–	312	Evergreen forest	FRSE	Forest-Evergreen
–	–	313	Mixed forest	FRST	Forest-Mixed
041	Natural pastures and grasslands	321	Natural grassland	RNGE	Range-Grasses
043	Forest pastures and grasslands	321	Natural grassland	RNGE	Range-Grasses
101	Bushes and grasslands	322	Moors and heathlands	RNGB	Range-Brush
–	–	324	Transitional woodland-shrub	RNGB	Range-Brush
102	Gullies and ravines	332	Bare rock	UTRN	Transportation
500	Disturbed areas	332	Bare rock	UTRN	Transportation
700	Bare, eroded areas	332	Bare rock	UTRN	Transportation
701	Sand, gravel, bare rocks	332	Bare rock	UTRN	Transportation
702	Scarcely vegetated areas	333	Sparsely vegetated area	UTRN	Transportation
802	Gorges	333	Sparsely vegetated area	UTRN	Transportation
402	Lakes, reservoirs, marshes	511	Watercourses	WATR	Water
403	Cannels	511	Watercourses	WATR	Water
401	Rivers and river beds	512	Water bodies	WATR	Water
404	Border water areas	512	Water bodies	WATR	Water

Table 3.2 Slope values within the defined classes for the Upper Ogosta watershed

Class	Lower limit (°)	Upper limit (°)
1	0	10
2	11	20
3	21	30
4	31	>31

Table 3.3 Location and elevation of climate data points

Points	Latitude	Longitude	Elevation (m)
429225	42.931	22.500	1217
432225	43.244	22.500	540
436225	43.556	22.500	870
439225	43.868	22.500	198
429228	42.931	22.813	664
432228	43.244	22.813	1455
436228	43.556	22.813	384
439228	43.868	22.813	109
429231	42.931	23.125	895
432231	43.244	23.125	368
436231	43.556	23.125	202
439231	43.868	23.125	27
429234	42.931	23.438	920
432234	43.244	23.438	998
436234	43.556	23.438	163
439234	43.868	23.438	11

3.2.4.2 Climate

The model requires climate data with daily or sub-daily time steps including values for rainfall, temperature, relative humidity, solar radiation, and wind speed. If such data are not available, the model has integrated Weather Generator Databases (WGEN) covering the USA, based on which the model can simulate the required input climate data.

For the Upper Ogosta watershed, neither measured data nor a WGEN database was available for the required variables. For that reason, data from the global climate database of the National Centers for Environmental Prediction (NCEP) – Climate Forecast System Reanalysis (CFSR)[3] was used. The data are available in the format required by SWAT from the Global Weather for SWAT[4] geoportal. Data for 16 points from a 30-km grid were downloaded. The points are distributed symmetrically around the case study area, but none of them falls within the modeled watershed. The coordinates of the points and their elevation are presented in Table 3.3.

[3] http://rda.ucar.edu/pub/cfsr.html.

[4] http://globalweather.tamu.edu/.

Table 3.4 Ecosystem services supply classes and respective quantities

Supply class	(a) Water flow regulation – groundwater recharge (m^3/ha)	(b) Water purification – water yield (m^3/ha)	(c) Water purification – percolation + lateral flow (m^3/ha)	(d) Freshwater – evapotranspiration (m^3/ha)
0	0–4,406	6,649–13,123	0–5,516	10,065–14,749
1	4,407–8,812	13,124–19,597	5,517–11,032	14,750–19,433
2	8,813–13,218	19,598–26,071	11,033–16,547	19,434–24,116
3	13,219–17,624	26,072–32,544	16,548–22,063	24,117–28,800
4	17,625–22,030	32,545–39,018	22,064–27,579	28,801–33,484
5	22,031–26,436	39,019–45,492	27,580–33,095	33,485–38,168

3.2.5 *Assessment and Visualization of ES*

After the SWAT simulation was finished and the outputs were calibrated, some of the variables were chosen as indicators of three water-related ES. The typology of ecosystem services used in this research is the one given in Kandziora et al. (2013). The definitions of the output variables are from Arnold et al. (2012).

Model outputs for groundwater recharge were used for the quantification of the regulating service *water flow regulation.* Groundwater recharge is the water recharge entering aquifers during a specific model time step.

For the quantification of the regulating service *water purification*, two independent assessments were made. One assessment relates to the contamination of surface and groundwater from pollutants in the soil. Here, the sum of the two variables *percolation* and *lateral flow* was chosen as indicator. Percolation is the water that percolates through the root zone during a time step. Lateral flow is the water flowing laterally within the soil profile that enters the main channel during a time step. The second assessment relates to the water purification from contaminants in the surface water. *Water yield*, the total amount of water leaving the HRU and entering main channel during the time step, was chosen as indicator.

For the quantification of the provisioning service *freshwater*, the actual evapotranspiration was chosen as indicator. The actual evapotranspiration is the sum of the soil evaporation and plant transpiration from the HRU during a time step. It is equal to the water consumed by the plants for their growth (Hoekstra et al. 2011).

For the spatial visualization of the results in the ES maps, a 0 to 5 classification method with respective colors for each class, suggested by Burkhard et al. (2009, 2012b, 2014), was applied.

3.3 Results

The quantities behind the different ES supply classes are represented in Table 3.4.

The values indicate a low amount of water reaching the aquifer (groundwater recharge) in comparison to the water quantities entering the main channel (water yield). This input makes the groundwater within the watershed a vulnerable resource and should attract the attention of the decision makers concerning local water management practices, because the maximum amount of groundwater that may be withdrawn from an aquifer, without irreversibly depleting it, is approximately equal to the long-term (e.g., 30 years) average groundwater recharge (Döll and Fiedler 2007).

The evapotranspiration, which indicates the amount of water that goes back into the atmosphere through evaporation and transpiration, shows relatively high average values within the watershed. Because the evapotranspiration approximates the water consumption of the different vegetation types, including crops (Hoekstra et al. 2011), it should be taken under consideration by decision makers concerning different land management practices. A trade-off analysis between the water-related and other services in the area (e.g., food provision, local climate regulation, recreation) would provide important information for the decision makers and the local people through a holistic evaluation of the benefits received from the environment and the present practices, which has high relevance for future management decisions.

The spatial representations of the final results in ES maps can be found in Figs. 3.2, 3.3, 3.4, and 3.5. The quantitative values for the supply of ES water flow regulation (Fig. 3.2) show extreme outliers, and most of the spatial unit values are concentrated in the lower range of all values, which makes the average supply of the service relatively low for the whole watershed. The spatial distribution of the quantities for the other analyzed services (Figs. 3.3, 3.4, and 3.5) is relatively homogeneous throughout the watershed, and no extreme outliers are present.

3.4 Discussion

Setting the data requirements of the SWAT hydrological model was related to multiple complications for a case study in Bulgaria. Nevertheless, the combination of local data sources (land cover, soil; MAF), European data sources (land cover; CORINE), and global data sources (soil, FAO; weather, CFSR) enabled its application and provided significantly better understanding of the hydrological processes within the Upper Ogosta watershed.

The quantitative assessment of the water-related ES in the area provided concrete values for their supply within every HRU. These results enable analyses of the relationships of different land cover/soil/slope combinations and the supply of

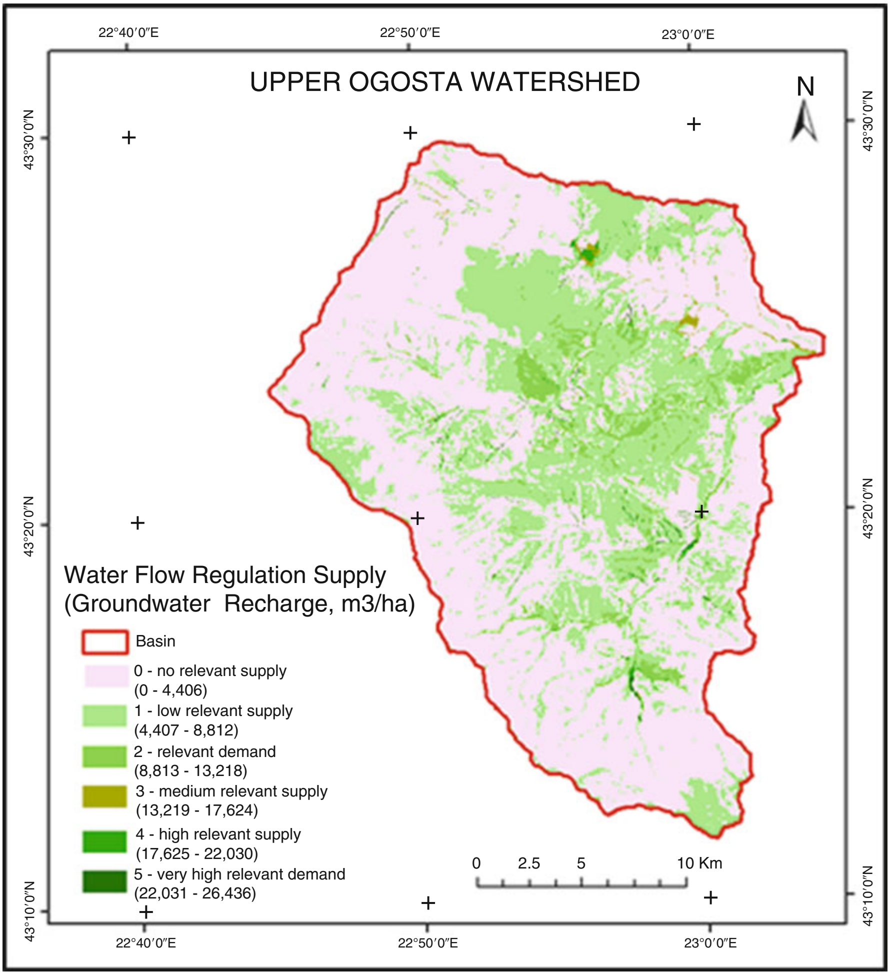

Fig. 3.2 Supply map of ecosystem services (ES) water flow regulation

water-related ES. The final maps provide thorough information about areas of low and high ES supply in the watershed. Such information has high relevance for decision making and concerning possible future management scenarios.

However, the lack of data responding to the model requirements limits the model simulation and increases the output uncertainties.

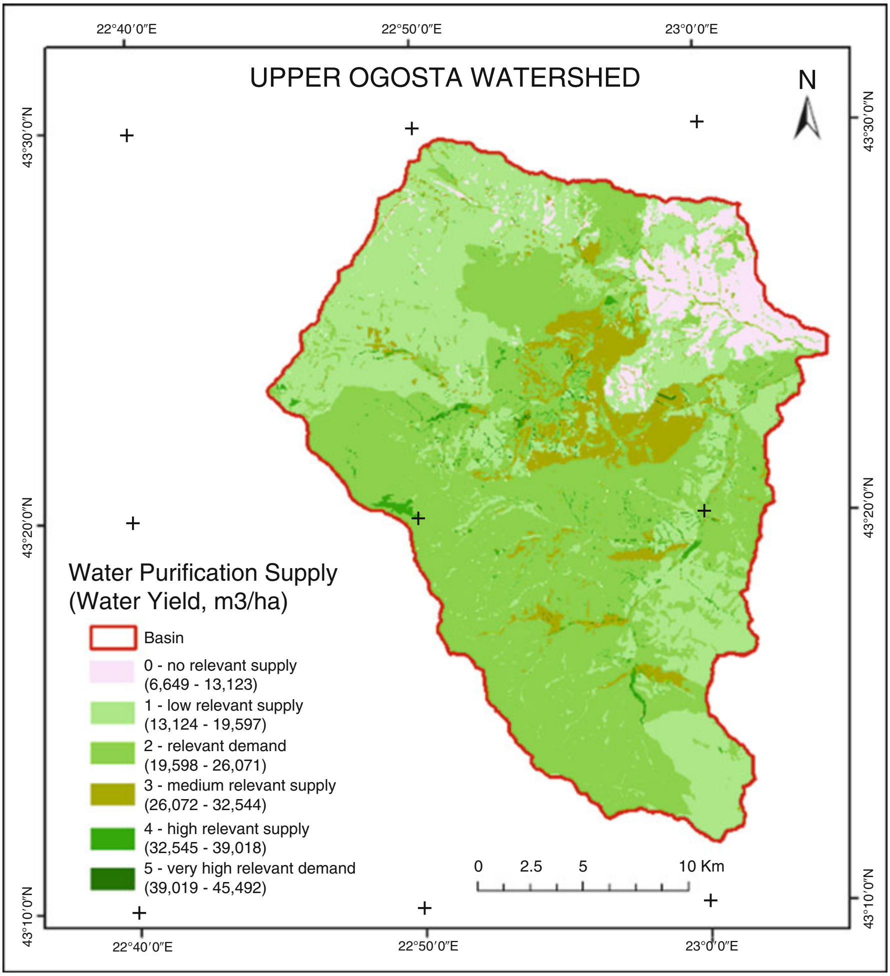

Fig. 3.3 Supply map of ES water purification from contaminants in the surface water

3.5 Conclusions

The application of hydrological modeling has multiple benefits for ES analyses and provides deeper understanding of the hydrological processes within a watershed. However, the comparably low quality of the available input data decreases the model's performance. Nevertheless, application of the hydrological model that was developed in the USA in Bulgaria is possible and opens new research options. The

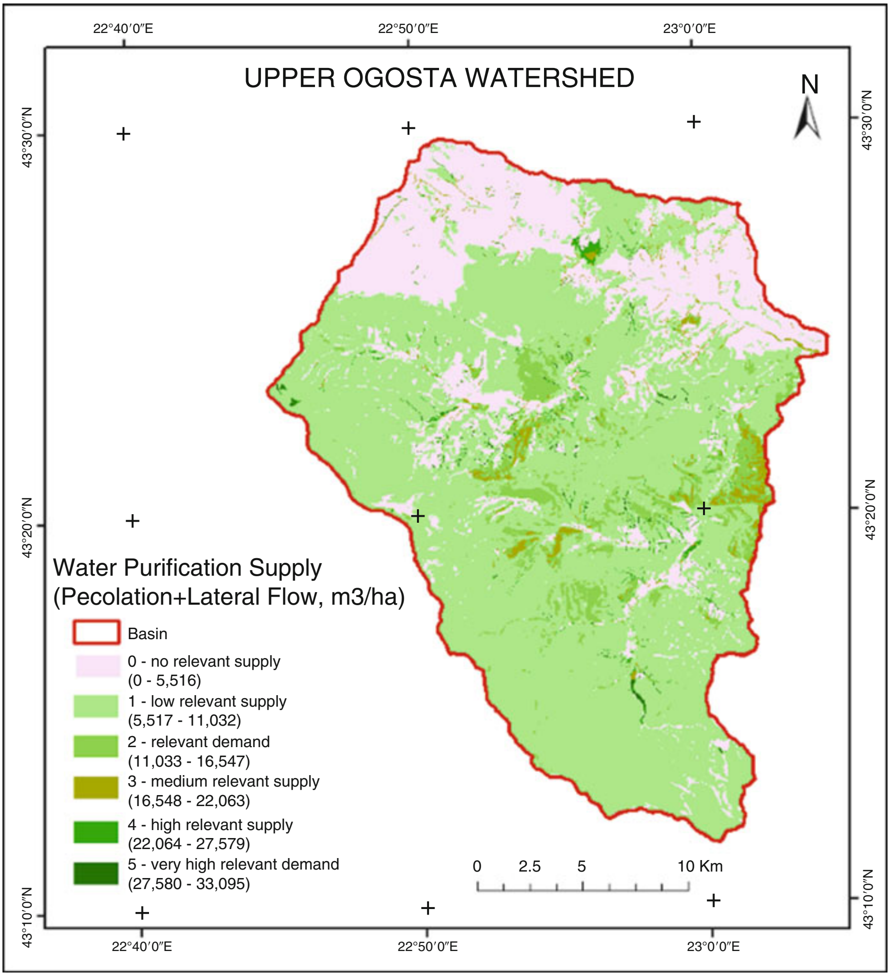

Fig. 3.4 Supply map of ES water purification from pollutants in the soil

need of translation between USA, European, global, and Bulgarian land cover and soil classification systems is a demanding field for scientists. The need for detailed weather data and a better network of weather stations should be a main target for the country, facing the challenges of climate change and other environmental pressures. A better understanding of natural phenomena, their relationship to human activities, and their influence on the supply of ecosystem services to the society is now possible through modeling, a useful tool for better future planning and decision making.

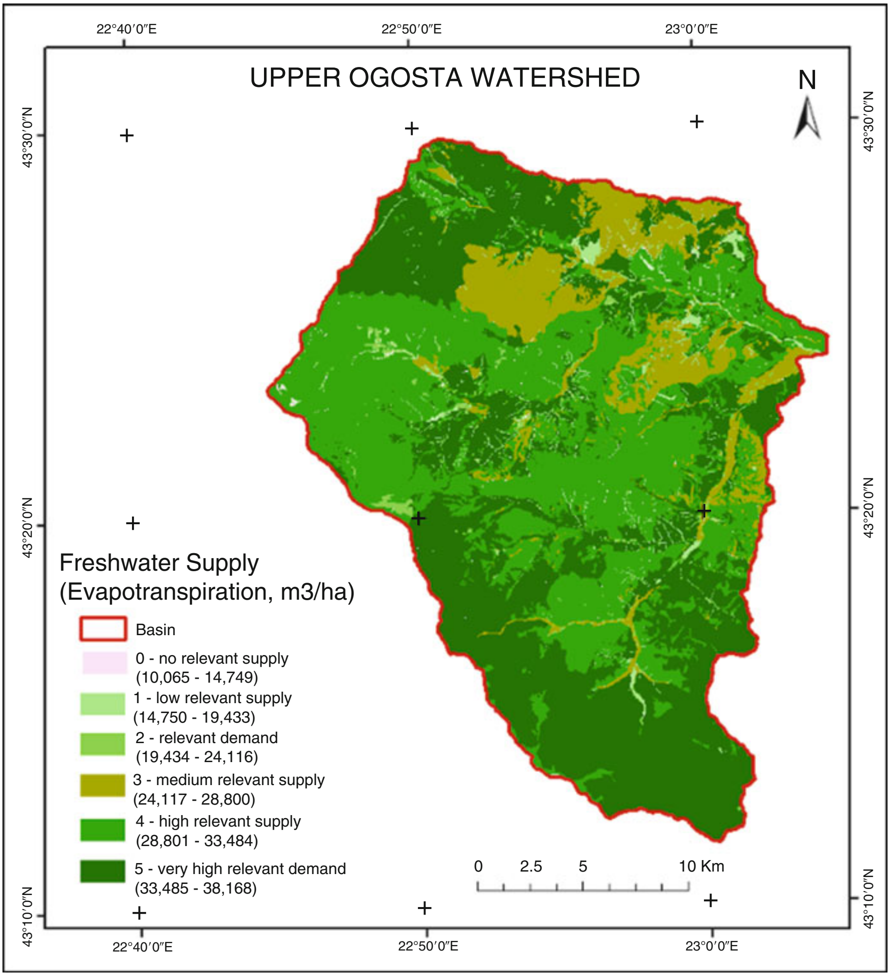

Fig. 3.5 Supply map of ES freshwater

Acknowledgments The work for this study has been supported by the EU 7th Framework Program project SWAN (Sustainable Water ActioN; Grant agreement no: 294947), the "National, European, and Civilisational Dimensions of the Culture – Language – Media Dialogue" Programme of the "Alma Mater" University Complex for the Humanities at Sofia University "Saint Kliment Ohridski," funded by the Bulgarian Ministry of Education, Youth, and Science Scientific Research Fund, the joint Bulgarian-German Project "Ecosystem-based information system covering sensitive mountain areas in Bulgaria," and the project ASCOR (Arsenic contamination of Ogosta River: Linking biogeochemical processes in floodplain soils with river system dynamics) of the Bulgarian–Swiss Research Programme.

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Chapter 4
Mapping Carbon Storage Using Land Cover/Land Use Data in the Area of Beklemeto, Central Balkan

Miglena Zhiyanski, Alexander Gikov, Stoyan Nedkov, Petar Dimitrov, and Lora Naydenova

Abstract This chapter presents the results of land cover and carbon storage mapping in a study area located in the Central Balkan Mountains. WorldView-2 satellite images and ortophoto maps were used to define the land cover in the area. CORINE land cover classification at the fourth level was applied for the mapping. The carbon stock was determined using InVEST model, and results were validated with in situ data from eight experimental sites in different land use classes.

Keywords Ecosystem services • Global climate regulation • Modeling • InVEST • In situ validation

4.1 Introduction

Global warming and climate change issues are among the most important challenges to people and the society. Understanding the processes that control them and which can contribute to mitigation of the negative effects is crucial. Earth ecosystems regulate climate by adding and removing greenhouse gases such as CO_2 from the atmosphere, and thus they are one of the most important factors for climate change. The commitments of the signatory countries of the Kyoto Protocol and those

M. Zhiyanski (✉) • L. Naydenova
Forest Research Institute, Bulgarian Academy of Sciences,
132, "Kl. Ohridski", Blvd., 1756 Sofia, Bulgaria
e-mail: zhiyanski@abv.bg

A. Gikov • P. Dimitrov
Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

S. Nedkov
Department of Geography, National Institute of Geophysics, Geodesy and Geography,
Bulgarian Academy of Sciences, Akad. G. Bonchev Str. bl. 3, 1113 Sofia, Bulgaria

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_4

expected within future legal frameworks as well as the reporting requirements under the UNFCCC prompt the need for better, substantiated, and regionalized knowledge on effects of land use change, land cover, and land management in many countries. There is a direct need to report effects on carbon storage from changes between forest land, cropland, and grassland under the UNFCCC and a need to quantify the potential of different land uses to sequester and store carbon. Efforts are also needed toward better understanding of the carbon cycle in the most affected and vulnerable complex ecosystems in mountain areas.

During recent years, there has been some effort to review and summarize the effects of land use change (LUC) on carbon storage (Guo and Gifford 2002; Jandl et al. 2007; Poeplau et al. 2011; Paul et al. (2008). LUCs are related to change in land cover and in vegetation composition. Many authors (Desjardins et al. 2004; Meyer et al. 2012a, b) have underlined that organic carbon stocks are influenced by the changes in vegetation and land use.

Forests, grasslands, peat swamps, and other terrestrial ecosystems collectively store much more carbon than does the atmosphere (Lal 2004), a valuable contribution from the perspective of the ecosystem services concept. Ecosystem services are described as the contributions of ecosystem structure and function in combination with other inputs to human well-being (Burkhard et al. 2012), and studies in this field have grown rapidly in recent years. Global climate regulation is one of the important services, which is related to the ability of the ecosystems to either sequester or emit greenhouse gases.

Satellite and aerial images are the most appropriate sources for land cover mapping. Globally, this has become the most convenient approach in such studies (Chandra 2012). Remote sensing methods are also successfully applied in Bulgaria for land cover mapping (Gikov and Dimitrov 2009, 2013), studies on vegetation changes (Gikov 2000; Naydenova and Jelev 2009), and water body dynamics (Jelev and Rumenina 2001).

This study focuses on mapping the carbon storage in different land cover classes in the area of Central Balkan Mountains through satellite and orthophoto data interpretation and aims to validate the InVEST modeled carbon stocks with an in situ measured dataset.

4.2 Study Area

The study area is located in the central part of the Balkan Mountains. It occupies the northern slopes of the area around the Trojan Pass, also known as the Beklemeto area. This is the highest pass crossed by an automobile road on the mountain. The case study covers a 3 by 2.5 km rectangle with an area of 750 ha (Fig. 4.1). The average altitude is 1250 m, with the highest point located in the southwestern part of the area (peak Gorelata glava, 1601.6 m), and the lowest in the northern periphery in the watershed of Krivia dol River (798 m). The relief is mid-mountainous, dominated by erosion and denudation landforms. Most of the case study area is occupied

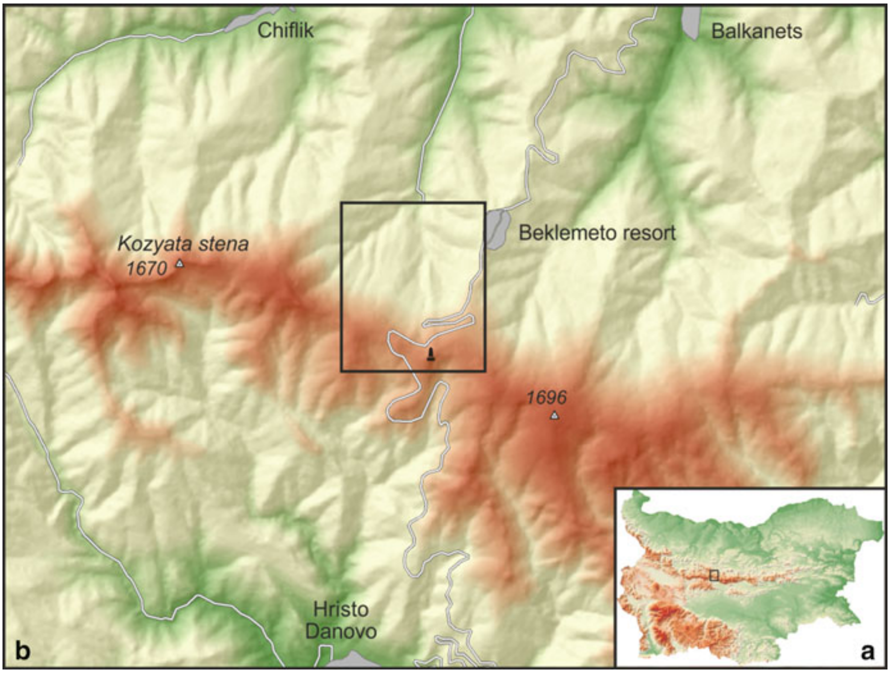

Fig. 4.1 Map of the case study area. A – Location of the area in Bulgaria. B – Location of the case study

by steep slopes greater than 15° (77 %) and even more than 20° (53 %). The areas with slopes of 7°–15° occupy about 19 % of the territory; the flat areas of the ridge's denudation plane occupy only 4 %. The average slope of the case study area is 20°. The aspect of the slopes is shared between east (38 %), north (31.3 %), and west (24.5 %). Taking into account that the area is located mainly on the northern macro-slope of Balkan Mountain, southern slopes have the smallest share, only 6.2 % of the area.

Almost the whole area is characterized by underlying Mesozoic sedimentary geologic formations. Lower Cretaceous rocks from the Neshkovska formation are located in the north and northeastern part of the area. They are presented by thin layers of marl, mudrocks, shales, and sandstones in flysch alteration. Clastic sediments from the Jurassic period are found in the limited area in the southwestern part, and in the southern part are carbonate rocks of the Iskar formation dated to the Lower Triassic period. A small area to the south of Gorelata gora peak is composed of older metamorphic rocks.

The study area has a temperate continental climate. The mean annual temperature varies between 4 °C and 8 °C, and the mean sum of annual precipitation is 901 mm (NIMH 1972–2012). The temperature regime directly depends on the altitude, and a trend of decreasing temperature with height is observed. The quantity and distribution of precipitation depend on both altitude and slope aspect. The soils in the area are referred to as Cambisols. Dystric/Eutric and Humic Cambisols are distributed from 700–800 to 1500–1700 m a.s.l. Dystric/Eutric Cambisols dominate, and their profile is shallow (up to 60 cm) with a thin humus horizon (up to 12–15 cm). Humic Cambisols are situated at the higher elevations, above 1200 m a.s.l. A major characteristic is a deeper profile, up to 80–90 cm, in the lower parts of the slopes and up to 40 cm in the highest parts of the crest.

4.3 Data and Methods

To achieve the aim of the study, two approaches were followed. Indirect calculation of carbon stocks using InVest modeling based on land cover data and direct measurements from eight experimental plots in different land uses were supported with reference data published in the literature for the region as well as for the specific land use type, forest stand, and tree species.

4.4 Initial Data

A WorldView-2 satellite image acquired in 2012 was used as a main source for land cover mapping. Four map sheets (C4-6, C4-7, D4-216, D4-217) of a national orthophoto map were used as additional source of information. The imagery of these sheets was taken on September 18, 2010.

The WorldView-2 satellite was launched into orbit on October 8, 2009. It is the first high-resolution eight-band multispectral commercial satellite. Operating at an altitude of 770 km, WorldView-2 provides 46 cm of panchromatic resolution and 1.85 m of multispectral resolution (Web site DigitalGlobe). Besides the traditional for such VHR sensors (QuickBird, IKONOS), four channels [blue (450–510 nm), green (510–580 nm), red (630–690 nm), near-IR1 (770–895 nm)], WorldView-2 has an additional four bands: coastal (400–450 nm), yellow (585–625 nm), red edge (705–745 nm), and near-IR2 (860–1040 nm). This rich spectral information facilitates the identification and differentiation of various types of land cover and improves the results of the mapping.

The scene, part of which was used in the study, was taken on November 11, 2012 in a completely serene environment in the region. Average off-nadir angle is 25°. The low position of the sun (29.6°) causes significant shading of the steep northern slopes, which impedes the identification of land cover classes but on the other hand emphasizes the plasticity of the relief. The orthophoto maps were used to define the land cover classes in the shadow areas of the satellite image. The image area of 27 km^2 is ordered in format Bundle, wherein the spectral bands are separate from the panchromatic image.

4.5 Image Processing

The satellite image was orthorectified and the spectral bands were merged with the panchromatic band by pan-sharpening. The rays of the central projection were transformed into orthogonal during the orthorectification. Further, a digital elevation model (DEM) was used to correct relief displacements. The precise orthorectification requires use of ground control points (GCP) with high accuracy. The points used for the orthorectification of the current image were taken in the field using a dual-frequency GPS receiver Topcon GRS-1 with PG-A1 antenna.

To improve accuracy, differential corrections in both real-time and post-processing RINEX data from network Naviteq/Smartnet were used. Orthorectification is done with the software Erdas Imagine 2013 using an RPC file, 11 GCP-s distributed spatially, and a 30-m DEM.

The pan-sharpening of spectral and panchromatic bands was also performed by Erdas Imagine using the subtractive method, which was chosen as the most appropriate among the other tested methods.

This method uses four of the eight sensor bands, three in the visible part of the spectrum and one in the near infrared (band 7, 770–895 nm).

4.6 Interpretation and Mapping

Visual interpreting of processed imagery has been performed. For land cover mapping the widely applied nomenclature of CORINE Land cover was used. According to standard it was developed up to level 3. The imageries are characterized by a very high spatial resolution that allowed obtaining higher detailing. Therefore, for the mapping of different land cover classes, the classification proposed by Feranec and Otahel (1998) for level 4 was applied. The names of the mapped land cover classes in accordance with the proposed classification are shown in Table 4.1.

4.7 In Situ Measurements

The characteristics of experimental plots for verification are presented in Table 4.2.

Field experiments were performed in 2013 and 2014 and included sampling of all components of the ecosystems: soil, forest floor, aboveground grass, vegetation, and biometrical measurements of tree stands. The following procedure was applied: soil profile to 50-cm depth was sampled per layers (0–10, 10–20, 20–30, and 30–50 cm, respectively) in five repetitions per plot. All related soil physical and physicochemical properties were determined: bulk density, soil pH, textural composition, coarse fractions content, and carbon and nitrogen content according to the standard methods applied in the laboratory of soil science in the Forest Research Institute.

Table 4.1 Description, codes, and area in plan of classes of land cover

Code	Description	Area (ha)
1221	Road network and associated land	0.2
1421	Sport facilities	5.7
1422	Leisure areas	3.3
3111	Broad-leaved forests with continuous canopy	322.9
3125	Plantation of coniferous forests	106.6
3131	Mixed forests created by alternation of single trees with continuous canopy	92.9
3211	Natural grassland prevailingly without trees and shrubs	117.6
3212	Natural grassland with trees and shrubs	10.3
3221	Heathlands and moorlands	85.2
3332	Sparse vegetation on rocks	6.3
5122	Artificial reservoirs	0.2

Table 4.2 Characteristic of experimental plots for in situ verification

Experimental plot	Soil type (WRB 2014)	Land cover	Land-use
1	Humic Cambisols	Natural grassland prevailingly without trees and shrubs	Pasture, extensive management
2	Dystric/Eutric Cambisols	Plantation of coniferous forests	Spruce, plantation, 45 years old
3		Broad-leaved forests with continuous canopy	Natural beech forest, 60 years old
4		Broad-leaved forests with continuous canopy	Natural beech forest, 60 years old
5		Mixed forests created by alternation of single trees with continuous canopy	Spruce, plantation, 55 years old, single broad-leaved tree
6		Natural grassland prevailingly without trees and shrubs	Pasture, intensive management
7		Sport facilities	Meadow, intensive management, football playground
8		Natural grassland with trees and shrubs	Meadow, abandoned, single trees and shrubs

Forest floor (all layers) was collected at the end of the growing season with a matrix 25 by 25 cm in five repetitions per plot, and processed for further analyses of dry weight and carbon content. Grass cover was collected with a matrix 1 by 1 m in three repetitions per plot and analyzed for dry weight and carbon content. The biometrical measurements of tree biomass were performed in the field following the standard methodologies of forest valuation (Krastanov and Raikov 2004). In each afforested experimental site, the number of trees, mean diameter, mean height, and stocking rate were determined. The volumes of biomass were calculated based on tree species tables for trees with bark for the region of Central Balkan (Krastanov and Raikov 2004) and based on a forestry management project (1995). Carbon stock in the whole ecosystem is estimated based on the IPCC Good Practice Guidance for LULUCF (2003) and used as reference. For mapping the mean value of all data collected, both references and measurements were used.

4.8 Carbon Sequestration Modeling

Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) is a GIS-based model designed to estimate various ecosystem services and is an appropriate tool to inform and improve natural resource management and investment decisions. InVEST models are spatially explicit, and their outputs are in form of maps in either biophysical or economic terms (Tallis et al. 2011). The carbon storage and sequestration model aggregates the amount of carbon stored into four so-called carbon pools: aboveground biomass, belowground biomass, soil, and dead organic matter. The model uses grid land cover data and a look-up table of the four pools as input. The model aggregates the carbon in each of the pools, providing an estimate of total carbon storage in each grid cell and across the whole landscape (Tallis et al. 2011), and the outputs are expressed as milligrams (mg) of carbon per grid cell. For the current work we used the land cover map of the area, described in the previous part, and the carbon pools look-up table provided with the model. The CORINE Land Cover classes were correlated to the land cover classification used in the model.

4.9 Research Findings

As a result of the visual interpretation performed, a total of 11 land cover classes at level 4 of CORINE classification were determined. In Table 4.1 the description of these classes was presented, and their distribution is shown in Fig. 4.2. It should be underlined that in the studied region class 3221 refers to the dense communities of *Juniperus communis* subsp. *alpina* whereas class 3111 refers to the mapped beech forests. The coniferous plantations are artificial I origin, and their species composition is various. The species planted are both typical for a Bulgarian wood line area, including tree species such as *Picea abies* Karst., *Pinus sylvestris* L., and *Pinus peuce* Grisb., and exotic species such as *Pseudotsuga menziesii* Mirb. Franco. In class 1221 the road area of Troyan Pass is not included, because of its relatively small width, but only parking area with asphalt cover is presented. The mountainous relief prerequisite is that the third classes with forest cover (3111, 3125, 3131) occupy more than two thirds of the territory. The classes with grass cover (3211,

Fig. 4.2 Land cover map. The codes and description of the land cover classes correspond to present in Table 4.1

3212) occupy 17 % from the key area, and the class with shrub vegetation (3221) covers 11.3 %, respectively. All other land cover classes have a total cover of only 2 % relative share.

The results of the InVEST model showed that the amount of carbon stored in the landscapes of the case study area varied between 0 and 525 tC/ha (Table 4.3). The largest part of the area had high carbon storage, between 450 and 525 tC/ha, which comprises the forested landscapes. The areas of low carbon storage, between 0 and

Table 4.3 Variations in the in situ measured carbon stock (tC/ha) in the components of different land covers

Code	Description	Soil (0–50 cm depth)	Forest floor and grass vegetation	Belowground biomass (roots)	Aboveground biomass
1221	Road network and associated land	<15.0[a]	n.a.	<5	<10
1421	Sport facilities	68.00	9.60	20–22	>30
1422	Leisure areas	<30[a]	9.60	5–20	10–30
3111	Broad-leaved forests with continuous canopy	92.00[a]	18.37	48.00	63–83
3125	Plantation of coniferous forests	74–144	33.01	16.10	37.57
3131	Mixed forests created by alternation of single trees with continuous canopy	85.0	23.61	28–54	50–75
3211	Natural grassland prevailingly without trees and shrubs	48.0	8.00	5–20	10–30
3212	Natural grassland with trees and shrubs	58.0	8.00	8	16
3221	Heathlands and moorlands	86–116[a]	15.00	10	10
3332	Sparse vegetation on rocks	5.0[a]	2.00	5	10
5122	Artificial reservoirs	n.a.	n.a.	n.a.	n.a.

[a]Reference Artinova et al. (2014), National System for Monitoring of Forests Ecosystems ICP Level 2 (2009), Dimitrova and Zhiyanski (2011), Dimitrova et al. (2014, 2015), Hristovski et al. (2008)

100 t/ha, were also well presented; they correspond to the artificial and grassland classes. The third part of the area had about 250–300 tC/ha.

The results of in situ measurements showed variations in all components of the land uses studied. The highest carbon stock was located in soils and aboveground biomass of forest land cover, where the total stock varied between 161 and 241 t C/ha. The areas of low carbon storage, between 10 and 59 tC/ha, correspond to artificial areas (including sport and leisure facilities) and grasslands. The third part, mainly grasslands with shrubs and single trees, had carbon stock between 90 and 91 tC/ha, .

4.10 Discussion

Combining the data obtained from in situ analyses for validation and references in the bibliography, the total C stock per different land cover was calculated and mapped according the relevant land cover classes (Fig. 4.3b). The higher carbon

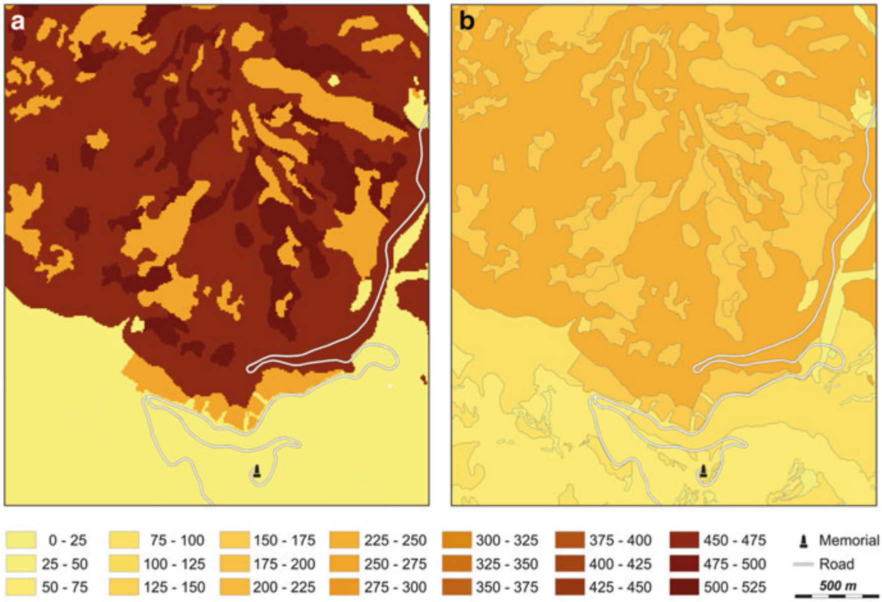

Fig. 4.3 Results for carbon storage in the study area from InVEST modeling (**a**) and direct measurements (**b**)

stock was calculated for broad-leaved forests with continuous cover with mean age more than 50 years (241.37 tC/ha). Concerning carbon stock in different ecosystem components, it was confirmed that soils are the main accumulator of carbon in land cover types with codes 1221, 1421, 1422, and 3221. A significant part of carbon was stored in belowground root biomass of different forests as well as in the aboveground tree biomass. It was established that carbon in root systems and in the tree biomass of broad-leaved forests was 48 tC/ha and 83 tC/ha, respectively, compared to the mixed forests, where 19 tC/ha was carbon stored in roots and 40 tC/ha was carbon stored in aboveground biomass. The coniferous forests stored 16 tC/ha and 38 tC/ha in these ecosystem components, respectively, which is similar to those quantities stored in mixed forests. The forest plantations were characterized by the highest C stock in the forest floor layer, 33 tC/ha, compared to the other types of forests: 23 tC/ha for the mixed and 18 tC/ha for the pure broad-leaved forests. The total C stock was significantly higher in the area with code 3111 land cover, that is, broadleaved forests with continuous canopy, 241 tC/ha, compared to the other land cover, where the calculated stocks were less than 167 tC/ha. A strong connection is observed between the land cover and total C stock in the studied area, but the connection with the distribution of carbon in the different components is not clearly expressed.

Concerning carbon stocks modeled with InVEST, the values obtained were twice as much higher for all studied land cover classes where vegetation exists (Fig. 4.3a).

A possible explanation of the differences between modeled and in situ measurements and calculations concerns differences in some input parameters. Soil carbon stock from in situ calculation considers all specifics including content of coarse fraction, depth of sampled soil layer, and bulk density at each sampled plot and is estimated in equivalent soil mass, which decreased the value obtained. The belowground carbon stock is a dynamic characteristic and the data used are averages, based on references and local measurements. Aboveground vegetation in forest areas is the other important feature that affects the differences between both stocks. Mixed forests in land cover class in the InVEST model use as reference basis stands with mean age of more than 80 years, whereas the real situation in the area is presented by younger (<40 years old) mixed stands of coniferous and broad-leaved tree species. The other explanation is the dead wood biomass, which is not included in the in situ measurement, whereas it is included in the model.

4.11 Conclusions

The values of total carbon stocks modeled with InVEST were higher compared with the in situ measured stocks for all studied land cover classes. These variations could be explained with the differences in the reference sites used for the specific land cover class in the InVEST model. A similar tendency was established in total carbon sequestered in different land uses when applied to modeled and measured carbon stocks. This endeavor prompted us to recommend additional measurements and application of the model after further validation.

Acknowledgments This work is a part of the project "Land-use and management impacts on carbon sequestration in mountain ecosystems" financed under the framework of the Bulgarian-Swiss Research Programme ("BSRP"), 2011–2016, between the Government of Bulgaria and the Swiss Federal Council and the bilateral project "Elaboration of e-based information system for sensitive mountain regions in Bulgaria" funded under DAAD (Germany) and NSF (Bulgaria).

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Chapter 5
Consequences of Non-intervention Management for the Development of Subalpine Spruce Forests in Bulgaria

Alexander Dountchev, Momchil Panayotov, Nickolay Tsvetanov, Petar Zhelev, and Stefan Yurukov

Abstract Subalpine spruce forests are among the best preserved woodland ecosystems in Bulgaria with respect to their structure, functions, and biodiversity. Considerable territories of these forests were declared as protected areas at the beginning of the twentieth century, which allowed them to develop predominantly naturally. Nowadays, climate changes and the consequent increasing number of disturbances in the spruce forests across Europe raises the question to what extent the non-intervention regime of protected forests is compatible with the concepts of sustainable management and the protection functions of these forests. To answer this question we studied the natural development of three subalpine spruce forests in the nature reserves Parangalitsa (1933) in the Rila Mountains, Bistrishko branishte (1934) in Vitosha Mountain, and Beglika (1960) in the Rhodopes Mountains. We created GIS databases for these reserves and used them to analyze satellite and field data. We found that small- and large-scale disturbances such as windthrows, bark beetle outbreaks, and fires are part of the natural dynamics of subalpine spruce forests. Their resilience to disturbances is mainly dependent on the availability of structural elements that are often missing in managed forests, such as heterogeneous forest structures and spatial patterns, as well as specific regeneration substrates such as deadwood or windthrow mounds. Thus, we recommend that the sustainable management of subalpine spruce forests should be focused on preserving and, where needed, restoring the structural elements that are characteristic for the natural spruce forests.

Keywords Norway spruce • Natural disturbances • Forest reserves • Bulgaria

A. Dountchev (✉) • M. Panayotov • N. Tsvetanov • P. Zhelev • S. Yurukov
University of Forestry, Kliment Ohridski Street 10, 1756 Sofia, Bulgaria
e-mail: alexdountchev@hotmail.com

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_5

5.1 Introduction

Norway spruce (*Picea abies* (L.) Karst.) forests cover vast territories from sea level to the treeline in the boreal region of Europe, and significant areas of the mountainous regions in Central and Eastern Europe (Schmidt-Vogt 1991). The most southern distribution of *Picea abies* is found on the Balkan Peninsula in the Rhodopes Mountains in Bulgaria, where it shapes the subalpine forests. Large areas of spruce forests are also spread in the mountain ranges of Rila, Pirin, Vitosha, and Stara Planina, at an altitudinal range of 1400 to 2200 m a.s.l.

The subalpine *Picea*-dominated forests in Bulgaria are characterized by a high level of naturalness, specific species composition (including endemic tree species such as *Pinus peuce* Griseb., *Pinus heldreichii* H. Christ., and *Acer heldreichii* Orph. ex Boiss.), and important protective functions (e.g., water protection, soil erosion control, and avalanche protection). Also, they are one of the main sources of commercial timber and are economically extremely important for the mountain regions of Southern Bulgaria. These forests were among the first ecosystems to be protected in natural reserves at the beginning of the twentieth century: namely, back in 1933–1934 were established the spruce forest reserves Parangalitsa in Rila Mountain, Baiovi dupki-Djindjiritsa in Pirin Mountain, and Bistrishko branishte in Vitosha Mountain, situated in remote areas where intensive logging was still limited at that time. Later were established the spruce forest reserves Beglika (1960) and Mantaritsa (1968) in the Rhodope Mountains and Chuprene (1973) in Western Stara Planina. At present, large areas of the spruce forests in Bulgaria are situated in protected areas with a limited or no intervention regime, allowing for natural development of these ecosystems.

At the same time recent studies on the natural dynamics of subalpine spruce forests in Europe demonstrated that they are highly susceptible to natural disturbances such as windthrows and bark beetle outbreaks, causing the death of a high number of individual trees or whole mature stands with areas of thousands of hectares (Schmidt-Vogt 1991; Korpel 1995; Schelhaas et al. 2003; Svoboda et al. 2011, 2014; Panayotov et al. 2011; Zielonka et al. 2010). The role of natural disturbances in the development of these ecosystems is expected to increase further as a result of climate changes associated with increased frequency of weather extremes such as windstorms and droughts (Dale et al. 2001; Schlyter et al. 2006). Because natural disturbances have always been perceived as "natural disasters" that threaten the integrity and the protective functions of spruce ecosystems, the post-disturbance management has traditionally been focused on salvage logging and artificial planting of the cleared areas. In this respect, the non-intervention of subalpine spruce forests in protected areas, particularly after large-scale natural disturbances, is often not accepted as a proper management option (Brang et al. 2006).

To identify and analyze the influence of the non-intervention management on the development of subalpine spruce forests in Bulgaria we compiled available data and compared the disturbance regimes, the forest structure, and the current regeneration patterns in three *Picea*-dominated forests with different site conditions and history, situated in nature reserves.

5.2 Data and Methods

5.2.1 Study Sites

We studied three subalpine Norway spruce (*Picea abies* (L.) Karst.) forests in Bulgaria, Southeastern Europe. The first site is situated in Parangalitsa Nature Reserve (1450–1950 m a.s.l.) within Rila National Park (42°05′ N, 23°28′ E), Southwestern Bulgaria. The forests (250 ha) developed without serious human intervention for at least 200 years and were shaped by medium- to large-scale windthrows (Panayotov et al. 2011a). The second site is situated in Bistrishko branishte Nature Reserve (1400 and 1950 m a.s.l.) within Vitosha Nature Park (42°33′ N, 23°18′ E), Western Bulgaria. This forest (650 ha) was subjected to intense management activities before its designation as a protected area, which resulted in predominantly homogeneous even-aged stands not older than 140–150 years (Panayotov and Georgiev 2012; Tsvetanov and Panayotov 2013). This site was affected by large-scale disturbances at the beginning of the twenty-first century: a 60-ha windthrow (2001) and subsequent bark beetle outbreak on a territory of more than 200 ha (Dountchev et al. 2014). The third site is situated in Beglika Nature Reserve (1600 and 2100 m a.s.l.) in the Rhodopes Mountains (42°33′ N; 23°18′ E), Southern Bulgaria. This forest (1200 ha) has an average age of 90 years, but large parts of it are multi-cohort with a tree age of more than 200 years. Our data are based on studies in the core part of the reserve, for which there are no data for intensive management of the forests.

The climate at the study sites is typical for mountain locations, with annual temperature ranging from 2.3 °C to 2.5 °C in the higher parts of the forests to 5.2 °C to 5.7 °C in the lower parts. The annual precipitation varies between 930 and 1100 mm with the maximum in May–June and the minimum in July–September. The snow cover reaches 150 cm and lasts for more than 150 days.

The bedrock is mainly volcanic (granite in Parangalitsa and Beglika, syenite and andesite in Bistrishko branishte). Soils are predominantly dark mountain soils (Mollic Cambisols) and brown mountain soils (Dystric and Umbric Cambisols) with sufficient depth. In some areas of Bistrishko branishte Reserve the soils lie on large spherical syenite blocks and therefore the rooting depth is limited. The herbaceous layer is dominated by *Calamigrostis arundinacea* (L.) Roth, *Rubus ideaus* L., and *Vaccinium myrtillus* L.

5.2.2 Data Collection

Historical information about the natural disturbances in the Norway spruce forests in the studied nature reserves was collected on the basis of a review of available literature and field research using dendrochronological methods (Panayotov et al. 2011; Panayotov and Georgiev 2012; Tsvetanov and Panayotov 2013; Dountchev et al. 2014; Panayotov et al. 2015). Data for the distribution and development of the spruce forests in the study sites were acquired from the forest management plans of the respective forest territories. Detailed identification and mapping of the forest structure on landscape level was performed on the basis of actual forest maps and orthorectified digital aerial photographs from 1966, 2005, and 2011. The statistical data and the aerial photographs were processed and analyzed in geographic information systems (GIS) using ArcGIS 10 software (ESRI Inc.). The forest structure and the regeneration processes were studied in sample plots of 100 m^2, which were systematically distributed in the reserves. In each plot were measured the forest density and the DBH distribution, as well as the regeneration numbers, the regeneration substrates, and the species composition. Disturbance history was reconstructed by the means of tree ring analysis (Panayotov et al. 2011, 2015).

5.3 Results

5.3.1 Disturbance Regimes

The studied Norway spruce forests in the three nature reserves were dominated by both small- and large-scale natural disturbances.

In Parangalitsa Nature Reserve more than 23 % (55 ha) of the forest area was affected by disturbances at different periods. Most of these areas (18 %) suffered severe windthrows with areas of 1–10 ha. The largest of these was a windthrow from 1962, which affected an area of a total of 18 ha in several different patches in Parangalitsa forest (Panayotov et al. 2011, 2015). Before the windstorm, the affected stands were mostly pure Norway spruce and composed mainly of one cohort that was more than 170 years old (Georgiev 1933). Forest Service records (Nedialkov 1966) indicate that in the few years following the windthrows (1962–1965) stands adjacent to the windthrows patches were affected by sporadic tree fall and bark beetle mortality, which increased the total disturbance area to 22 ha by 1966. This storm also caused numerous single or small group tree falls in other regions of the forest. One other zone with area of 4 ha was affected by a windthrow in 1965 (Georgiev 1970). Between 1966 and 1997, when our second set of aerial photographs was taken, 12 new distinct disturbances occurred over a total of 3 ha on the borders of the 1962–1965 windthrows. Thirty-eight other small disturbances (i.e., <1 ha) that were not adjacent to the borders of the 1962 windthrow affected a total of 6.26 ha of our study area over this period of time. In 1983 a windthrow affected seven patches with a total area of 22 ha (average size, 3.72 ha; minimum, 0.91 ha; maximum, 7.32 ha) that were composed of uniform individual cohorts with ages of 90–160 years. The historical reconstruction of disturbances based on tree ring analysis performed by Panayotov et al. (2011) also provides data for five forest patches with sizes of 1–7 ha, which occurred after stand-replacing disturbances 100 to 150 years ago. In addition, there are clues for other disturbances before this period, but because they did not leave legacies as clear borders of patches with different stand structure there is no possibility of drawing conclusions on the spatial extent of these disturbances.

In Bistrishko branishte Nature Reserve, the forest dynamics were dominated by mid- and large-scale natural disturbances, such as the windthrows in the 1920s, 1950s and 2000s, the *Ips typographus* outbreak in the 2000s, and a forest fire in 2013 (Dountchev et al. 2014; Panayotov et al. 2015). In the past 100 years these events affected a total of 280 ha (i.e., 53 %) of all spruce forests in the reserve, the majority of which were left to regenerate naturally. The only intervention was after a windthrow in the treeline in 1956, when deadwood was collected, and plantations of spruce samplings occurred on half of the windthrow territory. Unaffected by natural disturbances were 250 ha of the natural spruce forests in the reserve, predominantly in younger (<100 years old) or mixed forests. The largest impact was caused by the bark beetle (*Ips typhographus* L.) outbreak that developed after the windthrow in 2001, affecting more than 190 ha for a 10-year period. The calamity of the insects has spread outside the reserve borders, damaging more than 20 ha of managed spruce forests. The main front of the outbreak was actually blocked by mixed forests at lower altitudes, as well as by young stands developed either after the large-scale windthrow in the treeline area in 1956 or by young forests (age <50 years) developed naturally on abandoned pasturelands.

In Beglika Nature Reserve Alexandrov (2015) and Panayotov et al. (2015) found that prevailing were the small-gap disturbances (up to 1 ha) affecting nearly 10 % of the forest cover. The mean size of the gaps was assessed at 100–150 m^2. Particularly susceptible to such disturbances were the older stands of age above 120 years. Despite the large number of dead trees and snags, there were no signs of bark beetle outbreaks in the reserve.

5.3.2 Forest Structure

The forest structure in the studied forests varied among the study sites.

In Parangalitsa Nature Reserve, 76 % of the forest patches were pure coniferous forest and 24 % mixed coniferous-deciduous stands. In terms of forest structure, eight patches with a total area of 29.3 ha (12 % of the total forest area) were classified as homogeneous (i.e., densely spaced with similar-sized crowns), 68.7 % of the area was forest patches with heterogeneous structure (i.e., different crown sizes), 8 % were timberline to treeline transition zone, and 11.9 % were post-windthrow stands that were disturbed before 1966. In treeline zones, 84 % of the forest stands were dominated by the shade-tolerant species *Picea abies*. At lower elevations in several stands, *Abies alba* and *Fagus sylvatica* were dominant. Deciduous pioneer species (e.g., *Betula pendula* Roth and *Populus tremula* L.) were found mostly in small groups and comprised more than 50 % of stems in only one patch. *Pinus sylvestris* L. was a codominant species in the canopy of most of the west-exposed and some of the oldest north-exposed stands. The Balkan endemic species *Pinus peuce*

(Macedonian pine) was found only at high elevations in patches that were classified as "treeline transition."

In Bistrishko branishte Nature Reserve, the largest part (i.e., 280 ha) of the spruce forests were in the stand initiation phase, that is, the regeneration phase, as a result of the recent disturbances (Dountchev et al. 2014). Still in these areas were found a few patches of surviving broad-leaved species such as European beech (*Fagus sylvatica* L.), Sycamore maple (*Acer pseudoplatanus* L.), Balkan maple (*Acer heldreichii* Orph. ex Boiss.), goat willow (*Salix caprea* L.), and rowan (*Sorbus aucuparia* L.). The intact forests were formed by even-aged homogeneous Norway spruce stands in the stem-exclusion stage of development.

In Beglika Nature Reserve, where the forest was characterized mainly with reversed J-shaped forest structures (Alexandrov 2015), fewer stands were dominated by uniform structure, particularly at lower altitudes. Along the timberline were found some stands with unimodal structure. In general, the structural heterogeneity was better expressed in the horizontal than in the vertical aspect. The spatial distribution of the trees was irregular. Particularly with increasing altitude, the trees were most often found in groups. There was no clear connection between estimated age and height of the trees; trees with equal height could have an age difference of as much as 120 years. Most of the stands were characterized by heterogeneous multi-age structure.

5.3.3 Regeneration Patterns

In Parangalitsa Nature Reserve, slow regeneration processes were observed in the areas affected by the windthrows of 1962 and 1983 (Tsvetanov et al. 2014). In the cleared windthrow area of 1962, the regeneration numbers in 2014 varied between 500 and 550 saplings ha^{-1}. In the uncleared windthrow area of 1983, the surviving advance regeneration of *Picea abies* and *Sorbus aucuparia*, formed during the decades preceding the disturbance, amounted to more than 1000 saplings ha^{-1}. A regeneration peak followed after the windthrow in 1983, which in a 10-year period added another 800 saplings ha^{-1} to the advanced regeneration. Initially the regeneration was focused on intact forest floor, hosting between 69 % and 80 % of the regeneration. After a few decades, the importance of lying deadwood for regeneration increased, and 41 % of the regeneration in the 1962 windthrow and 49 % in the 1983 windthrow were found on this substrate.

In Bistrishko branishte Nature Reserve, moderately intensive regeneration processes were observed mainly in the recently established disturbed areas, that is, the areas affected by the windthrow of 2001, the bark beetle calamity (2003–2010), and the forest fire of 2013 (Dountchev and Zhelev 2014). The regeneration numbers ranged from 400 up to 800 saplings ha^{-1}. In the areas affected by windthrow and the bark beetle outbreak, the regeneration was dominated by *Picea abies* (250 ha^{-1}, respectively, 150 ha^{-1}) and the short-lived *Sorbus aucuparia* (280 ha^{-1}, respectively, 360 ha^{-1}), whereas in the burned areas the pioneer species *Populus tremula* (200 ha^{-1})

and *Salix caprea* (130 ha^{-1}) were most abundant. The largest part of the *Picea abies* saplings were found on specific regeneration substrates originating from the disturbances: windthrow mounds, 45 %; the area close to lying or standing deadwood, 25 %; and decayed deadwood, 2 %, which altogether cover not more than 20 % of the disturbed area. Although grassy vegetation covered most of the disturbed area (up to 75 %), only 18 % of the spruce regeneration has overcome its suppression.

In Beglika Nature Reserve, the natural regeneration of the subalpine forests as studied by Alexandrov (2015) was taking place in small gaps and was mainly dependent on the presence of lying deadwood and patches of *Juniperus* sp. and *Cytisus* sp. The amount of lying deadwood was on average 6.1 % of the standing volume and hosted nearly 25 % of the regeneration. The concentration of the saplings on deadwood and patches of small bushes predetermines the development of tree groups. The average age of the regeneration under the forest cover was 68 years; in open spaces it was 32 years.

5.4 Discussion

Our results show that the development of the studied subalpine spruce forests was characterized by mid-scale to large-scale disturbances in Parangalitsa and Bistrishko branishte Nature Reserves as well as gap disturbances in Beglika and partly in Parangalitsa Nature Reserves. Particularly susceptible to natural disturbances were stands older than 120 years showing unimodal DBH structures. In Vitosha Mountain the high recurrence rate of windthrows is explained by the presence of a shallow ground layer over the syenite bedrock, which limits rooting stability, as well as by the frequent occurrence of very strong winds. Even though the gap disturbance model is considered as typical for non-intervention subalpine forests in Europe (Korpel 1995; Szewczyk et al. 2011), our study shows that large-scale windthrows can trigger subsequent bark beetle outbreaks. This concern is particularly valid for forests that were subject to intense management activities before their designation as protected areas that resulted in predominantly homogeneous even-aged stands not older than 120–140 years, such as Vitosha Mountain (Panayotov and Georgiev 2012; Tsvetanov and Panayotov 2013; Panayotov et al. 2015). Namely, the absence of natural barriers such as groups of trees of younger age or groups of other tree species besides Norway spruce assisted the spread of the bark beetles.

The resilience of the spruce forests to bark beetle outbreaks seemed to be higher in high-altitude stands (e.g., in Beglika Nature Reserve) and in stands with higher structural heterogeneity (e.g., in Parangalitsa Nature Reserve). The development of bark beetles is known to be limited by low spring and summer temperatures at higher altitudes and by the presence of different species and age-classes at stand level (Wermelinger 2004).

The lack of management activities for a longer period in Parangalitsa and Beglika Nature Reserves allowed the development of heterogeneous forest structure. At higher altitudes, such as in Beglika Reserve, the heterogeneous structure resulted from the very slow regeneration and development of the forest in small groups. The gap disturbances further increased the vertical and horizontal heterogeneity of the spruce forests, which is considered as a critical factor for their resilience to disturbances (Brang et al. 2006). In Parangalitsa Reserve, medium- to large-scale disturbances formed a complex forest structure of patches at different ages and size.

The disturbance regime of the studied spruce forests had a different influence on their regeneration. In the forests disturbed by wind or bark beetle outbreaks, the Norway spruce and the rowan had the highest regeneration numbers, whereas the recovery of the burned-over area in the Bistrishko branishte Reserve was dominated by pioneer species. Particularly in the larger disturbed areas and at higher altitudes, the regeneration was slow, and dependent on specific microhabitats such as coarse woody debris and windthrow mounds, as also observed in Central Europe by Jehl (2001), Jonášová et al. (2010), and Wohlgemuth et al. (2002). In Parangalitsa and Beglika Reserves the lying decayed deadwood had key importance for the regeneration of spruce in the subalpine zone. This microhabitat is particularly suitable for the establishment of Norway spruce because it is free of grassy vegetation and rich in nutrients (Kuuluvainen and Kalmari 2003; Zielonka 2006). In Bistrishko branishte Reserve, however, the lack of intensive self-thinning processes before the natural disturbances has resulted in the absence of sufficient amounts of decayed deadwood. Until now the fallen logs resulting from the windthrow in 2001 and the subsequent bark beetle outbreak served only as a shelter for the young saplings established next to the logs, but in analogy with the data from the regeneration in older disturbed areas in Parangalitsa reserve (Tsvetanov et al. 2014), we expect that they will be quite important for a future second regeneration wave after 30–40 years.

5.5 Conclusion

We found that small- and large scale disturbances such as windthrows, bark beetle outbreaks, and to a smaller extent fires are part of the natural dynamics of subalpine spruce forests in Southeastern Europe. Their resilience to disturbances is mainly dependent on the availability of structural elements that often are missing in the managed forests, such as heterogeneous forest structure and spatial patterns, as well as specific regeneration substrates such as deadwood or windthrow mounds. After both small- and large-scale disturbances, the studied non-intervention forests were recovering in a way that allowed Norway spruce to regain its dominance, while pioneer species had a limited role except in the burned areas. Thus, we recommend that the sustainable management of subalpine spruce forests is focused on long-term regeneration silvicultural systems which allow permanent forest cover and heterogeneous forest structure. In particular, the silvicultural measures should be planned in a way that helps preserve and, where needed, restore the structural elements which are characteristic for the natural spruce forests: natural regeneration, multi-age structure, heterogeneous horizontal structure, appropriate species composition, and sufficient amounts of standing and lying deadwood.

Acknowledgments This research was carried in the framework of projects DMU 02/22/2009 funded by the National Science Fund of Bulgaria and project IZEBZO143109 of the Swiss Enlargement Contribution funded by the Bulgarian-Swiss Research Programme.

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Chapter 6
Technical Climate Change Adaptation Options of the Major Ski Resorts in Bulgaria

Osman Cenk Demiroglu, Mustafa Tufan Turp, Tugba Ozturk, Nazan An, and Mehmet Levent Kurnaz

Abstract Climate change has been and increasingly will be a major threat to the ski tourism industry, whose survival is highly dependent on the existence of snow cover of sufficient depth and duration. For this matter, it is even now more usual for the ski resorts to adapt to this issue by various measures at the technical, operational, and political levels. Technically speaking, snowmaking has become the method most used throughout the industry to combat the immediate impacts of climate change, while moving the ski areas to higher terrains has been standing out as an another option, wherever available and feasible. In this study, the aim is to project the future climatic changes in snowmaking capacity; in other words, technical snow reliability, and the moving requirements, if any, of the four major ski resorts in Bulgaria for the period of 2016–2030 with respect to the control period of 1991–2005. For this purpose, the past and the future climatic conditions for the technical snow reliability of the ski resorts and their immediate surroundings are determined by the temperature and the relative humidity values generated and projected through the Regional Climate Model RegCM 4.4 of the Abdus Salam International Centre for Theoretical Physics (ICTP) by scaling the global climate model MPI-ESM-MR of Max Planck Institute for Meteorology down to a resolution of 10 km. The model is further processed according to the recent RCP 4.5 and RCP 8.5 concentration scenarios of the IPCC. The model outputs on air temperature and relative humidity are utilized for determination of wet-bulb temperatures through psychographic conversions that ultimately provide us with thresholds for snowmaking limits.

O.C. Demiroglu (✉)
School of Tourism and Hospitality, Istanbul Bilgi University, 34060, Istanbul, Turkey
e-mail: cenk.demiroglu@bilgi.edu.tr

M.T. Turp • N. An
Institute of Environmental Sciences, Bogazici University, 34342 Bebek, Istanbul, Turkey
e-mail: tufan.turp@boun.edu.tr; nazanan@gmail.com

T. Ozturk
Department of Physics, Isik University, 34980 Sile, Istanbul, Turkey
e-mail: tozturk@isikun.edu.tr

M.L. Kurnaz
Department of Physics, Bogazici University, 34342 Bebek, Istanbul, Turkey
e-mail: levent.kurnaz@boun.edu.tr

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_6

Findings display the temporal changes in the snowmaking hours of the ski resorts at various altitudinal levels calculated according to the environmental lapse rates. Such displays can guide the practitioners in considering investment lives and moving the ski resorts according to optimistic and pessimistic projections.

Keywords Climate change • Climate modeling • Snowmaking • Ski area extension/expansion • Bulgaria

6.1 Introduction

The magnitude of the contemporary climate change phenomenon is growing at an ever-increasing rate, following a global warming trend caused by increasing anthropogenic greenhouse gas concentrations. According to the most recent report of the Intergovernmental Panel on Climate Change (IPCC 2013), a global air temperature rise of 0.85 °C has been recorded during the post-industrial era of 1880–2012. Such change has triggered other alterations within the ecosystems, making the cryosphere one of the most vulnerable layers of the Earth against climate change. A glacial mass worth 275 Gt per year has been lost just during 1993–2012, accompanied by a contraction of the Northern Hemisphere spring snow cover extent by 1.7 million km^2 during the period 1967–2012. Depending on the forthcoming amounts of greenhouse gas, mainly carbon dioxide concentrations, a further increase in air temperature by 0.3–4.8 °C is projected for the future. Ultimately, such changes will continue having their impact on glacier masses and snow cover with many direct consequences for the snow sports tourism industry.

Owing to its relatively high vulnerability against climate change, snow sports tourism has been coined as "the most directly and the most immediately affected" tourism type as "the first and the most studied aspect" studied within a "geographically and methodologically diverse literature" (Scott et al. 2012, pp. 201–202). The diversity of such literature was recently studied by Demiroglu et al. (2013) based on the geobibliographical map, www.skiklima.com (Demiroglu 2011). It was found that there were around 126 peer-reviewed articles published since the 1980s but mainly concentrated within the past decade. A quarter of these articles were categorized as social science papers ($n=30$) on the behavioral and economic issues of the subject, whereas the rest were equally distributed into physical science ($n=48$) and interdisciplinary papers ($n=48$). Thus, the presence of a physical component was evident in as many as 96 papers. Moreover, the solely social science papers also mostly had to base their departure on physical analyses that had studied their snow tourism supply domain. Therefore, it is apparent that the physical component is a vital initial phase of vulnerability analyses.

Despite the fairly distributed multidisciplinarity of the climate change and snow sports tourism research, a similar situation could not be pronounced for the spatial foci, such that 91 of the 126 papers have been concerned only with the Alpine and the North American countries while the few remaining papers have discussed another 72 countries (Demiroglu 2011) involved with snow sports supply. Of these few papers distant to Alpino- and Amero-centrism, only 7 articles studied East European countries, such as Slovakia (Holko and Kostzka 2007; Demiroglu et al. 2015), Croatia (Gajic-Capka 2011), and Romania (Micu 2009, Surugiu et al. 2010, 2011), in a physical or interdisciplinary manner.

Bulgaria, on the other hand, has been the one last East European country to be studied for its snow sports tourism vulnerability to climate change. Within the framework of the CLAVIER (Climate Change and Variability: Impact on Central and Eastern Europe) Project (Mochurova and Mishev 2008) and through an interdisciplinary attempt that combines qualitative, econometric, and climatological methods, Mochurova et al. (2010) figured out that one of the major ski resorts in Bulgaria is not to be deprived of its natural snow reliability until 2020, but would suffer more during the 2020–2050 period because of the likely increasing frequency of snow-deficient winters and their consequent negative effects on tourist travel decisions. Such change will pose more threats to the small accommodation establishments that offer limited services, such as bed and breakfast only, whereas larger hotels with qualified staff, flexible marketing abilities, and the capacity to offer diverse tourist products, such as meetings, spas, and non-snow sports, are assessed to be more resilient against long-term climate change, given the proven acceptance and satisfaction of the tourists to such alternatives (State Agency of Tourism 2008, in Mochurova et al. 2010). Moreover, as further recommended by Mochurova et al. (2010, p. 123), "operator of the ski facilities should invest in snow-making facilities" and plan for extension into not the lower but the highest altitudes to build technical adaptive capacities besides the operational remedies. Similarly, another Bulgarian major ski resort has recently adopted snowmaking technology to its fullest with heavy investments in 161 cannons that can cover 70 % of the ski areas with snow (Andreeva 2008), whereas the case resort of Mochurova et al. (2010) has also invested in 150 snow cannons for the 2014–2015 season (Borosport Bilgi 2015), and another one lost no time and equipped its ski areas with 126 cannons (Hamzaoğlu 2015).

This study considers the extent to which the ski resorts can utilize technical options for adaptation to climate change such as snowmaking and related terrain extension. The scope is the four major resorts in Bulgaria, whose climatological and physiographic thresholds are assessed toward an understanding of their total vulnerabilities with regard to their latent adaptive capacities. The selected ski resorts are the top four in Bulgaria in terms of their lift capacity and the number and the length of ski runs. Two of them are situated in the "depopulated regions" and a third one lies on the mountains of a "rural service region" as defined by the EU FP6 Project CLAVIER (CLAVIER Project Team 2009). These locations signify the relative socioeconomic importance of the sustainability of these resorts for the sake of reducing vulnerability on a regional scale. The fourth resort, on the other hand, may not be perceived as a resort town fostering regional development, but rather an important suburban asset that caters to the immediate recreation market based in the capital, Sofia.

6.2 Data and Methods

Natural snow reliability analyses have been a central way to climate change impact assessment methodology for snow sports tourism (e.g., Abegg et al. 2007), being mostly based on the so-called 100-days rule that states, for a ski resort to be viable, at least 100 days of snow cover with a minimum depth of 30 cm in 7 of 10 winters (Witmer 1986) is needed. Yet with the acknowledgment of snowmaking for the sake of climate change adaptation, as well as competitiveness (Steiger and Mayer 2008), technical snow reliability analyses, in other words; snowmaking projections, have also been increasingly carried out by various researchers for different snow sports tourism destinations in North America (Scott et al. 2003; Bark et al. 2010), Europe (Steiger and Mayer 2008; Steiger 2010; Pons-Pons et al. 2012; Schmidt et al. 2012), and Asia-Pacific (Hennessy et al. 2008; Heo and Lee 2008; Pickering and Buckley 2010; Hendrikx and Hreinsson 2012).

The major methodology incorporated here is based on the recent work applied to ski resorts in Turkey and Norway (Ozturk et al. 2014a, b). It has two essential parts: climate modeling and psychrometric calculations. Compared to previous work, the methodology was improved for this analysis in terms of spatiotemporal resolution, such that the space has been downscaled to 10 km, compared to the previous 50 km, the temporal outputs have been defined by hours instead of days, and a seasonal distinction has been made in terms of artificially made snow quality, ensuring a sound base layer formation in the early season.

In the modeling part of the study, the regional climate model RegCM 4.4 was employed, which is a hydrostatic regional climate model developed by the Abdus Salam International Centre for Theoretical Physics (ICTP). The dynamic structure of RegCM 4.4 consists of the hydrostatic version of the model MM5 (the mesoscale model) (Grell et al. 1994) of the National Center for Atmospheric Research (NCAR) of Pennsylvania State University. The BATS1E (Biosphere-Atmosphere Transfer Scheme) (Dickinson et al. 1993) model is used for the processes concerning surface and, similarly, the Community Land Model (CLM) version 3.5 is also in the dynamic structure of the code as an option. Radiative transfer was modeled using the NCAR Community Climate Model, version CCM3 (Kiehl et al. 1996), a radiation pocket in the RegCM regional climate model. Solar radiation transfer was modeled using the δ-Eddington (Kiehl et al. 1996) approach. Three parameters including the amount of cloud cover, liquid water content of the cloud, and effective droplet radius were used in the cloud radiation part of the model. The planetary boundary layer (PBL) scheme based on the concept of non-local diffusion developed by Holtslag (Holtslag et al. 1990) has been used in the model. The convective rainfall system of the model is calculated by choosing one of the three schemes including the modified Kuo scheme (Anthes 1977), Grell scheme (Grell 1993), and MIT-Emanuel scheme

(Emanuel 1991; Emanuel and Zivkovic-Rothman 1999). This regional climate model system has been effectively used in climate change studies for the past 10 years.

In the scope of the study, the changes in air temperature (T) and relative humidity (RH) for the relevant ski resorts were examined. In this context, 3-hourly values of these two parameters within the related time period were analyzed. Therefore, first, the MPI-ESM-MR (Taylor et al. 2012) global climate model of the Max Planck Institute for Meteorology was dynamically downscaled to 50 km for the ski resort regions via RegCM 4.4. Second, the RegCM 4.4 was driven at a 10-km resolution by applying the double-nested method to the outputs of 50-km resolution simulations. In this step of the modeling, the first-run outputs, with 50-km resolution, were employed as forcing data to RegCM 4.4. In other words, to represent the ski resort area climatology more accurately, the RegCM 4.4 was once again run with the previous model outputs, and thus all the regions were dynamically downscaled to 10-km resolution. RCP 4.5 (the mid-range greenhouse gas concentration scenario) and RCP8.5 (the high greenhouse gas concentration scenario) (van Vuuren et al. 2011) outputs of the global models were used for future model forecasts, as the researchers do not expect that the highly optimistic scenario (RCP 2.6) could be realized in the future.

For the second phase of analysis, three sets of outputs resulting from one historical projection (1991–2005) and two future (2016–2030) concentration scenarios (RCP4.5 and RCP 8.5) on the 3-hourly temperature (T) and relative humidity (RH) variables for the various altitudes (bottom, top, higher) of the four ski resorts have been utilized for psychrometric calculations regarding snowmaking capacity and extension needs. Following lapse rate corrections on the temperature variable according to model physiography (topo) at a universal value of 0.5 °C/hm, 3-hourly wet-bulb temperature (T_w) values have been derived according to the formula developed by Stull (2011):

$$\begin{aligned} T_w &= T[\operatorname{atan}(0.151977(RH + 8.313659)^{1/2})] + \operatorname{atan}(T + RH) - \operatorname{atan}(RH - 1.676331) \\ &\quad + [0.00391838(RH)^{3/2}][\operatorname{atan}(0.023101RH)] - 4.686035 \end{aligned} \tag{6.1}$$

As a final step of the analysis, the critical wet-bulb temperatures are used as indicators of snowmaking thresholds, because a wet-bulb temperature below −7 °C implies the possibility of good-quality snowmaking, which is especially needed for the base layer formation in the early season during November and December, whereas a value between −7 °C and −4 °C signals the ability of wetter but somewhat sufficient snow for additional snowmaking for the latter part of the season (Pröbstl 2006; Steiger and Mayer 2008; Demiroglu et al. 2015). Thus, the past and the future snowmaking capacities of the major Bulgarian ski resorts can be identified in hours by a count of sufficiently cold wet-bulb temperatures for various ski area altitudes, including those unexploited higher terrains, if any.

6.3 Research Findings

The total snowmaking capacities (Fig. 6.1) of the ski resorts, where and when T_w is below the −4 °C threshold, are predicted to have only very slight decreases in production, concerning both scenarios at all elevations examined. An interesting result here is that the relatively more pessimistic RCP 8.5 can even outperform the RCP 4.5 scenario in terms of snow production, especially at ski resorts 1 and 4. This situation becomes even more visible when looking at the higher-quality snowmaking projections (Fig. 6.2), where and when T_w is below the −7 °C threshold. Nonetheless, the overall production in all qualities does not seem to be under much threat until the end of the 2020s. Therefore, higher terrain extension plans in response to climate change concerns could hold for the next two decades, at least with respect to technical, if not the natural, snow reliability.

A third main result of the study refers to the change in the amount of high-quality snow production in the early season, which is crucial for the initial base layer formation that triggers the winter tourism season start. To evaluate such capacity, the results of quality snowmaking (Fig. 6.2) were filtered for the months of November and December, which are the vital times for preparing the resorts for the visitation peaks during Christmas and New Year's holidays. Because the model runs lack December 2005 and November–December 2030, November 2005 was also omitted,

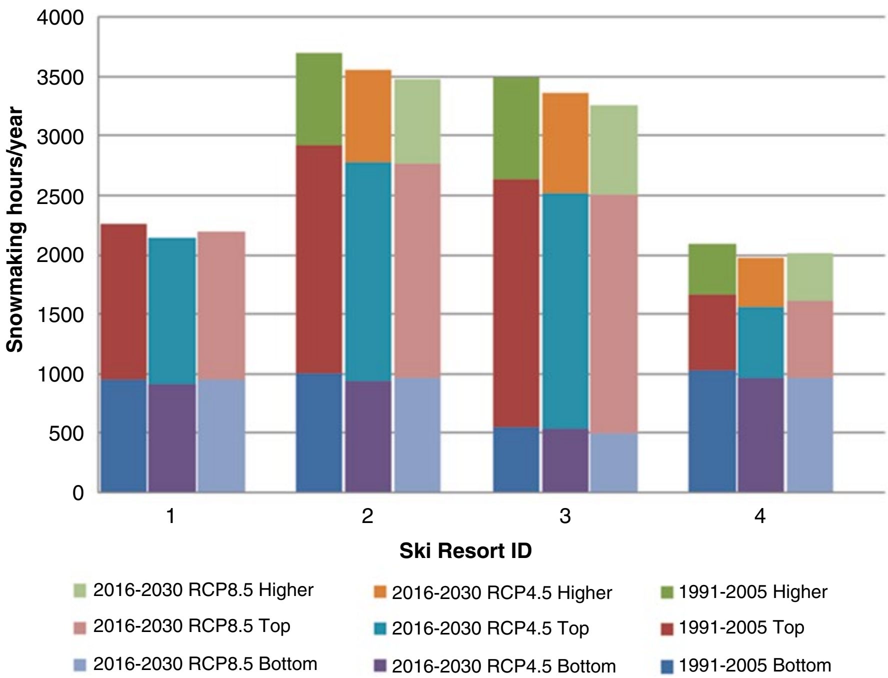

Fig. 6.1 Change in total snowmaking capacities

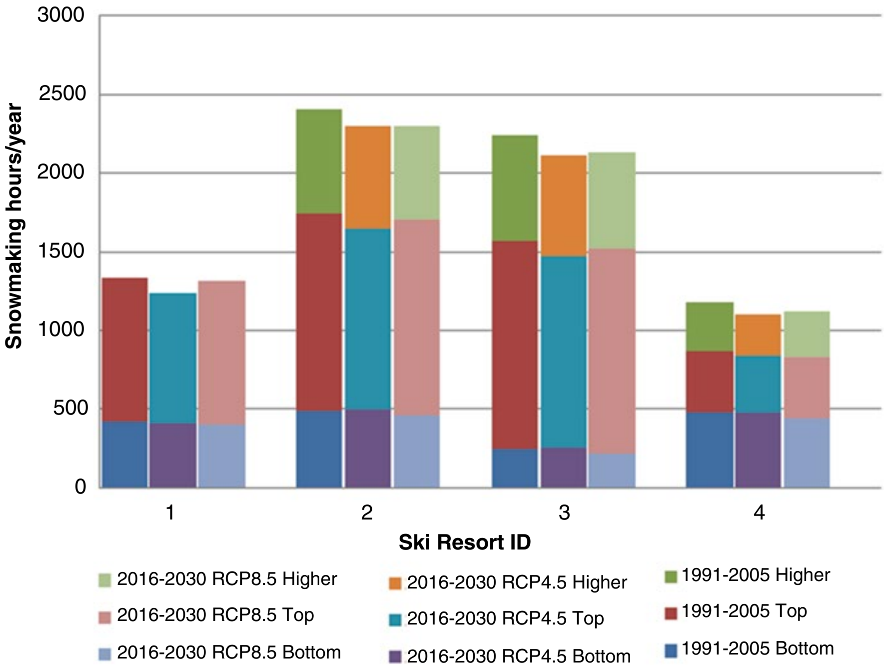

Fig. 6.2 Change in quality snowmaking capacities

and annual hourly capacity calculations were based on 14-year periods (Fig. 6.3). An interesting result here is the near-term cooling of the pre- and early ski season. However, even such cooling will not be enough to provide base layer assurance at the bottom, but the top stations of all four ski resorts as average snowmaking systems are only able to produce 20 cm of deep, groomed snow in 120 h (Steiger 2007). Such a disadvantage will hold true for the whole ski area of ski resort 4 despite the anticipated cooling effect projected for both future scenarios RCP 4.5 and RCP 8.5. Therefore, an extension of snowmaking facilities to higher terrains could be suggested here, considering the RCP 4.5 scenario.

6.4 Discussion

Results show that snowmaking could be utilized as a technical adaptation tool for the climatic survival of major Bulgarian ski resorts, without a general need to extend resorts into higher terrains, in the mid-run, where an increase in the frequency of winters lacking snow was previously anticipated (Mochurova et al. 2010). However, it should be noted that such adaptation would come with its limits and consequences, because the amount of water consumption and the financial costs of investment and operations could unbalance the feasibility of such implementation (Rixen et al. 2011). Moreover, as a major energy consumer, snowmaking technologies could also

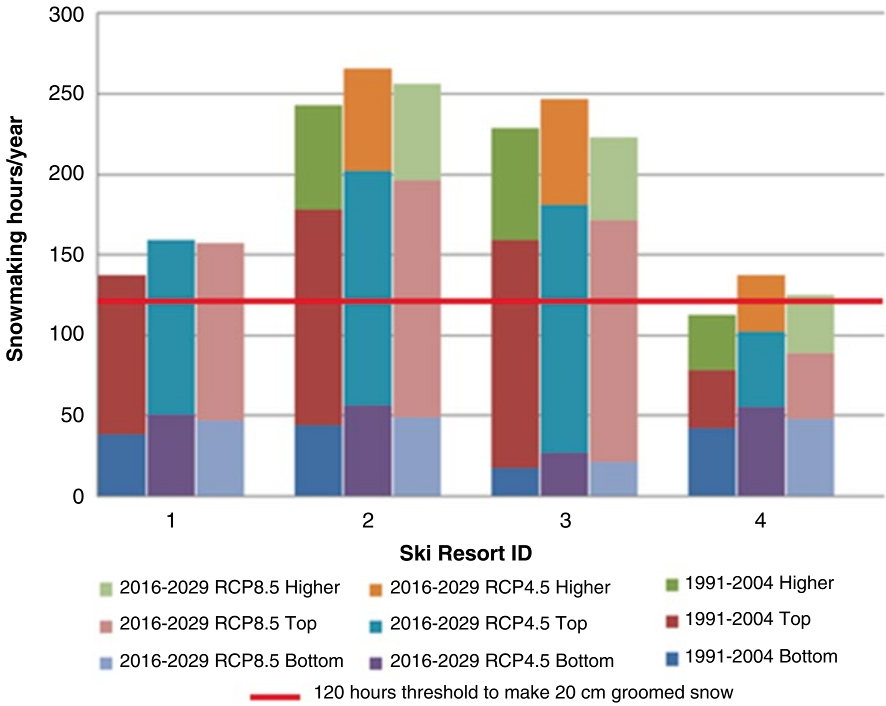

Fig. 6.3 Change in base layer snowmaking

become a major source of greenhouse gas emissions resulting from the tourism industry, posing a paradox over their own raison d'être.

The findings for the technical snow reliability of major ski resorts in Bulgaria could be compared with those in Turkey (Ozturk et al. 2014a) and Norway (Ozturk et al. 2014b). Both cases examined either the largest (by number of lifts) or the most popular (by visitation) ski resorts of these two countries in terms of their quality snowmaking capacities according to the RCP 4.5 pathway. The Norwegian case was analyzed for the period 2016–2040 and the Turkish case for 2015–2025. These periodic differences would imply an advantage for the Turkish case, and a disadvantage for the Norwegian, because mean values obtained from earlier future period outputs would indicate fewer changes as they would be subject to less warming, and vice versa. However, the Turkish case, despite such methodological advantage, has been proven to suffer from a loss of snowmaking days down to none at its bottom station (1780 m a.s.l.) and only six at its ski area summit (2150 m a.s.l.) from an observed reference of 30 and 44 days during the 1970–2010 period. The Norwegian case, on the other hand, is projected to lose only 11 and 21 days of snowmaking at its bottom and top stations, respectively, thereby still maintaining 33 and 69 days with respect to the modeled historical period of 1981–2005. The Bulgarian resorts display quality snowmaking days, converted from hours (Fig. 6.2), of 17–51, 21–69, 11–61, and 20–35 for the bottom and top stations of the ski areas 1, 2, 3, and 4, respectively, during the 2016–2030 period and under the RCP 4.5 scenario. Thus, it can be implied that the Bulgarian resorts are, technically, almost as snow reliable as the Norwegian resort, and much more advantageous than their regional Turkish competitor. Yet it should also be noted that moving the Turkish resort to its adjacent higher terrain would restore its future snowmaking days to a maximum of 51.

Finally, the reason why RCP 8.5 has sometimes outperformed RCP4.5 in terms of snowmaking capacity for some ski areas should be clarified, being because both concentration pathways are almost convergent for the study projection period of 2016–2030 (Fig. 6.4). Although a slight divergence is observed for RCP8.5 in terms of an increase in radiative forcing in the latter part of the projection period, such change may not have been reflected in an increasing temperature in such a short term because of response lags (Wetherald et al. 2001).

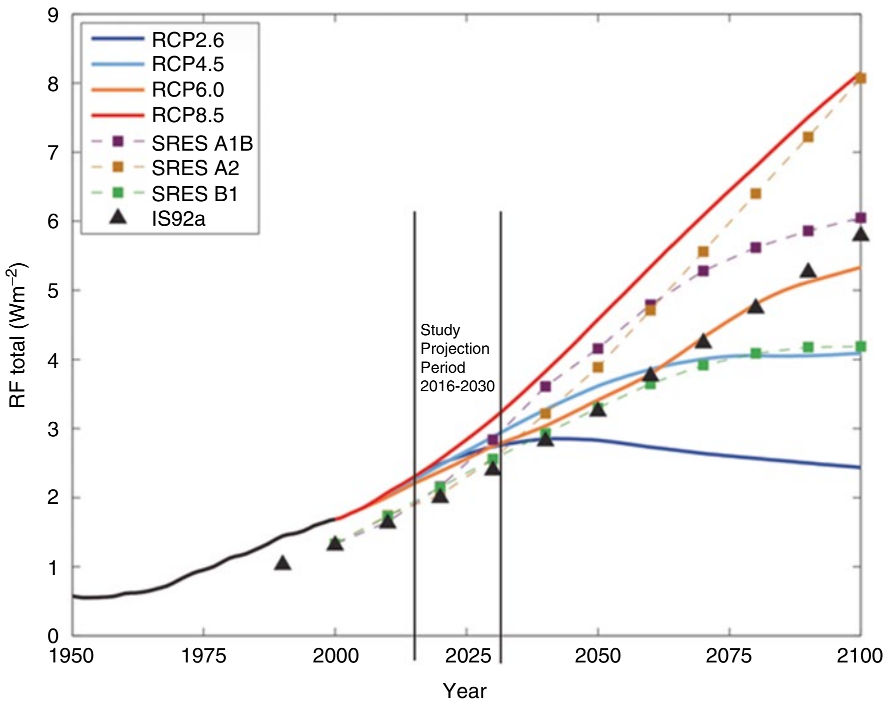

Fig. 6.4 Study projection period within the greenhouse gas emission and concentration scenarios (Adapted from IPCC 2013, p. 146)

6.5 Conclusions

This study was part of an umbrella research on the climate change-related vulnerability of snow sports tourism in the Balkans, the Middle East, and the Caucasus. The results showed that the major ski resorts in Bulgaria could make use of snowmaking at its fullest, except at the bottom stations in the early season, at least for the next 15 years. Further research on technical as well as natural snow reliability is needed to understand if such advantage could be utilized within regional competition. Moreover, such efforts should also take later future periods into consideration, if not only financial feasibility, which is almost dependent on just investment life, but also economic, social, and environmental sustainability would be the ultimate goal of development policies.

Acknowledgements This study was supported by the Istanbul Policy Center – Sabancı University – Stiftung Mercator Initiative under the Mercator-IPC Fellowship Program.

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Chapter 7
Hydric Significance of Landscape in a Mountain River Basin

Barbora Šatalová

Abstract The aim of this contribution is to determine the hydric significance of the mountain river basin of Poprad, with focus on its land use, and to estimate the impact of the current landscape structure on the hydric functions. To follow this aim, attributes such as geomorphological, hydrogeological, soil, and climatic conditions, current landscape structure, and the ecological status of the forest were analyzed and evaluated. These attributes have particular range and weight. After an analysis, the hydric significance of the study area was determined and subsequently classified into four categories. Also, hydric significance was determined on the level of river sub-basins. The following categories of hydric significance were set: excellent, good, average, and limited; these express the ability of the landscape to retain water. Such knowledge, hand in hand with optimal management, can contribute to the prevention of floods in the study area.

Keywords River basin • Hydric functions • Hydric significance

7.1 Introduction

The landscape water regime is affected qualitatively and quantitatively by factors including watercourse modifications, hydro-melioration, drainage and irrigation systems, soil and forest management, urban rainwater management, drinking water requirements, and wastewater treatment. Currently, the views on water functions in landscape are changing to some extent. The previously considered appropriate management encouraging the most rapid water runoff has been replaced by the principle of water retention in areas where it causes no harm, and with slow and gradual subsurface drainage preceding surface runoff (Kovář 2008). Hydric functions represent the landscape's ability to slow down and retain precipitation and promote

B. Šatalová (✉)
Institute of Landscape Ecology, Slovak Academy of Sciences,
Štefánikova 3, 81499 Bratislava, Slovakia
e-mail: barbora.satalova@savba.sk

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_7

infiltration. This function depicts the overall drainage impact on the landscape in aligning runoff extremes and reducing flood flows (Lepeška 2010). Here, rainfall-runoff models highlight water accumulation, retention, and infiltration. Landscape attributes determining hydric function include geologic (especially hydrogeological), soil, climatic, and geomorphological conditions, type of land cover (elements of the landscape structure), and the conditions of land use. This chapter determines the hydric significance of the basin of the mountain river of Poprad based on its land use and the impact of the current landscape structure on hydric function.

7.2 Data and Methods

The study is based on integrated landscape management (Izakovičová et al. 2006) and methodology to determine landscape hydric functions (Lepeška 2010). These procedures are derived from Landscape Ecological Planning (LANDEP) (Ružička and Miklós 1982), which can be used at different processing levels and for different goals. Although its procedure is fixed, logical individual steps are adequately flexible to accommodate different study objectives, scale, and area characteristics.

The methodology herein is based on the geosystem approach of (1) analyzing study area resources, (2) evaluating landscape properties and its hydric functions, (3) evaluating landscape structure, and (4) classifying the study area.

Determination of hydric functions of the landscape includes analysis of the river basin attributes, which affect the water flow in the study area. Hydric characteristics (functions) of landscape present the ability of the landscape to retain precipitation, slow runoff, and promote its infiltration into the lower layers (retention, infiltration, accumulation). The following factors were determined (Lepeška 2010):

- Geomorphological conditions: slope inclination
- Hydrogeological characteristics: transmissivity
- Soil conditions: soil subtypes and soil texture
- Meteorological conditions: rainfall, potential evapotranspiration
- Land cover characteristics: the current landscape structure
- Forest character: degree of threat to forests

Data processing of individual river basin characteristics was by the ArcGIS 10.0 program in 10×10 m grids. Input data were analyzed in further steps according to the modified methods of evaluation of hydric functions of the landscape (Lepeška 2010). Attributes were given points and then were weighted.

7.2.1 Scoring River Basin Attributes

Slope (S) Determines rainfall retention and infiltration intensity, where more rapid surface runoff and decreased infiltration occur on steeper slopes. Factor range was divided according to Midriak (1988), based on the curved surface runoff from the slope, into five categories with point values:

- $S < 7.0°$ +2
- $S = 7.1 - 18.0°$ +1
- $S = 18.1 - 31.0°$ 0
- $S = 31.1 - 50.0°$ −1
- $S = 50.1°$ −2

These categories indicate that there is no surface runoff for a slope inclination of 7° and less, and water infiltrates the soil. Slopes with 7° to 18° inclination have linear increase in surface runoff, and runoff rapidly increases from 31°, so that infiltrated precipitation approaches zero at 50°.

Transmissivity (T) Expresses flow capacity coefficient in $m^2\ s^{-1}$. In terms of bedrock transmissivity there are three categories in the study area within the classification of Krásny (1986), with higher values expressing better transmissivity:

- $T = \text{high} = 1.10^{-3} - 1.10^{-2}$ +1
- $T = \text{medium} = 1.10^{-4} - 1.10^{-3}$ 0
- $T = \text{low} = 1.10^{-5} - 1.10^{-4}$ −1

Soil Subtypes (SS) Classified into the three categories based on the degree of waterlogging (Bedrna 2002). Depends on soil organic matter content and granularity. The area contained these soils:

– Strong: Gleyic Fluvisol, Gleyic Mollic Fluvisol, Histic Gleyic Mollic Fluvisol, Stagnic Cambisol, Haplic Planosol, Histic Gleysol, Haplic Gleysol, Histosol (Dystric)
– Medium: Haplic Fluvisol, Cambic Rendzic Leptosol, Histic Rendzic Leptosol, Rendzic Leptosol (Skeletic), Cambisol (Calcaric) Stagnic, Rendzic, Rendzic Leptosol, Mollic Fluvisol, Haplic Cambisol, Cambisol (Calcaric), Leptic Luvisol
– Weak: Lithic Leptosol, Cambic Leptosol (Skeletic), Leptic Podzol (Skeletic), Haplic Leptosol (Skeletic), Rendzic Lithic Leptosol (Skeletic), Entic Podzol, Albic Podzol

The given values are as follows:

- SS = strong +1
- SS = medium 0
- SS = weak −1

Soil Texture (ST) Determines water infiltration rate to the soil. As a measure of water infiltration into the soil, the coefficient of infiltration is used. Šály (1988) reports that the coefficient decreases from coarse-textured (light) to fine-textured (heavy) soils. Water infiltrates more easily through sandy soils than clays, because highly grained soils have a larger active surface and therefore better sorption properties. This concept is confirmed by the measurements by Kutílek and Nielsen (1994) determining the minimum infiltration rate to previously saturated soils.

Lepeška's (2010) eight soil texture categories are modified by the soil-textural-triangle method. Here, lighter soils promote better infiltration:

- ST = loamy sand +2
- ST = sandy loam +1.5
- ST = loam +1
- ST = silt loam +0.5
- ST = silt 0
- ST = sandy clay loam −0.5
- ST = clay loam −1
- ST = silty clay loam −1.5

Although clay soils have high retention capacity, slow water infiltration rates induce surface runoff. These soils are also more susceptible to compaction, and this reduces their retention capacity. Houšková (2013) reports that soil compaction susceptibility increases in the following order: sand and loamy-sand, sandy-loam, loam, clay-loam, and then loam soils.

Retained Precipitation (RP) Calculated by rainfall minus evapotranspiration, and potential values are examined herein. The average rainfall in the 1981–2010 observation period ranged from 626 to 1503 mm (SHMI 2013), subdivided into the following intervals: 626–800, 800–1000, 1000–1200, and 1200–1503 mm. This designation is based on lower annual rainfall values proposed for individual climatic-geographic subtypes (Kočický and Ivanič 2011). Potential evapotranspiration is from 400 to 600 mm (Hrvoľ et al. 2011). After deducting this from rainfall, the potentially retained precipitation is 51–993 mm; this was divided into the five intervals below, reclassified after deducting minimum and maximum potential evapotranspiration from rainfall thresholds. The retained precipitation values are positive because rainfall exceeded evapotranspiration:

- RP = over 800 mm +2.5
- RP = 600.1–800 mm +2
- RP = 400.1–600 mm +1.5
- RP = 200.1–400 mm +1
- RP = below 200 mm +0.5

Current Landscape Structure (CLS) Reflects human impact and determines water retention ability. The Petrovič et al. landscape classification (2009) eventuated from mapping six groups and the following 19 elements: (1) coniferous forests, (2) deciduous forests, (3) mixed forests, (4) transitional woodland shrubs, (5) non-forest woody vegetation, (6) dwarf mountain pine stands, (7) meadows and pastures, (8) arable land, (9) gardens and permanent crops, (10) rock formations, (11) debris, (12) mining and destroyed areas, (13) watercourses, (14) backwaters, (15) built-up areas, (16) urban vegetation, (17) sports and recreational areas, (18) manufacturing and technical areas, and (19) roads, railways, and transport areas.

Five positive and three negative water retention classes are listed (Lepeška 2010): (Element 13; watercourses and element 14; backwaters are not evaluated; these carry zero points.)

- CLS = element 1, 2, 3, 6 +3
- CLS = element 4 +2.5
- CLS = element 7 +2
- CLS = element 5, 11 +1.5
- CLS = element 9, 16 +1
- CLS = element 8 −1
- CLS = element 12 −2
- CLS = element 10, 15, 17, 18, 19 −3

Degree of Threat to Forests (DTF) Expresses the projected threats to forest stands from internal and external forces during a 10-year period. This threat is evaluated on the international 0–4 scale (Bavlšík 2008). The study area includes all degree of threat classes. Higher-degree values define lower ecological stability. Forest vegetation was given the following values:

- DTF = 0 non endangered forest +2
- DTF = 1 slightly endangered forest +1
- DTF = 2 moderately endangered forest 0
- DTF = 3 strongly endangered forest −1
- DTF = 4 very strongly endangered forest −2

7.2.2 Weighting River Basin Attributes

Attribute scoring classifies the properties of an area, wherein individual attributes are evaluated in relationship to rainfall retention and infiltration, expressed as positive or negative values, and weighted according to hydric function significance.

Herein, attributes are weighted in paired comparison of individual attribute importance and expressed by simplified Fuller's triangle method. The more important attribute is chosen from each pair and the following values given: 1 = the characteristic is more important, and 0 = the characteristic is less important. The addition of values in a given row determines attribute significance and rank (Miklós and Špinerová 2010). The following order was assigned to attributes: rainfall–slope inclination–soil texture–soil types–landscape structure–transmissivity. Forests were assessed separately, included within current landscape structure as an element, and were given additional values on the base of their ecological stability.

Precipitation is considered the most important hydric function attribute because it determines the maximum water the landscape can retain (Lepeška 2010). *Evapotranspiration* is deducted from rainfall, and weighting factor 4 is assigned to retained precipitation. *Slope inclination* determines water movement velocity. Steeper slopes promote faster runoff and less infiltration, as confirmed by Sharma et al. (1983), Fox et al. (1997), and Koláčková et al. (2002). However, surface runoff is influenced more by rainfall intensity than by slope, so slope impact on infiltration and runoff has a 3.5 assigned *weighting factor*. Soil texture (granularity) is defined by the soil textural triangle, which has significant impact on soil water infiltration rate wherein lighter soils promote better infiltration and the rate is expressed by infiltration coefficient. The weight factor 3 is assigned to soil texture, and empirical formulas calculate the infiltration time course (Šály 1988; Šútor 1985; Kutílek and Nielsen 1994). Slope has greater weight than soil texture because steeper slopes promote less infiltration in identical soil textures (Soil Science 2012). *Soil subtypes* are evaluated by their degree of waterlogging; weighting factor is 2.5. *Current landscape structure (CLS)*: Land use attributes are related to human activities and CLS element classification. Individual human activities affect various landscape properties, for example, vegetation cover or soil density and thus its hydric functions, so weight 2 was assigned them. *Transmissivity*: The geologic environment is the last attribute having contact with infiltrated water, so transmissivity shows the lowest weight value, 1.5. *Forests* are individually classified. Because forests are already included in the current landscape structure, they were given additional value, the weighting factor 1.

7.2.3 Study Area

The study area is the basin of the mountain river of Poprad. The Poprad is in north-eastern Slovakia, formed in the Vysoké Tatry Mts. by confluence of the Hincov brook and Krupá stream. At 145 km, it is the longest Slovak river flowing into the Baltic Sea, and 31 km of its length forms the border with Poland. The Slovak Poprad river basin is approximately 1602 km^2 in area (Porubský 1991).

Figure 7.1 depicts the following basin-delimiting boundaries. The northern and a small part of the western boundary are formed by the Spišská Magura Mt ridge. The Vysoké Tatry Mts. form most of the western boundary; the Kozie chrbty Mts. forms the southern border, and the eastern boundary is formed by the Levočské vrchy hills and the Čergov Mts., and then passes through the Ľubovnianska Vrchovina highlands.

The largest portion of the river basin is at 600–800 m a.s.l., with less at 800–1200 m and much smaller areas below 600 m and above 1500 m. The western part of the study area has Tatra mountain and basin topology, whereas the eastern part maintains its highland character (MŽP SR 2011). Hydrologically, the study area is

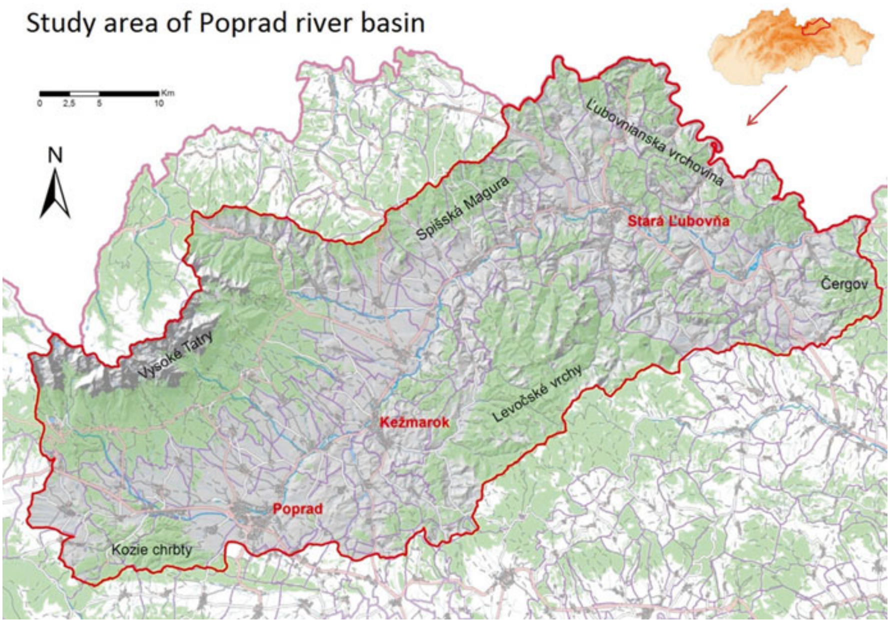

Fig. 7.1 Study area of Poprad River basin

subdivided into 225 river sub-basins, with 190 at 500–1000 m a.s.l.; 5 at 500 m a.s.l.; 22 up to 1500 m a.s.l.; and 8 above 1500 m a.s.l.

The study area has the following two climate types (Kočický and Ivanič 2011):

- Mountain climate, with small temperature inversion. It is humid to very humid with 800–2000 mm annual precipitation,
- Basin climate, with large temperature inversion. It is slightly dry to humid with 600–900 mm annual precipitation.

The typical regime of mountain watercourses also exists in the Poprad River basin; with the highest average monthly flow during the April–June spring–summer and the smallest in January–February winter (Kollár and Fekete 2002).

The study area lies in the Prešov administrative region; covering the Poprad district (21 municipalities), Kežmarok (28 municipalities + the former military district), Stará Ľubovňa (39 municipalities), and a small part of the Sabinov district (5 municipalities). These are all mountain areas under the Slovak 'disadvantaged agricultural area' classification (Vúpop 2014).

The 2011 study area population was 198,113 (Šú SR 2011). Although the northern part has weak potential for economic development as a result of the area's relief, in the Podtatranská kotlina basin and the northeast part of the river basin economic potential lies in agriculture and construction and industry and the limited settlements (MŽP SR 2011).

The current Poprad River basin land use is classified into six groups with 19 specific elements (as described in Current Landscape Structure in Sect. 7.2). Almost half the area has tree and shrub vegetation (elements 1–6; 49.11 %), then grassy-herbaceous vegetation (element 7; 23.23 %), arable land (elements 8–9; 20.05 %), settlement and built-up areas (elements 15–19; 3.86 %), uncovered raw soil and subsoil (elements 10–12, 3.30 %), and surface waters and wetlands (elements 13–14; 0.45 %).

7.3 Research Findings

7.3.1 Hydric Significance

River basin hydric significance (S_H) is calculated by $\mathbf{S_H = 3.5\ S + 1.5\ T + 2.5\ SS + 3\ ST + 4\ RP + 2\ CLS + 1\ DTF}$.

The final landscape significance related to hydric function is determined by multiplying the attribute point value by its weighting factor; this gives river basin hydric significance categories, and the hydric significance is then determined for individual sub-basins.

Here, the individual attributes were converted to 10-m grid size in ArcGIS 10.0 and determined by Raster Calculator; this produced total hydric significance ranging from −6.5 to 29 in value. These values are divided into four categories as in Lepeška (2010), where higher significance denotes higher water retention and infiltration ability.

Figure 7.2 highlights the Poprad River basin categories of "excellent to limited," which are listed and explained next:

- 1. $S_H \geq 20.5$ Excellent 4.51 % of the area
- 2. $S_H = 10.5–20$ Good 76.79 % of the area
- 3. $S_H = 0.5–10$ Average 17.65 % of the area
- 4. $S_H \leq 0$ Limited 1.05 % of the area

Excellent S_H Land with excellent S_H covers 72.23 km^2 on 7° slopes of the Tatra foothills and Podtatranská kotlina basin. It is forest and transitional woodland shrub with higher precipitation and better transmissivity, and its soil subtypes have improved soil texture and high water retention ability. There is also excellent S_H land with good water retention, but with less area, dispersed in the Belianske Tatry and Spišská Magura Mts. and in the Ľubovnianska vrchovina highlands. Most of this is on small slopes in forested areas, especially around streams in valleys; these areas have better transmissivity. Less area is situated in meadows and pastures.

Good S_H This class covers the largest portion of the model area, with 1230.29 km^2. It contains mostly forested CLS elements with good water retention; these are in

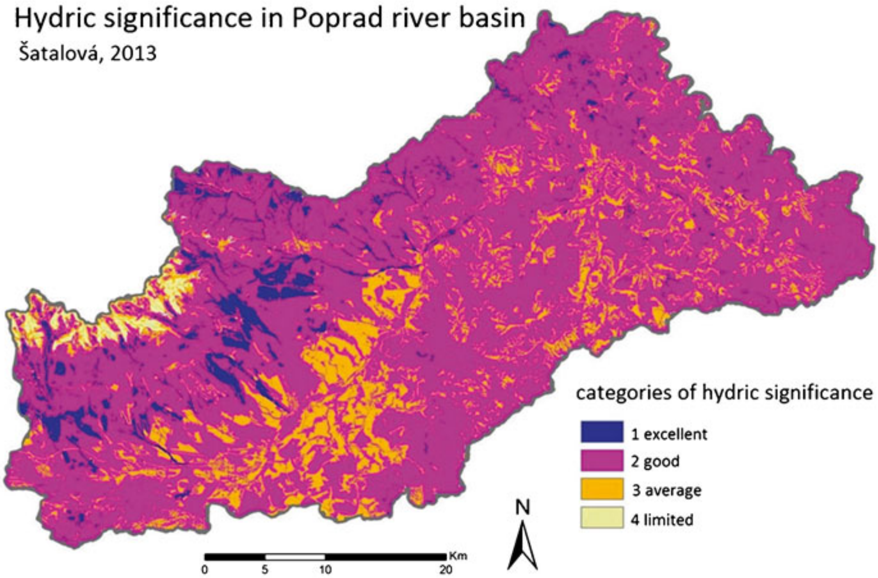

Fig. 7.2 Hydric significance in Poprad River basin

stark contrast to Tatra forests with negative ecological stability, easily leading to intensely endangered forest areas. Additional landscape elements include grasslands, non-forest woody vegetation, and transitional woodland shrubs. There is more overall precipitation in this area than in the Popradská kotlina basin and also less evapotranspiration. The slope here is up to 30° and, although it contains all soil types, lighter soils and texture prevail with medium water retention and there are fewer soil types with low retention ability. The transmissivity is medium to high, especially close to streams.

Average S_H This S_H accounts for 282.82 km^2 in the river basin; it is prevalent in the Tatras, the Podtatranská kotlina basin, and the Levočské vrchy Mts. areas, which all have similar attribute groups.

In Tatra Mountain areas, soils were not evaluated, but some areas with long or steep slopes contained debris with a positive effect on water retention and medium transmissivity. Although there are areas of arable land and urban areas with small slope, there is little water retention or infiltration through these surfaces. A significant factor is low precipitation and high evapotranspiration.

The Podtatranská kotlina basin area lies in the populated Poprad river valley with agriculture and urban infrastructure and industry. It stretches to east and southeast settlements in the Spišsko-šarišské medzihorie intermontane reaches of the Poprad and its tributaries.

The small portion of the Levočské vrchy Mts. has forest and transitional woodland shrubs on high slopes with low rainfall. The Leptosol soil here has low water retention, and the area is influenced by seriously endangered forest.

Limited S_H This classification covers only 16.9 km^2. The area is in the Vysoké Tatry and Belianske Tatry Mountain; slopes here are steep and the area is predominantly rocky with low transmissivity. Despite adequate rainfall, the combined current landscape structure (rocks) and slope have the greatest effect. A soil was not evaluated.

Zonal statistics evaluated hydric significance at the sub-basin raster level, and Fig. 7.3 highlights the 225 sub-basins divided into four categories with similar value.

- 1. Excellent S_H 26 sub-basins
- 2. Good S_H 106 sub-basins
- 3. Average S_H 78 sub-basins
- 4. Limited S_H 15 sub-basins

The first three categories show that higher rainfall and smaller slope engender better significance. The fourth class can be divided into the following two landscapes: (1) landscape with high altitude, high rainfall, high slopes and rocks, and (2) urban building, manufacture, and transport (artificial surfaces) situated at lower altitudes with less inclination and less rainfall.

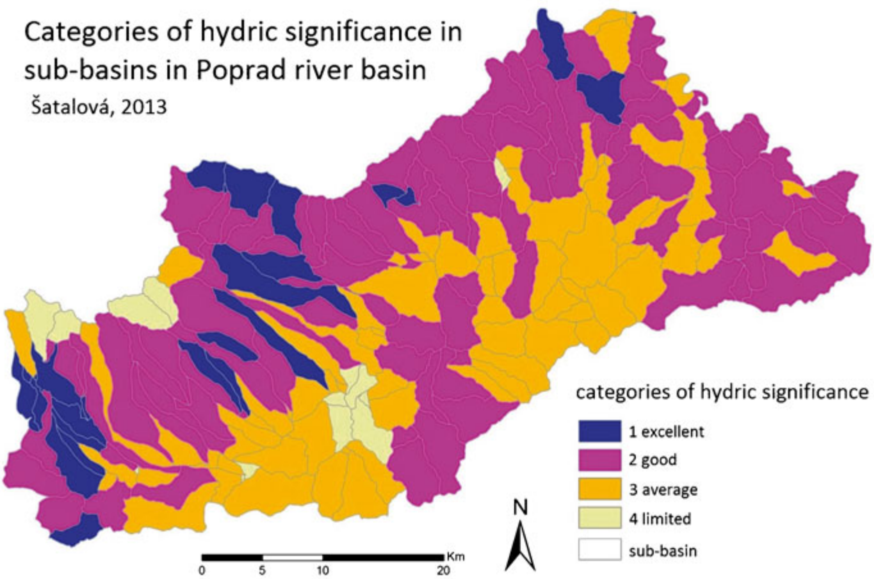

Fig. 7.3 Hydric significance in sub-basins in Poprad River basin

7.4 Discussion

Individual attributes such as slope, soil type, texture, and transmissivity affect hydric significance, and it is evident here that their combination increases complexity at both river basin and sub-basin levels.

Land use and landscape structure assessment also revealed that current landscape elements have both positive and negative roles in water retention, and that hydric significance quality conforms to land use configuration. This point is noted in landscape elements assigned to the following hydric significance categories:

1. Excellent S_H	forest, transitional woodland shrub
2. Good S_H	grassland, transitional woodland shrub, non-forest woody vegetation, forest
3. Average S_H	artificial surface, arable lands, debris
4. Limited S_H	rock formations, artificial surface

The CANOCO 4.5 ordination analyzed the influence of landscape structure on sub-basin hydric significance (Ter Braak and Šmilauer 2002). The resultant data matrix clarified the spatial conformation of all 19 landscape elements in the 225 sub-basins. Unimodal ordination was used in further analysis because gradient lengths exceeded 3 SD units (Lepš and Šmilauer 2003). Indirect gradient analysis (DCA) determined total data variability and detected the main gradients affecting sub-basin character. Only statistically significant variables at $p < 0.05$ were depicted in the ordination diagram, and sub-basins were classified with excellent, good, average, or limited hydric significance.

Figure 7.4 depicts DCA analytical determination that individual sub-basins are considerably mixed and lack element aggregation. The first ordination axis highlights anthropogenic influence. The left side of the diagram depicts natural ecosystems such as debris, rocks, and dwarf mountain pine, with results confirmed by the Tatra River basin presence in this portion of the diagram. The right side of the diagram has sub-basins with obvious anthropogenic elements, including built-up areas, transport, permanent crops, and arable land. The second axis refers mainly to the naturalness of landscape versus anthropogenic impact but also to the hydric significance. Here, the top of the diagram highlights first and second category sub-basins containing mixed deciduous and coniferous forest and grassland elements which best retain water. Below these are the third and fourth categories with less water retention ability, including mining, manufacturing, built-up, and infrastructural elements.

Furthermore, it can be concluded that the group with $S_H = 1$ lies in the middle of the diagram. It contains those elements that best retain water, including transitional woodland shrub and conifer forest. The most numerous are river basins with $S_H = 2$. These elements are more scattered in the diagram. Most are arranged along meadows and pastures, with less in the transitional woodland shrub and conifer forests. $S_H = 3$ elements are aligned close to meadows and pastures, but also in arable land,

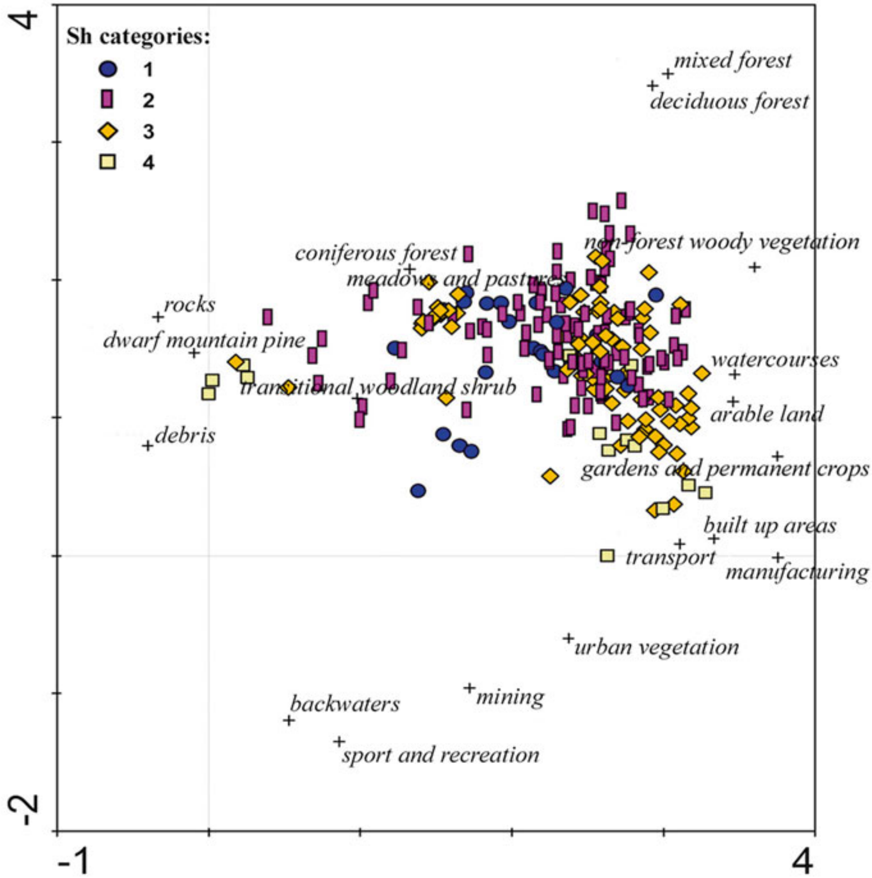

Fig. 7.4 Detrended correspondence analysis (DCA) of elements of CLS and 225 sub-basins categorized by S_H. Length of gradients: 3275 (1 axis), 2.575 (2 axes); eigenvalues: 0.502 (1 axis), 0176 (2 axes)

permanent crops, gardens, and in built-up areas with railways, roads, and other infrastructure. Group with $S_H=4$ is represented by two clusters of elements. (1) Anthropogenic artifices (including built-up areas, manufacturing and technical areas, railways, roads and infrastructure) are concentrated on the right side of the diagram, and (2) natural elements (dwarf mountain pine, rocks, debris) are on the left.

CLS has considerable effect on hydric function, but depends on several factors. Similar to all the other attributes, CLS also is affected most by rainfall: intensity, quantity. Jeníček (2007) confirmed this in his land cover impact model with runoff curve numbers (CN). Land cover's beneficial effect on runoff decreases with rainfall extremes, and river basin saturation from prior rainfall also significantly lowers runoff. Poórová et al. (2005) evaluated flooding influence on land use using the

WETSPA physical model, which determines water and energy transfer between soil and plants and the atmosphere. This model indicated that non-forested and steeper areas have very high runoff coefficients, and here we confirmed very poor and occasional zero water retention on high slopes without vegetation.

Our Poprad River basin model determined the potential ability of this landscape to retain water, but each hydric characteristic demonstrated limitation and also the propensity to react differently in altered rainfall conditions, in different seasons, and in varied soil saturation.

Hydric significance results identified the river basin weaknesses, with their potential vulnerability and increased flood risk. We include the following areas with limited and average hydric significance because they have the lowest water retention ability: (1) 15 sub-basins have limited significance; 4 of these are in rocky Tatra areas and 11 are close to towns, and (2) 78 sub-basins in the average significance category are in anthropogenic use and have increased flood risk. These sub-basins results were compared with those in the "Preliminary assessment of flood risk in the sub-basin of the Dunajec and Poprad" (MŽP SR 2011). The document identifies sections of watercourses with existing potential significant flood risk (24 sections), and also rivers with probable occurrence of potential significant flood risk (2 sections). Our categorization identifies 19 Poprad River sub-basins in hydric significance $S_H=3$ and $S_H=4$ classes, with the remaining 7 in $S_H=2$. The watercourse/municipality relationship is listed:

Watercourse	Municipality
Limited S_H	
Ľubica	Ľubica Kežmarok
Poprad	Poprad, Kežmarok, Nižné Ružbachy, Svit
Average S_H	
Poprad	Veľká Lomnica, Huncovce, Krížová Ves, Stará… Ľubovňa, Plaveč, Orlov
Holumnický potok	Jurské, Holumnica
Jakubianka	Jakubany, Nová Ľubovna, Stará Ľubovňa
Šambronka	Šambron, Plavnica
Good S_H	
Poprad	Podolínec, Chmeľnica, Mníšek nad Popradom
Holumnický potok	Ihľany
Hradlová	Kyjov, Pusté Pole

7.5 Conclusions

Excellent, good, average, and limited hydric significance categories all exist in the Poprad River basin, and our landscape mapping confirms hydric function in the river basin and sub-basin models. CANOCO assessment determined the significance of landscape structure on the river sub-basins and indicated natural and anthropogenic effects on the element of water retention ability.

Our results contribute to measures and recommendations proffered as initial steps in river basin management and flood prevention, but most importantly, they provide evidence that immediate concrete proposals are imperative to increase Poprad River basin water retention.

Much work and research confirms that the reduction of flood risk is possible by increased water retention in the landscape (Vilímek et al. 2003; Lepeška 2010; Szolgay et al. 2010) and using natural potential for retention (Langhammer and Rettichová 2011).

Acknowledgments The contribution was supported by the project APW-0866-12: Evaluation of ecosystem functions and services of the cultural landscape.

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Part III
Mountain Economies

Chapter 8
Small-Scale Mountain Tourism in Bulgaria: Development Patterns and Sustainability Implications

Vasil Marinov, Mariana Assenova, and Elka Dogramadjieva

Abstract Bulgarian mountain tourism locations show great variety in terms of their size and the facilities offered, the type and level of product and market development, as well as in the patterns of economic structures, local community involvement, and tourism impacts. This chapter presents results of a wider project dedicated to identification of tourism development models in mountain areas and related supporting policies. The research is focused on three small destinations in the Central Balkan Range and the Rhodope Mountain. The studied destinations are compared against a set of 30 characteristics united in three groups, and different patterns of local tourism development are identified based on current business practices. Their sustainability implications are discussed in terms of general development approach, policy implementation, and tourism impacts. The study results confirm the idea that two types of preconditions are needed for successful tourism development: (1) "necessary" – pull factors and (2) "sufficient" – the will to develop tourism industry through investments in accommodation and infrastructure. The latter refer not only to the entrepreneurship but also to the crucial role of local authorities.

Keywords Mountain tourism • Development patterns • Tourism policy • Sustainability

8.1 Introduction

Mountain areas of altitude above 600 m comprise 28 % of Bulgarian territory and cover wide regions in the central, western, and southern parts of the country, including the highest point on the Balkan peninsula (2925 m). The current development of mountain tourism represents a small fraction of its perceived potential as mountain

V. Marinov (✉) • M. Assenova • E. Dogramadjieva
Geography of Tourism Department, Sofia University "St. Kliment Ohridski", 15 Tzar Osvoboditel Blvd., 1504 Sofia, Bulgaria
e-mail: vasil.marinov@gmail.com; mariana.assenova@gmail.com; elidogramadjieva@gmail.com

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_8

areas generally suffer economic and demographic deterioration because of the overlapping of peripheries (Koulov 2013). Yet, tourism is usually considered among the few development alternatives available in the mountain areas and is anticipated to utilize the existing potential, to contribute to local well-being, and to balance regional disparities.

Mountain tourism in Bulgaria has already a century old tradition with periods of growth and decline. Its historical development largely reflects the socioeconomic transformations in the country: the dramatic change after World War II with nationalization and the introduction of a centralized planning system, the construction and management of big resorts, through the phase of privatization in the 1990s after the fall of socialism, and the period of transition to market economy with the boost of private initiative in tourism.

Currently mountain tourism in Bulgaria is based on a wide range of settlements and out-of-settlement complexes without a permanent population. According to the latest inventory of mountain tourist centers (Assenova et al. 2013), their total number is nearly 200, of which 77 are officially declared resorts. Most of them are villages and small towns with 500 to 10,000 dwellers at elevations between 400 and 1000 m. Out-of-settlement formations are mainly situated at a medium altitude (1100–1400 m); high mountain tourist complexes at altitudes more than 1800 m are few in number.

Bulgarian mountain tourism locations show great variety in terms of bed capacity and the facilities offered, the type and level of product, and market development, as well as in the patterns of economic structures, local community involvement, and the impacts of tourism. Different patterns of local development not only stir up academic interest but are essential for sustainable tourism planning and policy making. However, their identification is quite a challenging task as there is a widely recognized lack of both quantitative and qualitative information about mountain development at the local level (Böjrnsen Gurung et al. 2012). In Bulgaria this problem is most evident in small mountain destinations that often do not even appear in the official statistics. This chapter presents the results of study on small-scale mountain tourism in three destinations located in the Central Balkan Range and the Rhodope Mountain.

8.2 Research Scope and Methodology

The research scope and methodology are based on existing models of the system of tourism and tourism destinations (Gunn 1988; Marinov 2003; Vodenska 2004) as well as the destination life cycle and the related impacts of tourism (Butler 1980; Cooper 1997; Buhalis 2000). Another starting point of the study is the generalized model of the tourism development process (Andriotis 2000) consisting of five components: nature of development; approaches to development; implementation; and outputs and outcomes of the development process (Fig. 8.1).

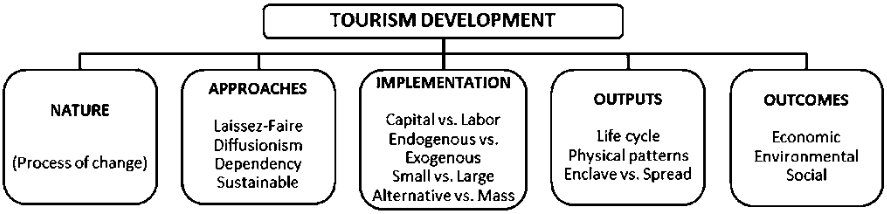

Fig. 8.1 The components of tourism development process (By Andriotis 2000)

Fig. 8.2 The three studied destinations

This research was carried out in 2013 and 2014 at three destinations representing examples of small-scale mountain tourism in Bulgaria: (1) the municipality of Apriltsi, located north of the Central Balkan Ridge; (2) the town of Kalofer and its adjacent Balkan area, within the municipality of Karlovo; and (3) the Upper Arda Valley in the Rhodope Mountain, which comprises a number of small villages in the southern part of Smolyan municipality, close to the Greek border (Fig. 8.2).

The research implemented a combined methodology based on secondary data analysis and field studies in the selected destinations. Various sources of information were used, such as official data from the National Statistical Institute, municipal administrations, and the National Tourism Register, as well as quantitative and qualitative information from questionnaire surveys, interviews, and personal observations. However, the approach of comprehensive, parallel to the official statistics "census" of tourism supply and demand applied in other studies (Marinov et al. 2000; Dogramadjieva 2003; Dogramadjieva et al. 2012), was avoided, having in mind the large number of small tourism enterprises and the reluctance of entrepreneurs to provide specific data on their business. The main technique used in this case was the one of personal semi-structured interviews with key informants. Therefore, the field study results reveal rather general trends and respondent perceptions than precise quantitative parameters of local tourism development. Such a technique was preferred for its cost-effectiveness and the ability to ensure in-depth insight and understanding in complex situations (Marinov 2012).

Personal interviews with 36 key local informants were conducted: 9 in Apriltsi, 17 in the municipality of Karlovo where the town of Kalofer is located, and 10 in the municipality of Smolyan, which comprises the Upper Arda destination. These interviews provided both "soft" and "hard" information regarding past and present tourism development, destination management, and tourism policy considerations. The selection of key informants included business entrepreneurs, local government officials (e.g., current and previous mayors, heads of tourism departments in local administration), local representatives of central authorities, and tourism NGO activists. The semi-structured questionnaire contained 40 questions covering a wide range of topics such as assessment of tourism premises and limitations; the importance of tourism for the local economy and the willingness of local communities to develop tourism; the history of tourism development; recent projects in support of tourism development; key problems and supposed responsibilities for their solution as well as the priority actions required; attitude to partnerships in local tourism development; visitor profile and behavior; and observed trends and expectations concerning such matters as tourist demand, local supply, and price level.

The information gained from personal interviews and observations was completed with data from secondary sources and made it possible to compare the three destinations against a set of 30 characteristics united in the following groups: (1) destination tourism potential and local development context; (2) tourism development driving forces; and (3) tourism supply-and-demand features. Comparative analysis was extended by identifying the patterns of tourism development in terms of current business practices (Assenova 2013). Additionally, the evolutionary approach (Butler 1980; Buhalis 2000), as well as the model of tourism development process (Andriotis 2000), were applied to ensure in-depth comparative analysis regarding sustainability implications of tourism development at local level.

8.3 Research Findings and Discussion

8.3.1 Tourism Potential and Local Development Context

The three studied destinations are featured by considerable tourism potential and specific development context. Peculiarities of their location and spatial structures have influenced the accessibility as well as the availability and distinctiveness of tourism resources.

The destinations of Apriltsi and Kalofer seem to be privileged in terms of location and accessibility. They are situated in Central Bulgaria at a distance of 150 to 200 km (travel time, 2.30–3 h) from the capital city of Sofia and are easily accessible within the country, that is, from the majority of bigger cities, seaside and spa resorts, and important centers of heritage tourism. Conversely, the Upper Arda Valley is rather isolated in the country's southern periphery close to the Greek border. It is less than 300 km away from Sofia but around 4.5 to 5.0 h distant in travel time by car.

The destination of Apriltsi covers the whole municipality, consisting of four settlements located in the northern footsteps of the Central Balkan Range. On the southern slope of the same ridge is the destination of Kalofer, encompassing the homonymous town with the adjacent mountain area. Although the settlements in both neighboring destinations are of relatively low altitude (550–650 m), the area is characterized by considerable displacement as it includes the highest point of the Balkan Range, the peak of Botev (2376 m), which can be reached from both sides. The two destinations are also favored by the availability of impressive waterfalls in their territory. However, the Eden Waterfall, which is the highest one on the Balkan Peninsula (129 m), lies in the land of Kalofer. Another well-known natural attraction there is the White River Ecotrail that starts some 12 km from the town and leads to the imposing wilderness of the Djendema Nature Reserve. Similarly to Kalofer, Apriltsi is closely associated with the Balkan Range, but it has gained its popularity for the curative climate and the magnificent mountain views from the valley rather than the hiking routes and the available natural phenomena.

The Upper Arda Valley is a typical polycentric destination encompassing 29 settlements scattered in the Rhodope Mountain at altitudes between 950 and 1280 m. Relief of the area is generally lower and gentler, which has determined the existence of a dense network of easy hiking routes. The main nature-based attractions there include the Arda River springs, the Uhlovitsa Cave, and several smaller caves that could be visited in the region, as well as the possibilities of horseback riding, fishing, and other outdoor activities.

In contrast to the Central Balkan Range with its rigorous wilderness and the availability of vast untouched natural landscapes, Rhodope Mountain features a higher level of adoption of natural resources and a greater density of human activities, including agriculture and tourism. This appeal is reflected in the number and type of protected areas and the corresponding opportunities and restrictions concerning tourism development of the three studied destinations. Apriltsi and Kalofer are not only included in the NATURA 2000 network of protected zones but partly fall into the territory of the Central Balkan National Park (II IUCN category), which is one of the three national parks in the country. Additionally, each of the two destinations involves a Nature Reserve of the highest level of protection (I IUCN category). In the Upper Arda Valley there is not such a high level of nature protection but only NATURA 2000 sites. Despite the differences regarding natural environment and related tourism resources, the beauty of the mountains and well-preserved biodiversity are definitely among the main attractions (pull factors) of each of the three studied destinations.

Table 8.1 Local tourism development context

	Apriltsi	Kalofer	Upper Arda Valley
Destination area	238 km^2	155 km^2	185 km^2
Number of settlements	4	1	29
Settlement altitude	550–650 m	603 m	950–1280 m
Distance from the capital city of Sofia	185 km (2.30–3 h)	155 km (2.30 h)	270 km (4.30 h)
Population number (Census 2011)	3338	3103	3157
Population density	14 persons/km^2	20 persons/km^2	17 persons/km^2
Population change (2001–2011)	−20 %	−17 %	−19 %
Age structure (<15: 15–64: 65+)	8 %: 58 %: 34 %	11 %: 64 %: 25 %	10 %: 63 %: 27 %
Religious structure	~100 % Christians	~100 % Christians	55 % Christians; 45 % Muslims
Unemployment on municipality level (2011)	10.8 %	13.50 %	12.40 %
Duration of tourism development	Since 1960s	Since 1970s	Since late 1990s

Cultural tourism potential is more differentiated. It is quite limited in Apriltsi, which is compensated by the proximity to monasteries and museums of national significance located in the neighboring municipality of Troyan. Conversely, the town of Kalofer holds a substantial cultural heritage potential. It is distinguished as the birthplace of the Bulgarian national hero Hristo Botev but also as a place of vivid traditions, numerous churches, and powerful monasteries. Situated in the Rose Valley, it is associated with rose picking and rose oil production. Additionally, Kalofer offers easy access to many significant cultural sites outside the destination borders as the result of its central location within the country and the suitable configuration of the road network. On the other hand, the Upper Arda Valley is highlighted by specific cultural potential represented by the well-preserved Rhodope folklore, local cuisine, and traditional production (diary, beans, crafts, etc.), as well as the dense network of picturesque villages and the availability of significant architectural and archeological monuments.

The tourism development context in the studied destinations shows certain similarities typical of all mountain areas in the country as well as distinctions that have influenced the contemporary tourism patterns at a local level (Table 8.1).

Despite the different number of settlements, the destinations are similar in area and population number. Their population density is much lower than the country's average (14–20 persons/km^2 vs. 66 persons/km^2). All three destinations suffer rapid demographic deterioration, clearly demonstrated by the quick negative change in the number of population and the unfavorable age structure with a small share of young people. A specific feature of the Rhodope region and particularly the Upper Arda Valley is the mixed Christian and Muslim population (Lambova 2015), whereas the religious structure in the other two destinations is almost homogeneous.

In all three destinations the unemployment rate is close to the country's average (12–13 %). Currently, the leading economic sector everywhere is that of services. However, local economies have shaped up in quite a different way. The history of tourism development is also dissimilar. Industrial production in Apriltsi has always been limited mainly to lumbering and woodworking. Tourism development there started in the late 1960s and since then has been important in the local economy. Conversely, industrial production was once well developed in Kalofer but has been constantly declining over the past 25 years. Despite the relatively strong agrarian sector, a continuous worsening of the overall economic situation has been observed there which has not been compensated by the growing share of tourism and services.

In the Upper Arda Valley, the main local economy drivers in the past were ore mining and machinery construction, but these industries were closed in the late 1990s after the collapse of the centrally planned economy. Other traditional economic activities included agriculture and dairy production; tourism was introduced only in the late 1990s to substitute the former existing industries. The lack of earlier development of tourism there was determined by the location of the area in the border zone between Bulgaria and Greece that belonged to different political and military systems on the both sides of the Iron Curtain. Therefore, before 1989 visitor access to the area was strictly limited to organized sightseeing tours for a couple of hours with no opportunities for an overnight stay.

8.3.2 Tourism Development Driving Forces

As already mentioned, the three destinations are quite different in terms of tourism development, which has a history of 50–60 years in Apriltsi and Kalofer but just about 15 years in the Upper Arda Valley. Several periods of local tourism development could be outlined, associated with the specific influence of the main driving forces represented by the public and private sectors as well as the tourism-supporting partnerships that have shown different features in the studied cases.

Before 1989, there were many state-owned accommodation entities in Apriltsi with significant bed capacity (2200 bed places in 1987), large rest houses of industrial enterprises and student camps. The private ownership was limited and embraced second homes with no commercial function. The situation in Kalofer was similar, but the scale of tourism development was smaller (1200 bed places in 1987) and emphasized hiking and heritage tourism rather than stationary mountain recreation. In the Upper Arda Valley no tourism developed at that time, with the exclusion of organized day trips from the ski resort of Pamporovo to a few local sites of interest. Therefore, privatization in tourism in the late 1990s took place only in the first two destinations; it was partly successful in Apriltsi and completely unsuccessful in Kalofer. Some of the former existing rest homes in Apriltsi were transformed into hotels that are now fully operational, but none of the privatized units in Kalofer is currently open for tourists.

Family-run businesses emerged in Apriltsi first (in the mid-1990s), followed by Kalofer and the Upper Arda region, with a few years delay, in the late 1990s. Family hotels and guest houses expanded everywhere, although at different rates. A quick growth of tourism supply was observed in Apriltsi until 2008, enhanced by much external investment and "easy" bank credits. Slower growth with fewer credits used is typical of Kalofer and the Upper Arda Valley. Most of the businesses there are local, although external private investments have lately appeared.

It should be stressed that considerable international donor support put the foundations of modern tourism development in all three destinations. Such public funding was first received in Apriltsi, where in the mid-1990s the Swiss Agency for Regional Cooperation initiated the establishment of a local tourism organization and financed various tourism-supporting actions at local and regional levels: the creation of tourist information centers, vocational training, and destination marketing activities. In Kalofer the US Agency for International Development was strongly involved in ecotourism development in the period 2001–2004. The USAID Program initiated the establishment of the Local Ecotourism Society in 2002 and funded local capacity building, construction of tourism infrastructure in the Central Balkan National Park, development of tourist services, etc. Foreign donors actively worked in the Rhodope region as well, supporting a number of projects of similar profile but of generally smaller scale.

However, the international donor organizations gradually withdrew their financial support after 2003–2005, leaving much greater space for internal initiatives of local stakeholders, incl. attaining financial resources from the EU pre-accession and structural funds. The new opportunities were not efficiently used in Apriltsi and Kalofer, as the local authorities there implemented a weak tourism policy while the local NGOs hardly sustained the restricted "secure" external funding. Local entrepreneurs were reluctant to cooperate, and previously established partnerships have been shown to be rather formal and highly dependent on external factors. In fact, no institutional and financial sustainability of the initial donor support has been ensured in these two destinations; non-operating NGOs and limited project-led support from the local authorities is currently observed there.

In contrast, the local authorities of Smolyan municipality and the Upper Arda villages together with the local and regional NGOs took over the ownership of activities initiated by foreign donors and have proved to be successful in tourism planning and management at destination level, implementing an effective strategy-led approach. Since 2000 these local authorities have vigorously utilized external funds in support of tourism development and have also efficiently mobilized internal resources. A specific advantage is that from the very beginning public support has been provided to bigger destinations, not to separate villages, so that several settlements had to decide what to do and how to do it together. Another distinguishing feature of the Rhodope region and the Upper Arda Valley in particular is that partnerships were initiated by the locally recognized need for cooperation and mutual support among local entrepreneurs. Therefore, a well-developed network of

Table 8.2 Current supply patterns

	Apriltsi	Kalofer	Upper Arda villages
Number of accommodation units	95	23	45
Number of beds	2300	362	604
Average bed capacity	24	16	13
Type of accommodation	Family hotels and guest houses of medium standard Several larger hotels (50–100 beds)	Guest houses and family hotels of low to medium standard No larger hotels (>45 beds)	Guest houses and rooms to rent, mostly of low standard No larger hotels
Average tourist expenditure	20–25 EUR/day, mainly for primary services within the hotel	Around 25 EUR/day, for both primary and complementary services	Around 35 EUR/day: higher share of complementary services
Recent price trends	Decreased rates: high competition and frequent promotional offers	Stagnating prices: have not been changed for years	Rising rates until 2012 followed by a slight drop in the price level

both formal and informal partnerships has been created that is currently an important driving force of tourism development at local and regional levels.

8.3.3 Current Tourism Supply and Demand Patterns

The three studied destinations show different current supply patterns in terms of the size and type of accommodation units, other facilities and complementary services offered, product distribution, and price level. Despite the similar area and population number, the bed capacity of Apriltsi is much greater compared to Kalofer and the Upper Arda Valley (Table 8.2). Family hotels and guest houses predominate there but the supply is also featured by the existence of several larger hotels that are not present in the other two destinations. Generally, the accommodation standard is higher in Apriltsi and lower in the other two destinations.

Other facilities and complementary services in Apriltsi are mostly developed within the separate accommodation units. Many of them have their own swimming pools, playgrounds, taverns, etc. while common attractions and complementary services at destination level are almost missing. Conversely, accommodation entities in Kalofer and the Upper Arda Valley offer limited amenities and services due to availability of either nature-based or cultural attractions at destination level. In Kalofer, nature-based attractions (the White River Ecotrail, the Eden Waterfall, horseback riding) are of major importance whereas cultural attractions are underdeveloped, despite the existing potential. In the Upper Arda Valley the variety of tourist offers is impressive: guided tours and horse riding on more than 20 well-signed hiking

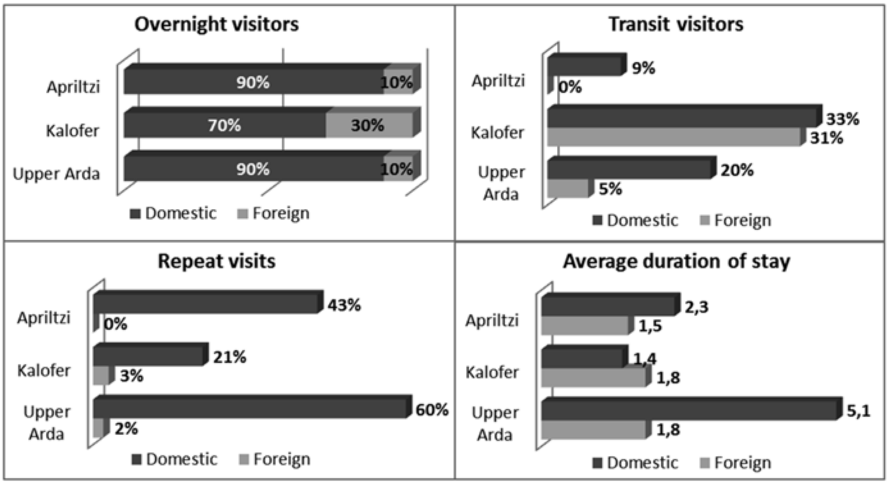

Fig. 8.3 Tourism demand features

routes; caving, fishing, bike rentals; visiting archeological and architectural sites; tasting of local products and cuisine; folklore performances, etc.

Product distribution channels are also different. In Apriltsi most used are promotional web sites for collective shopping; some entrepreneurs collaborate with traditional tour operators working in the field of incentives, adventure tourism, etc. In Kalofer entrepreneurs rely mainly on standard online reservations; few of them cooperate with tour operators offering special interest trips on the foreign market. The Upper Arda village products are distributed mainly through direct sales, often to repeat visitors; online reservations are of limited importance. Some entities work with tour operators offering special interest trips on the foreign market.

The accommodation rates are similar and just slightly higher in Apriltsi, despite the considerably better standard there. However, average tourist expenditures are the highest in the Upper Arda villages because of the greater consumption of complementary services. Everywhere either stagnation or reduction of prices has been observed over the past years as a result of increased competition and the inactive market in times of crisis. Such a problem is most prominent in Apriltsi, followed by Kalofer, and less evident in the Upper Arda villages.

All three destinations are oriented mostly toward the domestic market of non-organized tourists; the foreign market has a limited share (Fig. 8.3). The higher relative numbers of foreigners in Kalofer is because the town is situated in the Rose Valley, which is internationally known, as well as being a starting point of the most popular hiking route to the highest peak of the Balkan Range.

The highest share of transit visitors is also identified in Kalofer and could be explained by the proximity of the town to major tourist centers of the country offering better accommodation and food opportunities; many tourists stop there just to visit the main sites of interest and go on to other destinations. The relatively high

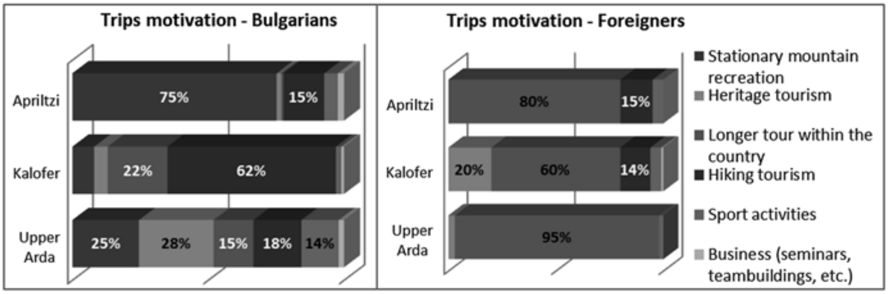

Fig. 8.4 Trip motivation of domestic and foreign visitors

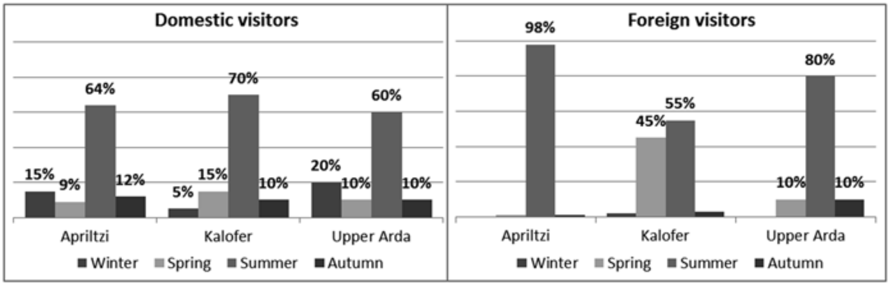

Fig. 8.5 Seasonality of tourism demand

share of transit visitors to the Upper Arda villages results from the fact that the area attracts day visitors who stay at larger resorts in the Rhodope region. On the other hand, the Upper Arda area features a very high percentage of loyal clients coming every year as the destination always has something new to offer.

The average duration of stay of Bulgarians is short in Apriltsi (2.3 days) and Kalofer (1.4 days), but considerably longer in the Upper Arda villages (5.1 days). This difference is explained by both the longer travel to the destination and the better development of various attractions and services at destination level.

The diverse tourism supply of the Upper Arda villages is also confirmed by the variety of trip motivations, for example, the types of tourism practiced there (Fig. 8.4). Domestic visits to Apriltsi are mainly motivated by stationary mountain recreation whereas visitors to Kalofer are attracted by the hiking tourism opportunities. The greatest majority of foreign tourists visit all three destinations within the compass of longer tours in the country.

Seasonality of demand is a problem in all cases; summer is the high season, although the Upper Arda villages and Apriltsi also attract domestic tourists for winter holidays. Foreigners visit the two destinations mainly in summer. In contrast, their interest to Kalofer is split between the spring and the summer because of the rose picking that takes place in May and June (Fig. 8.5).

Table 8.3 Tourism development patterns in terms of current business practices

Apriltsi	Kalofer	Upper Arda villages
Hotel is everything	Hotel is just for lodging	Stay like at home
Considerable private investments (mainly external) – higher accommodation standard and many amenities within particular entities	Smaller private investments (local) – lower accommodation standard with limited amenities	Small private investments (mainly local) – low standard of accommodation but traditional home atmosphere and close contact with the guests
Almost missing attractions and services at the destination level	Limited complementary services at destination level. Yet, nature-based attractions are the main pull factor	Many attractions and complementary services at destination level
Stationary recreation in mountain environment – limited additional tourist expenditures and low duration of stay	Hiking tourism – limited additional tourist expenditures and low duration of stay	Active mountain recreation – longer duration of stay and higher additional tourist expenditures
Low financial turnover and high leakages	Limited economic benefits and considerable negative environmental impacts	Enhanced financial turnover and wider distribution of benefits

8.3.4 Tourism Development Patterns in Terms of Current Business Practices

Local tourism development patterns in terms of current business practices are drawn from the identified supply-and-demand patterns of the three studied destinations and their socioeconomic impact. The tourism business approach in the selected research destinations differs, resulting in three clearly distinctive development patterns that are characterized briefly in Table 8.3.

These business models impose different supply chains and value-added chains that are reflected in the tourism impact in all aspects of sustainability, especially socioeconomic. In Apriltsi and Kalofer, the economic benefits are limited, but in Upper Arda they are substantial and wider in distribution.

8.3.5 Local Tourism Development Process: Sustainability Implications

The model of tourism development process of Andriotis (2000) is applied to outline the similarities and differences between the studied destinations, and the sustainability implications of local tourism development process, which are presented in Table 8.4.

Table 8.4 Local tourism development process: sustainability implications

	Apriltsi	Kalofer	Upper Arda villages
General approach	***Diffusionist:*** Transformation of former existing tourist facilities Perceptive entrepreneurs but limited public support; inefficient partnerships	***Diffusionist:*** Core tourist attractions have stimulated local businesses Perceptive entrepreneurs but limited public support; inefficient partnerships	***Sustainable:*** Community-based strategic development Both private and public sector involvement; efficient partnerships
Implemen-tation	**Control:** external investments predominate **Scale:** small and medium **Rate of growth:** fast **Type of tourism:** mass individual and alternative	**Control:** completely local, no external investments **Scale:** small **Growth:** moderate **Type of tourism:** alternative and mass individual	**Control:** mostly local, emerging external investments **Scale:** small **Growth:** moderate **Type of tourism:** alternative and individual
Outputs	**Life-cycle stage:** rejuvenation **Physical patterns:** scattered development **Socioeconomic patterns:** spread (vs. enclave) development	**Life-cycle stage:** rejuvenation **Physical patterns:** three core tourist zones **Socioeconomic patterns:** spread (vs. enclave) development	**Life-cycle stage:** involvement **Physical patterns:** scattered development **Socioeconomic patterns:** spread (vs. enclave) development
Outcomes	**Economic:** positive effect on employment; low revenue from tourism tax (3500 EUR); limited linkages and high leakages – *only 8 % supply of goods and services at municipality level* **Environmental:** limited negative impacts in the mountain but overloading of local infrastructure (electricity and water supply) **Social:** prevailing negative than positive impacts – high rivalry and conflicts within the local community	**Economic:** limited effect on employment; low revenue from tourism tax (2500 EUR); limited linkages and quite high leakages – *25 % supply of goods and services at municipality level* **Environmental:** overcrowding of the eco-trail and increasing problems in the mountain – waste pollution, unregulated fire making, off-road driving, etc. **Social:** prevailing negative than positive impacts – limited support to the local culture but high rivalry and conflicts	**Economic:** positive effect on employment; low revenue from tourism tax but well-developed local linkages and limited leakages – *60 % supply of goods and services at municipality level* **Environmental:** no serious damages; considerable positive impacts – maintained hiking routes; better looking settlements **Social:** prevailing positive impacts – stimulated local production and traditions; However, emerging negative effects – commercialization, change in local people's traditional attitudes and perceptions

In terms of general approach to development, it is identified as *diffusionist* in Aprilitsi and Kalofer because “the neighborhood effect on innovations” is manifested in both destinations, whereas the community-based strategic development of tourism in the Upper Arda Valley displays the *sustainable* approach.

The implementation is characterized by predominant external investments, fast growth, and small and medium scale in Apriltsi, and mostly local investments, small scale, and moderate growth are typical for Kalofer and the Upper Arda valley. However, in the last case external investment interest already emerges. Alternative tourism is the common type in all destinations. Yet, mass individual tourism has a large share in Apriltsi and is also observed in Kalofer, while in the Upper Arda Valley it is not practiced at all.

As an output of development, a “spread” socioeconomic pattern is identified in all cases but some differences are obvious in the physical pattern, which is described as scattered in Apriltsi and Upper Arda; in Kalofer, three core tourist zones are delineated. The destinations differ in their life-cycle stage because their tourism development differs in length of time: Apriltsi and Kalofer are in the phase of rejuvenation, and Upper Arda is in the involvement phase.

Sustainability implications as an outcome of the development process are also different. In the economic aspect there is a positive effect on employment in Apriltsi and the Upper Arda villages, but in Kalofer it is rather limited. In all destinations the revenue from the tourist tax is low. Great differences are identified in the share of internal deliveries (goods and services provided at municipality level): the relative weight of local sourcing is only 8 % in Apriltsi, 25 % in Kalofer, and about 60 % in the Upper Arda region. Such differences are explained by the limited linkages and quite high leakages in the first two cases, whereas in the Upper Arda Valley, in contrast, there are well-developed local linkages and limited leakages.

Currently, there are some environmental problems in the mountainous part of Kalofer and in the town of Apriltsi, although in the Upper Arda Valley the positive environmental impact still prevails. Similarly, negative social impacts predominate in Apriltsi and Kalofer, and positive in the Upper Arda region, where some negative effects are just emerging. In general, the process of steady community-based tourism development in the Upper Arda Valley appears to be most successful in all aspects of sustainability.

8.4 Conclusions

The study results have confirmed our starting hypothesis, that the three destinations would show specific differences in the pattern of their tourism development, which would be essential for achieving sustainability, as well as the idea that two types of preconditions are needed for successful tourism development (Rostow 1960; Auty 1995 quoted by Andriotis, p. 10):

- *"necessary"* – pull-factors and available attractions
- *"sufficient"* – the will to develop a tourism industry through investments in accommodation and infrastructure

Moreover, the study results have indicated that the latter refers not only to entrepreneurship but also to the crucial role of local authorities.

Another important conclusion is that external donor support is important for initiating tourism development or directing it to a sustainable path. However, the sustainability of outcomes depends on the ability of local authorities and communities to take over the ownership. In other words, partnerships and networks – both formal and informal – are substantial for achieving sustainability.

Acknowledgments This research was carried out within the project "Mountain Areas – Models of Economic and Cultural Development. Perspectives for Regional Policies and Transborder Collaboration," implemented by the Center of Excellence in the Humanities "Alma Mater" at Sofia University and funded by the Ministry of Education, Youth, and Science Scientific Research Fund. The authors thank all the colleagues involved in the project for their support and suggestions.

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Chapter 9
Beyond Existing e-Tourism for Mountains: Findings from the Case of Zagori, Greece

George Panagiotopoulos, Loukas-Moysis Misthos, and Dimitris Kaliampakos

Abstract For certain mountain regions, tourism appears as the most prominent developmental perspective. Therefore, promoting and underpinning the unique natural, morphological, and cultural traits of such regions are essential to enhance their economies in a proper and sustainable manner. Zagori, Greece, is a typical example of such regions because of its rich natural and cultural heritage. Nowadays, e-tourism emerges as one of the most popular means of tourism services. There are many commercial e-tourism applications that offer valuable services. However, they do not address certain limitations sufficiently. One of the typical problems is that of misinformation or information overload. Although this applies mainly in urban areas, the existence of a large city close to a mountain region could confuse the visitor because of the many and spatially concentrated points of interest in this urban area compared to the more sparse ones in the mountains. Thus, it is important to design the pertinent application both to be adjusted to the visitor's preferences and to highlight the local advantages of a region. Moreover, mountainous regions require extra services to provide security details, especially during activities in the wilderness. Another significant issue is that of visual occlusion and user disorientation induced by the rugged terrain and the landscape heterogeneity, regarding the matter of navigating and finding areas of interest. To tackle these issues, the respective solutions are employed: (1) providing a properly classified content, particularly for the specific area of study, attached to a user-friendly interface giving the ability to switch between natural and cultural points of interest in a handy manner; (2) enabling alerts to inform the users about certain risks concerning dangerous routes or harsh conditions; (3) and integrating augmented reality (AR) with dynamic viewshed (2D

G. Panagiotopoulos, PhD Student (✉) • L.-M. Misthos, PhD Student
Metsovion Interdisciplinary Research Center, National Technical University of Athens,
9 Iroon Polytechniou Str, GR 15780 Zographou, Greece
e-mail: g.panag@metal.ntua.gr; lmisthos@central.ntua.gr

D. Kaliampakos, Professor
Metsovion Interdisciplinary Research Center, National Technical University of Athens,
9 Iroon Polytechniou Str, GR 15780 Zographou, Greece

Laboratory of Mining & Environmental Technology, School of Mining and Metallurgical Engineering, National Technical University of Athens,
9 Iroon Polytechniou Str, GR 15780 Zographou, Greece
e-mail: dkal@central.ntua.gr

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_9

visibility) maps to navigate through the mountain environment. The combination of these state-of-the-art technologies furnishes great opportunities to overcome the distinctive mountainous geography. In this chapter, we explore the possibilities of an e-tourism application that implements the aforementioned solutions. In addition, by fitting the design and architecture of this application to the specific characteristics of Zagori, a general framework of e-tourism services oriented to mountainous areas is suggested.

Keywords e-Tourism • Mountainous regions • Augmented reality • Dynamic viewsheds • Zagori

9.1 Introduction

e-Tourism has been successfully applied to urban environments and along main road networks. However, mountains and generally rural remote areas are remarkably different from urban ones. Thus, locating and understanding the unique characteristics of the mountains can be the key to an effective tourism application design. Obviously, variations may exist even in similar urban areas, but mountain visitors usually demand special services and information while traveling.

Some of the services that a tourism app may offer are information about a place, its location, and navigation. By adding web services, a visitor may get information about the quality of the place from other people in the form of comments or reviews. Other services may include marketing, transactions, and entertainment. Emmanouilidis et al. (2013) and Kennedy-Eden and Gretzel (2012) have proposed taxonomies for tourism apps based on various criteria such as their interactivity, the services they offer, and their context. Some services address both urban and mountain visitors (e.g., an impartial criticism that comes from an assortment of comments or ratings), whereas others may be better suited to specific visitor groups. Most popular worldwide tourism apps try, often very successfully, to increase the range of their users by adding personalization. In this way, the users may get services tailored to their needs, based on a profile built from selections and information that they submit, sometimes even without the users' approval. This function is called context-awareness, and its efficiency has greatly increased after the establishment of mobile devices and social networks. Although worldwide apps offer many advantages, mainly for the evaluation of both the app itself and the tourism destinations, it is hard to target a large proportion of tourists and, at the same time, to include attributes useful in mountainous and remote areas. For this reason, an app specifically designed for a mountain region can have many benefits to the visitor as much as to the region itself.

Mountainous areas also feature another peculiarity while attempting to design an effective tourism app that is enabled by the technology of augmented or mixed reality (AR/MR), which is currently a popular addition in many tourism apps. The high vertical relief variability inherent in such areas poses certain limitations in locating points or features of interest (POIs/FOIs) that are concealed behind local elevated terrain surfaces with respect to the users' oblique perspective. This phenomenon is called visual occlusion and tends to afflict 3D first-person (i.e., egocentric) visualizations in AR and VR (virtual reality) environments. In addition, these visualizations immerse the user in the virtual world in such a manner that the person can be disoriented if no other exocentric cues are involved in the AR environment of the app as well.

Recent research papers and current applications are dedicated in addressing the information-based requests of the users while efficiently dealing with the intrinsic limitation of the first-person 3D perspective and of the rugged mountainous terrain effect (Deng et al. 2013; Harrower and Sheesley 2005). The common insecurity of the risky navigation in mountainous areas (e.g., unforeseen events, getting lost in the wilderness) is also a matter of concern. So, in the following section, current apps and relative research articles are handled as if they were the inputs for our research. By delving into the functionality of these apps, we try to enhance their potentialities and mitigate their limitations while trying to optimize their usability for mountainous areas.

Overall, the objective of this chapter is to outline the generic architecture and design of a touristic app optimally suited to mountain areas, using Zagori as an example. More specifically, the merits of AR prompted by cues affording better navigation and (spatial) context-awareness (i.e., viewsheds, personalization, etc.) are harnessed in the integrated architecture and design of the proposed app. Yet, principal to the promotion of such an integrated approach is to explore the following points in detail:

- How can a touristic app be compatible with both the preferences of tourists in mountainous areas and the intrinsic characteristics of such areas similar to Zagori?
- To what extent can the visual occlusion and disorientation limitations that are inherent in the AR of mountainous terrains be abated?
- In what ways can this forwarded integrated architecture and design be effective for users of pertinent apps?

9.2 Study Area and Methods

9.2.1 Study Area

The municipality of Zagori covers about 1000 km^2, from which a large proportion is dominated by the mount Tymfi (2497 m). Mount Mitsikeli sets the boundaries in the west, and on the east side the foothills of two mountains (Lygkos and Zygos) can be found. The elevation ranges from 410 to 2497 m with a mean value of 1159 m, which renders the region one of the most mountainous in Greece. Precipitation is high (around 1300 mm annually), and four major rivers cross or spring from the area (Aoos, Voidomatis, Vikos, and Zagoritikos). Lacking human intervention, Zagori has kept a rich and untouched natural environment that adds to the special geology of mount Tymfi that has shaped the famous Vikos gorge. Apart from the natural environment, Zagori is well known for the unique vernacular architecture based exclusively on stone. The combination of unspoilt natural environment and rich cultural heritage makes Zagori an attractive tourism destination. Yet, this was not the case until recent times. According to Zomeni et al. (2008), Zagori is characterized by three major transition periods in the last century. The last period (mid-1980s until today) is the one in which tourism has become the main, if not the only, economic activity in the area whereas all other economic sectors have been abandoned. It is not in the context of this chapter to discuss the development issues that occur in Zagori, although opportunities or implications may arise from the use of ICT (information and communications technology) in the promotion and, by extension, to the sustainable development of the area. The fact remains that the municipality is supported heavily on tourism, which can be said for several mountain regions in Greece. Therefore, it is crucial to make good use of the relevant ICT, not only for the visitor's experience but also to support a different view of the area.

9.2.2 Data: Concepts and Analysis

9.2.2.1 Information

When a user needs to find information for an area, he would either use a worldwide app or search for a standalone app for the specific area. Zagori is a well-known place and, thus, most of its FOIs are already included in the popular tourism apps, such as TripAdvisor (http://www.tripadvisor.com). Still, we argue that Zagori needs a standalone tourism app that will offer the right amount and quality of information to the visitors, one of the main reasons being the distribution of FOIs in space. A mountain region varies significantly from an urban one in that respect. For instance, the region of Zagori sprawls approximately 40 km along both the north–south and the east–west axes. Inside this 1000 km^2 areareside 46 villages, and it is very common to travel long distances (in a difficult mountainous road network or through various trails on foot) without finding any clearly defined FOI. From a visitor's perspective, it is hard to plan a trip or find special places in the area, especially while using the popular "near me" function that locates FOIs close to the position of the mobile device's GPS. This situation is considerably different from a city, where FOIs are usually clustered and organized in a rather predictable way in space (e.g., in accordance with the road network). The situation gets more complicated when urban centers are found relatively close to the mountain region. In the case of Zagori, the neighboring city of Ioannina offers a vast amount of FOIs (Fig. 9.1) that, in some cases, may be similar in content with the Zagori FOIs. The users can be easily confused, especially if they are not accustomed to maps or the area and, even more, if they travel across the borders of the region.

But it is not only the visitors that may benefit from a standalone app. The region itself could profit from such an action. Although a standalone app can be used as a

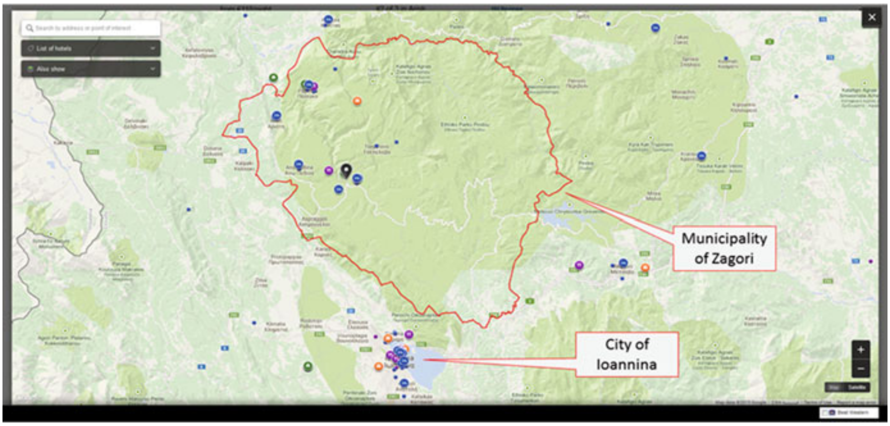

Fig. 9.1 Layer of Zagori municipality on top of TripAdvisor map depicting the disparity of the spatial distribution of features of interest (FOI) spatial distribution inside the municipality compared with their distribution in the neighboring city of Ioannina

promoting tool, it should be intended neither to compete with neighboring regions in the number of tourist attracted nor to offer another mean of advertisement. The true value of a standalone app is to reveal the identity of the region. Simple references/recommendations of the hotels, restaurants, or archaeological sites cannot enclose such a concept. In Zagori, the worldwide apps fail to capture its rich history and social structures that have shaped its current form. As a consequence, they miss some important elements because they were never designed to promote the unique traits of specific regions.

9.2.2.2 Navigation and Security

Another useful service that apps may provide is navigation to tour around an area from feature to feature. Inside the settlements, navigation can be easily done because a road or pedestrian network exists. However, in the wilderness, navigation can only be accomplished (at least in a precise manner) in predefined trails. A straight line from the GPS position to a place cannot guarantee a safe path, making the navigation system dangerous and misleading if the user deviates from the trail. Hence, navigation in a mountain region is safer to perform in predefined trails and paths and not on-the-fly as the user moves. Yet, this is not enough on its own to provide a fully secure navigation in a mountain region. Although security issues arise in both urban and mountain environments, they appear to be more predictable (the origins are usually known) in mountain regions. The most pressing issue in mountains is touring on trails aside from the main roads (hiking or trekking) where the rugged terrain, high slopes, dense vegetation, and weather conditions may be proven dangerous. There are several good examples of apps that offer services related to security, such as sending emergency signals with a GPS locator and online monitoring of the weather, which may be added to a route and be given to the user as additional navigational instruction.

9.2.2.3 Visual Occlusion and Disorientation

The physiography of mountainous areas presents distinct landscape patterns shaped partly by the underlying topography: both by its indirect influence on disturbance regimes and by its direct formation of natural breaks in vegetation patterns (Dorner et al. 2002; Swanson et al. 1998). Besides, inhabited highland regions exhibit an even higher landscape diversity as the result of both natural and structured environment heterogeneity. Zagori constitutes such a typical region, and, when the task is to promote its FOIs, this diversity may create some problems with (tourism) information management and visualization.

However, although the potential landscape heterogeneity and complexity of mountains may raise some issues in 3D navigation and visualization, it is the topographic complexity that poses the most daunting limitations. In recent articles, virtual 3D navigation in mountainous areas is examined with respect to the visual occlusion limitation (Deng et al. 2011, 2013). In essence, the problem of visual occlusion refers to the de facto obscurity of certain portions of a 3D surface when the viewing perspective is oblique (i.e., egocentric perspective), a problem that is aggravated the lower the viewing angles and the higher the ruggedness of a terrain (e.g., mountains) (Harrower and Sheesley 2005). Therefore, although this 3D oblique first-person egocentric perspective resembles our actual perception of and interaction with the real landscape, and so aids us to navigate through it, this perspective is liable to visually occluding certain FOIs. In contrast, this does not occur in a 2D vertical third-person exocentric perspective because users are not immersed in the virtual environment. What is more, users of immersive 3D worlds face the challenge of navigation and disorientation (Bowman et al. 2004; Chittaro and Burigat 2004; Harrower and Sheesley 2007), whereas in cases of predetermined path 3D flyovers in particular, the problem is not related to navigation, but solely to orientation, that is, disorientation (Harrower and Sheesley 2005).

9.2.2.4 Augmented Reality Plus Viewsheds Integration

Such pressing limitations should be addressed in the promoted app that is enabled by AR (augmented reality). Because “augmented reality is inherently bound to the frame of reference of the real world scene being perceived” (Grasset et al. 2011, p. 382), an application that both harnesses the merits of direct perception of the environment and overcomes the inherent limitations of 3D first-person perspective is the desideratum.

An important issue, however, is how this can be attained in terms of a user interface that is easy to perceive and manage. Granted that AR and MR are intrinsically amenable to be complemented by other (prompting) interfaces, designing an effective and efficient app for navigation relies on adequately contemplating the transition among multiple interfaces (Grasset et al. 2011). In the context of handling the aforementioned limitations related to high variations of vertical relief, several authors have utilized techniques of blending multiple viewing perspectives into a single view or/and deforming the relief with respect to the viewing position (Degener and Klein 2009; Deng et al. 2011, 2013; Möser et al. 2008). Even though these techniques are effective in that they afford "the ease of perception of a single view" (Möser et al. 2008, p. 1859), they can also "introduce misleading distortions to the scenes […,] be difficult to apply for visualization at satisfactory frame rates [, or introduce] higher viewing positions to enhance visibilities of FOI" (Deng et al. 2013, pp. 389, 390). Furthermore, terrain deformation can significantly alter the vertical relief in particular, an alteration not wanted when the task of promoting the distinctive topography of an area is crucial. Another alternative strategy is to fully transform the perspective, in shifts between egocentric and exocentric perspectives, by tilting the device: (by turning it to the horizontal orientation an exocentric vertical projection map is displayed) (Lehtinen et al. 2012). Although this switch can be valuable in cases where the display extent is limited (e.g., i-Phones, smart phones), users are not provided the potentiality of directly linking the two perspective types.

In this sense, a viewshed's linked on-screen display that dynamically changes at different locations along a suggested route could serve as a valuable locator map also including terrain visibility information. The attempt to integrate these two different displays simultaneously could eventually raise the split attention effect/problem (see Mayer 2002; Harrower 2003), thus rendering the app not easy to manage. However, when accepting the thesis that there is "no unique model to detail how spatial knowledge is structured into a mental map" (Grasset et al. 2011, p. 381), this could not raise such a problem. To elucidate, the more entrenched models or elements pertaining to spatial knowledge in mental maps refer to landmarks, routes, or other 'strategic' locations/districts or some combination of them (Goldin and Thorndyke 1981; Lynch 1960; Siegel and White 1975). Adopting a landmark-based approach along a route can be especially fruitful in a tourism application in a mountainous region such as Zagori as there is no dire necessity for watching both displays at every possible location/moment along the suggested routes. Such an approach is also in line with the high computational complexity of viewsheds. The most prevalent GIS-based algorithm implemented on gridded digital elevation models (DEMs) is making use of the line of sight (LoS) (Fisher 1993; Nagy 1994; Sorensen and Lanter 1993) and is of complexity greater than $O(N^2)$ (Tabik et al. 2013).

9.3 Research Findings and Discussion

Based on the issues that were discovered in the study area concerning tourism electronic services, in addition to the special characteristics of mountain regions, the design and architecture of a tourism app for mobile devices is presented and discussed. The proposed app is meant to provide useful and innovative services to the visitors of a specific mountain region and thus increase their tourism experience and support the sustainable development of the area.

9.3.1 A Guide Toward Mitigating Limitations and Enhancing the Touristic Experience in Zagori

9.3.1.1 Information

First, it is of paramount importance to provide a content that will present the cultural and natural features of the area, properly categorized and linked. The content must be bounded to the area of study to present its uniqueness. The classification does not have to follow the usually routine that most tourism apps use. Although users are accustomed to the prevailing taxonomy (e.g., hotels, restaurants, archaeological sites), a classification that would display special features of a specific region plays a functional as much as an advertising role. For instance, a category for Zagori could include the numerous stone bridges found all around the region over the equally numerous river streams. Those bridges are part of Zagori's cultural heritage and display the uniqueness of the region.

Another significant addition is the history of the region. People in mountains have struggled for centuries to survive in a harsh environment, and that can be a rich historical resource in technological and social terms. A fairly good example in Zagori is the nomadic tribe "Sarakatsani," who used to travel great distances with their whole families to find food for their herds. The app could contain those trails along with special landmarks and historical information.

As Schmeiß et al. (2010) have noted, most apps lack temporal information about an area, which brings out an issue of missing information about social events, an important part of the cultural heritage in mountain regions. Obviously, a worldwide app cannot contain that much information, yet a standalone app for a specific region should and must include a calendar connected with the relevant locations in the map that will provide temporal and spatial information for the social events.

9.3.1.2 Navigation and Security

Having predefined routes as a navigational system service is not only crucial to highlight special landmarks and historical information. Security issues may arise in the harsh environment of the mountain areas, especially because of the rugged terrain, abrupt slopes, and intense weather conditions. Therefore, predefined routes with appropriate alerts can help the visitors to avoid dangerous paths, inaccessible locations, or getting lost. More advanced versions may include a map of susceptibility that will combine dangerous terrain and other natural hazards and alert the user

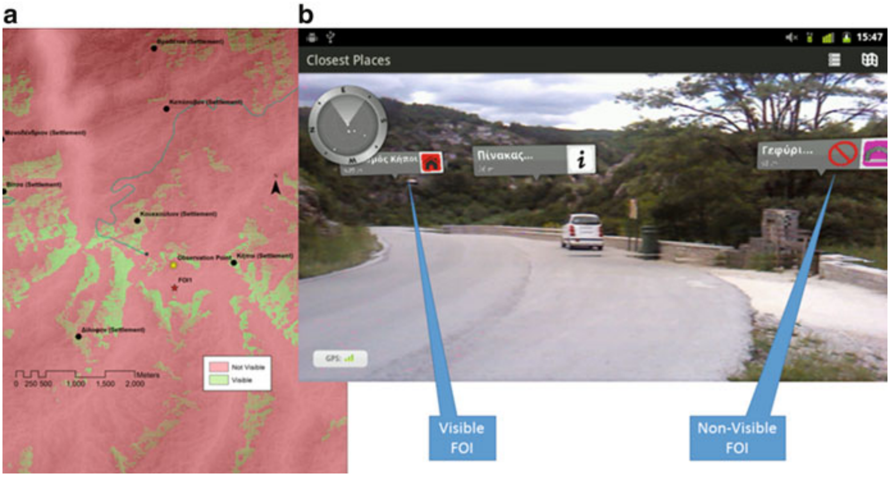

Fig. 9.2 Suggestion for integrating: a predefined viewshed analysis from specific locations (**a**) into a sample augmented reality (AR) app (made with Wikitude) that displays the FOIs with a visibility indicator (**b**)

when entering a dangerous area through the mobile device's GPS. In addition, provided that there is an Internet connection, users may get live weather status for their locations.

9.3.1.3 Visual Occlusion and Disorientation

As mentioned before, locating FOIs while simultaneously enabling users' positioning in mountain regions can be a difficult task. To tackle this issue, a combination of viewshed visualization and augmented reality is suggested. Even if viewshed analysis and visualization can take place along the trails or even for the whole area of study, such an action is not recommended as it will consume much of the relatively limited computational power of mobile devices. The visualization of dynamic (animated) viewsheds does not require their computation from every available viewpoint even for a 'complete' exploration of the changing visible regions along a route; contrariwise, such a 2D flyover metaphor can facilitate and approximate the portrayal of the changing visual landscape from viewpoints that their spacing greatly depends on the DEM's resolution (Misthos 2014; Misthos et al. 2014).

Thus, in this proposed predetermined landmark-based approach, viewsheds need not and should not be visualized at every location, but they can be crucial in both revealing FOIs that are actually occluded by the terrain in the AR window and providing a sense of the broader spatial context, eliminating disorientation; this can work by implementing the visualization of the FOIs extracted from a viewshed analysis for the predetermined landmarks along the trails. The user may enable the AR in the mobile device when reaching one of the landmarks and explore the surrounding area (Figs. 9.2 and 9.3). Viewsheds can have been precomputed from a set

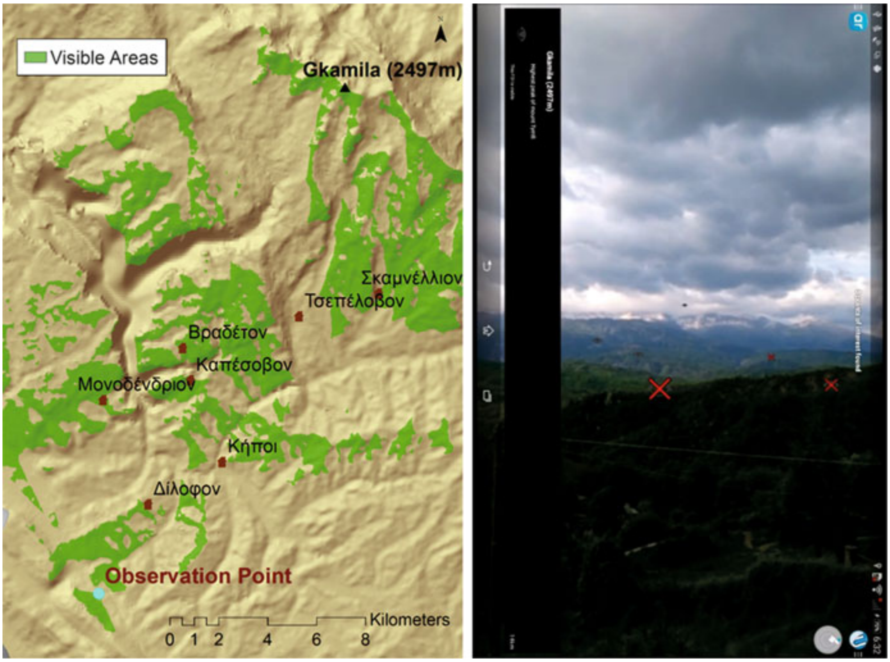

Fig. 9.3 Another example of the Viewshed–AR integration made with the Layar app

of points near the landmarks or can be calculated on-the-fly. Given the purpose of the proposed application, even a 25-m cell-sized DEM (e.g., SRTM) can facilitate this task. Different graphical symbols will separate the visible from the nonvisible features and so the visitor will be able to get a better understanding of the terrain and the surrounding area, enhancing the tourism experience and supporting tour planning.

9.3.2 Conceptualizing the Integration of the Appropriate Elements in a Proper Architecture

Table 9.1 summarizes the opportunities and limitations that were discovered by analyzing current technologies in the mountain area of Zagori along with the proposed solutions, concerning tourism apps. Note that all these technological solutions are already available one way or another, even though they are not available as an integrated package or, especially, as a tool to support the unique characteristics of a region. Figure 9.4 shows the generic architecture of an app that can support the integration of these technologies, properly linked between them. In general, the app should consist of the FOIs as entities containing the required information. To display the FOIs to the user, a map and an AR environment are utilized, in addition to

Table 9.1 Proposed responses to current requirements

Crucial concepts	Opportunities and limitations				Suggestions		
Information	Promotion of the area	Unique characteristics often overlooked	Target specific user groups or regions	Disparity of FOIs	Additional/pertinent information (temporal, historical)	Standalone app for a well-defined region	Proper taxonomy
Navigation and security	Hazardous environment	Lack of road network			Predefined routes	Maps of susceptibility	Alerts and suggestions
Visual occlusion/disorientation	Rugged terrain	3D vs. 2D	Mobile device's screen size		Viewsheds	AR	Appropriate design
Integration	Multiple data inputs	Useful services	Many available technologies		Standalone app for a region	All available technologies as one package	Content and services more suitable for visitors and region

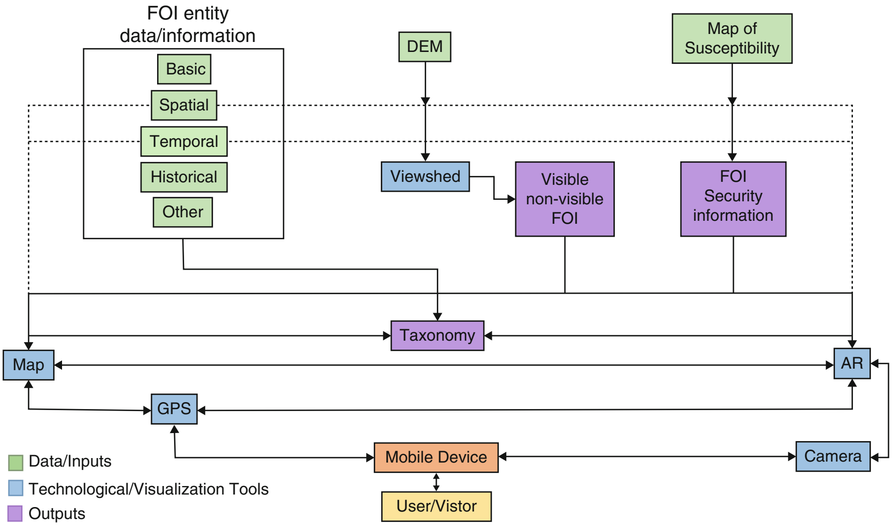

Fig. 9.4 The general architecture of the proposed app

an interface that presents further information (text, images, etc.). Viewshed analysis and maps of susceptibility are considered background processes for which there is no need to be shown to the user (unless the user desires). The selection of the desired FOIs may be implemented through a proper taxonomy that should be available in both visualization tools (map and AR).

9.4 Conclusions

Tourism apps can significantly ameliorate the visitor's experience. However, mountain regions exhibiting a significant natural and cultural heritage require some sorting of the available information displayed in the app. This information filtering can have multiple merits in both eliminating the vastness of undesired information (on the users' behalf) and in directing the attention toward the distinctive FOIs of the region by adding further pertinent content that will educate the visitors about the customs of the region or provide better environmental awareness. In this way, visitors may be prompted to connect with the genius loci, that is, the distinctive atmosphere or spirit of the place, something that can reveal latent information related to the unique natural and cultural mountainous environment and considerably enhance the touristic experience.

AR appears as an appropriate mode in attaining an upgraded touristic experience. Nonetheless, highland areas such as Zagori require a special treatment when it comes to managing and visualizing FOIs. The disorientation rise in 3D AR immersive environments and the visual occlusion caused by the rough topography need to be addressed for optimizing the effectiveness of mountain-oriented tourism apps. The embedment of 2D viewshed visualizations in an interlinked window greatly improves the awareness of both the location and of the broader geographic context, while also removing the limitation of visual occlusion resulting from the oblique perspective in egocentric AR environments. In this sense, FOIs that are occluded by the terrain in the oblique perspective are included in the 2D viewshed, being further classified as being visible or not visible from the observer's position. This implementation enables the app's graphical interface to include FOIs actually (currently) in view as much as potential FOIs while retaining a mixed 3D/2D perspective harnessing their combined advantages.

Yet, as it appears, the devil is chiefly in the integration. There is need to embed several data inputs and technological/visualization tools in a proper architecture to get the most of such an app. For the derived information content, navigation and visualization outputs to incite the users'/tourists' experience, it is of utmost importance to establish an interface that is easy to perceive and convenient to use. Integrating 2D viewshed visualizations in the AR display in a suitable interlinked manner depending on the portable device's surface is the key to an effective app. A larger device (e.g., tablet) could afford the inserting of viewsheds in the same display, whereas a smaller one (e.g., smartphone) should probably actuate a switch between 3D/2D views depending on the tilting (vertical: 3D/horizontal: 2D).

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Chapter 10
Sustainable Tourism in Mountain Destinations: The Perceived and Actual Role of a Destination Management Organization

Urs Wagenseil and Myrta Zemp

Abstract Mountain destinations face many challenges from local displacement, harsh climatic conditions, or strong competition. Sustainable tourism development is therefore crucial to maintain the natural and cultural resources, which often are the main capital of mountain destinations. This study has been conducted to find out how destination management organizations (DMOs) operate in sustainable tourism. Results show that the DMOs do not perceive themselves as leaders but rather the political stakeholders and service providers. Furthermore, the perceived role of DMOs in the context of sustainable development does not fully match with the role they actually play today. The DMOs often are present in rather operational tasks, even though they say that a DMO should also undertake strategic tasks such as developing a sustainability strategy. Strategic tasks, which would help managing sustainable development in a more efficient way, are often neglected. A DMO looking for enhancement of sustainable tourism needs to undertake additional tasks and therefore has to create sufficient resources to go forward. Only DMOs taking on responsibility can sustainably develop their destinations in the long run.

Keywords Mountain DMO • Sustainability • Roles • Responsibilities

10.1 Introduction

Mountain destinations often are situated in remote locations with harsh climatic and environmental conditions, which make these regions particularly vulnerable to inappropriate use practices (Kohler et al. 2012). Further challenges such as migration, obsolescence, and economic stagnation result in a decline of social structures as well as traditional lifestyles and consequently endanger the mountain destination diversity (Schweizerischer Bundesrat 2015). Hence, because of these challenges

U. Wagenseil (✉) • M. Zemp
Institute of Tourism (ITW), Lucerne University of Applied Sciences and Arts,
Rösslimatte 48, 6002 Lucerne, Switzerland
e-mail: urs.wagenseil@hslu.ch

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_10

and the fragile ecosystem of mountains (Veith and Shaw 2011), sustainable development is essential to make these locations viable in the long term (Alpine Convention 2013).

It is important to understand and undertake measures to protect these areas as mountains cover one fourth of the world's surface, provide a home for approximately 12 % of the human population, and provide fresh water to half the world's residents (Veith and Shaw 2011). In addition, besides agriculture and forestry, mountains also play a crucial role in tourism (Price et al. 2011). Every seventh person (approximately 13 % of the population) in mountain regions works directly or indirectly in the tourism industry (BAKBASEL 2014; OECD 2007). Tourism activities generate yearly around 50 billion Euros in the Alps (Agrawala 2007). There is no clear information about how many people yearly visit mountain regions; some research indicated that around 15–20 % of tourism flows traveled to mountain destinations (Debarbieux et al. 2014), whereas others counted 50 million visitors per year (Veith and Shaw 2011). However, the inrush of tourists is distributed unevenly: 40 % of the mountain communities have no tourism at all, but 10 % have an extensive and specialized tourism infrastructure (United Nations Environment Programme 2007).

Tourism, compared to other industries, has a unique connection to the environment and society. Environmental quality, social and cultural distinctiveness, security, and well-being provide the bases of a quality tourism experience, yet nonsustainable overdevelopment can destroy the key resources of tourism (Tourism Sustainability Group (TSG) 2007). For mountain destinations sustainable development should therefore have priority. Mountain tourism has to face several challenges that require long-term planning and sustainable development to overcome them.

The Tourism Sustainability Group (2007) defined sustainable tourism as it should embrace "concerns for environmental protection, social equity and the quality of life, cultural diversity and a dynamic, viable economy delivering jobs and prosperity for all" (p. 2). Therefore, not only the ecological but also the social and economic aspects have to be considered.

10.2 The Role of Destination Management Organizations in Terms of Sustainability

Even though there are several strategies a destination can pursue to cope with the challenges and global competition, it is often unclear who has to make such fundamental decisions. In case of destinations it is difficult to take strategic decisions, as there are plenty of stakeholders, such as service providers, authorities, tourists, and locals (Buhalis 2000; Presenza et al. 2005). Further, specific attributes of destinations that make the management of such entities difficult are listed as following by Morrison (2013): destination management organizations (DMOs) often are not the owners of the products and services offered in the destination; therefore, it is difficult to control them and to ensure high overall quality.

To overcome difficulties, DMOs have several different internal and external tasks to fulfill. The marketing functions that are often considered as the core tasks of these organizations belong to external functions, but internal functions contain other responsibilities such as visitor management, product development, leadership, and other organizational tasks (Morrison 2013). These internal tasks often require actions and resources from other stakeholders in the destination (Presenza et al. 2005). According to the authors Weber and Wehrli (2015), the DMO further needs to undertake the superior task of managing sustainability within the destination. Because sustainable development is a long-term issue, the management of a DMO needs to be considered as not only an operational but also a strategic task. As sustainability strategies are to be integrated in the overall destination strategy, the associated tasks should also be integrated in the classical tasks. Further, DMOs have to act as catalysts to change (Presenza 2005) and consider probable outcomes of issues as a base for product development (Wyss et al. 2014).

Stakeholder management and cooperation are considered to be the key elements of a successful destination management (Wyss et al. 2014; Bornhorst et al. 2010). This is even more important in mountain destinations, as traditionally there are small, individual (family) businesses; therefore, the offered products and services tend to be fragmented (Pechlaner and Tschurtschenthaler 2003). To ensure sustainable development, a DMO needs also to cope with the challenges such as lack of stakeholder participation and awareness (Waligo et al. 2013; Hoy et al. 2011). Raising awareness and providing knowledge about sustainability would be essential to win stakeholders to support sustainable tourism (Velleco and Mancino 2010). Once awareness is raised, DMOs and other authorities have to create tourism policies that elicit sustainable adaptation strategies (Pechlaner and Tschurtschenthaler 2003). Therefore, it is inevitable that destination managers have the knowledge and qualifications about sustainability issues, as so far often only personal conviction decides in favor of sustainable actions (Velleco and Mancino 2010). However, even if sufficient awareness is given, the implemented adaptation strategies might still not be sustainable. Stakeholders tend to rather focus on cost-saving processes (Velleco and Mancino 2010) or take sustainability measures for other benefits such as quality improvement, hazard prevention, or infrastructure protection (Wyss et al. 2014).

It is crucial to understand and that, even though DMOs cannot implement all actions on their own, they still should set a common direction for all stakeholders. They can do so by identifying the most important challenges for their destination and formulating strategic goals to address these issues (TSG 2007). Also, visitor education is a key element in successful sustainability management as tourists have to be aware about their impacts in a destination and have to understand their own responsibility in sustainable development (UNEP 2007). Thus, according to the literature, there are several tasks a DMO should undertake regarding sustainability. However, these tasks should not be treated as an independent, isolated unit, but rather should be integrated and incorporated in all other functions of the organization.

10.3 Data and Methods

To gain more knowledge about the perceived and actual role of DMOs in the context of sustainable tourism, the research design has been divided into a qualitative and a quantitative part. The goal of the twofold study was to compare sustainable mountain destinations with a broader sample of mountain destinations. A destination was considered to be successfully sustainable when it is either certified with a sustainability certificate (e.g., UNESCO), has been suggested by superior associations/organizations, or has been cited as best practices in terms of sustainable tourism.

In a first phase, guided expert interviews were conducted with exemplary sustainable destinations in the Alps, namely in Switzerland, Austria, Germany, and Italy (South Tyrol). The sample consisted of ten tourism directors and one product manager who is specialized in sustainable tourism products. With the goal to find out more about the experts' knowledge and experiences in terms of enhancing sustainable tourism, different guiding questions were asked and altered, depending on the answers given. Topics such as the motivation for and/or trigger of sustainable development, the roles played by the DMOs, strategic issues such as the development process of the sustainability strategy, as well as stakeholder management, were discussed. Finally, the experts were asked to give advice to destinations that want to reinforce sustainable development.

Having gained a broad range of insights from those interviews, which helped designing a subsequent questionnaire, an online survey was sent out to 27 Swiss, 72 Austrian, 6 German, and 9 Italian mountain destinations with average of at least 100,000 overnight stays per year between 2000 and 2013 and with more than five hotel businesses (BAKBASEL 2014, p. 13). The survey included similar but rather closed questions as the expert interviews, whereas the answer options were derived from the experts' statements.

10.4 Research Findings

10.4.1 Qualitative Expert Interviews

Although for some experts all three perspectives of sustainability (economic, ecological, and social) were of the same importance in the context of sustainable tourism, the economic perspective was identified as being the most important by the other experts. The explanation thereof was that if the (local) economy is not doing well, the social as well as the ecological aspects cannot be managed satisfactorily.

Further, various reasons to enhance sustainable development were offered: be it natural resources such as a nature park, cultural landscape, or unique diversity, the destinations decided to sustainably protect them. However, protection is not the same as preservation. According to the Executive Director of Bregenzerwald (Austria), the goal of sustainability is not to simply create conservational areas that no one is allowed to enter, but to protect sensitive areas as well as possible. She further confirmed the paradox between natural resources and tourism aforementioned by the TSG (2007): the tourism industry itself is taking advantage of the natural resources by making them accessible for tourists but is dependent on their existence at the same time. Therefore, the biggest challenge for the industry will be to make use of those resources in a resource-saving and responsible way to retain them as a major selling point of the destination. Another reason to promote sustainable development for the destination was to create a clear brand positioning and a point of differentiation. The Manager of the Biosphere Reserve Grosses Walsertal (Austria) claimed that becoming a sustainable model region is a great opportunity to establish the destination as a unique place with great potential. The Product Manager at the South Tyrolean Marketing Association (Italy) and the Manager of the UNESCO Biosphere Entlebuch (Switzerland) further claimed that sustainability is about creating added value for the tourists. Sustainability is no longer a "nice-to-have" feature, but it is more and more a standard requirement of tourists. Their increasing awareness for sustainability will be influencing future travel decisions. Further, for some interviewed destinations a certain event or happening lead the destination into a sustainable future: the director of the Mostviertel Region in Austria identified the application for a sustainability award as the initial point for several sustainable initiatives thereafter.

Asking the experts about the perceived role of the DMO within the context of sustainable development in tourism, several tasks were identified. Besides key activities, such as increasing the tourism demand or marketing a destination, a modern DMO needs to add functions in terms of sustainability. Taking responsibility can, for example, be observed in the organizational adjustments: The director of the destination Engadin Scuol Samnaun Val Müstair (Switzerland) has consequently established job positions assigned to sustainable tourism. Also, the South Tyrolean Marketing Association created a 100 % position for sustainable products and projects. For the CEO of the Lake Geneva Region (Switzerland), it also starts with internal measures. In his office, the staff is obliged to follow certain sustainability rules such as saving energy or printing documents only when needed. His intention is to not only save money thereby but to increase the awareness of sustainable behavior.

The collaboration with partners is a crucial issue for each DMO because the tourism industry is known as being very fragmented. However, a DMO should guide them in a specific direction in the long run to achieve common goals. One possibility is to create leader groups, as it is the case in Tegernsee-Schliersee (Germany). In collaboration with the strong stakeholders the DMO is able to create exemplary offers and carry out best practice projects. If a DMO manages to win strong and influential partners, more and more would want to get involved as a consequence ("snowball effect"). According to many experts, also the governments need to be considered as being highly influential. Examples in South Tyrol show that, according to the director of Merano Marketing, the government is forcing the topics of innovation and sustainability and therefore strongly encourages the destinations to follow sustainable development.

Awareness raising is to be considered as a further role of a DMO: the values of sustainability are either implicitly existing in the minds of the people already and/or are conveyed actively in the form of sensitization. For instance, in Villnöss (Italy) a wide range of frequent trainings is offered to various stakeholders. Besides this, the DMO also occupies the role of a communicator. Depending on the stakeholder group, various types of information need to be transferred. For instance, the director of Merano Marketing (Italy) is summarizing and prioritizing information for the service providers that he receives from the destination-wide marketing association. However, the communication of sustainability is not trivial, because it must be authentic and cannot just be misused for marketing purposes only. The DMOs should further play a strategic role in the sustainable development of the destination. A good example is the destination Allgäu (Germany): the DMO committed to take leadership by developing and managing a sustainability destination brand.

10.4.2 Quantitative Survey with Mountain DMOs

The quantitative survey was sent to 114 DMOs of mountain destinations within the European Alps. With a response rate of 29 %, the final sample of the quantitative population consisted of 33 respondents: 40 % of the DMOs consist of "5 to 15 full time employees (FTE)," therefore rather small organizations. The others varied from "under 5 FTE" (18 %), "between 16 and 25 FTE" (21 %), up to "more than 25 FTE" (21 %). When analyzing the overnight stays, the results showed that the destinations have evenly distributed seasons: 51 % of all overnight stays are generated in summer, the other half in winter. In terms of certifications, only 18.2 % of all respondents have a certificate on sustainability.

In the first part of the survey, the DMOs were asked about their understanding of sustainability in tourism: 55 % of all respondents said that all sustainability perspectives (ecological, economic, and social) are of the same importance. However, results show that for 24 % the economical and for 18 % the ecological perspectives are of highest importance. The social perspective was largely neglected as rated by 3 %. Further, the respondents were given terms related to sustainability that had been derived from the answers of the experts. The five terms most connected with sustainability were "scenery," "authenticity," "regional products," "local value creation," and "soft mobility".

Sustainable development is, for 61 % of all DMOs, a part of their mandate; however, only 36 % have created an explicit sustainability strategy. Almost 90 % of the DMOs have embedded sustainability within their own destination strategy. Of the 12 DMOs that have created an explicit sustainability strategy, the most involved actors in the strategy development process besides the DMO were the service providers as well as the governments. DMOs and governments are perceived to be the initiators and process leaders for implementing the sustainability strategy, whereas the service providers and the local population rather are contributors. The guests were almost neglected when developing the strategy. Regarding the overall responsibility of sustainable tourism, 91 % of the respondents think that the DMO should not take sole responsibility, but also the governments (29.7 %) as well as the service providers (24.2 %).

The DMOs were further asked if they have the skills and resources necessary to be a leader in sustainable tourism. In terms of skills, nearly two thirds (63.3 %) of the DMOs said that it largely/fully applies having the necessary skills to be a leader in sustainable tourism. In terms of necessary resources, more than half (51.5 %) said that it does (rather) not apply having them (see Fig. 10.1).

Reasons given for not having the necessary resources to be a leader in sustainable tourism were especially lack of financial resources (25.4 %), lack of time (17.3 %), and lack of personnel (14.7 %). Answers about building further resources for sustainable tourism showed that of 33 DMOs, only 5 have created extra job positions, of average 60 % by position.

To compare the perceived with the actual role of a DMO, the sample was first asked which of the following tasks an organization should undertake and which they are actually undertaking. Most of the DMOs think that "development & implementation of sustainable products" (24 %), "external communication" (23 %), and "support of service providers in development and implementation" (17 %) are the most important tasks. Comparing the answers with the exact roles the DMOs are actually undertaking, the most suggested tasks were almost the same. However, the percentages show that the variance between the perceived roles is higher than the variance between the actual roles; this means that the DMOs suggested to undertake more tasks than they do now and therefore should redistribute their resources from core tasks such as communication and product development to rather strategic tasks such as developing sustainability strategies or integrating locals in the topic (see Fig. 10.2).

Future steps planned for encouraging sustainable development are initiating sustainable projects in collaboration with the partners (22.8 %), developing own sustainable products and offers (18.5 %), as well as position and market the destination in the field of sustainability (17.4 %). Almost none (3.3 %) of the DMOs are planning to become certified in the future, and none is planning to implement a sustainability management system.

10.5 Discussion

One aim of the study was to highlight the gap between the perceived and actual role of a DMO within the sustainable development in mountain destinations. Analyzing the expert interviews and the surveys, some discrepancies can be observed.

The understanding of the DMOs about sustainability clearly demonstrates that not all sustainability perspectives have been rated as being of the same importance. Twenty-four percent of the respondents said that the economic perspective is the most important, which was also noted by some of the experts. This observation confirms that in economically difficult times with intensive (global) competition,

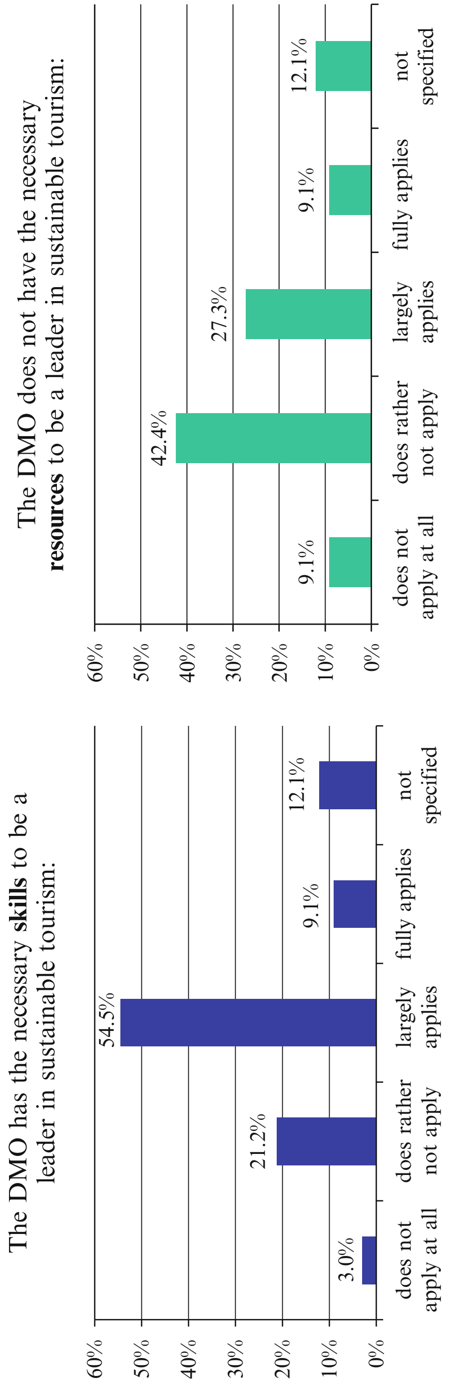

Fig. 10.1 Level of skills and resources of a destination management organization (DMO) regarding the leadership in sustainable tourism ($n = 33$)

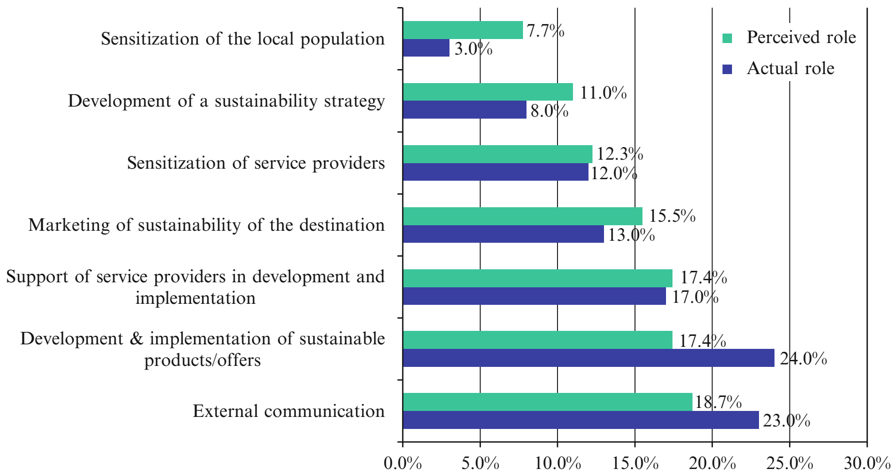

Fig. 10.2 Actual and perceived role of a DMO in sustainable development in the destination ($n = 33$)

the mountain destinations neglect a comprehensive understanding of sustainability and focus mostly on the economic perspective. The results further reflect the act between the economic and ecological perspective, which was rated to be the second most important perspective, as natural resources are fundamental for the tourism industry.

For 60 % of the DMOs, sustainable responsibility is a part of their mandate, which means that they are obliged to include sustainability in their business plan. However, when asking the DMOs about the leader role in terms of sustainable development, they interestingly do not perceive themselves as leaders. In fact, they see the governments and service providers as being more eligible for taking over leadership. DMOs further believe to be skilled enough but claim to have too few resources to assume the leadership. So far, only a small number of DMOs have created extra job positions for such additional tasks and activities, which is clear evidence that the DMO have not or could not attributed importance to it yet.

When asked about taking responsibility in terms of sustainable development in general, the DMOs see themselves still behind the governments and equally with the service providers even though the theory and experts advise to get in the lead. A surprising fact is that 50 % of all DMOs which incorporated sustainability in their mandate did not create an explicit sustainability strategy so far. The 45 % having a strategy involved various actors such as the governments and the service providers. The guests were hardly involved. This fact is notable, because one outcome of the expert interviews was that sustainability needs to be experienced by the guests. The low involvement of the guests in terms of strategy development raises the question if destinations really know enough about their guests in this context.

Comparing the perceived with the actual function of a DMO in the context of sustainable development, it can be observed that there is a gap between the two roles. In the core tasks of a DMO (e.g., increasing tourism demand), the DMOs are more active than they said a DMO should ideally be. On the other hand, they are less active in terms of sensitization of locals and service providers as well as development of a sustainability strategy than perceived. These tasks, which are rather neglected, are more of a strategic nature. To align the actual and perceived role of a DMO, the resources should be redistributed from the rather operational tasks to more strategic tasks. Therefore, the DMO will need to assume more functions than before, which makes the management more complex. Consequently, a DMO needs to create more resources to be able to handle the complexity and to strengthen the output regarding sustainable development of their destination.

10.6 Conclusions

Facing the challenges of mountain destinations, sustainability is key to positive growth in the future and creating a competitive advantage on a local and even global level. Therefore, the DMO has a crucial role in developing and implementing a sustainable development strategy. Being a strong leader in sustainable tourism, as well as taking responsibility toward various actors, are examples of how successful sustainable destinations cope. The modern DMO needs to play new and different roles, as well as to undertake additional and more strategic tasks. It is therefore crucial that DMOs more strongly embed sustainability on a strategic level within their organization and destination. Creating job positions and assigning responsible persons for the sustainable development are concrete solutions. This study further shows that the field of responsibility will grow even more and the overall role of the DMO will change accordingly.

Asking the experts about useful advice for destination leaders who would like to direct their destinations in a more sustainable direction, common answers were personal commitment, tenacity, and consistency. As a first step it is also recommended to define the term sustainability for oneself and to follow the principles personally. Furthermore, organizational changes are recommended to successfully embed the issue within the organization. It is crucial to understand that sustainability in tourism is not only a matter of the industry itself but also of surrounding players. Therefore, a DMO governance system can be useful. It defines the behavior of the organization toward various stakeholders, for example, the government. Becoming certified as a sustainable destination helps the DMO to further enhance the topic. As the experts advised, the DMO can certify the service providers within the destination by creating a guiding set of criteria. Giving the right incentives motivates the service providers to act sustainably and to share responsibility. A participative process involving all relevant stakeholders helps the DMO to broadly anchor sustainability. Last, the political levels should be involved as they can support the development. However, the public authorities should not be considered to be the leaders for a sustainable development in tourism: the DMO itself needs to take the lead. The subsequent implementation then could be done with classical public-private partnership activities and projects.

Many DMOs have already strategically anchored the topic of sustainability within their destination strategy; nonetheless, the study shows that their undertaken tasks are of rather operational nature. Rating the task of developing and implementing sustainable products as the most important raises the question about the definition of "sustainable products" created by a DMO itself. Further research is needed to define and evaluate this topic. However, a more strategic approach may be useful in many ways. It allows not only to manage the roles and tasks more efficiently but to acquire more in-depth knowledge in the field. For instance, a DMO could strategically manage the guests' expectations regarding sustainable experiences. Strategic partnerships with for example institutes of tourism to enhance knowledge may support the DMO's work.

Only DMOs that are willing to take the responsibility and to point intensively in the right direction for the entire destination are successful in enhancing a sustainable development of the destination. Therefore, the DMOs need to take a stronger lead and more responsibilities than they are doing at the moment.

Acknowledgments Tremendous thanks go to all the DMOs that have contributed to this study. For the expert interviews, the following destinations have helped to build a strong base for this study:

– *Switzerland:* Urs Wohler for Engadin Scuol Samnaun Val Müstair, Andreas Banholzer for Lake Geneva Region, Theo Schnider for UNESCO Biosphere Entlebuch

– *Austria:* Herlinde Moosbrugger for Bregenzerwald, Andreas Purt for Mostviertel, Christine Klenovec for Biosphärenpark Grosses Walsertal

– *Germany:* Bernhard Joachim for the Tourism Association Allgäu, Harald Gmeiner for Alpenregion Tegernsee-Schliersee

– *Italy (South Tyrol):* Johanna Torggler for the South Tyrol Marketing Association, Thomas Aichner for Meraner Land, Klaus Messner for Villnöss

Thanks to all DMOs responding to the online survey or having supported the study in other ways:

– *Switzerland:* Adelboden, Aletsch, Arosa, Bellwald, Disentis Sedrun, Engadin St.Moritz, Engelberg, Gstaad, Haslital, Interlaken, Kandersteg, Obergoms, Samnaun, Toggenburg

– *Austria:* Achensee, Gastein, Lech Zürs am Arlberg, Lieser-/Maltatal, Mühlviertel, Region Graz, Region Hall-Wattens, Salzburger Lungau, Salzkammergut, Seefeld, St. Anton am Arlberg, Wiener Alpen in Niederösterreich, Wipptal

– *Germany:* Ammergauer Alpen, Berchtesgadener Land, Garmisch-Partenkirchen, Reit im Winkl

– *Italy (South Tyrol):* Eisacktal, Kronplatz, Seiser Alm, Südtirol, Vinschgau

Finally, we express our gratitude to all the staff involved in the study of the Institute of Tourism at the Lucerne University of Applied Sciences and Arts: Laura Unyi, Anna Bernhard, and Angela Steffen.

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Part IV
Mountain Ecology, Risks and Protected Areas

Chapter 11
Biodiversity Protection of the Forest Ecosystems on the Base of Representative Geoecosystems

Zita Izakovičová and László Miklós

Abstract The chapter presents the new concept of forest ecosystem protection in the Slovak Republic. The concept is based on the evaluation of the potential and real representative geoecosystems (REPGES). Geoecosystems are particular entities bearing elements of geoecodiversity: they represent a certain landscape–ecological unit. Individual types of the REPGES have been determined on the basis of zonal (bioclimatic) conditions, most often represented by the vegetation zones in landscape, and azonal conditions, primarily quaternary geologic ground and relief, secondary soils, and levels of underground water. In all, 120 types of the REPGES were determined in the Slovak Republic. They were evaluated on the base of their current state of maintenance, endangerment, and protection.

Keywords Forest ecosystems • Representative geoecosystems • Natura 2000 • Stress factors

11.1 Introduction

Forests, apart from their production of biomass, are also very important for fulfilling various ecological and environmental functions (Jurko 1990). They contribute to the regulation of landscape–ecological phenomena and processes. They protect landscape biodiversity and stability, they participate in the protection of other landscape-forming components (natural resources), and above all in the protection of water and soil resources. Their role in the defence against manifestations of natural risks and hazards, especially erosion and accumulation processes and landslides, and in overall environmental protection is irreplaceable. Concerning the fulfilment of

Z. Izakovičová (✉) • L. Miklós
Institute of Landscape Ecology, Slovak Academy of Sciences,
Štefánikova 3, 814 99 Bratislava, Slovakia
e-mail: zita.izakovicova@savba.sk

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_11

ecological and environmental functions in the landscape, forest ecosystems have two basic categories: protective forests and forests of special assignment. Protective forests fulfil ecological functions important from the point of view of the protection of other landscape components such as soil, water, and lower-situated growth. Among the forests of special assignment are those in protected areas, zones of hygienic protection of water resources, minerals, and medicinal waters, suburban forests, forests adjudicating therapeutic and health functions, approved game forests and pheasantries, forests damaged by emissions, recreational forests, and the like. Purpose-bound forests (protective and those of special assignment) require a special regime of management ensuing from their established functions. At present, protective forests in Slovakia cover 17 % of the territory, and the area of forests with special assignment is 15.3 % of the total area of the forest pool (Správa ... 2014).

In spite of the irreplaceable function of forest in landscapes, forest resources of Slovakia are constantly threatened by several stress factors. The most serious ones include excessive logging, replacement of original forest growth by monoculture, shrinkage of forest ecosystems caused by the sprawl of the technosphere, threats ensuing from the development of recreational activities, and the effects of various anthropogenic (production of foreign substances, etc.) and natural (biotic and abiotic) factors. Emissions are the most important anthropogenic factors causing damage to forests. Biotic factors include first of all the leaf-eating and sucking insects, wood borers, bark eaters, different kinds of putrefaction, tracheomycosis, and game, and wind, draught, and black frost are among the abiotic factors.

Even in spite of these negative effects, there exist important and valuable forest ecosystems in Slovakia. A seminatural forest, which reproduces in a natural way with a species composition only slightly different from that of a natural forest, represents about 40–45 % of the total area of forest in the landscape. We also have here more than 70 fragments of natural forest and virgin forest. Species composition is characterised by the prevalence of broad-leaved wood species (58.8 %), and the share of coniferous forests is 41.2 %. Introduced species also occur, but their area does not increase with the exception of the expansive black locust; its area is 1.72 % (Správa ... 2009, 2013).

Speaking about landscape biodiversity and stability protection where forest ecosystems are significant, it is indispensable to preserve the broadest scale and diversity of natural forest ecosystems (The Pan-European Biological and Landscape Diversity Strategy 1996). Researchers at the Institute of Landscape Ecology SAS worked out a model for the preservation of the representative geoecosystems (Miklós et al. 2006) with the final objective to assess the present situation and protection of landscape geoecosystems of Slovakia against threats.

The aim of this chapter is to present an approach to the assessment of representative forest ecosystems of Slovakia and evaluation of the present situation in their exploitation, protection, and hazards.

11.2 Materials and Methods

The basis for the protection of biodiversity of forest ecosystems must be not only the preservation of the diversity of individual life forms but also preservation of the variability of conditions. From this aspect, it is important to recognize and map the individual types of forest ecosystems, their abiotic conditions, which are the determining factors of their frequency and development, as well as the factors (stress factors) threatening both the individual life forms and their life conditions. As far as the protection of representative forest ecosystems is concerned, cognition of their spatial representation is also important.

Representative geoecosystems (REPGES) are comprehensive landscape–ecological units characterised by a set of abiotic components (of lithosphere, hydrosphere, and atmosphere) and biotic components (vegetation including the biogeographic aspects). A system of representative potential geoecosystems (REPGES) on the supraregional level at a scale of 1:500,000 (Miklós et al. 2006) has been developed for Slovakia. The aim was to prepare a systemic scheme for the strategy of protection for life forms and life conditions on the level of the state, in other words, a list that contains all strategically important forest geoecosystems of the SR to preserve and protect all valuable and representative forest ecosystems.

The basis for the delimitation of units was the choice of potential vegetation units and properties of abiocomplexes. Hence, the potential REPGES express the potential state of landscape free of any human interventions. In this way they provide information on what types of forest ecosystems originally existed in the territory of Slovakia. Subsequently, the REPGES were reassessed based on the present use, the existing real vegetation, and the species composition of forest. The result is the picture of the present state of their conservation.

Individual types of the REPGES in the Slovak Republic have been determined on the basis of Miklós et al. (2006):

- Zonal (bio-climatic) conditions, most often represented by the vegetation zones in landscape. They are characterized according to the bio-conditions, which are expressed in their complexity in nine zones of potential vegetation.
- Azonal conditions, primarily Quaternary geologic ground and relief, secondary soils, and levels of underground water, which are divided into 37 types (Atlas SSR 1980).

In a real landscape, these conditions are expressed in a very complex way and they cannot be separated. The zonal conditions in a region cannot be changed at all, whereas azonal, such as soils, water forms, and relief, can, through investment of a certain amount of energy, be partially changed or affected.

Many potential REPGES have been considerably changed when their potential vegetation has been replaced either by agro-associations, urban ecosystems, or eventually secondary forest. The next step for specification of the real forest geoecosystems is the evaluation of this current state of the potential geoecosystems, their maintenance and endangerment. The assessment of the overall alteration of REPGES was based on the synthesis of an index of ecological quality of a spatial structure, which reflects the rates of natural, seminatural, and man-created ecosystems and their landscape–ecological significance, and an index of originality of flora associations, which reflects the rates of natural associations in the studied area. Protection of forest ecosystems was calculated on the base of percentage of protected areas.

11.3 Results and Discussion

In the Slovak Republic, by territorial synthesis azonal and zonal conditions have been determined altogether as 120 potential forest REPGES types. The REPGES types have a character of potential geoecosystems, because they have been determined based on abiotic conditions that represent a certain potential for the development of forest geoecosystems and are characterized on the basis of potential vegetation.

Over history, man has distinctly interfered in the structure of forests particularly by taking in and deforesting the forest ecosystems and changing them into arable land. Massive intensification of agriculture came in times of collectivisation and socialisation. It meant deforestation, land consolidation, dryout, alteration of the hydrological regime, and the like. Increased use of heavy machinery led to the removal of the remaining vegetation, and the landscape gradually changed into the deforested, landscape–ecologically unstable, and heavily exploited agricultural landscape (Ružičková et al. 1996).

Apart from deforestation, intensified agriculture caused the disappearance of some representative forest ecosystems, above all in geographic regions with favourable natural conditions for the development of agriculture, namely, in the lowland and plain relief with the most fertile soils and encouraging climatic (warm) conditions. Examples of Slovak regions so affected include the lowlands and hill lands of the Danube Plain, Danube Hill Land, East Slovakia Flatland and Hill Land, South Slovakian Basin. Ecosystems in mountain basins were also markedly affected (Basins of Zvolen, Rožňava, Žilina, Košice, Turiec, Basin of the River Hornád, and the Sub-Tatra Basin).

Regarding the change of forest ecosystems into agroecosystems, the REPGES of river floodplains, proluvial cones, loess tablelands and hill lands, big plains, lowland or basin foothill depressions with alluvial forests, bog alder woods, oak-hornbeam or turkey oak woods changed because of the development of massive agricultural production. Arable land dominates here as it covers more than half of the area.

Urbanisation and industrialisation also significantly interfered with the natural structure of REPGES. The negative outcome was not only the occupation of the area of natural ecosystems by technical objects but also production of pollutants, dust, and radiation, which affected the natural development of many ecosystems. As in agriculture, urbanisation and industrialisation anthropogenic activities altered most the lowlands and basins and particularly river floodplains, terraces, proluvial cones, big plains, loess tablelands and hill lands, polygenic hill lands, or dissected pediments.

The overall level of changes in forest ecosystems has been assessed by means of two basic indicators:

- *Coefficient of ecological quality of spatial structure*, which stands for the representation of natural, seminatural, and man-created ecosystems and their landscape–ecological significance.
- *Coefficient of naturalness of forest associations*, which expresses the share of representation of natural associations in a given REPGES. The higher the value of the coefficient, the higher representation of natural associations in a REPGES, hence the higher their ecological quality. The mean value of the coefficient of naturalness for the total territory of Slovakia is 14.68 %.

From the spatial point of view the territories with the most acceptable ecological quality are the mountainous areas with high representation of natural ecosystems; the opposite, with the least acceptable ecological quality of spatial structure, is that of lowlands: the Danube Plain, Danube Hill Land, East Slovakian Flatland, south Slovakian basins, Lower Moravian Dell, Valley of the River Váh, and the like. The dominant element of landscape structure here are large blocks of arable land or urbanised areas. Adverse ecological quality of spatial structure is also found in basins (Zvolen, Turiec, Žilina, Žiar, Pliešov, etc.) where the share of ecostabilising elements does not surpass 30 % of total area.

In terms of the coefficient of naturalness of plant associations, low values have been also identified in regions with a high level of forestation, but these are secondary forests with markedly changed species composition: the Valley of the River Váh, the Upland of Turzov, Beskydy Upland, Borská Lowland, Valley of the Upper Hron, Oravské Beskydy Mts., Kozie Chrbty Mts., Moravsko-Sliezske Beskydy Mts., etc.

More than half of the natural ecosystems were found in 13 REPGES, which are mostly located in mountainous and areas with difficult access such as those in the Veľká Fatra Mts. Kremické Mts., Levočské Mts., Skorušinské Mts., Oravské Beskydy Mts., and partially also in the High Tatras and Low Tatras. Many of them contain biotopes of national and international importance.

Based on the REPGES protection assessment and analysis of the rate of NATURA 2000 components in the individual REPGES, the following general conclusions have been made (Miklós et al. 2006):

(a) Of lowland types of forest REPGES, no protection is provided for some dominant types in terms of area, ecology, production, and economy, such as loess tablelands, and highlands, terraces, and proluvial cones. Of these types, the areas protected with degrees 4 and 5 of protection can be found only rarely. Often this is not caused by the protection of some characteristic structure of the type, but more often because of the occurrence of different curiosities and anomalies; this is because these areas are intensively used for agriculture and therefore are not particularly interesting for the “traditional” nature protection.

(b) With regard to lowland types of REPGES, the most often protected areas are wetlands, alluvial forests, sand dunes, and plains, which traditionally have been attractive for nature protection.
(c) The last declared Landscape Protected Area (Dunajské Luhy Flood-Plain Forests) is located on the lowland. This designation is evidence that the former "lack of concern" for these territories is hopefully a matter of the past and suggests a shift of nature protection from the traditional cultural-natural-historical approach to the ecological angle.
(d) Up to now, there has not been any individual basin declared as a protected territory. The someone's "protected" basins have become protected as a by-product of national parks planning, thanks to the legislation, which gives the same degree of protection to buffer zones as to landscape protected area. It is necessarily said that someone's basins are very important geographic units of Slovakia.
(e) Upland and hilly types of REPGES are quite well incorporated into the network of protected areas. Traditionally, karstic types enjoy the largest and best protection. Because of the broadmindness concerning the area of protected territories declared, the flysch REPGES types on the virtually whole verge of External Carpathian Arch have a very good protection, including the klippen zone, where the individual klippen can be protected in the degrees 4 and 5 (the highest degree of nature protection in Slovakia).
(f) Traditionally good protection is also typical for the forest REPGES types of mountain and high-mountain types, particularly in degree 3 of nature protection (national parks).
(g) Although the types of forest REPGES such as lower hills and uplands, submontane uplands and forelands of rolling landscape have lower degrees of protection, from the ecological point of view they are very important in terms of the area and bio-production.
(h) A similar situation has been observed in the case of the components of NATURA 2000, where protection is also predominantly focused on attractive forms of biota – endemic, rare, endangered, and similar types, reflected in the high overlapping with the current network of the protected areas.

11.4 Conclusion

Forest geoecosystems can be characterized on the level of topical (local), choric (regional), and planetary dimensions. Therefore, the foregoing criteria should be judged on a specific hierarchical level of the territory. For example, within a studied basin the geoecosystem occurring only in this basin within the whole landscape, or even if it is an endemic one, it can be considered the representative one for this basin. The key criterion for the definition of a hierarchical level of a geoecosystem is its spatial landscape–ecological relevance, that is, to be a spatial expression at least on the topical level (in other words, they have to have a map scale expression). The determination of the hierarchical level is a basic step of defining the representativeness of a forest geoecosystem. It is obvious that each part of a landscape, each natural or administrative territorial unit, each region, has its representative geoecosystem. In general:

- The same type of geoecosystem can be representative for several territorial units (including neighbouring ones) without losing its representativeness.
- The same type of geoecosystem can, in different (bio)geographic regions, have the certain specific features (especially different elements of flora and fauna) that could have a decisive influence on the geoecodiversity of the landscape.

It can be derived from the foregoing that each territorial unit has a representative geoecosystem, and each type of forest geoecosystem is the representative one somewhere (i.e., a certain territorial unit exists with the representative occurrence of the given type of geoecosystem). The strategic aim of the representative geoecosystem is as follows:

- To define a representative geoecosystem for each territorial unit on the given hierarchical level: regional principle
- To define a representative occurrence for each type of forest geoecosystem: typological principle.

Identification and characteristics of the types of representative forest geoecosystems have been proposed as a strategic scheme for the systemic plan of maintenance of representative life forms and life conditions in our country. In practical terms it should serve as an ecologically backed-up systemic basis for proposing new protected areas (pursuant the analysis in which representative geoecosystems are not sufficiently protected), for strengthening and management of the protection of forest ecosystems as well as for the systemic proposing of biocentres and biocorridors at supraregional and regional levels. The base of biocentres should precisely consist of individual forest REPGES, and the ecological networks should be conceived in a way that provides for the greatest representativeness possible of individual forest ecosystems. Elaboration of REPGES at scale 1:50,000 has created a nationwide base for the territorial planning documents prepared under a single methodology and based on individual credible source materials. These source materials will be passed on and provided to those who prepare spatial planning documentation, a step that avoids double funding of the preparation of this part of documentation. In this way, a fundamental stage for the assessment of ecological stability, and expert source materials, have been created for the preparation of projects concerned with land consolidation.

Acknowledgements This paper was prepared within the scope of the Research Project APVV-0669-11: Atlas of the Archetypes of the Slovak landscape.

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Chapter 12
Predicting the Potential Distribution of *Ailanthus altissima*, an Invasive Terrestrial Plant Species in Măcin Mountains National Park (Romania)

Ines Grigorescu, Monica Dumitraşcu, Gheorghe Kucsicsa, Mihai Doroftei, Mihaela Năstase, and Carmen-Sofia Dragotă

Abstract Under current global change conditions, invasive species show an increasing tendency to spread over larger areas in close relationship with their triggering environmental driving forces. Current research is seeking to assess the potential distribution of the invasive terrestrial plant species (ITPS) *Ailanthus altissima* in a natural protected area, the Măcin Mountains National Park (II IUCN category). The protected area is located in the southeastern part of Romania, sheltering a combination of Pontic, steppe, and well-preserved sub-Mediterranean and Balkan forest ecosystems. The authors propose a geographic GIS-based quantitative statistical analysis (potential distribution model, ITPS-PODISMOD) of *A. altissima* using bivariate analysis that takes into consideration the relationship between variables, such as *A. altissima* as the dependent variable and its driving factors as independent variables. Concurrently, each driving factor was ranked depending on the relationships between the analysed species and its ecological conditions. Thus, an ITPS-PODISMOD map displaying areas with different potential distribution of *A. altissima* in relationship to the key environmental driving factors has resulted.

Management Plan of Macin Mountains National Park, approved by Government Decision no. 1074/2013

I. Grigorescu (✉) • M. Dumitraşcu • G. Kucsicsa • C.-S. Dragotă
Institute of Geography, Romanian Academy,
12, Dimitrie Racoviţă Str., Sector 2, 023993 Bucharest, Romania
e-mail: inesgrigorescu@yahoo.com

M. Doroftei
Danube Delta National Institute, 165 Babadag Str., 820112 Tulcea, Romania

M. Năstase
Protected Areas Department, National Forest Administration – Romsilva,
9A Petricani Str., sector 2, Bucharest 023841, Romania

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_12

Keywords Invasive terrestrial plant species potential distribution model (ITPS-PODISMOD) • *Ailanthus altissima* • Măcin Mountains National Park • Romania

12.1 Introduction

Biological invasions range among the most critical ecological environmental and social threats to biodiversity, human health, and ecosystem services, especially under the intensification and diversification of global environmental change-driven impacts (Charles and Dukes 2006; Bailey et al. 2007; McGeoch et al. 2010), thus becoming key components of global change (Shea and Chesson 2002; Arim et al. 2006) through their high adaptive capacity that enables them to penetrate natural geographic barriers or political boundaries (Richardson et al. 2000; Anastasiu and Negrean 2005; Anastasiu et al. 2008; Andreu and Vila 2010). Invasive species are renowned for their remarkable spatiotemporal dynamics, thus becoming successfully established and spread over extended areas in Europe, causing major environmental and socioeconomic damage (Pyšek and Hume 2005; Lambdon et al. 2008), especially in protected areas, where they disturb habitat structure and functioning. In Romania, investigations of adventive species with a systematic and floristic character were synthesised by Săvulescu and Nyárády (1957–1972), Ciocârlan (2009), and Sîrbu et al. (2011). During past years, an increase of neophytes has been estimated (Anastasiu and Negrean 2005; Oprea and Sârbu 2010); thus, currently the adventive flora of Romania includes more than 671 species (17.2 % of the Romanian flora), of which 112 are considered invasive (Sîrbu and Oprea 2011). The current research is to be an important step in developing GIS-based modelling techniques for the assessment of the potential distribution of *Ailanthus altissima* (hereafter *A. altissima*) in relationship to the key environmental driving forces.

Ailanthus altissima ("tree of heaven") is a well-known invasive tree in many parts of the world, with an excellent ability to establish in natural and degraded sites where it can reduce biodiversity and change the abiotic characteristics of the invaded ecosystems (Vila et al. 2006; Badalamenti and La Mantia 2012). A deciduous tree originating in China, it was introduced into Europe in the second half of the eighteenth century as an ornamental plant. Ever since then it has spread all over Europe (Sîrbu and Oprea 2011), especially in the Mediterranean basin (Traveset et al. 2008). The species has a capacity for increased spreading and growth. It is known for its allergenic pollen and the toxic substance its bark and leaves produces (allelopathic) that prevent the establishment of other plant species (Feret 1985; Lawrence et al. 1991; Badalamenti and La Mantia 2012). It also shows increased tolerance to abandoned fields, railroad embankments, wastelands, and other disturbed sites, as well as to a wide range of pH conditions (Feret 1985) and extreme weather phenomena, such as drought (Trifilo et al. 2004). In naturally forested areas, it may establish in areas disturbed by storms, infestations related to insects, or even forest fires (DiTomaso et al. 2006). In Romania *A. altissima* was introduced as an ornamental tree and for the protection of degraded and inclined terrain (Sîrbu and Oprea 2011).

The control of this species is rather difficult because the mechanical eradication method stimulates resprouting from the remaining trunk and roots (Burch and Zedaker 2003); therefore, this method must be combined with chemical control techniques (Meloche and Murphy 2006). In Măcin Mountains National Park, the tree of heaven mainly affects the grasslands, forest outskirts, and disturbed sites by competing with and displacing the native vegetation.

12.2 Study Area

Măcin Mountains National Park is located in the southeastern part of Romania (North Dobrogea Massif) in the Steppic biogeographic region (Fig. 12.1). It hosts a complex flora and fauna in a mixture of Pontic, steppe, and well-preserved sub-Mediterranean and Balkan forest ecosystems (e.g., Luncaviţa beech forest, a Tertiary relict).

The Park is the only protected area in Romania sheltering old Hercynian Mountains with low altitudes (467 m maximum altitude; Ţuţuiatu Peak) and a mountain-like aspect, underlain by granites and crystalline schists (Fig. 12.2).

Măcin Mountains National Park was established in 2000 (II IUCN category – National Park), also including two scientific reserves, *Moroianu* and *Valea Fagilor*, which overlap SPA Măcin-Niculiţel and SCI Munţii Măcinului under the Natura 2000 European Network in Romania. The protected area covers a total surface of 11,321 ha, hosting 187 bird species (60 % vulnerable or rare), 41 mammalian species, and 11 reptile species that have been identified and protected under the Berna Convention; there are also 72 rare vascular plant species (Petrescu 2004). Among of the protected species are *Vipera ammodytes montandoni*, *Elaphe quatorlineata*, *Testudo graeca ibera* (Fig. 12.3), *Celtis glabrata*, *Achillea ochroleuca*, *Campanula romanica*, and *Dianthus nardiformis* (Fig. 12.3).

12.3 Integrated Methodology and Data

In the current research assessment the authors carried out comprehensive cross-referencing of the geographic and biological scientific literature coupled with complex investigations of the spatial data (e.g., GIS processing of the most relevant spatial input: topographic map, soil map, DEM, aerial photographs) and statistical data, as well as field surveys following a stepwise approach which included several succeeding stages (Fig. 12.4).

ITPS mapping and geospatial database elaboration on A. altissima and the related driving forces relied on various sources covering both raster and vector information at different scales (Table 12.1).

To achieve more accurate information, GPS (global positioning systems) measurements were conducted as well. The resultant mapped areas do not represent

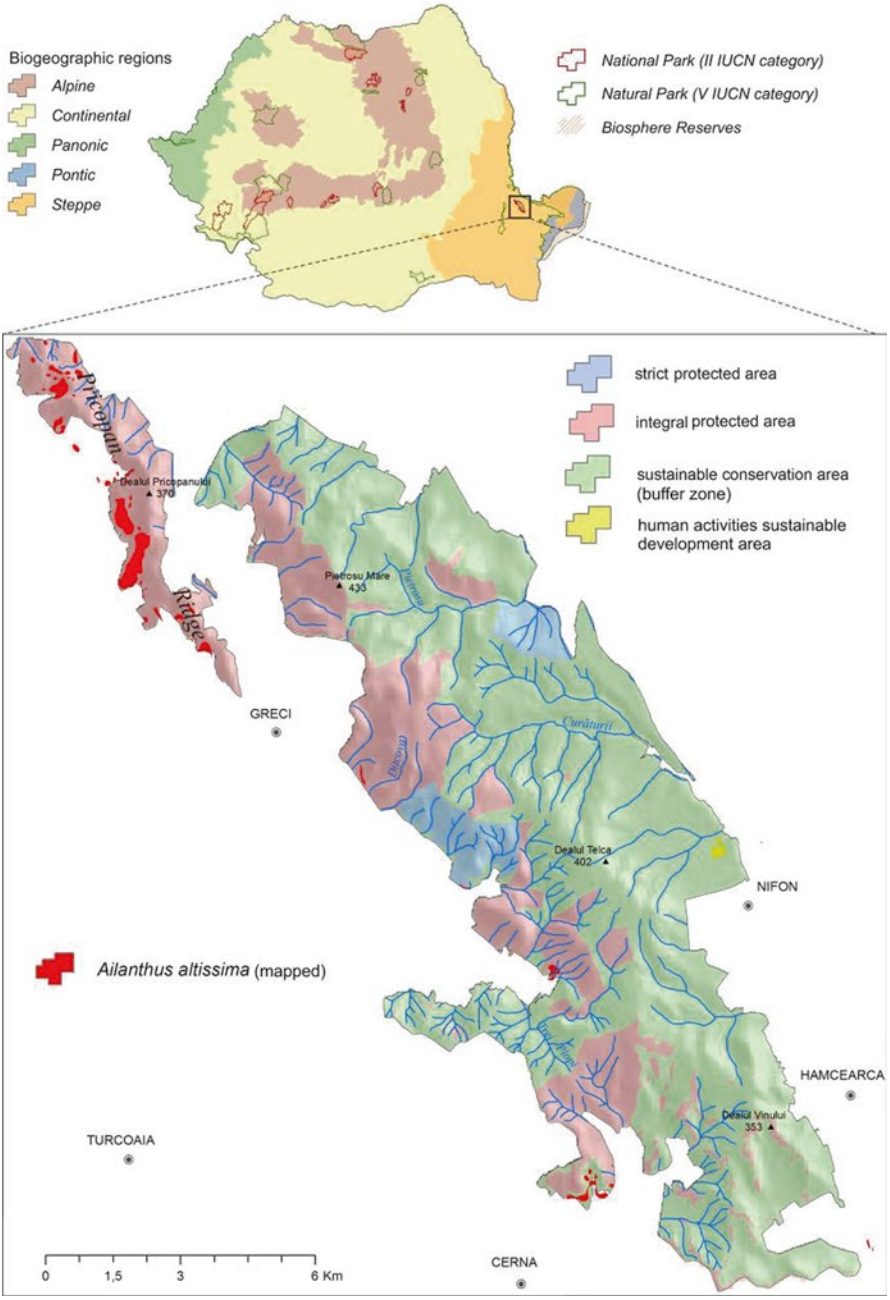

Fig. 12.1 Location of Măcin Mountains National Park in the major Romanian protected areas network and the distribution of *Ailanthus altissima* (mapped areas) in relationship to protected area zoning

Fig. 12.2 Pricopan Ridge in Măcin Mountains National Park (Photograph courtesy of Gheorghe Kucsicsa)

Fig. 12.3 *Dianthus nardiformis* and *Testudo graeca ibera* in Pricopan Ridge (Photograph courtesy of Gheorghe Kucsicsa)

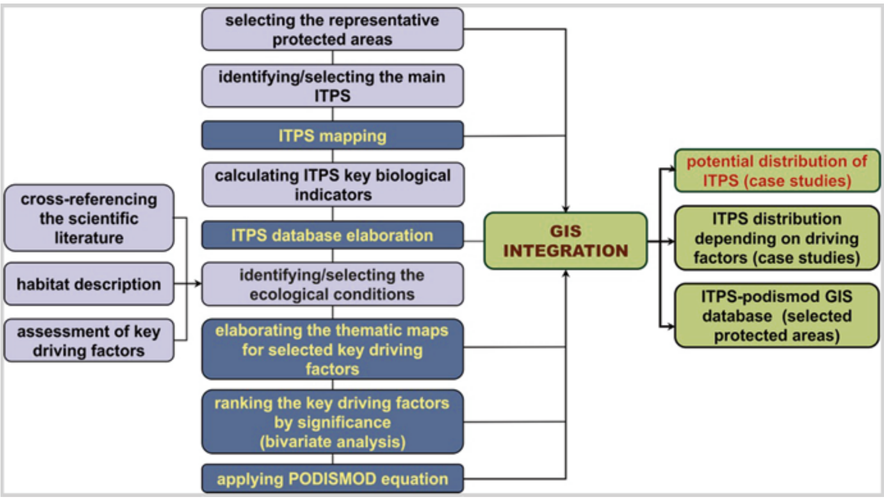

Fig. 12.4 Integrated methodology for the assessment of potential distribution of invasive terrestrial plant species (ITPS)

Table 12.1 Raster/vectorial sources and derived information

Layer	File type	Scale, resolution	Processed by
Soil type (S_T)	Vector	1:200,000	Soil map
Soil texture (S_{TXT})	Vector	1:200,000	Soil map
Land use/land cover (LUC)	Vector	1:100,000	Corine Land Cover database (2006)
Derived layers			
Hypsometry (H)	Raster	30 m	DEM
Slope exposure (S_E)	Raster	30 m	DEM
Slope declivity (S_D)	Raster	30 m	DEM

areas entirely covered with the identified invasive species as they display different coverage/abundance of the analysed ITPS within various habitat types. Moreover, key biological indicators (abundance, coverage, frequency) were computed. The information was then stored in the GIS environment as polygon and point geo-data types, based on which a ***GIS-based model (PODISMOD– ITPS)***, seeking to predict species spreading potential, was developed (Kucsicsa et al. 2013). The focal aim of the model was to identify similar ecological requirements of species in various habitat types (other than in the areas where the species were originally found) to assess the distribution potential in a certain region (Dumitraşcu et al. 2014). Several driving forces (e.g., pedological, geomorphological) were analysed, of which those with direct and indirect impact on species distribution and spread were selected. Consequently, based on the interactions between ITPS and their ecological requirements, *thematic maps* displaying the selected key driving forces triggering species development and spread were elaborated (e.g., soil type, soil texture, land use).

Two of the main steps of the ITPS assessment were *to rank and to weight the key driving factors by importance* using *bivariate analysis*, taking into consideration the relationship between two variables, that is, *A. altissima* (the dependent variable) and its driving factors (the independent variables).

The *rank (R)* values derive from the ratio values (*r*) calculated using the frequency analysis between pixels representing the *A. altissima* location and the total number of pixels representing each class of driving factors. For uniformity of results, the values were represented in percent, calculated depending of the total sum of the ratio values. Thus, the mathematical relationship can be expressed as follows:

$$\mathrm{R} = (r \times 100) / \sum r \tag{12.1}$$

$$r = p / t \tag{12.2}$$

where *r* is the ratio, *p* represents the number of pixels with ITPS (presence), and *t* represents the total number of pixels of driving factor class.

Consequently, the resulted values were grouped into five classes, based on which the authors were able to establish the ranking of the selected driving key factors to complete the potential distribution of species (very low, low, medium, high, and very high).

Assigning the *weight (W).* Not all selected driving factors can be categorized as having equal weight in ITPS distribution. In the study area, it was observed that the development of *A. altissima* is conditioned to a larger extent by soil type and to a smaller extent by slope exposure. As a result, driving forces classification based on weight (W) assignment is essential as it relies on both on expert judgement attribution based on specialist knowledge and expertise and on the scientific literature. Depending on the relationships between the ecological conditions and ITPS, each driving factor was evaluated on a 1 to 3 scale, higher values being assigned to the most important ones in the ITPS distribution. The final index was computed based on grid-type information, according to the following mathematical operation:

$$\mathbf{PODISMOD} = \mathbf{S}_{\mathbf{T}WR} + \mathbf{S}_{\mathbf{TXT}WR} + \mathbf{LUC}_{WR} + \mathbf{H}_{WR} + \mathbf{S}_{\mathbf{D}WR} + \mathbf{S}_{\mathbf{E}WR}$$

where PODISMOD = potential distribution model, R = rank, W = weight *(1…3)*, and $\mathbf{S_T}$, $\mathbf{S_{TXT}}$, **LUC, H,** $\mathbf{S_D}$, $\mathbf{S_E}$ = selected driving factors.

Finally, comparative graphs showcasing the spread of *A. altissima* in the mapped areas in relationship to PODISMOD spatial distribution classes were constructed.

12.4 Results and Discussion

Spread and habitat description of *A. altissima.* In the study area, the species was identified and mapped on 110.5 ha, mainly in the northwestern part, namely, the northern slope of Pricopan Ridge, close to Cheia Peak (260 m) and southwest of Pricopan Hill Peak (370 m) (Fig. 12.5). Significant areas were also mapped in close proximity to Cerna locality, on the southern slope of Şeaua Mare Ridge (northeast of Cerna locality, at the southwestern extremity of the Park area), and on Valea

Fig. 12.5 *A. altissima* invading natural pastures on the slopes of Pricopan Ridge and on abandoned arable land (Photograph courtesy of Gheorghe Kucsicsa)

Table 12.2 *Ailanthus altissima* recorded in different types of natural and seminatural plant communities/Natura 2000 habitats

Vegetation units	Plant community (Natura 2000 habitat type)
Slopes	*Quercetum pedunculiflorae* Borza 1937 (**91I0***Euro-Siberian steppic woods with *Quercus* spp.)
Broad-leaved forests	*Tilio tomentosae – Carpinetum betuli* Doniţă 1968 (**91Z0** Moesian Silver lime woods)
Open areas	1. *Medicagini minimae – Festucetum valesiacae* Wagner 1941; 2. *Botriochloetum* (*Andropogonetum*) *ischaemi* (Krist. 1937) Pop 1977; (**6250** *Pannonic loess steppic grasslands)
Rocky areas	1. *Agropyro – Thymetum zygoidi* Dihoru (1969) 1970; 2. *Festucetum callieri* Şerbãnescu 1965 apud. Dihoru 1969; 3. *Agropyro-Kochietum prostratae* Zólyomi (1957) 1958, (**6240** *Subpannonic steppic grasslands)
Sparsely vegetated areas	1. *Agrostetum stoloniferae* (Ujvarosi 1941) Burduja 1956; 2. *Agrostideto-Festucetum pratensis* Soó 1949; 3. *Ranunculo repentis – Alopecuretum pratensis* Ellmauer 1933, (**6510** Lowland hay meadows *(Alopecurus pratensis, Sanguisorba officinalis*)

Plopilor (north of Trei Plopi Valley) and Valea Jug slopes (northeast of Greci town) in broad-leaved forests, open areas, slopes, rocky areas and sparsely vegetated areas (Table 12.2).

In relationship to Park zoning, of the entire mapped surface with *A. altissima*, 80 % overlaps the *integral protected area*, 11 % the *sustainable conservation area (buffer zone)*, and only 0.5 % the *strict protected area*. The species was also recorded outside the Park area (8.5 %), close to its boundaries, thus representing a potential threat to protected area ecosystems (Fig. 12.1).

In relationship to the analysed driving factors, the areas mapped with *A. altissima* overlap and intersect various environmental conditions. In the study area *A. altissima* tolerates different environmental conditions, from sunny and semi-sunny slopes (94.4 %), with slopes ranging from 5° to 20°, to open areas or natural grasslands (65 %). It also prefers some specific soil types (litosoils and kastanozeoms) and textures (loamy and clay loam) with a high mineral content, thus proving the species preference for contaminated and degraded terrains (Table 12.3).

The tendency of *A. altissima* to develop within certain habitat types allowed the authors to select eight key areas for in-depth investigations where relevant biological indices were applied. The results revealed species preference for open areas (croplands) and semi-sunny slope exposure, driven by the highest abundance values registered in Strigoaie Valley (western slope of Pricopan Ridge). On the other hand, the lowest values are registered in the Carada Valley (southwest of Ditcova Valley/ Valea Ditcova), where the forest-covered areas do not represent a favourable habitat for *A. altissima*. In terms of frequency, Toader Mocanu (northern slope of Pricopan Ridge) and Izvoarele Valleys (western slope of Pricopan Ridge) rank first because of the rather reduced declivity and favourable soil texture, which enabled the development of a wider variety of phytocoenosis, whereas Carada Valley and

Table 12.3 Distribution of *A. altissima* on the mapped areas in relationship to the key environmental driving factors

By hypsometry (m)	**%**	**By declivity (°)**	**%**	**By slope exposure**	**%**
<50	2.9	<5	1.5	Shadowed slopes	5.6
50–100	26.3	5–10	29.2	Semi-shadowed slopes	36.3
100–150	42.5	10–15	23.1	Sunny	58.1
150–200	23.6	15–20	24.6		
>200	4.7	>20	21.5		

By soil type	**%**	**By soil texture**	**%**
Chernozems	1.0	Clay loam	34.1
Fluvisols	2.3	Loamy	41.2
kastanozeoms	28.2	Loamy sand …loamy	2.9
litosoils	37.1	Sandy	0.0
Grey-luvic phaeozems	3.7	Varied texture	21.7
Haplc chernozems	6.0		
Haplic luvisols	0.0		
Rocky areas	21.7		

By land use[a]	**%**
Discontinuous urban fabric	0
Mineral extraction sites	0
Nonirrigated arable land	6
Vineyards	0
Pastures	5
Land principally occupied by agriculture, with significant areas of natural vegetation	2
Broad-leaved forests	13
Natural grasslands	65
Sparsely vegetated areas	9

% = percent of total invasive terrestrial plant species (ITPS) mapped
[a]According to the Corine land cover (2006)

Cozluk Valley (southwest of Teica Hill/Dealul Teica) display the lowest rates from the reduced diversity of phytocoenosis (Fig. 12.6).

The coverage indicator shows more balanced values between the analysed test areas, ranging between 1 (the lowest) in Toader Mocanu, Strigoaie, Carabalu (south, southwest of Greci town) and Cozluk Valleys and 3 (the highest) in Largă Valley (western slope of Pricopan Ridge). La Chernoagă (northern slope of Pricopan Ridge), Carada, and Izvoarele Valley display mean values of this biological indicator (Fig. 12.6).

PODISMOD *A. altissima*. To apply the potential distribution model for *A. altissima*, six key driving factors were taken into consideration: *soil type*, *soil texture*, *land use/land cover*, *hypsometry*, *slope declivity*, and *slope exposure* (Table 12.4).

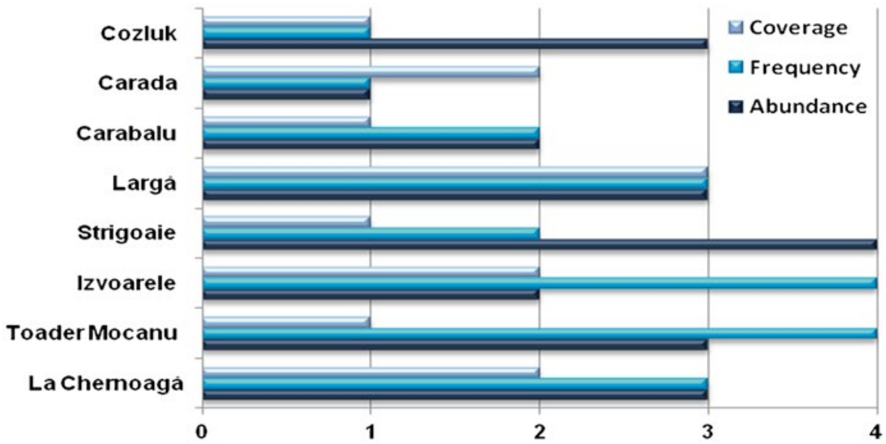

Fig. 12.6 Biological indices for *A. altissima* in Măcin Mountains National Park

Table 12.4 The selected key drivers of *A. altissima* and the assigned weight values (W)

Driving forces	S_T	S_{TXT}	LUC	H	S_D	S_E
W	3	2	2	1	2	3

PODISMOD Values. The application of the bivariate statistical analysis in the study area revealed that the low and very low potential distribution covered 60 %, especially on the eastern and northeastern slopes of Măcin Mountains where large oak, hornbeam, ash and linden forests are found. Areas displaying medium potential distribution cover nearly 26 %, mostly found on the upper slopes of the Valea Plopilor and Cerna basins. Medium values overlap areas located near Dealu Vinului (323 m) and along Pietrosu and Curătura valleys.

High and very high potential distribution covers 14 % of the Park area, on the western and southwestern slopes of Măcin Mountains, predominantly on the southern half of Pricopan Ridge, Şaua Mare Ridge, Moroianu Hill and forest glades (Fig. 12.7).

Comparing the plots where *A. altissima* was found with the spatial distribution of the PODISMOD classes indicated that 70 % of the mapped areas overlap the high and very high potential distribution, whereas approximately 5 % match with low and very low potential values (Fig. 12.8).

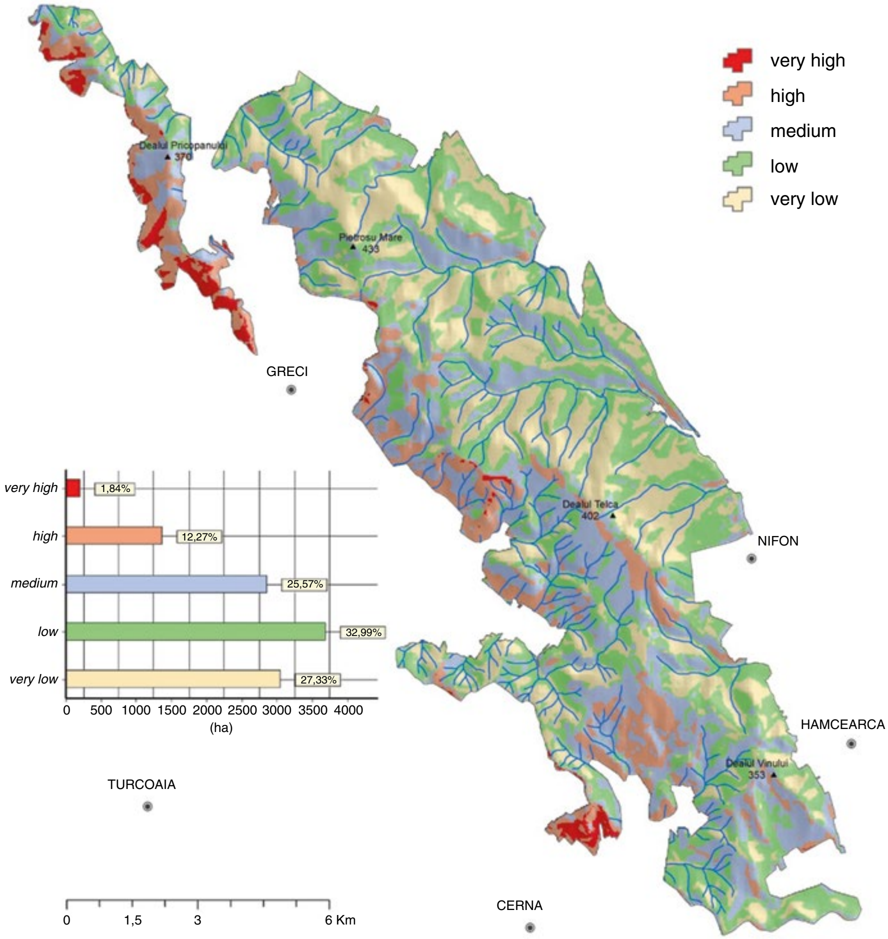

Fig. 12.7 PODISMOD of *A. altissima* in Măcin Mountains National Park

12.5 Conclusions

Relating the mapped areas of *A. altissima* to the habitat requirements of the species, in terms of natural and human-induced environmental conditions, allowed the authors to develop a spatial model that could identify areas with different distribution potentials. The overall PODISMOD analysis relies on spatial grid data, which had led to the generalisation of information, depending on the chosen pixel size. Hence, selection of the best resolution depending on the scale of the thematic maps considered (driving factors) and species mapping accuracy become the important

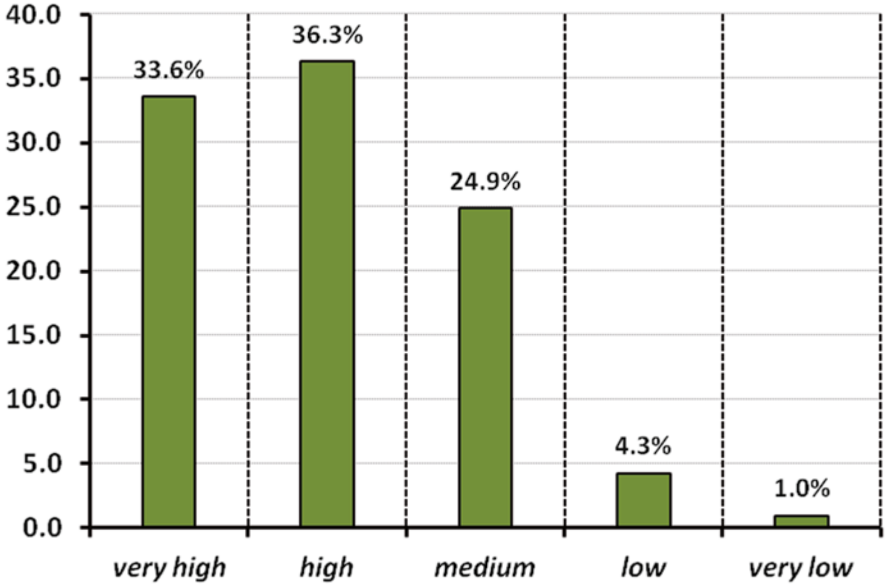

Fig. 12.8 Distribution of *A. altissima* (mapped areas) in relationship to PODISMOD

issues to be taken into consideration. Similar to other GIS-based methodologies, the current one can, to some extent, provide fairly accurate results, mostly in relationship to the scale and surveying year of the topographic maps used. Regarding the field surveys, in some cases accessibility is limited by the different local relief conditions or the lack or insufficiency of infrastructure. As a result, it is recommended to perform joint field campaigns with the personnel of protected areas (rangers, biologists, foresters) who have good knowledge of the local environment.

The final output of the current study will become an essential tool for decision makers in biodiversity conservation and invasive species monitoring, especially in protected areas.

Acknowledgments The current research was undertaken in the framework of the EU FP7 – Building Capacity for Black Sea Catchment Observation and Assessment System supporting Sustainable Development (EnviroGRIDS).

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Chapter 13
Determination of the Landscapes Regulation Capacity and Their Role in the Prevention of Catastrophic Events: A Case Study from the Lom River Upper Valley, Bulgaria

Daniela Avetisyan, Bilyana Borisova, and Roumen Nedkov

Abstract Floods are among the most dangerous natural disasters that threaten large territories in Bulgaria. The assessment of flood risk provides valuable information for environmental management. An important part of this assessment is the determination of landscapes flood regulation capacity. The study area is a small basin in the upper valley of the Lom River. The capacities of the landscapes to regulate floods were assessed through investigations of water retention functions of different natural components. Features of vegetation, land use, soil, orohydrography, and relief were considered. Each feature influencing the landscape regulatory functions was given a weight coefficient. To achieve more precise assessment, we combined field methods and remote sensing. The MODIS NDVI 250 m Multi-Temporal Imagery Dataset for the period 2008–2014 and widely accepted indices such as NDVI (Normalized Difference Vegetation Index), NDWI (Normalized Difference Water Index), and VCI (Vegetation Condition Index) were also applied. Thematic maps showing the regulating service capacity of each of the investigated components and that of the landscapes were generated, and a final assessment was made. In the study area, the natural landscapes of the Biosphere Reserve "Chuprene" and landscapes with different degrees of anthropogenic load occur as well. This work contributed the comparative characteristics of these two major landscape classes to be performed so that the main factors affecting their surface runoff regulation capacity could be determined.

D. Avetisyan (✉) • R. Nedkov
Space Research and Technology Institute, Bulgarian Academy of Sciences,
Acad. G. Bonchev str. Bl.1, Sofia 1113, Bulgaria
e-mail: davetisyan@space.bas.bg; rnedkov@space.bas.bg

B. Borisova
Department of Landscape Ecology and Environmental Protection, Sofia University,
15 Tsar Osvoboditel Blvd., Sofia 1504, Bulgaria
e-mail: bilyana08@gmail.com

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_13

Keywords Landscape regulation capacity • Remote sensing and GIS • Northwestern Bulgaria

13.1 Introduction

Floods are unfavorable natural phenomena that can be accompanied by pronounced and long-term negative consequences for human health, natural balances within a territory, and economic activity, natural heritage, and cultural heritage. Flood prevention and mitigation of their negative impact demand purposeful forms of impact structured in a system for management of flood risk (2007/60/EC). An important factor in this process is the analysis of a wide range of natural factors, the prerequisites for flood formation, and also factors favoring the regulating and self-restoration capacity of natural systems.

This case study is focused on landscape flood regulation capacity. The study is an attempt for a complex assessment of flood regulation capacity based on the analysis of landscape structure elements that reduce the possibility of flood occurrence and favor resistance of landscape structure for mitigation of the negative impact of floods on natural balances within a territory. Such an approach is directly related to the contemporary concept of ecosystem (landscape) goods and services and requires an introduction of some important methodological and terminological clarification in the text.

13.1.1 Flood-Regulating Ecosystem Services

Ecosystem services (ES) may be defined as “the benefits people obtain from ecosystems” (MA 2005). The concept of ecosystem services is defined as “an approach widely discussed to clarify and to assess the dependence of human society on ecosystems and landscapes” (Bastian et al. 2012, p. 7). Its expanding application is provoked by the increasing severity of ecosystem degradation (Boyd and Banzhaf 2007). The high potential of this concept may be explained by its transdisciplinary nature, integrating both natural science-based and socioeconomic science views and approaches (Müller and Burkhard 2007).

According to de Groot (2006), regulating functions of ecosystem correspond to potential of natural and seminatural landscapes for supporting and balancing important ecological processes and systemic interactions by biochemical cycles and other landscape processes. Same authors (de Groot et al. 2002) suggest a classification system of ecosystem services in which flood-related ecosystem services are “flood prevention” and “drainage and natural irrigation.” Flood-regulating ecosystem services depend to a great extent on structure of landscapes, dynamics of the evolution, and functional purpose (for economic utilized landscapes). Among them, characteristics of landscape spatial structure, content, and proportion of individual components in it have a leading position. Typical examples are the presence of forest vegetation, natural wetlands, relevant soil drainage, and the anthropogenic modifications of terrain. For that reason, we consider the research approach in analysis and assessment of ecosystem regulation services as very important.

13.1.2 Spatial Units for Assessment of Ecosystem (Landscape) Regulation Services

Ecosystem (landscape) services are permanently occurring system functions, qualities, features, or results (including material results) of systemic interactions. Therefore, for their unequivocal identification it is necessary the analysis to be focused on the system producing them (Borisova et al. 2015). In our study, we perceive the complex systems–landscapes to be spatial units. Landscapes provide a highly informative base for analysis of systemic characteristics that may be considered as "goods and services" (Willemen 2010) and their dependences in different spatial and temporal scales.

For the purposes of the assessment, a coherent analysis in respect to the interrelationships between watersheds, landscapes, and habitats was applied. An additional argument for such a decision is that high natural heterogeneity takes place within the investigated territory, which reduces the possibilities for application of land cover type-related approaches for assessment of ecosystem services widely used until now (Burkhard et al. 2009, 2012). Such assessment has been applied for analysis and assessment of flood-regulating ecosystem services in case studies in Bulgaria (Nedkov and Burkhard 2012; Boyanova et al. 2014).

13.1.3 Indicators for Assessment of Ecosystem (Landscape) Flood Regulation Services

Methodology concerning analysis and assessment of ecosystem services is highly controversial and requires further development. There are many methodological proposals (Kienast et al. 2009; Fisher et al. 2009; Haines-Young et al. 2012), which variations are mainly being explained with differences in interpretations of ecosystem services (actual and potential), in understanding of benefits that they provide, characteristics of the derived output database, resolution of conducted analysis and assessments, etc.

From the position of the landscape functions concept, Bastian et al. (2012) suggest a methodological frame for assessment of ecosystems and landscapes based on three pillars: (1) ecosystem properties - the description and analysis of ecosystem and landscape properties (structure, processes, biophysical functioning); (2) ecosystem potentials - the derivation of ecosystems and landscapes potentials to provide services;

and (3) ecosystem services- the definition and valuation of services for creating a human benefit. This framework allows making a clear distinction between the potential to supply services, their actual capacity, and demands of these services by humans. We share the view of Bastian et al. (2012) that clarification of the assessment focus is of great importance for achievement of unambiguous results and their application.

This case study is focused on analyzing individual landscape structure elements and characteristics (vegetation, land use, soil, orohydrography, relief) and on their role in formation of total landscape flood regulation capacity. In the study, remote sensing methods have been applied. The MODIS NDVI 250 m Multi-Temporal Imagery Dataset for the period 2008–2014 was used, and the widely recognized indices NDVI (Normalized Difference Vegetation Index), NDWI (Normalized Difference Water Index), and VCI (Vegetation Condition Index) were calculated.

NDVI measures the amount of green vegetation. The NDVI ratio is calculated by dividing the difference in NIR and red color bands by the sum of the NIR and red color bands for each pixel in the image (Jones and Vaughan 2010). Healthy vegetation absorbs most of the descending visible light and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. The formula can be expressed as follows (Jensen 2000):

$$NDVI = \frac{\rho_{\mathrm{NIR}} - \rho_{\mathrm{RED}}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{RED}}} \tag{13.1}$$

where ρ_{NIR} and ρ_{RED} indicate the reflectance of the near-infrared and red bands, respectively.

The precise determination of the forest vegetation species by applying a landscape map in combination with the ability of NDVI to separate the healthy vegetation from the unhealthy contributes to an accurate assessment of forest vegetation condition and to a more adequate assessment of its regulating capacity.

Vegetation condition is highly dependent on drought processes. In the study area and particularly in lower-located karst territories, there are evidences of increasing drought severity. The processes related to it reduce the natural regulating abilities of vegetation. For that reason, flood regulation capacity assessments that consider such processes are needed. VCI is a vegetation index that provides an accurate quantitative estimation of weather impact on vegetation and makes available drought studying not only in areas with well-defined, prolonged, widespread, and very strong droughts but also in areas characterized by very localized, short-term, and ill-defined droughts. VCI can be expressed as follows (Kogan 1995):

$$VCI = \frac{NDVI - NDVI_{\min}}{NDVI_{\max} - NDVI_{\min}} \tag{13.2}$$

where $NDVI$ is the current value and $NDVI_{\min}$ and $NDVI_{\max}$ are the maximal and minimal values of NDVI, respectively.

Water is one of the most common limitations causing drought. The Normalized Difference Water Index (NDWI) is a satellite-derived index from the Near-Infrared (NIR) and Short-Wave Infrared (SWIR) channels and is proposed for remote sensing of vegetation liquid water from space. NDWI can be expressed as (Gao 1996; Nertan et al. 2013):

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR} \tag{13.3}$$

where *NIR* and *SWIR* are the spectral reflectance measurements in the near-infrared and short-wave infrared regions of the electromagnetic spectrum.

Combined application of the aforementioned vegetation indices together with landscape data enables evaluation of landscape flood regulation capacity and determination of functional zones, which allowed separating of landscapes with distinctive qualities concerning floods regulation and their spatial location within the watersheds and against territories vulnerable to destruction.

13.2 Materials and Methods

13.2.1 Study Area

The study area is located in the northwestern part of Bulgaria. It covers an area of 285 km^2 (Fig. 13.1) and occupies parts of the northern slopes of the West Balkan Mountain and the Fore Balkan. The average elevation is 1112 m. The climate is temperate-continental, characterized by relatively warm summers and cold winters. The mean annual temperatures vary between 10.4 °C and 5.6 °C. The annual precipitation ranges between 727 mm and 1164 mm (NIMH-BAS, Climate Almanac of Bulgaria 1983a). The mountainous character of the region predetermined intensive extreme precipitations concentrated in certain parts of the catchment area. The inner part of the area is drained by the Chuprenska River and the western part by the Stakevska River. Both of them are tributaries of the Lom River, which drains the eastern part of the area. The river network of the area was formed in seven sub-watersheds. The Chuprenska River has a mean annual runoff of 1.37 m^3/s with a maximum value in April (2.47 m^3/s) and a minimum value in August (0.41 m^3/s). The Lom River has a mean annual runoff of 0.72 m^3/s with a maximum value in May (1.6 m^3/s) and a minimum value in August (0.33 m^3/s). The Stakevska River has a mean annual runoff of 2.02 m^3/s with a maximum value in April (4.06 m^3/s) and a minimum value in August (0.44 m^3/s). The maximum runoff in lower territories is distinguished with the most frequency in April (41 %; Chuprenska River) and in the mountain belt this maximum is in May (57 %; Lom River) (NIMH-BAS, Hydrological Atlas of Bulgaria 1983b).

The soils in the case study area are represented by six main soil types. The highest mountainous part is covered by Umbrisols (0.12 %) and Mollic Cambisols

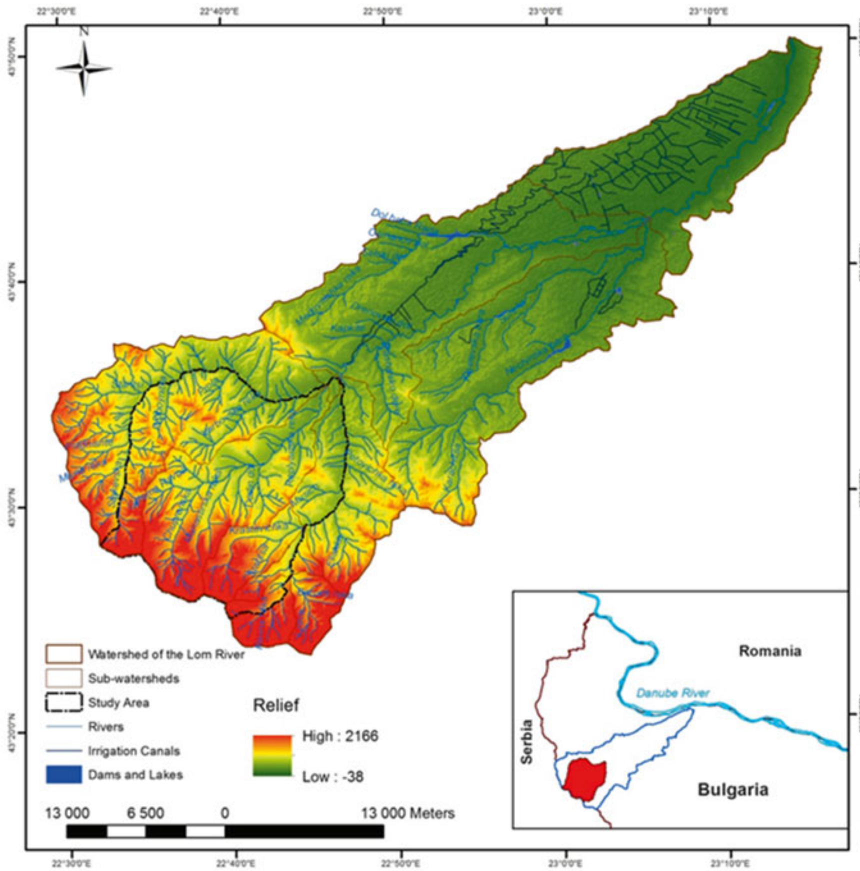


Fig. 13.1 Location of the study area

(2.28 %). Umbrisols are characterized with the presence of a peat horizon, soil organic matter (SOM) content more than 10 %, and medium texture. They are well drained and permeable soils. Mollic Cambisols are distinguished with a peat–humus horizon, a sandy loam texture, SOM content between 10 % and 20 %, and a litter layer more than 10 cm thick. Cambisols are predominant in the territories above 1000 m (43.15 % of the area), and Luvisols in the lower lands (43.21 %). Cambisols have a silty-clay loam texture and high content of SOM. Luvisols contain more clay, so their infiltration capacity is lower than that of the previous mentioned soil types. Luvisols have the finest soil texture. There are also two intrazonal soil types. Rendzinas occupy carbonate terrains (6.91 %), and Fluvisols are developed in river valleys (3.43 %). Rendzinas are shallow, with a high amount of gravel and stones. Fluvisols are characterized by a loam texture.

The territory is dominated by forest land cover (63 %). Deciduous forests cover 50 % of the territory, mixed forests about 9 %, and coniferous forests about 41 %, respectively. *Fagus sylvatica* forests occupy the largest area (26 %). Cultivated lands occupy 30 % of the territory, located mainly in the northern part of the area and near the rivers. The category "land principally occupied by agriculture with significant areas of natural vegetation" (27 %) covers a relatively large area, separated on the base of CORINE classification. Grasslands and pastures comprise about 21 % of the area, woodlands and shrubs cover about 10 %, perennials about 5 %, and settlements about 2 % of the area.

13.2.2 Data Collection and GIS-Based Modeling

See Fig. 13.2.

13.2.3 Assessment Approach

13.2.3.1 Flood Regulation Necessity

In the year 2014, Bulgaria was exposed to various catastrophic events. Most numerous and destructive among them were floods. The area that is the subject of the recent study was affected by floods twice. The first one was on 19.04.2014, and the second one only a few days later, on 24.04.2014. The damage caused by these extreme events affected many homes. Dozens of residents were evacuated. There was damage to road infrastructure and arable lands as well.

The main factors for flood formation in mountain regions are torrential rains and the mountainous relief, which facilitates fast downstream movement of the swelling river. The extreme precipitations that occur in the region have "patchy" spatial distribution with highest rainfall values in separate parts of the territory. This phenomenon is clearly depicted on Fig. 13.3 on which the results of the hydroclimatic factor index calculating are shown. This index interprets the impact of river network density in combination with the characteristics of climatic elements on surface runoff in every single watershed of the area, and by its application we try to assess the flood regulation necessity. The climatic elements taken into account in calculating this index are average air temperature, sum of precipitation, and evapotranspiration sum for the months with the highest risk of floods (April, May, and June), which furthermore are distinguished by the maxima of precipitation sum and snowmelts. The climatic data used are from the Joint Research Center of European Commission and cover the period between 2008 and 2013. Analysis shows that the sub-watershed II (Fig. 13.3) has the highest index value, which assumes that this sub-watershed forms most of the surface runoff and has the greatest need of regulation. Sub-watershed II, located in the western part of the area, also has high index values. The eastern sub-watersheds generate less surface runoff because they are located in territories with a "rain shadow effect."

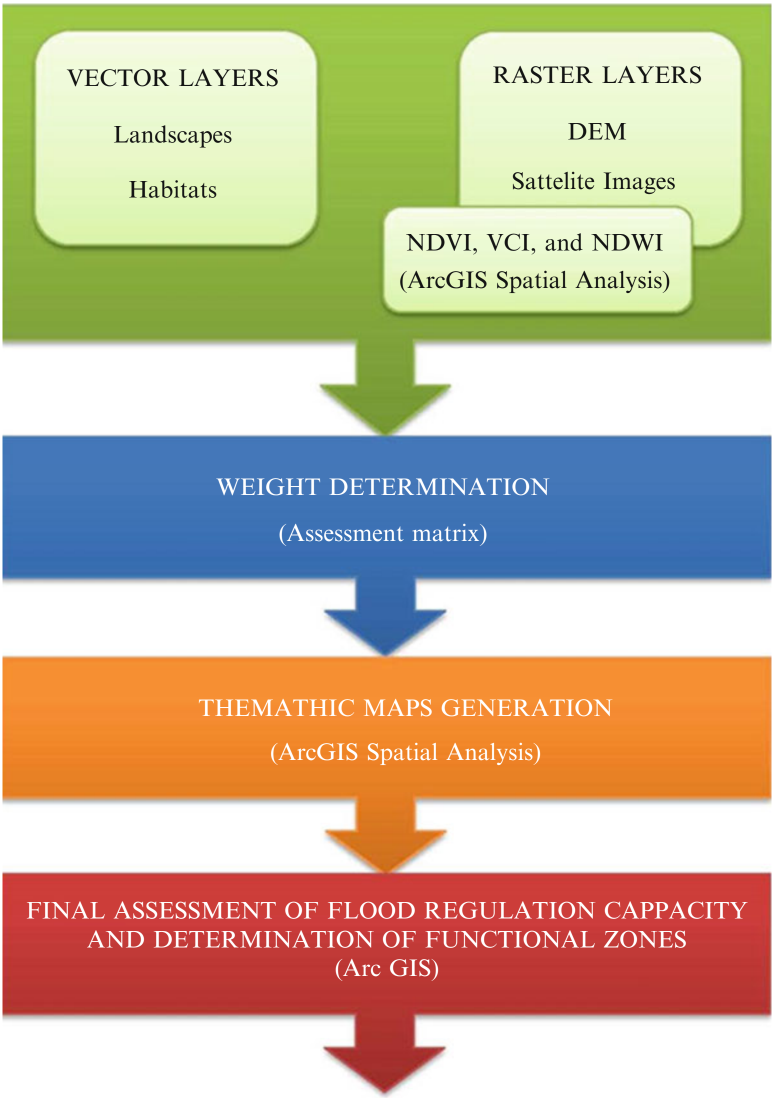
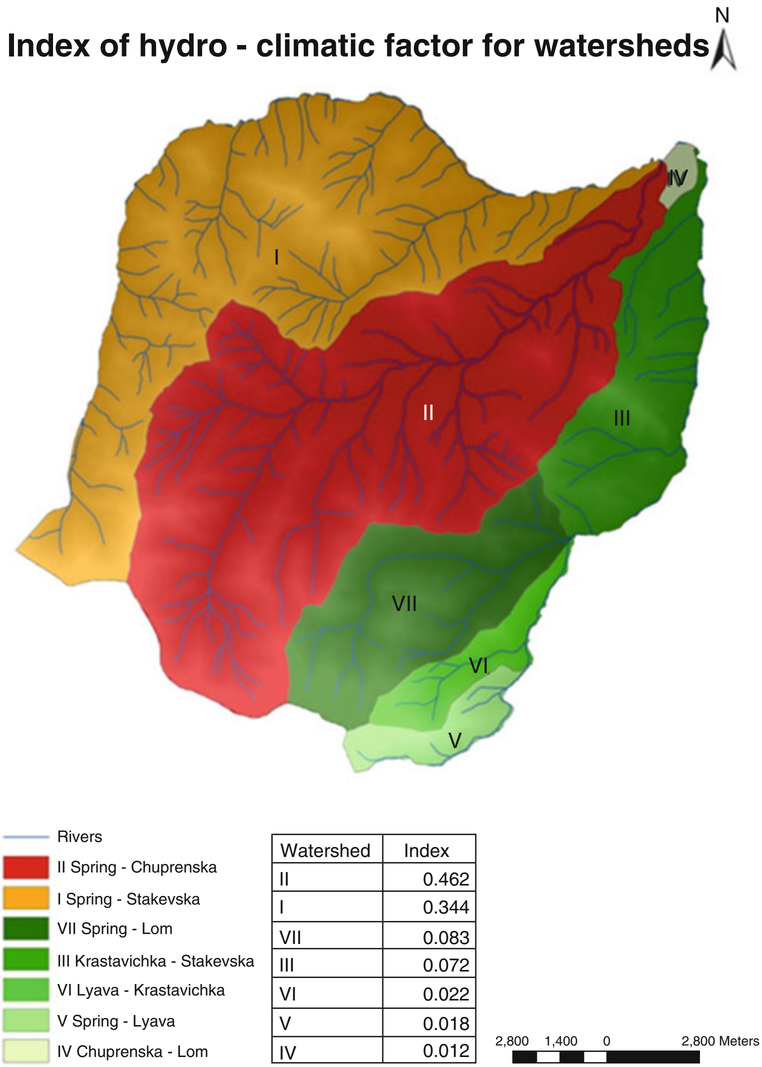


Fig. 13.2 Overview of the most important steps

13.2.3.2 Indicators for Assessment of Landscapes Flood-Regulating Capacity

Assessing the flood regulation capacity of landscapes (Fig. 13.4) is a complicated task because of the nature of landscapes manifested by the complexity of the systems they are actually representing. Systems contain various components connected in a specific way and incorporated by constantly ongoing functional processes.



Watershed	Index
II	0.462
I	0.344
VII	0.083
III	0.072
VI	0.022
V	0.018
IV	0.012

Fig. 13.3 Index of hydro-climatic factors for watersheds

Flood regulation capacity depends on different factors. On the one hand these are internal factors such as surface parameters (slope steepness, soil texture, presence or absence of litter horizon, soil organic matter content, vegetation type and condition, etc.) and functional processes (interception, infiltration, retention), and on the other hand such external factors as rainfall quantity and intensity, seasonal state of vegetation, and initial soil saturation.

When assessing the flood regulation capacity of landscapes it is necessary to select these landscape components and structural elements that best determine the

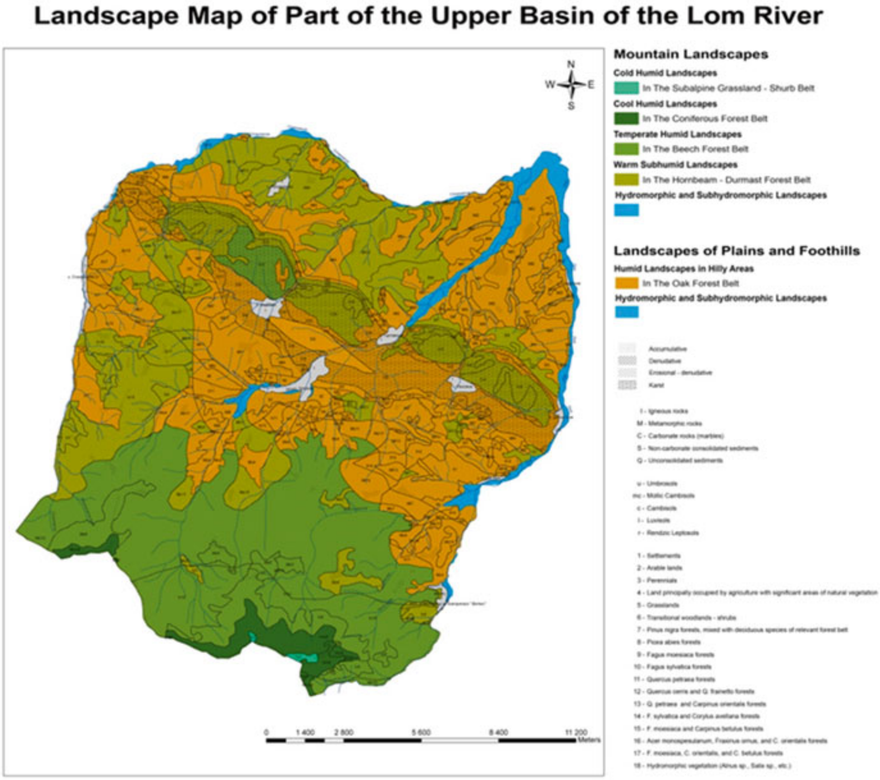


Fig. 13.4 Landscape map (Cholakova et al. 2012)

ability of different landscapes to "capture" water and to redistribute it into internal landscape structures and adjacent subordinate landscapes. This ability determines the flood regulation capacity of landscapes.

In the study, as the most appropriate landscape components and structure elements to be assessed, we consider relief (altitude, slope steepness), soil cover (texture, content of soil organic matter, presence or absence of litter layer, thickness of humus horizon, soil permeability), and vegetation cover (canopy, plant litter in forest floor, vegetation condition). In the assessment, the interception rate of vegetation and forest floor, water storage capacity of floodplains, and infiltration and retention capacity of soils were taken into account. To accomplish this, each component and each structural element was assigned a weight coefficient consisting of two parts: one determines "the weight" (in %) of each landscape component for flood regulation in the relevant geosystem and the other shows "the importance" of each landscape structural element (in relative scale). Derivation of the weight coefficients was on the basis of literature sources and physical features of the relevant elements to support flood regulation capacity (Tables 13.1 and 13.2).

Table 13.1 Weight coefficients of landscape structure elements

	III Hyerarchical level (10 %)	VI Hyerarchical level (30 %)	VII Hyerarchical level (30 %)
Subalpine grassland – shrub belt	5		
Coniferous forest belt	4		
Beech forest belt	3		
Hornbeam – Durmast forest belt	2		
Oak forest belt	1		
Umbrisols		5	
Mollic Cambisols		5	
Cambisols		3	
Luvisols		1	
Rendzic		2	
Fluvisols		4	
Settlements			0
Arable lands			1
Perrenials			2
Land principally occupied by agriculture with significant areas of natural vegetation			1
Grasslands			2
Transitional woodlands – shrubs			2
Pinus nigra forests and deciduous species of the relevant forest belt			4
Picea abies forests			4
Fagus moesiaca forests			4
Fagus sylvatica forests			5
Quercus petraea forests			4
Quercus cerris and Quercus frainetto forests			4
Pinus sylvestis and Quercus petraea forests			4
Quercus petraea and Carpinus orientalis forests			4
Fagus sylvatica and Corylus avellana forests			5
Fagus moesiaca and Carpinus betulus forests			4
Acer monospessulanum, Fraxinus ornus and Carpinus orientalis forests			4
Fagys moesiaca, Carpinus orientalis and Fagus sylvatica forests			4
Hydromorphic vegetation (Alnus sp., Salix sp., etc.)			3

Table 13.2 Weight coefficients of slope steepness

Slope steepness (20 %)	Weight coefficient
0°–5°	6
5°–10°	5
10°–15°	4
15°–20°	3
20°–25°	2
25° <	1

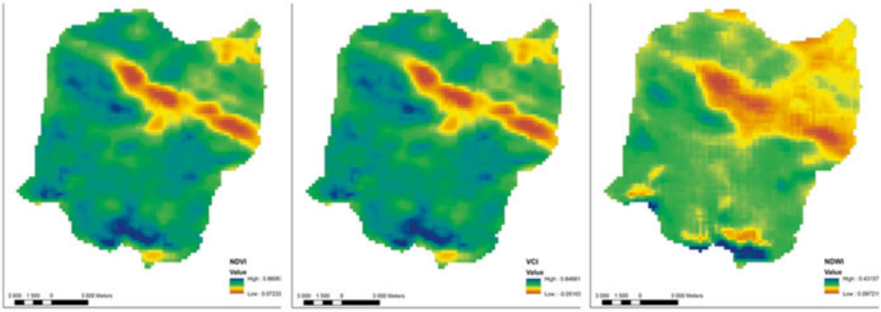


Fig. 13.5 NDVI, VCI, and NDWI indices values

The landscape component relief was assessed according to its structure elements altitude and slope steepness. Altitude determines the heat:moisture ratio in landscapes. So, to consider this factor, the case study area was divided into several landscape regions, representing the second and third hierarchical levels of the landscape map. Higher-located territories were assigned a higher weight coefficient (Gikov and Nedkov 2008; Nedkov 2010; Nedkov and Burkhard 2012). For the assessment of slope steepness factor, a DEM (digital elevation model) was used. The territory was divided into six classes as the steepest slopes were assigned the lowest weight coefficient (Table 13.2).

The main factors that determine interception rates of soils are the characteristics of the A-horizon texture, content of soil organic matter, presence or absence of a litter layer, thickness of humus horizon, and soil permeability.

Interception rate values of vegetation types are suggested in different studies (Burkhard et al. 2009). However, the interception rate of vegetation depends also on vegetation condition. For that reason, we have taken into account this element and have determined it by applying remote sensing methods and calculating vegetation indices. Thematic maps showing the vegetation conditions, according to NDVI, VCI, and NDWI values, were generated. Afterward, weight coefficients were assigned to the indices values (Fig. 13.5, Table 13.3).

On the basis of weight coefficients assigned to landscape components and their structure elements, thematic maps of flood regulation capacity of landscapes and of

Table 13.3 Weight coefficients of vegetation indices

Vegetation indices (10 %)					
NDVI		VCI		NDWI	
Value	Weight coefficient	Value	Weight coefficient	Value	Weight coefficient
≤2	**1**	0–0.2	**1**	0–0.1	**5**
0.2–0.3	**2**	0.2–0.4	**2**	0.1–0.2	**4**
0.3–0.4	**3**	0.4–0.6	**3**	0.2–0.3	**3**
0.4–0.5	**4**	0.6–0.8	**4**	0.3–0.4	**2**
0.5–0.6	**5**	0.8–1	**5**	0.4–0.5	**1**
0.6–0.7	**6**				
0.7–0.8	**7**				
0.8–0.9	**8**				

habitats were made. The next step was a comparative analysis of the obtained results and separating functional areas that show territories with expressed regulation capacity, vulnerable zones, and transitional zones.

13.3 Results

After weight coefficient determination and spatial analysis proceeded in GIS, final thematic maps of flood regulation capacity of landscapes and of habitats were generated (Figs. 13.6 and 13.7) The case study area is divided into five categories, representing the flood regulation capacity of the landscapes: 1, very low; 2, low; 3, mean; 4, high; and 5, very high capacity. Landscapes with mean capacity (37.2 %) occupy the largest area followed by these with high (32 %) and low (30 %) capacity. To achieve more precise assessment the flood regulation capacity of landscapes was considered on a sub-watershed level. On the habitat level, categorization is slightly more precise: six categories.

Landscapes characterized by mean regulation capacity prevail in sub-watersheds I, II, and V. Sub-watersheds III, VI, and VII have low capacity.

In sub-watershed IV, more than half the territory is distinguished with high regulation capacity (54 %), but lands with low capacity are also widespread (41.7 %). On the one hand, this is because of the small area of this sub-watershed and its location on the other. In the lowest part, prevailing landscapes are these with arable lands. Higher regulation capacities distinguish landscapes with hydromorphic vegetation along the rivers. On the habitat level, Pannonian–Balkanic turkey oak–sessile oak forests stand out.

Predominant landscapes in sub-watersheds with mean capacity are those on metamorphic rocks and Luvisols. The differences are in land cover types. In sub-watershed I prevail landscapes with *Quercus cerris* and *Q. frainetto* forests, with lands principally occupied by agriculture with significant areas of natural vegeta-

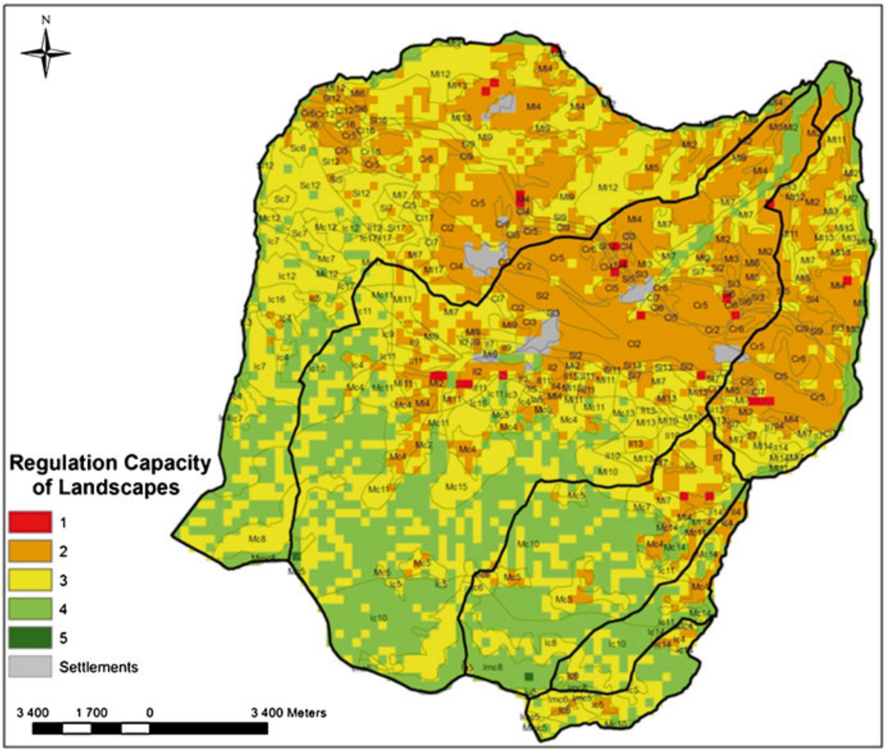


Fig. 13.6 Thematic map of landscape regulation capacity

tion, and with perennials, whereas in sub-watershed II prevail landscapes with *Fagus sylvatica* forests and with *Pinus nigra* forests mixed with deciduous species of the relevant forest belt. In higher-located territories of sub-watershed II and in the whole sub-watershed V, landscapes on igneous rocks, Cambisols, with *Fagus sylvatica* forests stand out. On land cover level in the aforementioned sub-watersheds *Fagus sylvatica* forests prevail, as in lower territories *Quercus cerris* and *Q. frainetto* forests are dominant. The anthropogenic loaded areas with lands principally occupied by agriculture with significant areas of natural vegetation and with arable lands also stand out. *Asperulo–Fagetum* beech forests are the main habitat type in the higher parts of these sub-watersheds. The lower territories are predominantly occupied by *Galio–Carpinetum* oak–hornbeam forests and seminatural dry grasslands and scrubland facies on calcareous substrates (*Festuco–Brometalia*: important orchid sites).

In sub-watersheds with low-capacity, anthropogenic landscapes on different fundaments prevail. Only in sub-watershed VI do landscapes with *Fagus sylvatica* forests have about the same area as these with lands principally occupied by agriculture with significant areas of natural vegetation. On the land cover level, *Pinus nigra* forests are mixed with deciduous species of the relevant forest belt, with lands prin-

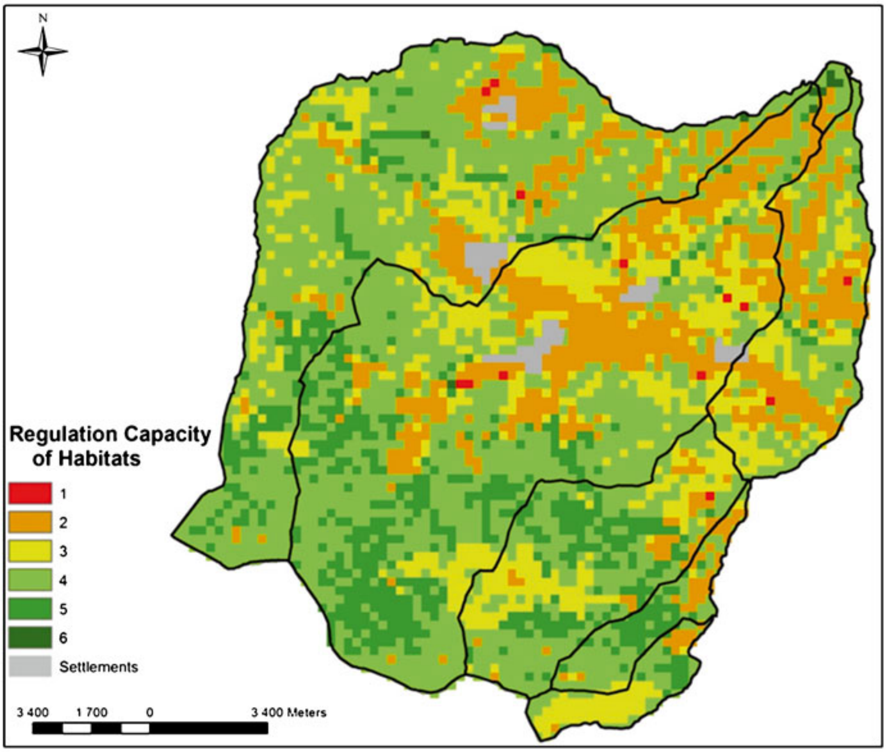


Fig. 13.7 Thematic map of habitat regulation capacity

cipally occupied by agriculture with significant areas of natural vegetation, and transitional woodlands–shrubs dominate. The main habitats are Pannonian–Balkanic turkey oak, sessile oak forests, and Pannonic woods with *Quercus petraea* and *Carpinus betulus* in the lower territories and Asperulo–Fagetum beech forests in sub-watershed VI.

According to the functional zoning (Fig. 13.8), 43.2 % of the area is with mean-, 33.3 % with low-, and 23.5 % with high-regulation capacity. With pronounced regulation capacity are mainly beech and spruce forests located in the southern part of the area. Lower-located landscapes are the most vulnerable. In this part of the area, anthropogenic landscapes prevail. Transitional functions are mainly found in the central zones where oak forests are predominant.

13.4 Discussion

In the recent study, free data are used. This circumstance has its advantages and disadvantages. The disadvantage is the lack of actual data related to river discharge and real-formed surface runoff. Such data would undoubtedly increase the worth of

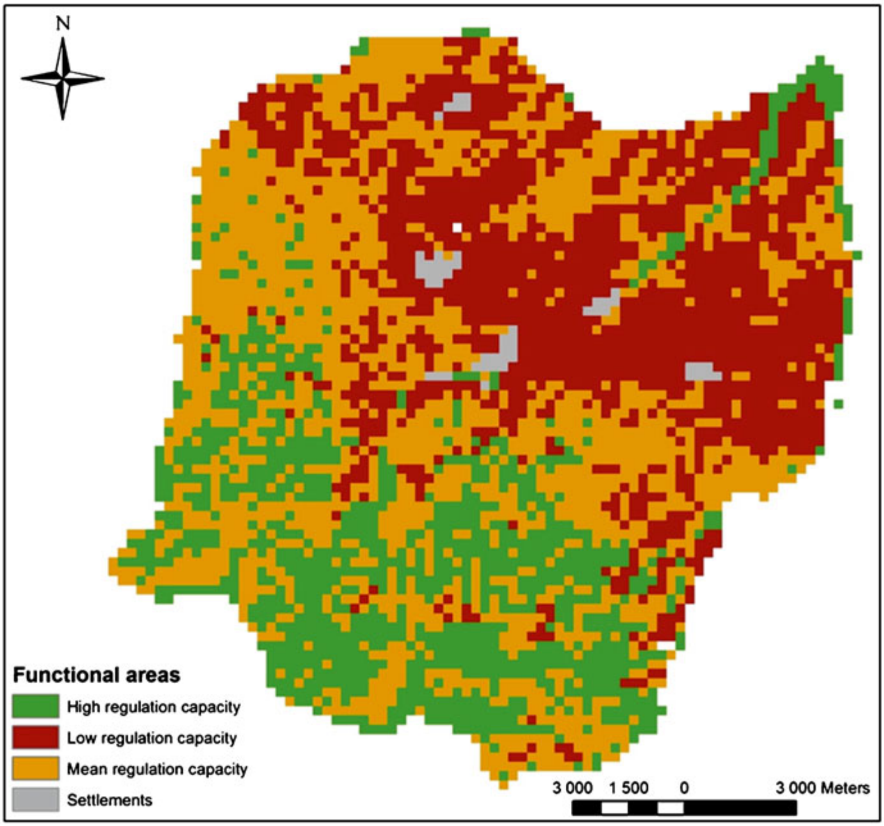


Fig. 13.8 Thematic map of functional areas

the study, especially concerning the derivation of information about the necessity of flood regulation in the territory. The index of the hydroclimatic factor suggested is calculated on the basis of climatic data and theoretical knowledge without taking into account the aforementioned hydrological indicators. Thus, the derivation of this index is an attempt for the need of flood regulation in the different sub-watersheds to be represented using only free data.

On the other side, the methodology suggested is focused on flood regulation ecosystem/landscape capacity assessment. The obtained results show that with applied data and methodology it is possible such an assessment to be made. Moreover, the public access to data used facilitates much studying of this problem, saving time and funds.

The study underlines advantages of flood regulation capacity assessment on landscape level. Using landscapes as the spatial unit to be assessed, there can be taken into account characteristics that in land cover-focused or just in habitat-focused studies remain "unnoticed." In the first case, important features of landscape structure are being overlooked and in the second there is generally a lack of information about anthropogenic territories that limits the spatial extent of the study area. These circumstances make landscape the most appropriate unit for surveying flood regulation capacity.

Another important aspect is selecting a suitable spatial extent of the study area. Studying the main watershed on the landscape level would increase the accuracy of research significantly. This point of view could serve as a basis for a future survey on flood regulation capacity within the whole watershed of the Lom River.

13.5 Conclusions

The conducted flood regulation capacity assessment of landscapes and derivation of functional zones on its base shows that the case study area is threatened by loss of regulation capacity. The rationale behind this statement is the spatial distribution of the three functional areas. Areas characterized with mean regulation capacity are located between areas with high and low capacity. Also observed is a penetration of the areas with mean capacity into the areas with high capacity and of those with low capacity, indicating that the landscapes in the territory are vulnerable to environmental changes and related processes. Especially crucial may be a potential increase of drought severity, which inevitably will result in narrowing of areas with mean and high flood regulation capacity.

The results obtained in this study can be applied in environmental management and territorial planning-related decision making, and the suggested approach and methodology can be used in conducting future surveys on the flood regulation capacity of different territories.

Acknowledgments This research is organized and sponsored by the “National, European, and Civilizational Dimensions of the Culture – Language – Media Dialogue” Program of the “Alma Mater” Center of Excellence in the Humanities at Sofia University “St. Kliment Okhridski,” funded by the Bulgarian Ministry of Education, Youth, and Science Scientific Research Fund.

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Chapter 14
GIS- and RS-Based Modelling of Potential Natural Hazard Areas in Mountains. Case Study: Vlahina Mountain

Ivica Milevski and Ekaterina Ivanova

Abstract A common approach of potential natural hazards assessment in mountain areas is presented in this chapter on the base of Geographic Information System (GIS) and Remote Sensing (RS) methods. The subjects include excess erosion, landslides, flash floods, and forest fires. For this purpose, Vlahina Mountain (Kadiitsa, 1932 m), covering 471.2 km^2 between the Republic of Macedonia and Bulgaria, was selected as a case study. This mountain border territory suffers from frequent and severe natural hazards that have high local impact on the environment, sociodemographic development, and the local economy. First, most relevant stable factors for each type of natural hazard were selected (topography, land cover, anthropogenic objects, infrastructure). Multi-layer calculation was performed based on available traditional equations, clustering and classifying procedures, using GIS and satellite images. In this way, suitable relatively “stabile” natural hazard maps were produced (modeled). Then, variable (mostly climate-related) factors are included in previous models correlated with different amounts of precipitation, temperature, wind direction, etc. Finally, the resulting GIS-based models were evaluated and tested with field verification and high-resolution Google Earth images. The verification of the models shows good accuracy. Further development of such GIS models is connected with situating of automatic remote meteorological stations and use of dynamic satellite imagery (such as MODIS), which will provide a timely warning of coming natural hazards and avoid potential damage.

Keywords Natural hazards • Erosion • Landslides • Forest fires • Mountains • GIS modelling

I. Milevski (✉)
Institute of Geography, Faculty of Sciences, University Ss Cyril and Methodius, Arhimedova 3, Skopje 1000, Republic of Macedonia
e-mail: ivicamilevski@gmail.com

E. Ivanova
Space Research and Technology Institute, Bulgarian Academy of Sciences, Acad. G. Bonchev Str. bl.1, Sofia 1113, Bulgaria
e-mail: ivanovae@space.bas.bg

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_14

14.1 Introduction

The increased vulnerability by natural hazards in mountains, especially in developing countries, is a major reason of concern. The International Strategy for Disaster Reduction (ISDR 2004) welcomes research to promote protection of the environment to reduce vulnerability to disasters. Joint analysis and quantification of all the natural risks which can affect certain territory (multi-risk approach) are both basic factors for the development of a sustainable environment and land use planning as well as for a competent emergency management before and during catastrophic events (Durham 2003). Although there is a growing recognition that similar research can help to mitigate damage caused by natural hazards, Bulgaria and Macedonia still do not have national-level multi-hazard maps and a cadastre of natural hazards in mountain areas (Blinkov and Mincev 2010). Therefore, emphasis should be given to the reduction of vulnerability, which requires multi-hazard assessment to make recommendations for prevention, preparedness, and response (Berz et al. 2001; Lerner 2007; Dragićević et al. 2011). Vlahina (Kadiitsa, 1932 m) is a border mountain between Bulgaria and the Republic of Macedonia highly exposed to natural hazards, especially to excess erosion, landslides, flash floods, and forest fires. The frequency of these hazards has increased in past decades generally because of climate change, causing significant damage (Kenderova and Milevski 2010). Thus, identification and mapping of potential hazard areas on the Vlahina Mountain is a task very significant for the better prevention and protection of landscapes and populations.

14.2 Study Area

Vlahina Mountain is located in the east part of the Republic of Macedonia (150.4 km^2 or 32 %) and the southwest part of the Republic of Bulgaria (320.8 km^2 or 68 %). Because of tectonic predispositions, the mountain generally has submeridian (N–S) direction with length of 30 km and width of about 20 km. Eastward the area borders clearly with Berovo-Delchevo graben and the same-named deep fault dislocation and westward with the Blagoevgrad depression and deeply submeridian Struma dislocation. However, north and south borders are less clear because the main ridge of Vlahina gradually passes toward Osogovo Mountain (Ruen, 2252 m) to the north and Maleshevska Mountain (1803 m) to the south (Kenderova and Milevski 2010). The submeridian mountain ridge (the main watershed) causes the westward (in the Macedonian part) and the eastward (in Bulgaria) flow direction. The western (Macedonian) side of the mountain is part of the Bregalnica River catchment, that is, its right tributary Želevitsa, whereas on the eastern side (in Bulgaria) there are several river catchments as right tributaries of Struma. Vlahina is an easily accessible mountain through several regional and local roads that approach it from both sides (Fig. 14.1).

Fig. 14.1 Geographic location of Vlahina Mountain

In the geotectonic view, Vlahina is a typical horst composed in the higher parts by older (Precambrian to Paleozoic) rocks: crystalline schists, granitoids, and metagabro-diabase, which are intruded by Tertiary quartzlatite rocks. In lower parts (below 1100 m), there are huge deposits of marine Eocene sediments and lacustrine Miocene to Pliocene sands, sandstones and clays (Arsovski 1997). Interestingly, small patches of Triassic limestones are found, especially in the Bulgarian side of the mountain. Thus, significant area of the mountain is composed of soft metamorphic and clastic sedimentary rocks generally covered by a thin layer of sandy soils (deluvial soils, rankers, cambisols), which make them easily erodible by surface flow (Table 14.1).

In regard to topography, the landscape is highly dissected because of the intensive and differential tectonic uplift of Vlahina horst in respect to near grabens and subsequently deeply incised Bregalnica tributaries on the west side and Struma tributaries on the east side. Thus, the valley slopes usually are steep (>30°) but large coastal terraces as well as denudation and fluvial terraces make the mean slope value of 16.5°. Terrain relief is in range of 28–565 m/km^2 with mean value of 221.4 m/km^2. Mountain altitude ranges from 295 to 1932 m with 915.5 m of mean altitude and 64.0 % of the area below 1000 m, where the human impact is highest (Fig. 14.2).

Climate of this area is mildly continental with high annual temperature variations of about 65 °C and a mean annual value of 10 °C. The annual amount of precipitation is relatively small for such mountainous area, with some 600–800 mm. However, there are heavy rain occurrences with maximal daily amount of even more than 100 mm (for example, on meteorological station Delchevo on 5 June 1957 with 105.0 mm; Lazarevski 1993). In the winter, the upper part of the mountain is generally in snow, which can rapidly melt in the spring. Heavy rains, prolonged rains, and rapid snowmelt produce high overland flow and severe erosion on uncovered or weakly covered areas (Kenderova and Milevski 2010).

Table 14.1 Altitude, slopes and aspects of Vlahina Mountain

Altitude (m)	Area (%)	Slope (degrees)	Area (%)	Aspect	Area (%)
1500–1932	4.53	>50	0.02	N	14.26
1200–1500	10.53	40–50	0.36	NE	13.14
1100–1200	9.08	35–40	1.62	E	12.99
1000–1100	12.62	30–35	4.58	SE	12.97
900–1000	13.29	25–30	9.71	S	11.01
800–900	12.30	20–25	14.85	SW	10.92
700–800	12.59	15–20	22.31	W	11.68
600–700	11.97	10–15	22.94	NW	13.05
500–600	7.03	5–10	18.39	N	52.74
300–500	6.06	0–5	5.04	S	47.26
300–1932	100.00	0–90	100.00	–	–

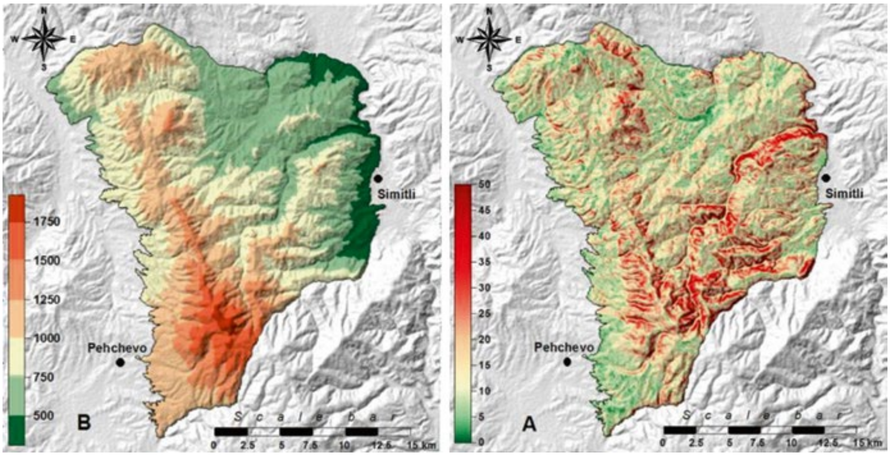

Fig. 14.2 Hipsometry in meters (m) (*left*) and slopes in degrees (*right*) of the Vlahina Mountain

Because of lithology, topography, and relatively weak vegetation cover, rivers in this region are mostly torrential (Želevica, Grashtica, Logodishka, Leshtanska), with high fluctuation in water discharge and a great amount of sediment load. The drainage network is dense with domination of first-order streams. On the Bulgarian side, rivers are longer and with greater discharge because of longer mountain slopes (Ivanova and Milevski 2013). Almost all rivers and streams have alluvial fans toward the mountain foothills (Milevski 2011).

A significant erosion factor in the area is vegetation cover. According to the Corine Land Cover 2006 (CLC2012) map, the largest area of the mountain is covered by forests and shrubs (70.6 %). Broadleaf forest occupies 104.8 km^2 or 22.2 %, and coniferous (generally afforested) only 45.8 km^2 or 9.7 % of the total area. The forests are generally above 1000 m of altitude, with grasslands, crops, and bare soils at lower levels. The comparison of NDVI from Landsat MSS (08.1977) and Landsat ETM+ (08.2007) shows significant increase of forest areas in contrast to crops, probably because of afforestation and natural forest spreading.

There are 15 villages in the mountain area. There were about 10,000 inhabitants until the middle of the twentieth century and only 2800 today. The towns of Simitli (7180 inhabitants) and Pehčevo (3200 inhabitants) are situated in the mountain foothills. Thus, all these settlements had a significant impact on the landscape in past centuries, contributing to the increase of natural hazard severity.

14.3 Data and Methods

14.3.1 Soil Erosion

In Macedonia and Bulgaria, generally two distinct models are used for estimation of soil erosion potential and sediment yield: USLE is mostly used in Bulgaria, and the Erosion Potential Model (EPM) of Gavrilović (1972) is mostly used in Macedonia. However, numerous analyses show that if properly used, the EPM model is more suitable and more accurate for mountain areas (Blinkov and Kostadinov 2010); therefore, it was chosen in this work. The EPM model was performed following Eq. (14.1):

$$W_y = T * H * 3.14 * \sqrt{Z^3} * f \tag{14.1}$$

where $\boldsymbol{Wy}$ is average annual soil erosion in m^3; $\boldsymbol{T}$ is temperature coefficient; $\boldsymbol{H}$ is mean annual precipitation in mm; $\boldsymbol{Z}$ is erosion coefficient ranging from 0.1 to 1.5 and more; and $\boldsymbol{f}$ is study area (in km^2). Temperature coefficient was calculated as follows:

$$T = (0.1 * t + 0.1)^{0.5} \tag{14.2}$$

wher: $\boldsymbol{t}$ is mean annual air temperature.

Among these factors, coefficient $\boldsymbol{Z}$ has highest importance, combining soil erodibility ($\boldsymbol{Y}$), land cover index ($\boldsymbol{X \cdot a}$), index of visible erosion processes ($\boldsymbol{\varphi}$), and mean catchment slope ($\boldsymbol{J}$) in relation:

$$Z = Y * X \bullet_a * (\varphi + \sqrt{J^{0.5}}) \tag{14.3}$$

Values of Z usually ranged between 0 (no erosion) and 1.5 (excess erosion). In the original form of the model, which is catchment oriented, coefficient $\boldsymbol{\varphi}$ and $\boldsymbol{X \cdot a}$ are very subjective in nature. Because of that, starting from 2001, the GIS approach of the model is introduced where most of the parameters are derived from the digital elevation model (DEM), satellite imagery, and digital thematic maps (Milevski

2001; Globevnik et al. 2003; Petras et al. 2007; Milevski 2008; Karim et al. 2009; Milevski 2011; Tošić et al. 2012; Milevski et al. 2013).

Thus, for the coefficient ***Y***, produced from a digitalized geological and soil map, are used corresponding values of the rock and soil erodibility proposed by Gavrilović (1972). Values range from 0.1 (very resistant rocks) to 2.0 (very soft rocks and soils). However, because it is very difficult to estimate exact erodibility correlation, value fitting is made with square rooting:

$$A = \sqrt{Y_1} \tag{14.4}$$

Land cover index ***Xa*** is prepared from CORINE Land cover model (CLC2012) with values ranging from 0.1 (dense forests) to 1.0 (bare soils). Corresponding values are added to the CLC classes according to values proposed by the original model.

For the value of coefficient $\boldsymbol{\varphi}$ of visible erosion processes, instead of very subjective visual estimation in the traditional model, Landsat ETM+ band 3 (b3-red) is used in such way that grayscale values (0–255) are divided by 255; this is because this channel has 255 + 1 tons of gray where low values correspond to areas without visible erosion processes, and values near 255 correspond to areas with excess erosion. However, high reflectance in the red range of the visible spectrum also may have anthropogenic objects, dumpsites, etc. For that reason, correction with slope gradient (***a***) was made, which provides much more accurate values for coefficient $\boldsymbol{\varphi}$ (Eq. 14.5).

$$\varphi = \left(\frac{b3}{255} * \log(a+1) \right) \tag{14.5}$$

Slope factor ***J*** is calculated from the available 20-m DEM as a raster layer for slope angle in radians (a = a/57.3). Finally, the GIS-calibrated coefficient ***Z*** is calculated according to Eq. (14.6):

$$Z = \sqrt{Y} * \varphi * \left((X_a + \varphi) * \log(a+1) + \sqrt{\frac{a}{57.3}} \right) \tag{14.6}$$

Mean annual temperature (***t***) and precipitation sum (***H***) were obtained in the GIS procedure, using vertical interpolation (regression) based on meteorological data and the DEM (where *h* is altitude in meters). The regression equations for mean annual temperatures (14.7) and mean annual precipitation (14.8) sum on the Vlahina Mountain are as follows:

$$t = 13.6 - 0.65 * \frac{h}{100} + \frac{h^2}{10^6} \tag{14.7}$$

$$H = 500 + \frac{2h}{10} + \frac{h^2}{3*10^4} \tag{14.8}$$

In this way the final ***Wy*** values can be calculated as average annual values. However, in this form the soil loss during only one rainfall event is not included in the assessment. Because of that, the daily rainfall value was introduced instead of the average annual precipitations (***H***), following Eq. (14.9):

$$H = H_y * \left(\frac{H_d}{0.1 * H_y} \right)^2 \tag{14.9}$$

where ***Hd*** is daily value of rainfall and ***Hy*** is average yearly sum of precipitation in the area. In that way, the daily amount of soil erosion that is precipitation related can be calculated (Milevski et al. 2013).

14.3.2 Landslide Susceptibility

For landslide modelling of Vlahina Mountain, landslide susceptibility analysis (LSA) is used as a simple and useful bivariate method of analysis that aims to determine the importance of different variables for landslide occurrence. In this research, six causative factors were considered: slope, lithology, land use, distance from streams, distance from roads, and curvature (profile curvature). Another four factors – aspect, relative relief, distance from faults, elevation and seismic zone – are usually part of the landslide zonation models (Tošić et al. 2014), but most analyses show their insignificance or their negligible influence on landslide processes (Milevski et al. 2010). The data of slope and curvature (profile curvature) were derived from a DEM of the study area using SAGA GIS v2.

Distance from the stream was found using the streamline buffer at a value of 0–100 m from the stream and more than 100 m from the stream. A similar procedure of 50-m buffering is performed for the main roads (Table 14.2). The lithology map was extracted from the available national geological maps. The land use map was determined according to CORINE classification hierarchy (CLC2012). After all data had been collected, all vector data were converted to raster grid with 15 × 15 m cells. Weighting factors were determined to evaluate the influence of each variable, comparing the calculated density with the overall density in the area (Süzen and Doyuran 2004). In the next step, all weights are summed up to produce a resultant LSI map for the study area. The same course of action as in the previous method is used for reclassifying the LSI values into different susceptibility zones and the map validation.

The values for lithology and land cover are the same as for the coefficient ***Y*** for erosion risk multiplied by 3, and for coefficient ***Xa*** for erosion risk multiplied by 6. Resulting values are calculated with addition of all six parameters with weighted values.

Final results are in range from 4.5 (lowest landslide potential) to 25.5 (highest landslide potential). A total of five classes are separated and arranged that show from very low to very high landslide potential of the terrain of Vlahina Mountain (Fig. 14.4).

Table 14.2 The weight values of factors used for LSA model

Factor	Value	Factor	Value
Lithology		Flat	1.5
Clastic sediments	5	Convex	1
Schists	4	Highly convex	0.5
Gneiss	3	**Land cover**	
Granitoides	2	Dense forests	1
Quartzlatites	1	Transitional forests	2
Amphibolites	1	Pastures	4
Slopes		Cultivated lands	3
0–5°	2	Urban areas	3
5–10°	6	Bare rocks	4
10–30°	10	**Streams**	
30–50°	8	0–100 m	1.5
>50°	4	>100 m	0
Convergence (curvature)		**Roads**	
Highly concave	0.5	0–50 m	1.5
Concave	2	>50 m	0

14.3.3 Potential Flood Areas

Potentially floodable area was estimated in SAGA GIS v2 with empirical approach based on the processing of five correlated parameters in this form:

$$F_a = V_i * L_i * \log C_a * \log TWI * \frac{2}{S_h} \tag{14.10}$$

The first parameter in this equation is the index of vegetation (***Vi***), according to the CLC 2006 model with values from 0.1 for the forest area with high density to 1.0 for uncovered area. For the value of land cover coefficient (***Li***), the Landsat ETM+ band 3 (red) was used in such way that grayscale values (0–255) are divided by 255, shown in value from 0 (dense vegetation) to 1 (bare soils). The next factor is catchment area (***Ca***), extracted in hydrology module (Flow Tracing) with square meters as units. The topographic wetness index (TWI) shows the topographic tendency of water retention. The last factor is slope height (***Sh***), which indicates relative altitude above valley bottoms in meters and the potential width of the floodplain. In the model, catchment area and TWI are logarithmic as the values are too high in nature (Milevski et al. 2013).

14.3.4 Forest Fire Risk

Five fire rating classes are used for the production of the forest fire risk map (Erten et al. 2004). These classes were formed according to slope, aspect, vegetation type, distance from roads, and settlements. Slopes and aspects, which are vital in spreading of the fire, were generated using the 15-m DEM data. Fires spread most rapidly upslope and less rapidly downslope. Southern slopes are more vulnerable to catching fire. For the aspect query, an aspect filter was used that calculates the aspect or direction of slope for a DEM. The map of the cultivation environment for the area in which the fire broke out was produced according to the vegetation type map. In accordance with this map, very dry, moist, fresh, and fresh-like areas were designated and classified into risk classes in terms of the water they contain. Vegetation, road, and settlement maps from the test area were digitized and made available in a GIS data base. Buffer zones were created around the roads and settlements. Distances from the center of the settlement were created around the center as polygon data. Similarly, buffer zones of distance from the roads were created around the roads. The closer is the forest to the roads and settlements, the more likely is a fire to break out. According to this, buffer zones were integrated to fire rating classes. The final model is in the form:

$$RS = 7*VT + 5*(S + A) + 3*(DR + DS) \tag{14.11}$$

RC is the numerical index of forest fire risk zones, where ***VT*** indicates vegetation type with five classes, ***S*** is the slope factor with five classes, ***A*** is the aspect variable with four classes, and ***DR*** and ***DS*** indicate distance factors from roads and settlements, respectively (Erten et al. 2004). Finally, a fire risk zone map was produced based on the analysis.

14.4 Research Findings

Excessive erosion is one of the worst natural hazards on Vlahina Mountain. As a consequence, there is a deterioration of the quality of the soil or their complete "loss," occurrences of floods, drought, landslides, gullies, rills, and numerous other destructive forms that make parts of the land completely "useless" for any purpose. The results of the GIS-based EP model show that Vlahina Mountain has significant areas with moderate, high, and very high erosion risk ($Z>0.8$) with 96.2 km^2 or almost 12.5 % of the total area. The mean value of the erosion coefficient Z is 0.31, but there are even areas with more than 1.2 of Z-value (Fig. 14.3). Considerable production, transport, and accumulation of alluvial material occur on these areas even during moderate rainfall; this is especially evident during intense (more than 0.5 mm/min) or prolonged rains. The mean annual erosion rate according to the model is 456.5 m^3/km^2 or 0.45 mm/year.

The occurrence of landslides is closely related to areas of high erosion. In the Vlahina area, landslides often occur on the rim of the valleys, on the valley sides, on the sides of deeply incised roads (deep cuts), in settlements on steep slopes, etc. (Jovanovski et al. 2013). Of the approximately 40 recorded landslides on the mountain, most are small and together cover an area of about 0.5 %. One of the largest landslides is near the village of Crnik (Fig. 14.4, right), 400 m in length, 100 m in

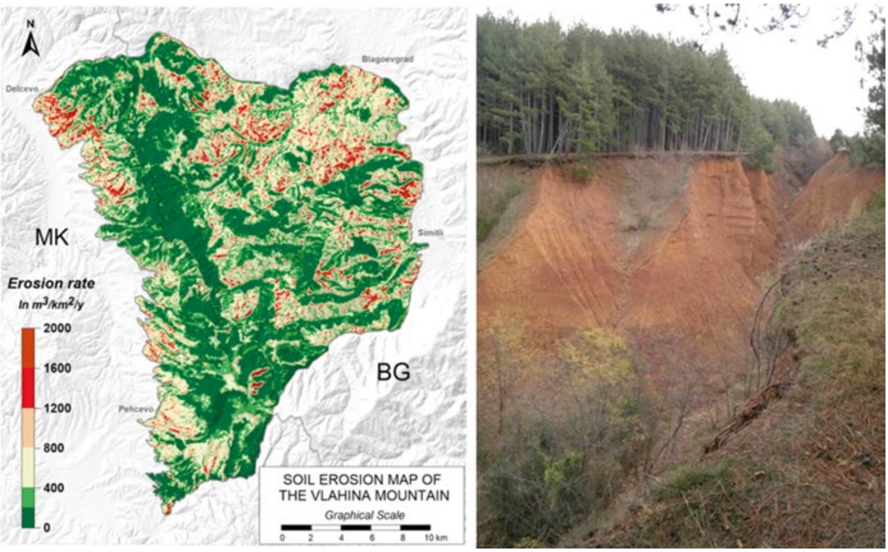

Fig. 14.3 Soil erosion map of Vlahina Mountain (*left*) and huge deep gully near Pehčevo (*right*)

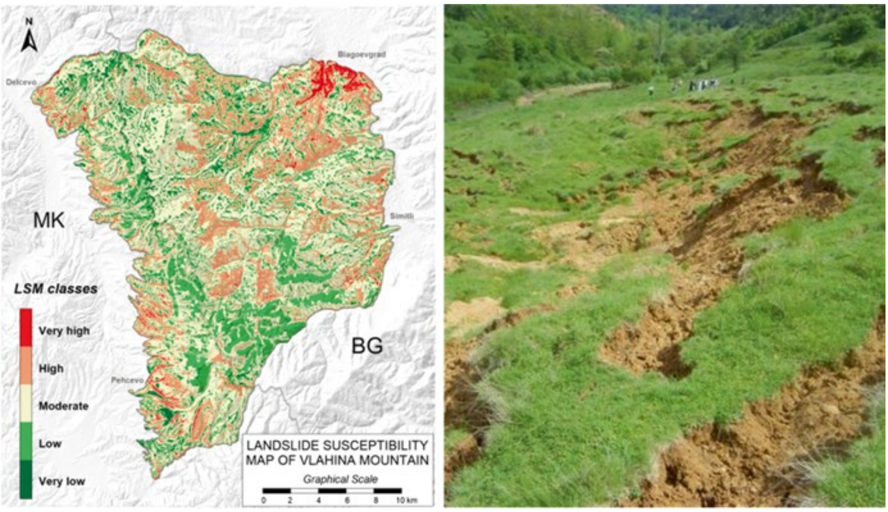

Fig. 14.4 Landslide susceptibility map (*left*) of Vlahina Mountain and large Crnik landslide (*right*)

width, and with estimated volume of about 700,000 m^3 (Milevski 2004; Milevski and Ivanova 2013). Some landslides in the area are almost without visible consequences, whereas others cause damage to the roads and constructions and represent a major threat to human lives. The landslide susceptibility model (Fig. 14.4, left) shows that the lowest part (up to 1200 m) of the mountain was especially susceptible to landslides.

According to the model, 26.5 % of the area of Vlahina Mountain is with low and very low (5.7 %) susceptibility to landslides, mostly in the higher part with good forests. However, 23.2 % of the area is under high to very high (1.7 %) landslide susceptibility, mostly in the vicinity of the settlements. To this class of high landslide hazard areas belong about 20 of the largest active landslides, which confirms the accuracy of the model.

Floods are natural disasters that often occur in the river valleys of Vlahina Mountain. The reasons are closely related to the high erosion in certain parts, accelerated runoff, setting of various unsuitable anthropogenic constructions along the riverbanks, interventions in river basins, and numerous other factors. According to the results of this research and taking into account the landscape structure of the researched area, floods do not cause major consequences in the region. However, in recent years (2010, 2013, 2014), the frequency of flash floods increased as well as damage to buildings, sliding of riverbanks, excess accumulation of deposits, etc. The model of potentially floodable area shows that the downstream parts of river valleys are most endangered and prone to flooding (Fig. 14.5, left). In all, the area with flood risk is calculated as 10.2 km^2 (or 2.2 %) for rainfall of 60 mm/day, and 27.2 km^2 (or 5.8 %) during the heavy rains or snowmelt (equivalent to more than 100 mm/day).

Forest fires recently have occurred more often in Vlahina Mountain, which is related to the climate change and very hot summers in past decades. According to the presented forest fire risk model, 97.0 km^2 (20.5 %) or one fifth of the total area has a high risk of forest fires, especially in natural and afforested coniferous forest (pine) near roads and settlements (Fig. 14.5, right).

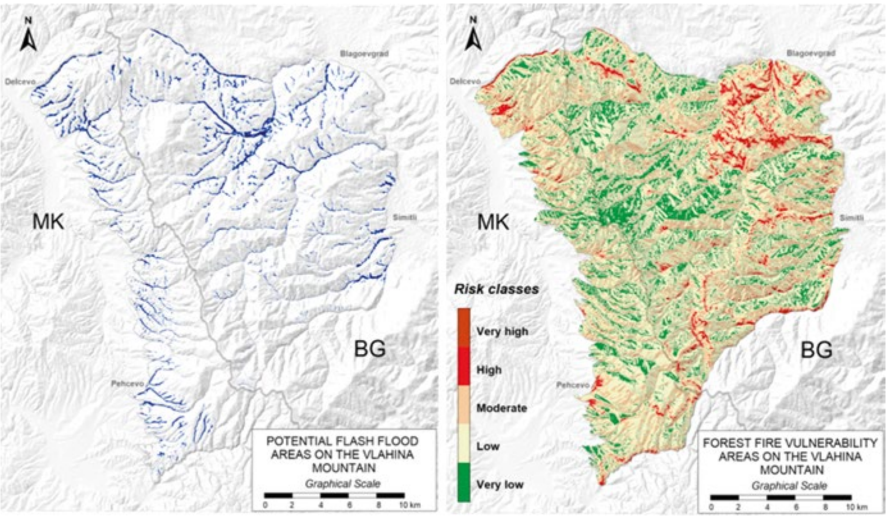

Fig. 14.5 Map of potential floodable areas (*left*) and forest fire risk map of the Vlahina Mountain

Another 108.9 km^2 or 23.1 % is under low to very low risk of forest fires, mostly on the top of the mountain, on the north sunless aspects, and on the areas with very weak vegetation. It must be mentioned that vegetation moisture, one of the key factors in the model, is a very changeable parameter. For that reason, instead of Landsat imagery, other satellite images with frequent update (such as MODIS) must be used for better accuracy.

14.5 Conclusion

Vlahina Mountain possesses valuable natural resources, but they are quite limited and susceptible to natural hazards and degradation, usually directly or indirectly caused by humans, except earthquakes as a typical geohazard. Particularly severe effects are excessive erosion, the occurrence of landslides, flash floods, and forest fires. The presented detailed GIS- and RS-based models show that a large part of the mountain is exposed to natural hazards. Actually, the combined multi-hazard map (Fig. 14.6) shows that 36 % (169.8 km^2) of Vlahina Mountain has a high potential of natural hazard occurrences. To summarize, on 58.2 % of the area occurs only one potential hazard, on 29.5 % occur two combined hazards, and on 12.2 % there are three or four combined hazards. With elevation, the natural hazard potential decreases from the foot of the mountain toward the mountain ridges, which is clearly related to the degree of human activity. Thus, 43.5 % of the mountain area

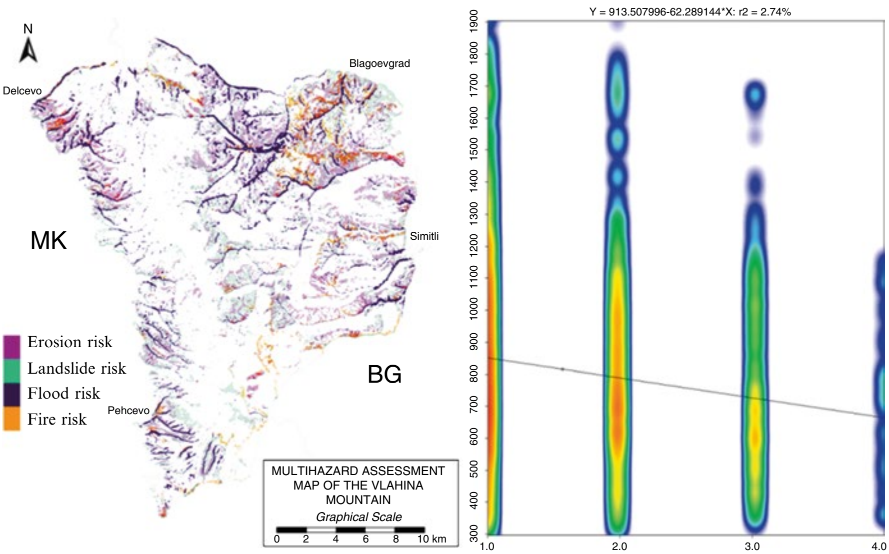

Fig. 14.6 Multihazard map of Vlahina Mountain (*left*) with altitude scatterplot of multihazards (*right*)

below 1000 m has high hazard potential (76.5 % of the total potential hazard area), in contrast to only 23.1 % of the area above 1000 m.

All climate change scenarios for the Balkan area show that in the near future natural hazards will be even more severe (Bergant 2006). Therefore, a complex of measures is necessary to reduce the hazards or limit their impact. In case of excessive erosion and flash floods, biotechnical measures must be taken as well as the construction of small and micro-reservoirs, retention basins, regulation of torrential watercourses, change of land use and land practices, etc. In regard to landslides, slope stabilization should be made with drainage of excess underground water and biological measures. Woodless shelterbelts are necessary for the fire protection. Other useful measures are establishing of observation posts in the forests and roads, penetration through inaccessible forest terrain, and informing the population and visitors. For better forecasting and monitoring of potential hazards on Vlahina Mountain, it is necessary to establish a good network of automatic meteorological stations from both sides of the border connected into integrated cross-border GIS.

Acknowledgments This paper is the result of the project Joint Applicable Research for Natural Recourses Preservation and Environmental Protection in the Cross border Region within the Municipalities of Pehchevo and Simitli, co-financed by European Union through IPA Cross-border Programme CCI 2007CB16IPO007.

One of the authors (E.I.) is supported by the European Social Fund and Republic of Bulgaria, Grant: BG051PO001-3.3.06-0051

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Chapter 15
Spatial Discrepancies of Ecological Networks in the Border Region of Serbia and Bulgaria

Assen Assenov

Abstract The main objective of the report is to analyze the current status of ecological networks in the border region of Serbia and Bulgaria, illustrate the spatial extent of future NATURA 2000 ecological network in Serbia, and indicate the potential network linkages with the already existing NATURA 2000 sites in Bulgaria. The author's participation in the verification and mapping of habitat types of NATURA 2000 sites in Bulgaria provoked his interest in their spatial configuration in the border regions, and so far consecutive studies have been carried out along the borders with Greece, Romania, Turkey, and Macedonia. Apart from analysis of relevant literary and electronic sources, comparative analysis between the Serbian model of establishing ecological networks and the experience of Bulgaria, and its Balkan neighbors, is also applied. Mapping as a method is used on one hand as an existing product, but also as a basis for a synthetic approach to derive new regularities and cartographic images. In the border area of Bulgaria there are 15 NATURA 2000 protected areas, of which 4 are under both Birds and Habitats Directives. The Emerald network of Serbia in the border area comprises 12 sites, and 5 more are proposed by a non-governmental organization. The enclosed specially developed schematic map of sites of ecological networks in the border area between Serbia and Bulgaria illustrates the spatial ecological gaps, and on that basis recommendations for the establishment or expansion of new sites are made.

Keywords NATURA 2000 sites • Habitat and birds protected sites • Emerald network sites

A. Assenov (✉)
Landscapes and Environmental Protection Department, Faculty of Geology and Geography, Sofia University "St. Kliment Ohridski", 15 Tzar Osvoboditel Blvd, 1504 Sofia, Bulgaria
e-mail: asseni.assenov@gmail.com

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_15

15.1 Introduction

The spatial linkages of the sites in the NATURA 2000 ecological network are a dominant topic in the recent scientific research of the author. Consistent results are published on this chapter about the border area with Greece (Assenov et al. 2012; Assenov 2013a), a conceptual design for the configuration of a NATURA 2000 ecological network in the border area with Turkey (Assenov 2013a) and Macedonia (Assenov 2013b; Assenov and Kostadinova 2014), as well as about the border area with Romania (Assenov 2014b). Relevance of the subject is determined by the freedom enjoyed by individual countries to determine the sites of NATURA 2000, limited by national borders that often interrupt the integrity and linkages of the sites in the network. The designation of NATURA 2000 protected areas is based entirely on scientific criteria, reflecting the preservation of the environment and spatial range of habitat types present in the sites. Directive 43/92EEC points out that it does not include rules for the designation of protected areas for habitats and species (PAHS) and that EU Member States decide this question at their own discretion. Understanding that nature conservation is by definition an international endeavor, because habitats and species do not recognize national borders, implies an optimization of spatial structure of PAHS in and between member states. The author's previous studies showed a certain determination and grouping of problems in establishing the NATURA 2000 network. Geographic determination is revealed according to the nature of relief along the state border, as well as dependence on the period of accession in the European Union (EU): Greece is an old member of the EU, since 1981, Bulgaria and Romania are both adopted in 2007, Turkey and Macedonia are in the process of negotiations, and Serbia has just been invited to start negotiations with the EU for accession.

The enlargement of EU is related to the establishment of the NATURA 2000 ecological network in candidate countries. The NATURA 2000 ecological network is an important part of the identity of the EU and, with the enlargement of the union, the network covers new territories from the new accession countries. Serbia received official candidate status for membership in March 2012. The negotiations for Serbia's membership in the European Union officially started on 21 January 2014. The Serbian state will seek to fulfill the conditions for accession until 2018 to be able to enter the union in the next financial period starting from 2020. The presented research is timely relative to the availability of sufficient required time until 2019–2020, when Serbia will join the EU NATURA 2000 ecological network, to not to repeat the problems arising with our other neighbors and to develop a network bound to the Bulgarian sites. Along the border line with Serbia, which is 341 km long, in Bulgaria 15 protected areas are designated, of which 11 are for habitats (SCI) and 4 are for birds (SPA). The state border between Bulgaria and Serbia extends from Kitka peak in the south to the mouth of the Timok River in the north and, besides the land boundary, includes a river section (26 km of the midstream of the Timok River).

Serbia is at the stage of an already created Emerald ecological network according to the Berne Convention (1979), which is the basis for the future development of the NATURA 2000 network. Interest in the establishment of ecological networks in Serbia is generated by the spatial contiguity of this country with Bulgaria in the Balkan region and the EU.

15.2 Material and Methodology

The main objective of the study is to analyze the current status of ecological networks in the border region of Serbia and Bulgaria, illustrate the spatial extent of future NATURA 2000 ecological network in Serbia, and indicate the linkages of the potential network with the already existing NATURA 2000 sites in Bulgaria.

The total area of Serbia is 77,470 km^2, of which 55,970 km^2 is in Serbia and 21,500 km^2 is in Vojvodina. According to the Serbian Ministry of Environment and Spatial Planning (2010), 5.86 % (518,204 ha) from the territory of the country is under a regime of protection. The total number of protected areas is 463: 5 national parks, 16 nature parks, 16 landscapes of exceptional importance, 72 special nature reserves, 312 natural landmarks, and 42 areas of cultural and historical value. According to the national legislation of Serbia, 215 plant and 429 animal species are protected (https://www.cbd.int/doc/world/cs/cs-nr-01-en.pdf). Protected areas under national environmental legislation of Serbia are valuable as potential natural objects, which after the adoption of the country in the EU will be included in the sites of the NATURA 2000 ecological network.

All EU candidate countries have been creating sites of the Emerald ecological network under the Berne Convention (1979, “Convention on the Conservation of European Wildlife and Natural Habitats”) as a basis for the future NATURA 2000 sites. The Emerald program takes advantage of the financial assistance of the European Environment Agency and is an important tool contributing to prepare the candidate country for future work on NATURA 2000 and to preserve, in advance, the habitats of plants and birds. The Serbian Emerald ecological network includes 61 sites, which are particularly important for the protection and conservation of flora and fauna species and their habitats (Gvozdenovic 2010). At a specially held biogeographic seminar the following protected areas were defined: 62 internationally Important Plant Areas (IPA), covering 7473 km^2 or 8.5 % of Serbian territory, 42 internationally Important Bird Areas (IBA), covering 1,259,624 ha or 14.25 % of Serbian territory, and 40 Prime Butterfly Areas (PBA), which occupy an area of 903,643 ha or 10.23 % of the territory of Serbia.

Certain areas of the Serbian Emerald network are of particular importance at the international level, namely, one biosphere reserve under the MAB program and nine Ramsar wetland sites with a total area of 55,627 ha, representing 0.63 % of the territory of the country. In the autumn of 2010, the Council of Europe began establishing the Emerald network in Serbia, and the evaluation report indicates that further work is needed in the region of Eastern Serbia (https://www.cbd.int/doc/world/cs/cs-nr-01-en.pdf), that is, the border area with Bulgaria. The Emerald ecological network of Serbia covers 11.54 % (1,019,269 ha) of the total area of the country. The sites of the Emerald ecological network have to be added to the protected areas of Serbia, as potential sites to be included in NATURA 2000.

The taxonomic biodiversity of Serbia includes a total of 44,220 taxa that have been found and classified at species and subspecies level. Actual assumptions are that the figure is greater and comprises about 60,000 taxa (Stevanović and Vasić 1995). Among the registered taxa, the most numerous are the insects (class Insecta with 35,000 species), followed by vascular plants (3662 species) and algae (1400 species). In Serbia there are 94 taxa of freshwater fish, 47 taxa of amphibians and reptiles, 350 taxa of birds, and 98 taxa of mammals. Although it is a small part of Europe, Serbia is a space in which 39 % of the vascular plants, 67 % of butterflies, 51 % of fish, 37 % of amphibians, 26 % of reptiles, and 74 % of the birds and 68 % of the mammals distributed in Europe are found. An important feature of the taxonomic species diversity in Serbia is the relatively high percentage of endemic species, especially Balkan endemics, representing 15 % of all species (Amidžić et al. 2014).

In terms of faunistic taxonomic diversity, there are other data than those just mentioned. The figure of 12,000 species and subspecies of invertebrates that referred to Serbia in the former Yugoslavia (Stevanović and Vasić 1995) seems to be rather understated.

The faunistic taxonomic diversity of Bulgaria is updated accurately and continuously and amounts to 30,359 species, representing part of 28 types and 75 classes; invertebrates are part of 251 orders and 1741 families (Hubenov 2008), and nowadays probably much more. According to the same author, Arthropoda includes 24,888 species (81.9 %), Nematoda includes 1007 species (3.3 %), and class Insecta includes 20,678 species (68.1 %), with its largest orders being Coleoptera, 6000 species (19.7 %); Hymenoptera, 4000 species (13.2 %); Diptera, 3500 species (11.5 %); Lepidoptera, 2900 species (9.5 %); and Hemiptera, 2350 species (7.7 %); class Arachnida, 2685 species (8.8 %); class Crustacea, 1056 species (3.5 %); and other groups with fewer species. The same source indicates that the Bulgarian fauna is part of three zoogeographical complexes and belongs to 20 faunistic elements. The number of endemic species is about 1300, and there are about 300 relicts that are not endemics. The rare species number around 2690, including 112 species inscribed in international lists of endangered species.

Considered separately, the taxonomic diversity of Serbian flora comprises 3662 species of vascular plants from 141 families and 766 genera (39 % of the European flora). In Serbia 59 species are local endemics (1.6 %) and 287 species and subspecies are Balkan endemics (8.06 %) (Karadžiđ and Mijoviđ 2007). The diversity of endemic flora in Bulgaria includes 444 species of vascular plants, of which 270 species are Balkan endemics and 174 species are Bulgarian endemics (Petrova and Vladimirov 2010).

When the Serbian and Bulgarian taxonomic diversity of flora species is compared, being, respectively, 3662 species (Amidžić et al. 2014) and 4102 species (Assyov et al. 2012), it is evident that in accordance with the greater national space,

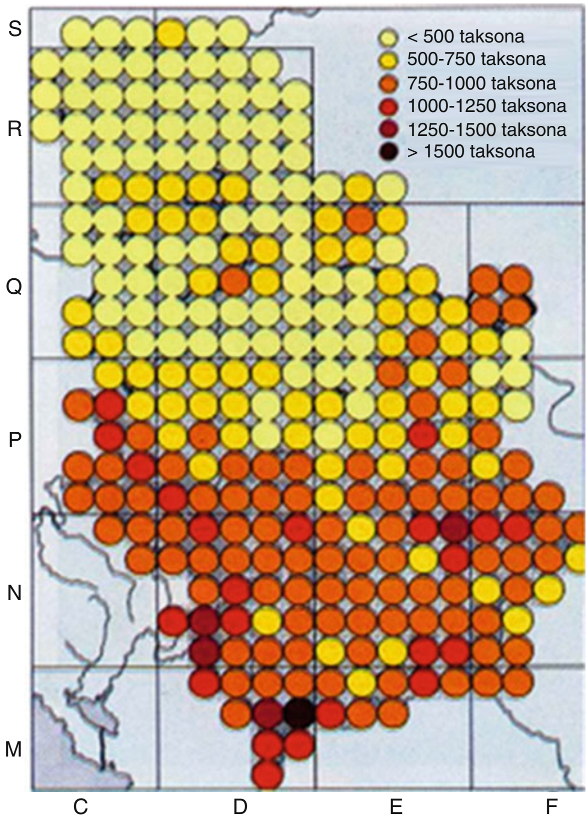

Fig. 15.1 Floristic richness in Serbia (From First National Report of the Republic of Serbia to the United Nations Convention on Biological Diversity, 2010)

Bulgaria has greater floristic taxonomic diversity, and also because Bulgaria falls in four biogeographic regions (EEA 2013): Continental, Alpine, Steppe and Black Sea, whereas Serbia is in only two: Continental and limited Alpine (only in Western Stara Planina). That comparison is made despite the relative uniformity of environmental conditions in the border area between the two countries. The published map (https://www.cbd.int/doc/world/cs/cs-nr-01-en.pdf) depicting the relative spatial weight of taxonomic diversity of Serbian flora (Fig. 15.1) gives grounds for assuming that in the border area with Bulgaria, future Serbian NATURA 2000 sites should be densely located.

The state of Serbian biodiversity is defined as rich in quality but low in quantity (Amidžić et al. 2014) and "Key Biodiversity Areas" (KBAs) have not yet been created as sites of international importance for biodiversity. The overall objective of the methodology for KBAs is to provide universal standards for the selection of sites of global importance for conservation by applying quantitative criteria. These criteria should be easily and consistently applied at the national or regional level, bottom-up, through an iterative process, in cooperation with all stakeholders. Four criteria are used to choose the KBAs: (1) endangered species; (2) restricted range of species, with a small global range of distribution; (3) congregation of species that concentrate in large quantities in a given area during some stage of their life cycle; and (4) biome-restricted assemblages (groups of species restricted to a particular habitat type or biome). These exclusive criteria meet two basic considerations used in the planning of networks of sites (areas), vulnerability and irreplaceability. IUCN is the leading organization for the formulation of a new standard (2014) for KBAs, helping to identify sites, contributing significantly to global biodiversity conservation. This standard includes and extends existing approaches, especially BirdLife's Important Bird and Biodiversity Areas (IBAs) and the Alliance for Zero Extinction (AZE) sites.

Indirect threats to biodiversity in Serbia outlined at the annual meeting of the NGO Network for Biodiversity in Central and Eastern Europe (CEEweb for Biodiversity) can be summarized as follows (Karanović and Ilić 2011):

1. Ineffective and inadequate system of protected areas
2. Lack of understanding for applying the economic value of biodiversity
3. Inadequate legal mechanisms and financing of biodiversity
4. Lack of integration of biodiversity in sectoral laws and policies
5. Lack of information, capacity and coordination in relation to conservation and management of biodiversity
6. Low level of public awareness of the importance of biodiversity

The preparatory phase of this study included analysis of relevant literary and electronic sources, covering both theoretical and methodological aspects concerning the basic idea of the study, and in particular the genealogical, functional, and regional dimension of biodiversity. Comparative analysis between the Serbian model of establishing ecological networks and the experience in this field of Bulgaria, and its Balkan neighbors, is also applied. Mapping as a method is used on one hand as an existing product, but also as a basis for a synthetic approach to derive new regularities and cartographic images.

15.3 Research Findings

Bulgaria established its NATURA 2000 ecological network with 231 protected areas under the Habitats Directive 92/43 EEC and 118 protected areas under the Birds Directive 2009/147 EC. In the border area of the country with Serbia there are 15 NATURA 2000 protected areas, which include the following protected areas (PA) under the Habitats Directive (Fig. 15.3): (1) SCI Karshalevo BG 0000294; (2) SCI Dolni Koriten BG 0000295; (3) SCI Karvav kamak, BG 0001017; (4) SCI Ruy, BG 0000313; (5) SCI Dragoman BG 0000322; (6) SCI Zapadna Stara planina i Predbalkan BG 0001040; (7) SCI Voynitsa BG 00,000,500; (8) SCI Shishentsi BG 0000523; (9) SCI Rabrovo BG 0000339; (10) SCI Deleyna 0000507; and (11) SCI Timok BG 0000525. The other 4 areas coincide, but not completely spatially, with the sites under the Birds Directive, which are (1) SPA Ruy BG 0002112; (2) SPA

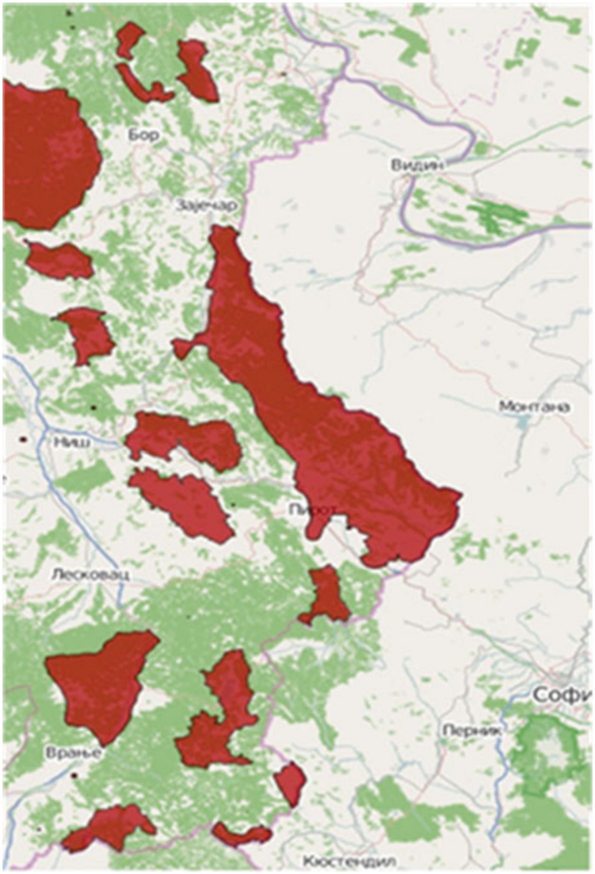

Fig. 15.2 Emerald network and ecological network of Serbia in the border area with Bulgaria (www.bioras.petnica.rs/tekst.php?id=11)

Rayanovtsi BG 0002021; (3) SPA Ponor BG 0002025; and (4) SPA Zapaden Balkan BG 0002002 (Fig. 15.3).

The Emerald network of Serbia in the border area with Bulgaria comprises the following 12 sites: (1) Vlasina SR 0000006; (2) Ostrozub SR 0000043; (3) Zeleničje SR 0000048; (4) Klisura Jerme SR 0000035; (5) Suva planina SR 0000019; (6) Jelašnička klisura SR 0000020; (7) Sičevska klisura SR 0000031; (8) Stara planina SR 0000011; (9) Ozrenske livade SR 0000052; (10) Rtanj SR 0000027; (11) Mala Jasenova Glava (Boljevac) SR 0000051; and (12) Kucajske planine SR 0000055 (Fig. 15.3). The Serbian non-governmental organization BioRaS has added another 5 sites to the ecological network of Serbia (Fig. 15.2), which from north to south are depicted by the author with the following codes after SR 0000061 (Fig. 15.3): (1) Golemi vrh SR 0000062; (2) Rudina SR 0000064; (3) Mali krs SR 0000065; (4) Veliki krs SR 0000066; (5) Deli Jovan SR 0000067. From the proposed Emerald

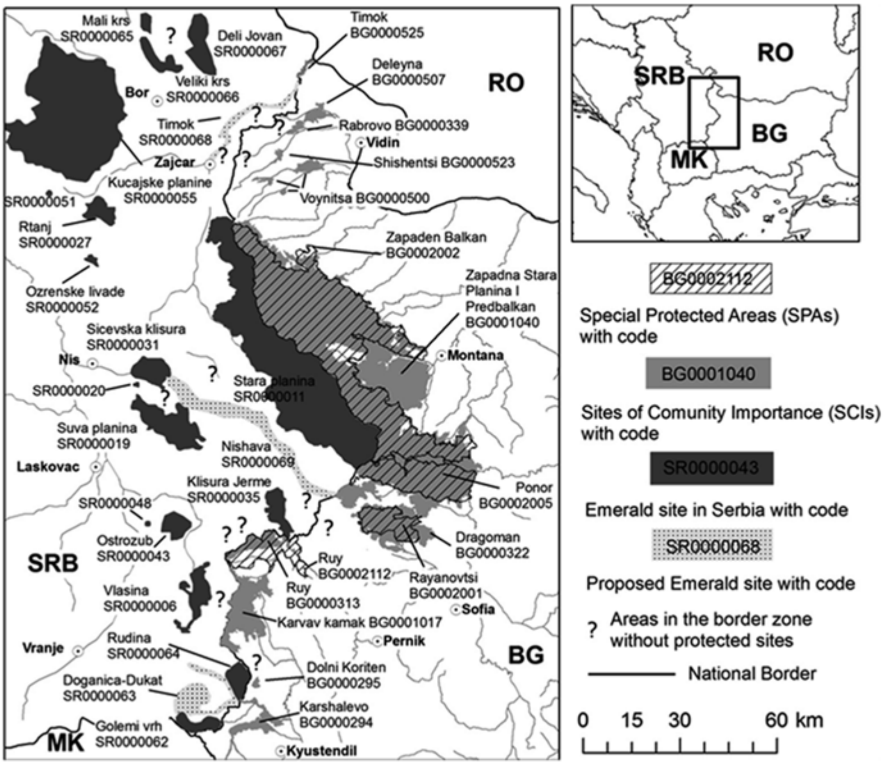

Fig. 15.3 Schematic map of sites of ecological networks Emerald and NATURA 2000 in the border area between Serbia and Bulgaria (Made by Peter Dimitrov)

and ecological network of Serbia (Fig. 15.2), only 4 of the 12 sites located in the border area with Bulgaria spread to the state border, namely, Golemi vrh SR 0000062, Rudina SR 0000064, Klisura Jerme SR 0000035, and Stara Planina SR 0000011 (Fig. 15.3).

The created “Portal for Biodiversity of Serbia” (BioRaS – Portal) is the result of coordinated initiatives and working groups of nature-oriented organizations related to “a consortium of civil society organizations for mapping and monitoring of biodiversity of Serbia,” supported by Netherland’s Embassy in Belgrade and the Ministry of Agriculture and Environment. This portal is in response to the lack of publicly accessible, systematized, and professionally verified information about the diversity of wild species and their distribution in Serbia, and aims at raising awareness for their conservation and the proper and wise use of natural resources in the further development of Serbia (www.bioras.petnica.rs).

That consortium plays the same role as the non-governmental “Federation of environmental associations – Green Balkans” in Bulgaria, which in the period 2005–2006 carried out the initial identification of future NATURA 2000, and as the Turkish national non-governmental organization “Nature and Society” (Doğa

Dernegi), which in 2006 was actively involved in identifying preliminary Key Biodiversity Areas in Turkey. The Serbian consortium is not specifically working on Key Biodiversity Areas, but the proposed sites on their website interactive map of the ecological network in Serbia, promulgated in the "Official Gazette of RS" (No. 102/10), includes Emerald network sites, internationally important bird areas (IBA), internationally important plant areas (IPA), the prime butterflies areas (PBA), Ramsar sites, speleological sites, border regions with regard to environmental networks with neighboring countries, areas of priority habitat types, habitats of rare and endangered species, and other important areas identified in development plans. The map (Fig. 15.2) shows that this is the most complete scheme of future Serbian NATURA 2000 sites and the afore-enumerated sites clearly indicate their significance in terms of biodiversity.

15.4 Discussion

Based on the high mountain character of the mountains Doganica and Dukat, and because of the cross-border basins of Rivers Dragovishtitsa and Nishava and the border Timok River as potential Ramsar sites, the author proposes new sites to be added to the Serbian Emerald network and ecological network with the perspective to become part of the future Serbian NATURA 2000. The three sites suggested by the author, tracked from south to north, are (1) Doganica-Dukat (with Dragovishtitsa River valley) SR 0000063; (2) Nishava SR 0000069; and (3) Timok SR 0000068 (Fig. 15.3).

From Kalotina to Babin nos there is a complete overlap of the Serbian Emerald network along the border, represented by the Serbian site Stara Planina SR0000011 with the Bulgarian NATURA 2000 sites. The geographic area of Stara Planina ridge to the South Morava River valley in Serbia has a mountain character and is much wider in parallel direction compared to the Bulgarian part of Stara Planina and the Predbalkan. West of the Serbian site Stara Planina SR 0000011 are located two parallel Emerald sites – Sicevska klisura SR0000031 and Suva planina SR0000019 – but they have no spatial relationship to each other or separately with Stara Planina SR 0000011. Question marks are placed in this area (Fig. 15.3) with the aim to consider connections between the aforementioned sites when detailing the future NATURA 2000 ecological network in Serbia. Question marks are also placed in Serbian territory (Fig. 15.3) between Bulgarian site SCI Karvav kamak BG 0001017 and the Serbian Vlasina SR 0000006 site, which have no connection with each other, and in the cases of lacking territorial connections between the Bulgarian sites SCI Ruy BG 0000313 and SPA Ruy BG 0002112, Serbian site Ostrozub SR 0000043 or any other future site on Serbian territory in this section of the border. In the current Bulgarian NATURA 2000 ecological network, gaps are also noticeable, indicated with question marks (Fig. 15.3), because except for the small site SCI Dolni Koriten BG 0000295, which does not even expand to the border, there is virtually no connection with the Serbian site Rudina SR 0000064. In the region of

Kalotina on both sides of the border question marks reveal the largest gap in terms of ecological networks in the border area between Serbia and Bulgaria.

To the north, question marks indicate the lack of network links between Serbian sites Mali krs SR 0000065, Veliki krs SR 0000066, and Deli Jovan SR 0000067 (Fig. 15.3). East of the site Timok SR 0000068 proposed earlier, question marks on both sides of the border reflect the missing connection between Serbian and Bulgarian sites. Establishment of a Bulgarian site in the area of Vrashka Chuka (692 m) is strongly recommended. So far, being an important plant area, coded BG IPA022 (Vladimirov et al. 2012), this area is only a protected locality under the Protected Areas Act, but it could be spatially linked with SCI Shishentsi BG 0000523 along the Topolovets River.

15.5 Conclusions

The proposals for new sites in the ecological networks of Serbia as a basis for the future NATURA 2000 network comply with the understanding that the delimitation of the sites in this network is the sovereign right of Serbia, and the names of those areas are likely be different from those proposed. The author's idea about the configuration of sites of ecological networks in Serbia on the border with Bulgaria is based on superficial impressions of this geographic area, which are supplemented with images of Google Earth and the interactive map of the EEA, providing a general picture of the structure of plant communities. The predominant part of the border area between Serbia and Bulgaria is a mountainous territory, and the Western Stara Planina is a high mountainous area where the effect of the "overlapping of periphery" (Koulov 2013) exists.

Regardless of the negative trends of deforestation of Serbian space and destruction of natural habitats since the early nineteenth century when forests covered 75–80 % of Serbian territory (Aleksić and Vučićević 2006), today they occupy only 30.6 % of the territory but still preserve quality characteristics for inclusion in ecological networks. The NATURA 2000 network, linking all EU protected sites, is perceived by the scientific community as a system of "natural and ecological compensation" (Borisova 2013). Statistics of the European Environment Agency (EEA 2013) for NATURA 2000 shows that the absolute area of ecological network sites in Bulgaria is ranked 9th among 28 EU countries. In proportion to the national territory Bulgaria is in third place in the EU (34.3 %) behind Slovenia and Croatia. Serbia has a national space comparable to Bulgarian in size and environmental conditions. It is hard to think of and recommend the future Serbian NATURA 2000 ecological network to reach the size of the Bulgarian network (34.3 %), but the current share of the Emerald network in Serbia (11.54 %) is too low, and even with the complementary sites proposed by BioRaS, it will expand only up to 15 % of national space (Fig. 15.2). These data are important for the future NATURA 2000 in Serbia, because of the example with Romania, which on entry into the EU has 17.8 % of national territory in NATURA 2000, and after the intervention of the EEC it reaches a share of 22.6 %.

An essential question for the future development of NATURA 2000 sites is their management. In the document "National Priority Framework for Action for NATURA 2000 in Bulgaria" (NPRD 2013), prepared by the Ministry of Environment and Waters for the period 2014–2023, it is pointed out that for the protected areas in NATURA 2000 network (339 sites including overlap) management plans to this moment are not finalized. Currently only eight management plans of protected areas are completed, whose boundaries overlap with the boundaries of areas under the Habitats Directive (SCIs), but none of them falls into the object of current study.

Strengthening the administrative capacity by the twinning project "Protected Areas in Serbia (NATURA 2000)" has been carried out by the Ministry of Environment and Spatial Planning of Serbia in partnership with the Environment Agency of Austria and the Organization for European Public Law from Greece. The project was implemented in the period 01.01.2010–31.12.2011 and promoted the harmonization of Serbian legislation with the EU Birds and Habitats Directives, the establishment of the NATURA 2000 network in accordance with the criteria of the EU, pilot development of management plans for NATURA 2000 sites, and the development and implementation of training programs, which will systematically build up capacity for the development of the NATURA 2000 network in Serbia.

Based on the studied spatial structure of sites in the border region of Serbia and Bulgaria forming part of their ecological networks, the following conclusions could be derived.

1. Serbia has a sufficient time horizon until 2019–2020 before entry into the EU system, and the future NATURA 2000 sites should be delineated as a natural extension of already existing networks in neighboring countries.
2. Formalizing the links between the sites of ecological networks along the border to build a real NATURA 2000 network is in compliance with the requirements for continuity and sufficient amount of reserved spaces, ensuring the production of the required quality and quantity of ecosystem/landscape goods and services.
3. Given the share of ecological networks is too small as a percentage of national space and the negative example of Romania, Serbia should increase the spatial extent of future NATURA 2000 sites.
4. Delays in elaboration of management plans of NATURA 2000 sites in Bulgaria, Romania, and other EU countries show that in parallel with the establishment of the NATURA 2000 ecological network Serbia should start preparation for the management of sites and possibly together with the neighboring EU Member States for the border regions, which is still an aspiration only.
5. The development of any new national ecological network such as the Serbian one is part of the future NATURA 2000 ecological network, which is an open project, and with good will discrepancies in the network linkages between Serbian and Bulgaria sites could be adjusted.

Acknowledgments This research is sponsored by the "National, European, and Civilizational Dimensions of the Culture – Language – Media Dialogue" Program of the "Alma Mater" University Complex for the Humanities at Sofia University "St. Kliment Ohridski", funded by the Bulgarian Ministry of Education, Youth and Science' Scientific Research Fund.

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Chapter 16
Invasive Plant Species in the Northern Part of Mala Planina

Borislav Grigorov

Abstract The aim of the current research work is to identify invasive plant species and analyse their possible impact on the biodiversity of the territory of Mala Planina. Modern tendencies in the dynamics of vegetation are a result of long historical development under the influence of geologic, climatic, and soil factors and anthropogenic pressure. An invasive species is a plant or an animal that is not native to a specific location and has a tendency to spread, which is believed to cause damage to the environment or human economy and/or human death. Invasive species cause problems all around the world, including Mala Planina, which is a part of Western Stara Planina. It is important to differentiate the term invasive species from the term introduced species. Invasive plant species are capable of affecting the functional biodiversity of Mala Planina. Investigation of invasive species in the studied area has theoretical and practical importance. *Robinia pseudoacacia* and *Ailanthus altissima* are among the most common invasive species of the plant kingdom along the mountain range. Cameral and terrain research has been done. Remote methods are used to accomplish the aim of the current work.

Keywords Mala Planina • Invasive species • Damage

16.1 Introduction

The modern foundation for invasion ecology was established by the SCOPE program in the 1980s (Drake et al. 1989). The past two decades have seen an explosion of research in the field. Considerable effort is being devoted to practical aspects, such as predictions of which species will invade (Krivanek and Pysek 2006). There are two basic questions that have fascinated ecologists since biological invasions have emerged. The question: 'Which species will invade and under which conditions?' has stimulated the search for traits that separate successful from less

B. Grigorov (✉)
Faculty of Geology and Geography, University of Sofia "St. Kliment Ohridski",
15 Tzar Osvoboditel Blvd., 1504 Sofia, Bulgaria
e-mail: borislav.g.grigorov@gmail.com

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_16

successful invaders (Rejmanek and Richardson 1996; Williamson and Fitter 1996; Keane and Crawley 2002). 'What features of ecosystems makes them prone to or resistant to invasions?' has spurred attempts to define the set of community characteristics and environmental situations under which invasion is realized (Lonsdale 1999; Davis et al. 2000).

Nevertheless, terms crucial to understanding ecology have often been criticized for their nonoperational nature (McIntosh 1985; Peters 1991). There are widely divergent perceptions of the criteria for 'invasive' species (Davis and Thompson 2001; Rejmánek et al. 2002; Chew and Laubichler 2003). Adjectives such as 'invasive,' 'alien,' 'noxious,' and 'exotic' are commonly used (Binggeli 1994; Chew and Laubichler 2003). Other adjectives such as adventive, alien, colonizing, cryptogenic, foreign, immigrant, imported, introduced, nonindigenous, pest, translocated, transplanted, and travelling are synonyms for invasive species (Colautti et al. 2004).

What in fact are invasive alien species?

According to the Convention on Biological Diversity and the GB non-native species secretariat: "Invasive alien species (IAS) are species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity." IAS occur in all taxonomic groups: animals, plants, fungi and microorganisms; include any part, whether gametes, seeds, eggs, or propagules; and can affect all types of ecosystems. If a species new habitat is similar enough to its native range, it may survive and reproduce. For a species to become invasive, it must successfully outcompete native organisms, spread through its new environment, increase in population density and harm ecosystems in its introduced range. It can damage the economy and our health. Rapid reproduction, high dispersal ability and the ability to survive on various food types and in a wide range of environmental conditions are common characteristics.

Invasive alien species (IAS) are the second cause of global biodiversity loss after direct habitat destruction (Genovesi and Shine 2004). Ingo Grass et al. 2014 concludes that loss of natural habitat and exotic plant invasions are two major drivers of global change. As more and more exotic plant species are introduced, the likelihood of new invasion events with negative ecological impacts increases rapidly (Vitousek et al. 1997).

Pysek and Richardson (2006) summarize some key generalizations in plant invasions, which are shown in Table 16.1.

A wide variety of organizations and programs is involved with invasive species. Only a few are mentioned here.

The Global Invasive Specises Programme (GISP) is a project of DIVERSITAS aiming at preventing and managing invasive species. Its mission is to conserve biodiversity and sustain human livelihoods by minimizing the spread and impact of invasive alien species. GISP has published a Global Strategy on Invasive Alien Species and a Toolkit of Best Prevention and Management Practices (McNeely et al. 2001; Wittenberg and Cock 2001).

The European Network on Invasive Alien Species (NOBANIS) is a gateway to information on alien and invasive species in North and Central Europe.

Table 16.1 Key generalizations in plant invasions

Generalization	Scale	Source
1. Temperate mainland regions are more invaded than tropical mainland regions	Global	Rejmanek (1996a), Lonsdale (1999)
2. Number of naturalized species in temperate regions decreases with latitude	Continental: Europe	Sax (2001)
3. Geographic ranges of naturalized species in temperate zone increase with latitude	Continental: Europe	Sax (2001)
4. Clonal species increase their representation in alien floras with latitude	Global	Pysek (1997)

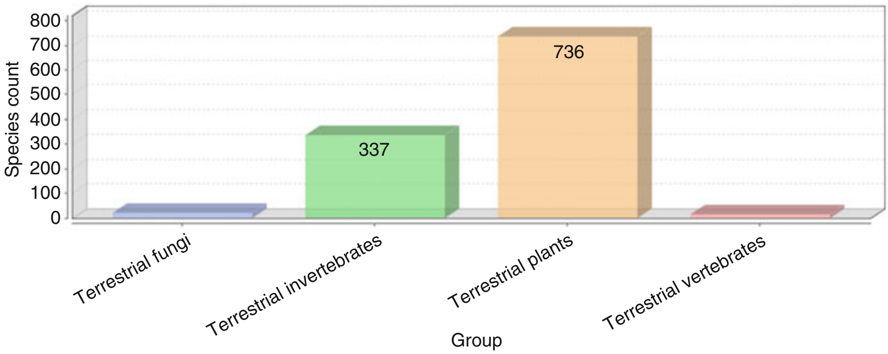

Fig. 16.1 Number of recorded alien species per group

In the Global Invasive Species Database, one can check the "One Hundred of the World's Worst Invasive Alien Species."

The European Alien Species Information Network (EASIN) aims to facilitate the exploration of existing alien species information in Europe to assist the implementation of European policies on biological invasions.

Delivering Alien Invasive Species Inventories for Europe (DAISIE) provides information about marine and terrestrial invasive species around Europe. A chart of the number of recorded alien species per groups is displayed in Fig. 16.1.

Bulgaria and Mala Planina are an inseparable part of Europe. Bulgaria is a part of international organizations, networks and programs dealing with invasive species, such as the European and Mediterranean Plant Protection Organization (EPPO), which is an intergovernmental organization responsible for European cooperation in plant protection in the European and Mediterranean region. EPPO is the regional plant protection organization (RPPO) for Europe under the International Plant Protection Convention (IPPC).

Bulgaria participates in the East and South European Network on Invasive Alien Species (ESENIAS), which provides data on invasive alien species: scientific names, biology, ecology, habitat, invasiveness, and impact.

Bulgaria took part in a survey by Giuseppe Brundu, Guillaume Fried, and Sarah Brunel on invasive alien plants in Mediterranean countries.

The country participates in RESIPATH – Responses of European Forests and Society to Invasive Pathogens. RESIPATH aims at studying how European forest communities have been affected by and responded to invasive pathogens and also to develop means to mitigate their impact.

16.2 Data and Methods

Terrain and cameral research was accomplished for this chapter, and some interesting findings were made. According to Pysek and other authors (2009) 62.8 % of the established plant species in Europe were introduced intentionally for ornamental, horticultural, or agricultural purposes. The remaining species were introduced unintentionally, mostly associated with transport vectors, or as contaminants of seeds and other commodities. An average of 5.3 European species are found in parts of the continent outside their native range each year (Lambdon et al. 2008). The most invaded habitats in Europe are in heavily transformed landscapes such as agricultural land, coniferous forests, urban areas, and dump or construction sites. In contrast, broad-leaved and mixed forests, pastures, natural grasslands, moors and heathlands have remained relatively uninvaded (Chytrý et al. 2008). According to the DAISIE database (Lambdon et al. 2008), 5789 plant species have been recorded (not necessarily established) from the wild in at least one European country to which they are not native.

Invasive alien species in Bulgaria are a common phenomenon. Nevertheless, some of them are a greater threat to the environment than others, and these are included in the "top 10" list of the most problematic invasive species in our country (Petrova et al. 2013):

1. *Acer negundo*
2. *Ailanthus altissima*
3. *Ambrosia artemisiifolia*
4. *Amorpha fruticosa*
5. *Bidens frondosus*
6. *Elodea nuttallii*
7. *Falopia x bohemica*
8. *Opuntia humifusa*
9. *Paspalum distichum*
10. *Robinia pseudoacacia*

Some of these species are spread out in Mala Planina. The mountain is a part of the biogeographic region of Stara Planina (Assenov 2006). A map of Europe in an article by Chytrý et al. (2008) of alien plant invasions shows that some areas of Mala Planina have a level of invasion greater than 5 % and other parts have a level of invasion less than 1 % or between 1 % and 5 %.

16.3 Research Findings

Many invasive plant species were discovered in Mala Planina during the terrain and cameral research. Part of the boundaries of the mountain is described by Grigorov et al. (2015). Specific characteristics of every species are given by Petrova and others (Petrova et al. 2013). Their locality is shown in Fig. 16.2.

Acer negundo L. is included in the List of "Worst invasive alien species threatening biodiversity in Europe," Annex 1. 2007. It is a deciduous tree, reaching 12–15 (20) meters (m) in height. It has pale grey bark, which becomes darker when the tree ages. Anemochory, zoochory, and ornitochory are typical. It is usually situated near rivers. The species *Acer negundo* is native to North America and the tropical part of South America and was introduced in Bulgaria as a decorative tree species in the last two decades of the nineteenth century because it has the ability to grow rapidly. The species *Acer negundo* has gone wild in the whole country. It is widely distributed and reaches altitudes of 1000 m. It is naturalized in anthropogenic habitats, near rivers, roads, and railways. An efficient herbicide is 2,4-D.

Weber and Gut (2004) conclude that *Acer negundo* has a risk class III (high risk).

Ailanthus altissima (Mill.) Swingle is included in the List of "Worst invasive alien species threatening biodiversity in Europe," Annex 1. 2007, and also in the list of invasive species of The European and Mediterranean Plant Protection Organization

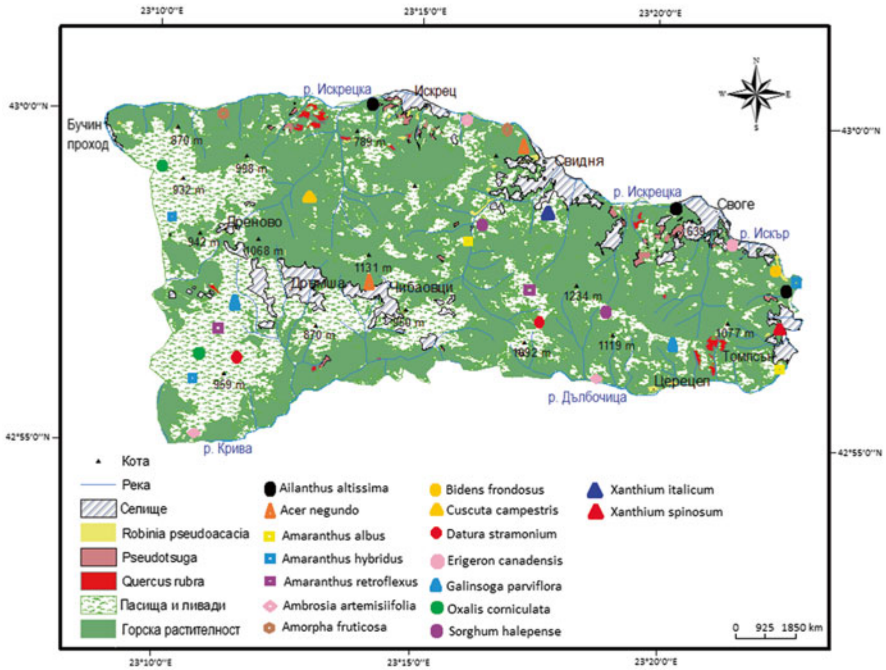

Fig. 16.2 Locality of invasive alien species in Mala Planina

(EPPO 2012). It is a deciduous tree, often 6–10 m tall. The roots and leaves contain allelopathic and herbicidal compounds (Zheng 1978; Heisey 1990, 1997; IWS 1982). Ornitochory and anemochory are typical. *Ailanthus altissima* is native to Eastern Asia (China and Northern Vietnam). The natural pasture and grassland vegetation is replaced by bushes and dense low forests formed by the Tree of Heaven (Peev et al. 2009; Uzunov et al. 2012).

Control is effective with glyphosate, triclopyr, or 2,4,5-T, as a foliar spray, a basal bark application, or onto freshly cut stumps (Hoshovsky 1988; SE-EPPC 2002). The fungi species *Verticillium* and *Fusarium* have pathogenic effect.

Weber and Gut (2004) conclude that *Ailanthus altissima* has a risk class III (high risk).

Amaranthus albus L. is an annual herbaceous plant, reaching 10–50 cm in height. Ornitochory, zoochory, and anthropochory are typical. It flowers between May and October. A xerophyte, a weed and a ruderal species, it is grazed by horses and cows. The species is native to North America. It is naturalized as a weed and ruderal invasive species. Correct agricultural methodology is enough to restrict its habitat.

Amaranthus hybridus L. is an annual herbaceous plant, reaching 15–100 cm in height. Ornithochory and anthropochory are typical. It flowers between July and September. It prefers soils that are rich in organic matter and is a part of ruderal habitats. The species is native to tropical and subtropical America. It is widespread around the country, and for this reason Bulgarian botany scientists have not paid much attention to its habitats. Application of correct agricultural technologies is a proper way of control.

Amaranthus retroflexus L. is an annual herbaceous plant, reaching 15–100 cm in height. Anemochory, hydrochory, zoochory, and anthropochory are typical. It flowers between June and September, preferring higher temperatures, rich soils, and light. It is a spring weed and a ruderal plant. The species is native to those parts of America characterised by temperate and tropical climate. Herbicides such as 2-4-D are used for control.

Ambrosia artemisiifolia L. is also a species included in the List of "Worst invasive alien species threatening biodiversity in Europe," Annex 1. 2007, and in the list of invasive species of EPPO (2012). The species is an annual herbaceous plant without scent, reaching 15–120 cm in height. Anthropochory, hydrochory, and zoochory are typical. It flowers between July and September. As a ruderal plant, it is a dangerous weed. The pollen of invasive *Ambrosia artemisiifolia* is highly allergenic to humans.

The species is native to North America. *Zygograma suturalis*, a leaf-eating beetle, is used for controlling the spreading of the species. *A. artemisiifolia* can be controlled in field crops by the usual weed control operations, including use of common herbicides. It poses more of a problem when it grows in wasteland or along roadways or waterways.

Amorpha fruticosa L. is included in the List of "Worst invasive alien species threatening biodiversity in Europe," Annex 1. 2007, and in the list of invasive species of EPPO (2012). A deciduous shrub, it reaches 2–5 m in height, with greyish-black or brown bark. Hydrochory is typical and occasionally zoochory is present. It is a preferred plant for bees. It flowers between May and July. Rich soils and humid habitats are preferable, but the species can survive in extreme conditions. It is found in riverside habitats, and around roads and railways, and secretes toxin for many insect species. The species is native to the southeastern part of North America. Larger plants are cut to the ground and treated with herbicides.

Bidens frondosus L. is included in the List of "Worst invasive alien species threatening biodiversity in Europe," Annex 1. 2007, and in the list of watched invasive species of EPPO (2012). It is an annual herbaceous plant, reaching 20–100 cm height, flowering between July and October. Zoochory and anthropochory are typical. It forms dense populations. It prefers humid habitats and is found in the eastern part of Mala Planina. The species is native to North America and was announced as a new species to the Bulgarian flora in 2004. Control is practically impossible.

Cuscuta campestris Yunck. is an annual parasitic plant without roots and leaves. It flowers between June and October. Hydrochory, anemochory, ornitochory, and anthropochory are typical. It climbs around the leaves or the stem of the host and uses its haustoria to obtain nutrients. The species is native to North America. One of the most dangerous parasitic weeds, it attacks a wide variety of hosts. Prevention and chemical control are needed.

Datura stramonium L. is an annual herbaceous plant that flowers between April and August. Anthropochory, ornitochory, and other types of zoochory are typical. All parts of the plant are toxic for humans and animals. It is native to America. Using herbicides such as atrazine, 2,4-D, and bromoxynil is one way to control the spreading of this plant.

Erigeron annuus (L.) Desf. is an annual or biennial herbaceous plant. It flowers between June and September and forms massive amount of seeds. As it is a pioneer species, it colonizes habitats very quickly. The species is native to North America (Canada and northern parts of USA). Full extinction of the species is impossible. Its populations must be treated with herbicides when possible.

The species is found in the southern part of Mala Planina and may spread in the northern part.

Weber and Gut (2004) conclude that *Erigeron annuus* has a risk class II (further observation).

Erigeron canadensis L. is an annual or biennial herbaceous plant. It flowers between May and November. Anemochory is typical. It is a ruderal plant. The species is native to North America, has naturalized in all continents, and is probably the most cosmopolitan alien plant in the world.

Galinsoga parviflora Cav. is an annual herbaceous plant and a weed. It flowers between May and October. Anemochory is typical. The species prefers deep and humid soils. It is native to South America.

Iva xanthiifolia Nutt. is included in the List of "Worst invasive alien species threatening biodiversity in Europe," Annex 1. 2007. It is an annual herbaceous plant and flowers between July and September. Anemochory and anthropochory are typical. The species is native to North America. It was found for the first time around

Sofia in 1987. More than 15 habitats were registered in 2006, including an area around Blato River, which is not far from Mala Planina.

Lycium barbarum L. is a deciduous shrub, reaching 2.5 m height, and flowering between June and October. The species is native to China.

The species is found in the southern part of Mala Planina and it may spread in the northern part.

Oxalis corniculata L. is a perennial herbaceous plant. It flowers between May and October. Hydrochory and anthropochory are typical. The species is native to Central and South America. Mechanical control and use of herbicides are needed.

Robinia pseudoacacia L. is included in the List of "Worst invasive alien species threatening biodiversity in Europe," Annex 1. 2007. It is a deciduous tree and flowers in May and June. Anemochory is typical. The species is native to North America and is extremely dangerous for Bulgarian flora because it is widespread and initiates the loss of habitats. The species is impossible to control. The use of glyphosate is the most effective way to control a population.

Weber and Gut (2004) conclude that *Robinia pseudoacacia* has a risk class III (high risk).

Sorghum halepense (L.) Pers. is a perennial herbaceous plant. It flowers between June and September. Anemochory, hydrochory, zoochory, and anthropochory are typical. It is considered to be one of the most dangerous weeds in the world. The species is native to the Mediterranean part of Europe and Asia. Chemical control can restrict its habitats.

Xanthium italicum Moretti is an annual herbaceous plant with a scent. It flowers between July and October. Anthropochory and zoochory are typical. The species is native to North and South America. Herbicides are used to restrict its habitats.

Xanthium spinosum L. is an annual herbaceous plant. It flowers between July and September. Hydrochory, anthropochory, and zoochory are typical. The species is native to South America. It is vulnerable to the action of numerous herbicides such as 2,4-D and glyphosate.

Other problematic plant species are also found in Mala Planina. Species such as *Pseudotsuga* and *Quercus rubra* are not defined as invasive species in Mala Planina by Petrova et al. (2013), but they are not native for this region. Based on this fact, it is considered that some day they can become invasive.

Pseudotsuga is a genus of evergreen coniferous trees with a straight trunk, reaching 20–120 m height. The bark is thick and corky.

Quercus rubra is a deciduous tree. Its bark features bark ridges. It is native to North America.

16.4 Conclusions

Investigation of the spreading of invasive alien species in Mala Planina is an important task. The mountain is quite near to the capital city of Bulgaria, Sofia, one of the reasons that biodiversity in Mala Planina should be studied and protected.

There is no doubt that invasive alien species have conquered territories in Mala Planina. One of the aims of the current chapter was to identify those species and others which have the ability to become invasive. It is very important to prevent new plant invasions. There is an urgent need for the development of early warning systems (Panetta and Scanlan 1995; Sandlund et al. 1999; Groves et al. 2001; Wittenberg and Cock 2001; Andow 2003).

Acknowledgements This research is sponsored by the "National, European, and Civilizational Dimensions of the Culture – Language – Media Dialogue" Program of the "Alma Mater" University Complex for the Humanities at Sofia University "St. Kliment Ohridski," funded by the Bulgarian Ministry of Education, Youth and Science Scientific Research Fund.

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Part V
Population and Heritage Challenges

Chapter 17
Monitoring Glacier Changes with the Use of Archive Images: The Example of the Julian Alps (NW Slovenia, NE Italy)

Mihaela Triglav Čekada, Matija Zorn, and Renato R. Colucci

Abstract In the last century and a half, average summer temperatures have slowly been rising worldwide. The most observable consequence of this is the change in glacier sizes. For monitoring glacier area and volume, various measuring techniques exist—from measurements with a measuring tape and geodetic measurements to remote sensing and photogrammetry. Many of these techniques were used to monitor very small glaciers in the Julian Alps through the twentieth century. At least eight very small glaciers existed in Julian Alps in the previous century. Since the second half of the twentieth century some have disappeared, but some still exist. In this chapter we focus on three small glaciers: two on Mount Canin (NE Italy) and one on Mount Triglav (NW Slovenia). We present the changes in glacier sizes since the end of the nineteenth century with the use of archived non-metrical images. The acquisition is based on interactive orientation method (mono-plotting) using detailed digital terrain models (DTM).

In the studied period, the Canin and Triglav glaciers behaved in a similar manner and also had similar sizes. At the end of the nineteenth century, the Western Canin Glacier covered 28 ha, the Eastern Canin Glacier 13 ha, and the Triglav Glacier 22 ha. By the mid-twentieth century, the glaciers had already broken up into several parts. The Western Canin Glacier covered 7.6 ha in 1957 and the Triglav Glacier covered 13.7 ha in 1958. In 2000, the eastern (largest) part of the Western Canin Glacier and the Triglav Glacier measured 5 ha and 1.1 ha respectively. Since then they have lost at least half their size.

M.T. Čekada (✉)
Geodetic Institute of Slovenia, Jamova cesta 2, 1000 Ljubljana, Slovenia
e-mail: mihaela.triglav@gis.si

M. Zorn
Research Centre of the Slovenian Academy of Sciences and Arts, Anton Melik Geographical Institute, Novi trg 2, 1000 Ljubljana, Slovenia
e-mail: matija.zorn@zrc-sazu.si

R.R. Colucci
Department of Earth System Science and Environmental Technology, National Research Council, Marine Science Institute, Viale R. Gessi 2, 34123 Trieste, Italy
e-mail: r.colucci@ts.ismar.cnr.it

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_17

The article highlights the usefulness of archival imagery for long-time monitoring of glaciers.

Keywords Archive images • Photogrammetry • Mono-plotting • Glaciers • Julian Alps • Italy • Slovenia

17.1 Introduction

Alpine glaciers are an important part of the hydrological and geomorphological natural heritage. They also represent a source of drinking water and are important tourist destinations. They can be used to monitor short-term climate changes, and the study of their accumulation forms also reveals information about earlier environmental changes (Triglav Čekada et al. 2012).

Measuring glaciers usually involves measuring the retreat of the glacial terminus, the reduction in the glacier's area or volume, or the speed of its movement. The first glacier measurements in the Alps were primarily made by hand, using a tape measure and compass. In the Eastern Alps, regular measurements with a tape measure were made as early as 1878, for example, to measure the retreat of the terminus of the Pasterze Glacier (Pasterze am Großglockner, Austria), the longest glacier in the Eastern Alps (Avian and Bauer 2006). In the first half of the twentieth century measurements of glaciers were begun using standard geodetic means. In the last few decades, alpine glaciers have mostly been measured using various remote sensing methods: from terrestrial (oblique) and aerial photogrammetry to processing satellite images and using terrestrial and aerial laser scanning data (Triglav Čekada et al. 2012).

This chapter focuses on non-metric photogrammetry of archive images of three small glaciers in the Julian Alps (SE Alps; Fig. 17.1): the two Canin glaciers (Eastern Canin Glacier and Western Canin Glacier; NE Italy) and the Triglav Glacier (NW Slovenia), for studying their size. The acquisition is based on interactive orientation method (mono-plotting) using a detailed digital terrain model (DTM) (Triglav Čekada et al. 2011). For the largest extent of the glaciers, the oldest available images from the end of the nineteenth century were used.

17.2 Glaciers in the Julian Alps (SE Alps)

In the mid-1980s there were a total of eight small glaciers in the Julian Alps (Table 17.1): four Canin glaciers (Italy), Triglav Glacier (Slovenia), and three glaciers in the area of Mount Montasio (Italy). Among these, only the Eastern and the Western Canin glaciers (Fig. 17.2), Triglav Glacier (Fig. 17.3), and the Western Montasio

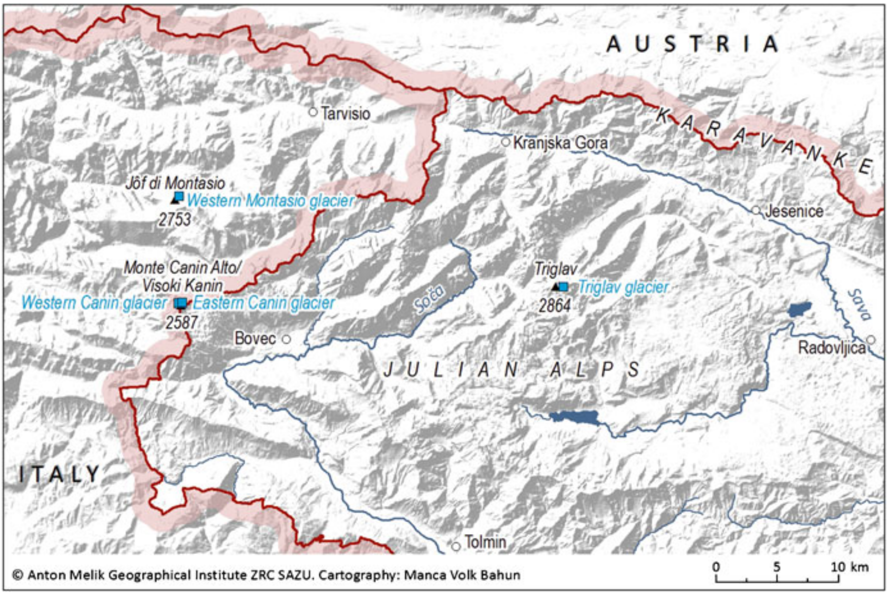

Fig. 17.1 Small glaciers in the Julian Alps

Table 17.1 Area and mean elevation of glaciers in the Julian Alps in 1985 (Triglav Čekada et al. 2014)

Glacier (English name used in the paper)	Glacier (original name)	Country	Area (ha)	Mean elevation (m)
Minor Montasio Glacier	Ghiacciaio Minore di Montasio	Italy	1	1850
Eastern Montasio Glacier	Ghiacciaio orientale di Montasio	Italy	7	1920
Western Montasio Glacier	Ghiacciaio occidentale di Montasio	Italy	8	1940
Prestreljenik Glacier	Ghiacciaio del Prestreljenik	Italy	3	2200
Ursic Glacier	Ghiacciaio dell'Ursic	Italy	9	2240
Eastern Canin Glacier	**Ghiacciaio orientale del Canin**	**Italy**	**15**	**2220**
Western Canin Glacier	**Ghiacciaio occidentale del Canin**	**Italy**	**27**	**2250**
Triglav Glacier	**Triglavski ledenik**	**Slovenia**	**10**	**2480**

The glaciers discussed in this article are marked in bold

Glacier can still be classified as small glaciers (or glacierets), whereas the others can be described only as occasional snowfields.

The Canin glaciers have been observed for the longest time. The first mention of measurements on the Western Canin Glacier dates back to 1880, and those on the

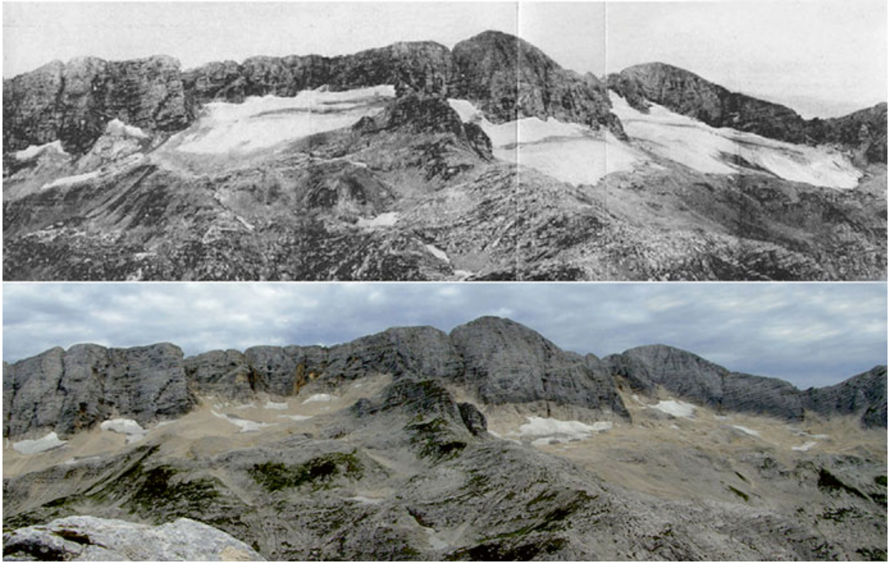

Fig. 17.2 Ursic Glacier (*left*) and Eastern and Western Canin glaciers (*right*) on 30 July 1893 (*upper photo*: photographer, Arturo Ferrucci) and 8 September 2011 (*lower photo*: photographer, Renato R. Colucci)

Eastern Canin Glacier date back to 1896. Regular measurements of the Triglav Glacier started in 1946 (Triglav Čekada et al. 2012; Triglav Čekada and Gabrovec 2013; Triglav Čekada et al. 2014a, b).

17.3 Method: Processing Archive Images

The boundaries of the Canin and the Triglav glaciers were measured from the archival images (old photography and archive aerial images) by applying the method of DTM-based absolute orientation of images. This is a mono-plotting method that makes it possible to obtain 3D data from a single image. It is based on seeking the best-fitting projection of DTM points onto the image, in which the parameters of the external image orientation (three coordinates of the camera's projection center, three rotation angles, and the scale of the projected model) are determined through a visual search for the best fit. This method is interactive and requires that the operator knows the details on the image very well to derive best fit of the image to the DTM projection. This part of the method is time consuming because the sparse control points available on archival images mean that the fitting process cannot be done automatically. A 1 m × 1 m grid DTM based on aerial laser scanning was used.

In analyzing archival images of glaciers, it is assumed that the surface below the glacier did not significantly change between the time when the image was taken and

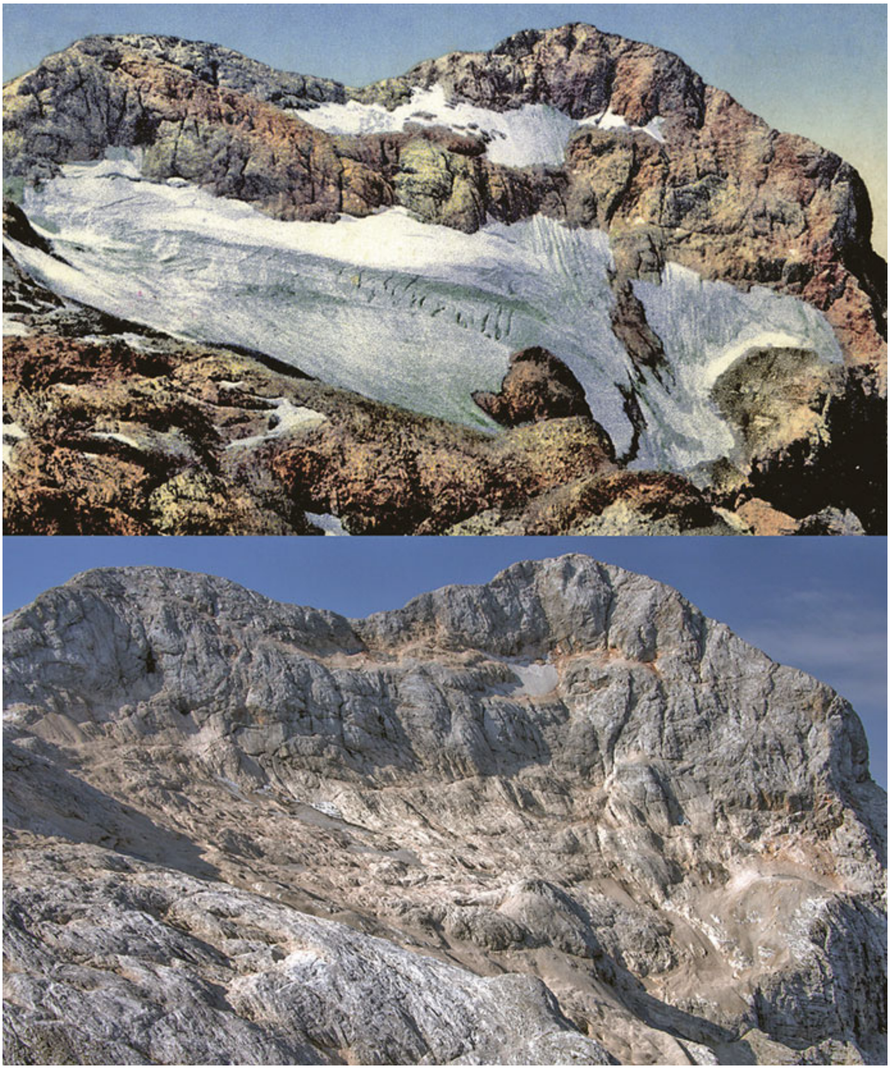

Fig. 17.3 Triglav Glacier before 1897 (*upper photo*: photographer, Alois Beer) and on 11 September 2012 (*lower photo*: photographer, Jaka Ortar)

the time when the basic data were measured for producing the DTM. Therefore, a past boundary of the glacier can be displayed on the current DTM (Triglav Čekada et al. 2011). This assumption has also been confirmed for the Canin and Triglav glaciers because no major geomorphic changes (e.g., rockfalls) have been recorded in the close surroundings of these glaciers in the past 120 years, and minor movements can be overlooked (Triglav Čekada et al. 2014a).

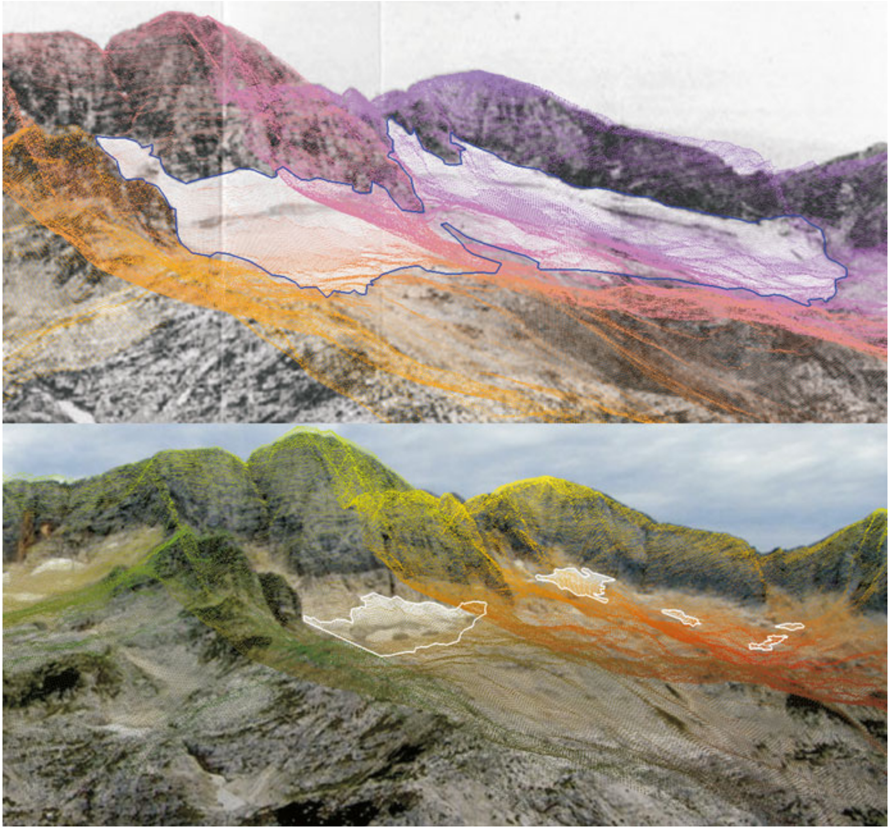

Fig. 17.4 Interactive orientation of the Canin glaciers on the 1893 (*upper photo*: photographer, Arturo Ferrucci) and 2011 (*lower photo*: photographer, Renato R. Colucci) photographs

The interactive orientation procedure is also based on the assumption that the image is in the central projection and that all the errors (especially any distortions) have been removed. Unfortunately, if very old images are used (older than 100 years), no information on the distortion is available. Old images of glaciers have another weakness: they show areas with no manmade elements in the landscape (roads and paths) that could be used to estimate the distortion of the image (Triglav Čekada et al. 2014a).

To avoid old image problems we tried to obtain the best fit between the image and the DTM projection based on the known approximate location of the camera (accurate at approximately 500 m; Fig. 17.4). In the majority of cases this was not sufficient, especially in studying the details on the edges of the images, where the greatest errors are generally expected, and so we also took into account corrections caused by radial distortion in DTM projection onto the image (Triglav Čekada et al. 2011).

Table 17.2 Area of the Canin glaciers based on archive non-metric images, images produced as part of the cyclic aerial photogrammetric measurements of Slovenia (CAS), and aerial laser scanning

Image date	Author/source	Western Canin Glacier (ha)	Eastern Canin Glacier (ha)
30 July 1893	Arturo Ferrucci	28	13
1908	Map by Olinto Marinelli	30.1	12.9
Before 1934	Wilhelm Dronowicz	23.6	12.1
10 Sept. 1957	Dino Di Colbertaldo	7.6 (5.0[a])	
1970s	Photo courtesy Manlio Roseano	10.1	5.5
18 Aug. 2000	CAS	5.9 (2.4[a])	2.7
18 Aug. 2011	CAS	14.6 (4.7[a])	6.4
8 Sept. 2011	Renato R. Colucci	– (1.3[a])	1.2
29 Sept. 2011	2011 aerial laser scanning	8.8 (3.6[a])	4.7

[a]Size of the largest section of the Western Canin Glacier

17.4 Results

In the studied period the Canin and Triglav glaciers behaved in a similar manner and also had similar sizes (Tables 17.2 and 17.3). At the end of the nineteenth century, the Western Canin Glacier covered 28 ha, the Eastern Canin Glacier 13 ha, and the Triglav Glacier 22 ha. By the mid-twentieth century, the glaciers had already broken up into several parts. The Western Canin Glacier covered 7.6 ha in 1957 and the Triglav Glacier covered 13.7 ha in 1958. This was followed by a period of growth. The Western Canin Glacier covered 10.1 ha in the 1970s, and Triglav Glacier covered 18 ha in 1976. The 1980s saw an accelerated glacier retreat. In 2000, the eastern (largest) part of the Western Canin Glacier and the Triglav Glacier measured 5 ha and 1.1 ha, respectively. The end of the 2010s saw several winters with abundant snow that protected the glaciers. Accordingly, the 2011 aerial laser scanning of the Canin glaciers revealed its larger size as a decade earlier. The 2012 aerial laser scanning of the Triglav Glacier was conducted after a winter without abundant snow cover and, accordingly, the smallest size was recorded; its central section covered 0.4 ha (Gabrovec et al. 2013, 2014; Triglav Čekada et al. 2014b). The values correspond to the global trend of glacier retreat (World Glacier Monitoring Service 2012).

17.5 Potential Use of This Method in Southeastern Europe

Nationwide aerial laser scanning (LIDAR) is almost becoming a must in Europe (Triglav Čekada et al. 2015). Among other results, it allows detailed studies of the current behavior of very small glaciers (Abermann et al. 2010). As was seen, by

Table 17.3 Area of the Triglav Glacier based on archival non-metric images taken between 1897 and 2000, and the 2012 aerial laser scanning

Image date	Author/source	Triglav Glacier (ha)
Before 1897	Alois Beer	22.0
Before 1934	Janko Skerlep	27.6
23 Sept. 1956	Milan Šifrer	14.4
28–30 Sept. 1958	Milan Šifrer	13.7
16 Sept. 1962	Milan Šifrer	21.5
13 Aug. 1976	Horizontal camera	18.0
26 Aug. 1977	Horizontal camera	22.3
15 Aug. 1979	Horizont camera	24.1
12 Sept. 2000	Horizontal camera	1.1
13–14 Sept. 2011	Field measurements	2.4[a]
18 Sept. 2012	2012 aerial laser scanning	0.8 (0.4[b])

[a]Snow-covered glacier
[b]Correction after detailed analysis

applying archival images to detailed DTMs based on laser scanning, the monoplotting method makes possible detailed historical studies of very small glaciers. The method can thus be used to study small glaciers in the Balkan Peninsula: the Debeli Namet Glacier in the Durmitor Mountains (Montenegro), several glaciers in the Prokletje Mountains (Albania), and two glaciers in the Pirin Mountains (Bulgaria) (Milivojević et al. 2008; Grunewald and Scheithauer 2010; Djurović 2012; Gachev and Stoyanov 2012). All these small glaciers have characteristics similar to the one described.

The observations of the Debeli Namet Glacier started in 1960s. Archival images are known to exist for this glacier because Djurović (2012) used them for reconstructing the glacier area for 1954, 1971, and 1981.

Two small glaciers in the Pirin Mountains are the Snezhnika Glacier and Banski Suhadol Glacier (Gachev et al. 2009). Ongoing measurements of these glaciers have been performed since 1994, but the first measurement of the Snezhnika Glacier was already made between 1957 and 1961. Because these glaciers were also photographed during their measurement, they also have the potential for 3D area reconstruction based on the method introduced.

Application of the method is more of a challenge in the case of the Prokletije Mountains because research has been carried out on these small glaciers only in recent years (Milivojević et al. 2008; Gatchev and Stoyanov 2012), and the authors are not aware of the existence of any older archive images.

The potential use of this method can also be extended to some other areas because it has also been used to monitor various geomorphic processes and floods (Triglav Čekada and Radovan 2013; Triglav Čekada et al. 2014), and its use can be extended to various natural or human-induced landscape changes if proper data are provided.

17.6 Conclusions

This chapter presents the application of archive images to determine changes in the sizes of glaciers. Non-metric images of the Eastern and Western Canin glaciers and the Triglav Glacier, taken from 1893 onward, were processed using an interactive orientation method. This method employs a detailed DTM determine the best fit between the DTM superimposition and the image. Because similar small glaciers also exist in southeastern Europe, the method could also be used in the future for those glaciers if appropriate imagery and detailed digital terrain models were available.

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Chapter 18
Tourism and the Commodification of Cultural Heritage in the Eastern Black Sea Mountains, Turkey

Mehmet Somuncu

Abstract In Turkey, until the beginning of the 1990s, the coastal areas were the top destination for many people during their summer vacation. However, this preference has started to shift toward the mountain areas. Nowadays, mountainous regions of the Eastern Black Sea Region, especially the summer pastures, "*Yayla (plural: Yaylalar)*" have become popular vacation spots for domestic tourists. Highlands and summer pastures possess a rich natural and cultural heritage in the Eastern Black Sea Region of Turkey. Therefore, the Ministry of Culture and Tourism is promoting rural tourism in the region. With the expansion of the tourism industry, tourist activities have also gained momentum in some summer pastures, turning them into important tourism centers with increased tourism investments. This activity has also brought a rapid change in land use patterns and functions of summer pastures along with the lifestyle of the local people. This shift has resulted in positive changes such as development in the area on one hand and negative changes in environmental, socioeconomic, and cultural values on the other. Therefore, it is assumed that rural tourism *(yayla tourism)* and the protection of our cultural heritage have correlation in terms of conflict and mutual benefits.

Keywords Rural tourism • Cultural heritage • Commodification • Yayla • Eastern Black Sea Mountains • Turkey

18.1 Introduction

Rural communities and peripheral areas such as mountains and islands face the challenge of continuous economic development. Where primary traditional industries such as fishing and farming are in decline, tourism often becomes another tool to help create jobs and to raise the standards of living (MacDonald and Jolliffe 2003).

M. Somuncu (✉)
Department of Geography, Ankara University, Sihhiye, 06100 Ankara, Turkey
e-mail: somuncu@ankara.edu.tr

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_18

The economic potential that tourism holds for many, although not all, mountain communities, is quite clear: in most mountainous regions of the world, people have limited possibilities for generating income. Agriculture, forestry, and animal husbandry form the backbone of local economies, but these contend with shallow soils, harsh weather conditions, and low market competitiveness. Therefore, diversification of livelihoods is often not a choice but a necessity for mountain households. Mountain ranges offer possibilities to all kinds of tourists: sport fans come for hiking, climbing, or skiing. Others come simply to appreciate beautiful landscapes. In remote valleys and on mountain peaks, many endemic plants invite visitors to discover unique biodiversity. Those interested in cultural heritage find compelling destinations along Andean Inca trails, in the rock churches of Ethiopia, or at sacred Buddhist sites and ceremonies in the Himalayas. On the other hand, tourism carries risks of harming ecological goods and services, compromising cultural identities, and increasing social inequalities (Debarbieux et al. 2014).

The Eastern Black Sea Region is located in the northeastern corner of Turkey (Fig. 18.1). The population of this region is 2.2 million, accounting for 3.8 % of the country's total population; the area is 39,203 km^2, 5.1 % of the country's total area. Within the Eastern Black Sea Region, high mountain ranges run parallel to the Black Sea coast in the north with an undulating plateau on the southern foot of the mountains.

Cropland is scarce in rural areas of the Eastern Black Sea Region because of its mountainous and uneven topography. For this reason, livestock husbandry has been

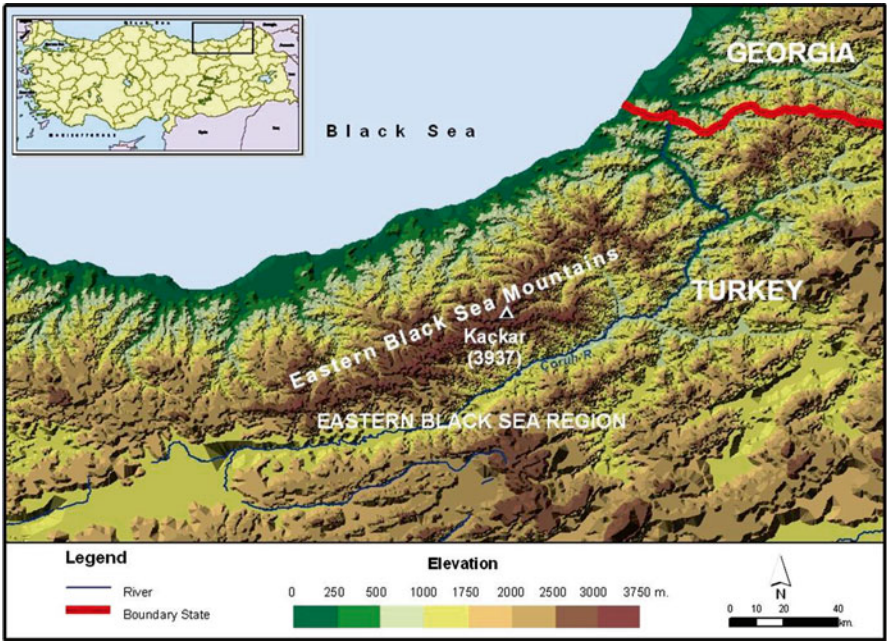

Fig. 18.1 Location map of the Eastern Black Sea Region

an important economic activity for centuries. Seasonal migration (transhumance), "*Yaylacılık*," between low-lying villages and high mountain pastures has been an integral part of rural life in the region. Herders living in the region use the highlands for pasture and for haymaking for winter fodder. The Turkish word *yayla* (English, Alp; German, Alm; French, Alpage) refers to a place where farmers go to spend the summer; it is either a residence on a mountaintop or a summer pasture (Özden et al. 2004).

"Mountain plateau" and "summer pasture" are the dictionary definitions of the word but they tell only part of the story. *Yayla* is derived from the verb *yayılmak* (to spread out or disperse), as in the action of a grazing herd of goats, sheep, or cattle, but the *yayla* is much more than a meadow to the locals. It is home for the summer, almost always successive summers, and *yaylas* belong to particular villages whose individuals are livestock owners (Dubin and Lucas 1989; Somuncu 1989).

This traditional transhumance system has experienced a great change from the 1950s to the present day (Somuncu 2010a, b). Starting from the 1950s, a large number of people have immigrated to urban centers in response to insufficient economic resources, leaving elderly people and livestock in rural areas, which has affected transhumance activities in these areas. However, a great increase in recreational activities has been observed in these mountain pastures from the 1990s onward. Moreover, because of the expansion of the tourism industry policy of the central government, tourist activities have also gained momentum in some mountain pastures and have turned them into important tourism centers with increased tourism investments. This development is also bringing a rapid change in land use patterns and the functions of *yaylas* and lifestyle of local people. The changes in traditional transhumance activities have decreased already with the fading animal herding and production. Significant increase in infrastructures with investment on unplanned construction of new roads is very obvious. A serious increase in the construction of illegal second homes in these areas has also emerged. Domestic tourism is rising and transforming to an attractive mass tourism in the region. This shift has resulted in changes in environmental, socioeconomic, and cultural values (Somuncu 1994, 1997; Somuncu et al. 2011, 2012a, b). The first aim of this chapter is to evaluate the development of tourism in the Eastern Black Sea Region highlands. The second is to evaluate the commodification of cultural heritage that depends on tourism in the same area.

18.2 Data and Methods

This study is part of a project on "*A Study on Assessment of Changes in Land Use and Function of Mountain Pastures in the Eastern Black Sea Region*" (Somuncu et al. 2012b). Four different types of sample have been taken based on a research in 30 *yaylas* from three provinces of the Eastern Black Sea Region. Both quantitative and qualitative research techniques have been used in the study for collection of data. Land use change in the *yaylas* during the years from 1973 to 2004 has been determined with help of aerial photographs and a geographic information system. Primary data have been collected by a survey during the summer of 2010 in which 1350 people participated. The qualitative data have been collected through personal observations and in-depth interviews with 45 local residents, visitors, managers, and representatives of civil society organizations. Ultimately, all of the collected quantitative and qualitative data have been analysed.

18.3 Research Findings

18.3.1 Cultural Heritage of the Yaylas in the Eastern Black Sea Region

There are many elements of the cultural heritage in the Eastern Black Sea Region *yaylas.* The cultural heritage elements could be classified into two main groups: intangible heritage and tangible heritage. The main elements of the intangible cultural heritage are rural lifestyle, local music, local dance, and festivals. The main elements of the tangible cultural heritage are rural houses built in traditional architectural style, historic bridges, and religious sites.

18.3.2 Transhumance Culture and Rural Lifestyle

High mountain ranges with steep slopes and limited flatlands restrict agricultural activities. As mechanization is difficult under these conditions, crop cultivation depends largely on manpower. Therefore, livestock in the region provide a very important economic activity. In particular, cattle, dairy, and honey production are of great importance (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

Livestock husbandry performed in the mountainous areas of the Eastern Black Sea Region is a low-efficiency *"extensive livestock husbandry"* dependent on grasslands, summer pastures and human efforts. During summer, the villagers move into the *yaylas* where there is pasturage for their herds. The transhumance begins with the hot weather that comes in early summer, and in those cool *yaylas* the herders live in traditional wood homes, to return again to their villages with the approach of autumn. In fact, most villages and towns in the Eastern Black Sea highlands have their own *yayla*, the upper limit for this being 2500 m elevation (Somuncu 1989). So, in rural areas of the region, economic activity, depending on the natural structure of the area, has shaped a binary lifestyle. The villagers in the region stay at villages in autumn and winter seasons, and in spring and summer seasons they move to the *yaylas.* Although lifestyle at the *yayla* is just like that of the villages, in *yayla* only animal grazing takes place instead of other agricultural activities. Therefore, all family members engage in activities such as grazing and milking of animals, production of butter, cheese, and yogurt, and marketing of products that exceed their needs (Somuncu 2010a).

18.3.3 Local Music and Dance

These characteristics of the region, which is covered with mountains and thick forests, have shaped a specific lifestyle of the people. People of the Eastern Black Sea Region, especially those living in rural areas, have to work very hard to make a living. Therefore, they have a very active and vibrant lifestyle. This lifestyle of the people has also made an impact on the local music and dance. For instance, the music played with *Tulum* (Fig. 18.2a) and *Kemençe* (Fig. 18.2b), two local instruments of the area, is very active and lively. The local music of the region, in the form of pastoral folk songs, describes the natural beauty and human relationships with mountains, meadows, and *yaylas.*

The local dance of the Eastern Black Sea region is most active and lively as compared to local dances of other regions in Turkey. This extremely lively dance, to the music of *tulum* and *kemençe*, is called *Horon* in the local language (Fig. 18.3). The most important feature is that everyone participates in this dance, including young and old, men and women, holding hands together in a circle, and an experienced person in the group directs the dance. Everyone who participates in the dance sings songs accompanied with played music. Sometimes, singers divide into two groups while dancing and sing the songs improvisationally facing one another (Somuncu 2010a).

Fig. 18.2 Local instruments: *tulum* (**a**) and *kemençe* (**b**)

Fig. 18.3 Local dance (Horon) in Kadırga Yayla festival in the district Gümüşhane

18.3.4 Festivals

Yayla festivals have been are celebrated traditionally for hundreds of years as part of the transhumance culture. These festivals are celebrated in the summer season. Although the majority of festivals are held for 1 day only, in some places 3-days and 4-day festivals are also celebrated. The people who live in the *yaylas* gather in these festivals and make fun collectively. Mostly, the features of entertainment fashions in these festivals are in common. People, especially young girls and boys, wear their traditional clothes for these festivals. During festivals people dance the traditional dance *horon* (Fig. 18.3) with the music of the local instruments *tulum* (Fig. 18.2a) and *kemençe* (Fig. 18.2b). The dance in the festivals continues all day until evening without interruption and even sometimes lasts till midnight. During the festival, a bullfight is also conducted in some *yaylas* in the highlands of the Eastern Black Sea region. Every year festivals are celebrated in the majority of *yaylas* of the region. However, Sis Dağı Yayla, Kadırga Yayla, Ayder Yayla, Kümbet Yayla, Hıdırnebi Yayla, and Kafkasör Yayla festivals are the most popular among these (Fig. 18.4).

Fig. 18.4 Kadırga Yayla Festival in the district Gümüşhane

18.4 Tangible Heritage (Built Heritage)

The rural areas in a large part of the Anatolian region depict similar traditional architecture. However, the architectural features of houses in the rural areas of the Eastern Black Sea region are very different from other regions. The rugged and steep topography of region along with cover of thick forests up to the altitude of 2000 m also make the area different from others.

In the construction of traditional houses in *yaylas*, natural material from the surrounding environment such as forest wood has been used. Therefore, the houses are made up of wood in the *yaylas*, which are located within or close to the forests (Karadeniz and Somuncu 2003). However, in the *yaylas* located above 2000 m in alpine meadows above the forest line, the houses are built of stone. The houses made of wood are specific to this region in terms of form and function.

Basic functions of *yayla* houses are to accommodate livestock, provide storage facilities for processed dairy products, and in short to fulfill all daily needs. As the functions are simple, one family room and one animal barn is enough for these houses. Therefore, these *yayla* houses generally cover a limited space in rectangular shape. One half of the rectangular area is composed of a soup kitchen at ground level whereas the other half is constructed in the form of a raised wooden floor where family members sit in daytimes and in the night sleep. The animal barn is

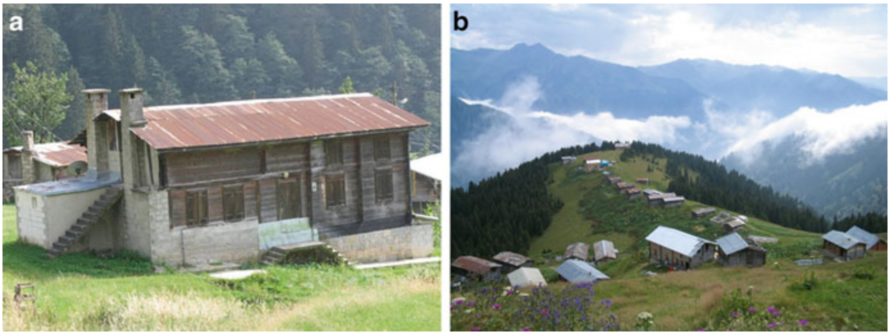

Fig. 18.5 (**a, b**) Traditional houses in the *yaylas*

adjacent to one end of the rectangular shape house in the *yaylas* with plane topography (Sümerkan 1997); in others, with steep topography, it is located at the basement. In some *yaylas* such as Ayder Yayla, Pokut Yayla, and Kümbet Yayla, wider houses with several rooms have also been made of wood (Fig. 18.5a, b).

In the Eastern Black Sea Region the altitude increases steadily from west to east, and the topography becomes more steep and rugged. This condition makes the flow of rivers into the sea more rapid, which further creates deep valleys in the region. Accordingly, local people living in the highlands have constructed bridges to cross these river valleys and approach their homes, pastures, and agricultural fields. In this respect, stone arch bridge architecture is well developed in this region, especially in the areas of Rize and Artvin. These bridges are often worn down by floods in the area but are quickly repaired. There is no written document relating to the construction of the bridges; it is assumed that these bridges were constructed during the last years of Ottoman Empire.

All the bridges are in form of a rising round shape or sharply pointed arches staying upon two opposite bases on both sides of the river bed. All are rectangular in plan and many are single and round in shape. The stone arches of bridges are made up of arranged ashlars (dressed stones) whereas the bases and other parts are constructed of rubble stones. Fences are built of stones in unified form, and in some places iron railings are also added later on. The height of these bridges varies according to the depth of valleys, from 2–3 m in some areas to 15–20 m at others. In the same way, the length of the bridges also varies, from 20 m to 45 m, according to the width of the valleys (Fig. 18.6a, b).

18.5 The Commodification of Cultural Heritage in *Yaylas*

The traditional transhumance system has experienced a great change since the 1950s to present day in the Eastern Black Sea Region. This change can be divided into four periods: before 1950, from 1950 to 1980, from 1980 to 1990, and from 1990 to 2015 (Somuncu 2010b; Somuncu et al. 2012a, b; Tunçel et al. 2004).

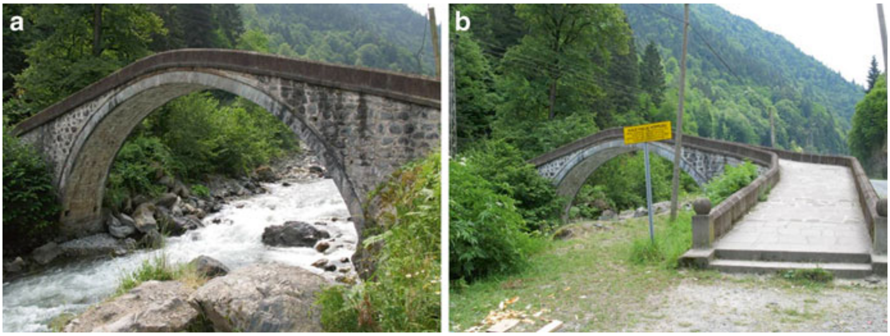

Fig. 18.6 (**a, b**) Historical bridges in the Fırtına valley in the district Rize

Before the 1950s, the proportion of the population that was rural was greater than that currently. In 1950, 89 % of the total population of 1.8 million people lived in rural areas in comparison to 11 % in urban areas. As livestock husbandry served as one of the basic subsistence activities for a high percentage of the rural population, transhumance was an important and widespread economic activity. In the spring villagers moved toward high mountain pastures with their herds of livestock, spent spring and summer there, and in the autumn returned to their villages.

In the 1950s the development of transportation between rural and urban areas and the proliferation of new job opportunities in urban areas spurred rural–urban migration in Turkey, with a subsequent decline in the traditional transhumance in the region. Rural–urban migration from the Eastern Black Sea region was among the most pronounced because of the region's mountainous topography and the lack of economic resources other than livestock grazing. In addition, on the mountain slopes facing the Black Sea, especially in the areas of less than 1000 m elevation, the cultivation of hazelnuts and tea replaced livestock husbandry. In the early 1980s agricultural policies were unfavorable toward livestock husbandry, leading to lower incomes and further abandonment of transhumance activity at a large scale. The human and livestock populations using mountain pastures started to decline, with some *yaylas* abandoned completely.

During the period of 1980–1990, tourism development started in the *yaylas* (Seckelmann 2002; Somuncu 1997). New roads to the *yaylas* were constructed as infrastructure, such as electricity, telephone lines, water and health services, was set up and improved (Somuncu and İnci 2004; Somuncu 2011). At the same time, hotels and pensions for tourists began to pop up as well as second homes for the urban population. Such three- to four-storey buildings, however, were incompatible with traditional rural architecture, and moreover were illegal according to Turkish laws (Somuncu and Khan 2013). The *yaylas* are state-owned areas and the government normally allows only those villagers who come there to graze their animals to construct their simple huts temporarily in the mountain pastures (Figs. 18.5b and 18.6a).

In the 1990s, a period of increased investment in tourism infrastructure, the Ministry of Tourism began promoting rural tourism in *yaylas* and, in this context, 16 *yayla* were declared ***tourism centres*** by the Council of Ministers. The Ministry of Tourism has encouraged tourism companies to invest in these *yaylas*, and today a large number of *yaylas* in the Eastern Black Sea region have been transformed into tourism centres, with still others planned.

The Ministry of Culture and Tourism sees the development of sustainable rural tourism and ecotourism in the Eastern Black Sea Region as a strategic objective, referring to this mountainous region as the ***Corridor of Yayla Tourism*** and highlighting the goals for the region in its planning document, Tourism Strategy of Turkey 2023 (Ministry of Culture and Tourism 2007). As recreation and tourism demand has increased in the *yaylas* of the region, so has the need for tourism-related businesses and services. Improved access to the *yaylas* is also contributing to the growth of *yayla-centred tourism* (Somuncu 2010b, 2014; Somuncu et al. 2012a, b).

Owing to both its natural features and cultural heritage, the Eastern Black Sea region highlands has become one of the important points of attraction for the mountains. This context mostly includes climbing, trekking, camping, photography, observing the flora, fauna, and natural beauty, and meeting the local people who live in *yaylas* and learning about their lifestyle. In recent years, the region has become a well-known and popular destination for local tourists and growing number of foreign tourists. From these activities, the local people earn for accommodations, transportation, souvenir sales, guidance services, etc., which further adds to the rural economy (Somuncu and İnci 2004; Somuncu 2007).

Recreation and tourism demand in the *yaylas* of the region increases every day along with demand-oriented work to meet these needs. New easier ways to approach the *yaylas* are constructed; tourism-related businesses and services are provided. Moreover, construction of illegal second homes and irregular concrete-made buildings (Fig. 18.7) in the *yaylas* still continues (Özden et al. 2004; Somuncu and Khan 2013). Although this situation has led to spatial and functional changes in the *yaylas*, the issue is not so limited because many problems have arisen related to this transformation period and land use changes in *yaylas* (Somuncu 2010b; Somuncu et al. 2012a, b).

One of the important factors in the increase in tourism and recreation demand in the *yaylas* was the transformation of the coastal highway into an expressway (Somuncu 2011). The renovation facilitated access to the region and *yaylas* in higher elevations and further led to the development of tourism in the mountain areas (Somuncu 2010b). Construction of new roads is continuing and guarantees easy access to the *yaylas* of mountainous areas in the region. The number of companies providing services for tourism in the *yaylas* is also increasing; such services include accommodations, transportation, guiding, or entertainment.

Fig. 18.7 Second homes, pensions, and hotels in Kümbet Yayla in the district Giresun

18.6 Conclusion

The Eastern Black Sea region, a mountainous area, has rich natural and cultural heritage values. These features of the region make it very attractive and important in terms of tourism. Therefore, major developments in tourism have been brought to *yaylas* in the rural highlands of this region since the 1990s. Tourism has become an important and new source of income for development of the highlands where the population is decreasing by migration because of poverty and the lack of sufficient income resources. However, this is only one side of the coin. On the other side, there are also negative consequences of changes in use of the *yaylas.* The rich natural and cultural heritage of the region has begun to show damage because of unplanned development activities related to tourism. The unplanned roads, hotels, and restaurants and growing construction of second homes in the *yaylas* and highlands are damaging the natural environment of the area. Further, with the development of tourism, commodification has started in the *yaylas*, which were used only for livestock activities in the past. This situation has also adversely affected the traditional culture of the *yaylas.*

Especially since the beginning of the 2000s, this environmental and cultural damage in the region has been recognized and efforts have been made to overcome this situation by relevant government agencies, NGOs, and the local people. In this context, a ban on unplanned construction and rehabilitation of the degraded landscape are in primary focus. Structures that are incompatible with natural and cultural tradition of the *yaylas* in the region are demolished or renovated according to the traditional architecture of the area. Environmental awareness has also increased in local communities of the *yaylas*, especially tourist centres. In the past few years, new buildings for tourists and second homes have been constructed according to maximum possible compatibility with the traditional architecture. In this concern, new decisions of government agencies for the protection of natural and cultural traditions of the area are of great importance. For instance, in Ayder Yayla, located within the boundaries of Kaçkar Mountains National Park, the majority of structures with inharmonious appearance have been demolished and sections of the concrete buildings have been covered with wooden exterior according to the traditional architecture of *yayla* houses. Also, abandoned or completely demolished houses are beginning to be restored, another positive aspect of tourism and an important development in terms of protection of the cultural heritage of the area (Somuncu 2010a).

The goal of conservation of the natural and cultural heritage along with development of tourism in the *yaylas* of the region can be achieved through application of sustainable tourism. Therefore, it is necessary for all stakeholders, especially government agencies, local authorities, NGOs, local communities, and tourism companies, to understand the matter seriously and to work together.

Acknowledgements This study was supported by the projects "A Study on Assessment of Changes in Land Use and Function of Mountain Pastures in the Eastern Black Sea Region" (SOBAG/109 K079) financed by the Scientific and Technological Research Council of Turkey (TUBITAK).

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Chapter 19
The Role of Cultural Heritage in the Development of Mountain Tourism: Case Study Mountain Rudnik, Serbia

Snežana Štetić, Sanja Pavlović, and Sara Stanić Jovanović

Abstract Rudnik Mountain, as the most dominant mountain in the Šumadija region, is located about 100 km south of Belgrade, which is connected to Ibar highway. Because of its exceptional climatic conditions, in 1922 it was declared an air spa, and the geologic-geomorphological features (mountain peaks more than 1000 m above sea level, lookouts, caves, etc.), as well as the wealth of water and preserved flora and fauna, contributed to its excursion potential. Archaeological findings testify to early habitation of the area. In ancient times the mountain was the scene of mining, and remnants of the period before and after the arrival of the Romans, the Serbian medieval state, and Turkish times are preserved. The preserved cultural heritage (monasteries: Blagoveštenje, Voljavča, Vraćevšnica, Nikolje and Petkovica; the residence of Prince Miloš; the remains of medieval towns; Ostrvica and Gradovi; archaeological site Misa; remains of mining pits and localities; rich monumental complex, etc.) had a significant role in the development of mountain tourism in Rudnik Mountain in Serbia. Regionally recognizable as a year-round holiday destination with great potential for excursion, recreation, sports, health, and other forms of tourism development, Mountain Rudnik has, thanks to the rich cultural heritage, a chance for popularization through various forms of trips, excursions, schools in nature, recreational classes, and other programs of travel agencies intended for children and adults.

Keywords Cultural heritage • Mountain Rudnik • Tourism

S. Štetić
College of Tourism, Bulevar Zorana Đinđića 152a, 11070 Belgrade, Serbia

S. Pavlović • S.S. Jovanović, MSc (✉)
Faculty of Geography, University of Belgrade, Studentski Trg 3/III, 11000 Belgrade, Serbia
e-mail: sara.stanic.zemun@gmail.com

B. Koulov, G. Zhelezov (eds.), *Sustainable Mountain Regions: Challenges and Perspectives in Southeastern Europe*, DOI 10.1007/978-3-319-27905-3_19

19.1 Introduction

The highest form of relief of Šumadija region, Rudnik Mountain, with its gentle slopes, a small town of the same name, and an abundance of natural and anthropogenic tourist motives as well as the vicinity of the highway, is an important center of excursion and other forms of tourism in Serbia. The vicinity of the city centers enables a rapid development of Rudnik Mountain as a tourist destination. The vicinity of Belgrade makes this mountain a destination for weekend tourism, which is very important because this type of tourism is at the same time the origin of the largest number of tourists. The Ibar highway is one of the most important road routes in Serbia, which also results in a good transit and tourist position of the areas. The value of tourists and the geographic position of Mountain Rudnik should be viewed in the context of adjacent complementary tourist attractions, among which are the memorial tourist complexes at Oplenac, in Topola, in Orašac, Takovo, and other tourist attractions of the surroundings. Work on Corridor XI will significantly accelerate the development of tourism in this region and therefore the development of Rudnik as a mountain tourist destination. The mountain and its namesake town Rudnik have long been known for their exceptional climate, healthy food, numerous picnic areas, and preserved cultural heritage sites, which in the function of realization of specific forms of tourism can achieve cash inflows and encourage the development of the entire region. Considering that the tourism product today is characterized by uniqueness, authenticity, and the presence of local factors, with mountain tourist destinations it is not only natural resources that are very important but also the anthropogenic tourist potentials that contribute to the development of selective forms of tourism.

19.2 Natural Resources of Mountain Tourist Destination Rudnik

The name Rudnik indicates that it is the place where ore is mined. The name is of Slavic origin and it confirms that Serbs were familiar with mining when they were settling in this area. The territory of Gornji Milanovac, where Rudnik belongs, borders on the north with the municipalities of Ljig and Aranđelovac, on the northeast and east with the municipalities of Topola and Kragujevac, on the southeast and south with the municipalities Knić and Čačak, and on the west and northwest with municipalities Knić and Mionica. The first-order road passes next to Rudnik Mountain, the Ibar highway (M-22) which connects it with Belgrade, Gornji Milanovac, Čačak,Užice, Zlatibor Mountain, Montenegro and Skopje and over Kraljevo and with Trstenik and Kruševac, which is connected with the highway E-75 (Belgrade–Niš–Skopje–Đevđelija–Thessaloniki). The mountain has a dominant position, as well as its namesake town, that is in fact a settlement in the municipality Gornji Milanovac in Moravica district. It is located at about 100 km south of Belgrade and only 15 km north of Gornji Milanovac (Štetić et al. 2011).

Rudnik Mountain is the largest mountain "island" that rises from the lake surface of Šumadija and occupies a central position in Šumadija. Among a dozen mountains of Šumadija, Rudnik Mountain is the highest at 1132 m and with its hydrographic node, the watershed between the basins of Great Morava, West Morava, and Kolubara. According to Dr. Jovan Cvijić, Rudnik Mountain does not belong to the Dinaric Alps or the Rhodopes; instead, it constitutes a "northern transition zone." In addition to the dominant skeletal forms of relief, in the relief of Rudnik area and the entire Šumadija there are also karst landforms, recent forms of erosion, landslides, and paleo-volcanic landforms. It was ascertained that there are several small-sized caves at Rudnik that are not adequately explored. There are small rivers arising as springs that merge at the foot of the mountain with larger rivers: Zlatarica (springing west of Cvijićev vrh in the inhabited place of Rudnik), Srebrenica (springing between the peaks Javor and Paljevina), Jasenica (springing at the northeast side of the mountain slope), and Brezovica (springing west of Rudnik settlement). Jasenica is the largest river that rises on Rudnik mountain (Strategic Master Plan of sustainable development of Rudnik Mountain 2014).

The highest peak is Veliki Šturac or Cvijićev vrh, 1132 m above sea level. Other better known peaks of this mountain range include Mali Šturac (1115 m), Marjanac (1029 m), and Bjelica (1089 m). From these peaks, the terrain descends to the north toward the River Jasenica, to the east toward Lepenica, south to Gruža, and to the southwest toward the River Despotovica. Rudnik Mountain was formed in the middle of the Tertiary by folding of Mesozoic formations; during the Neogene, the Pannonian Sea covered the lower parts of Rudnik, which was then an island. During the older Tertiary, strong volcanic activity has led to a spill of heated liquid mass of the Earth's crust when many volcanoes, whose conical shape still remains, arose: Ostrvica, Krnja Jela, Gradina, and others. The hydrographic node of this part of Serbia is located on Rudnik Mountain. From it, the water flows toward West Morava across River Despotovica, which flows into River Dičina, toward Great Morava across Jasenica and the left tributaries of Lepenica, and toward Kolubara across tributaries of Ljig (Štetić 2007).

The climate of Rudnik area and its surroundings is moderately continental. The average annual air temperature is from 10.5 °C (at 250 m above sea level) to 7.7 °C on the peak of Rudnik Mountain (1132 m). Cold days occur from November to March, with their peak in January. Late spring frosty days often occur in April and even May, and the first autumn frosts occur in September. Lower temperature values on the mountain are sufficiently encouraging for summer excursions, especially when there is hot weather in the city. Hypothetical lower temperature values are even more evident at the picnic sites of the massif because it is almost entirely covered with forest vegetation. On the other hand, the relatively modest height of the mountain cannot influence the formation of such winter temperatures as would cause longer retention of a sufficiently thick winter cover for winter sports. In addition, the sloping terrain itself does not meet the minimum standards for the formation of ski slopes (Romelić and Ćurčić 2001).

The duration of sunshine is 2111 h per year. The greatest is in July (300 h/m) and August (230 h/m), and the least is in December (59 h/m) and January (75 h/m) per month. Average annual rainfall is from 788 mm, up to 300 m above sea level, and reaches 985 mm at the peak of Rudnik. Snow is a regular occurrence, and the longest average duration of snow cover on the mountain Rudnik is about 70 days per year, whereas at the peak of the mountain that period is 15 days longer. Average snow depth is 44 cm. Snow persists for 80–120 days in the lower areas and 160–200 days at higher elevations (Various authors 1987).

In contrast to the nearby city, to which municipality it belongs, Rudnik Mountain is characterized by frequent air currents. The winds collide over the tops of the massif, making a wind rose particularly suitable for the health of people who live on the mountain; this is why, back in 1922, Rudnik was declared the air spa of Serbia (Stanić 2009).

Rudnik Mountain dominates not only the area but the entire Šumadija region. The dominance is expressed by its vastness and peaks that have no vegetation, which gives them even greater aesthetic value. It has a significant number of vantage points from which one can enjoy an amazing view. Benefits of the climate and its elements for the development of tourism are reflected in a moderate climate with rare occurrence of distinct summer heat and extremely frosty winters, as well as much sunshine, high ionization, and moderate air currents. It represents a hydrographic node of this part of Serbia, with Despotovica, Jasenica, Jarmenovačka, and other rivers, two thermomineral springs (Svračkovačka and Stragarska Spa), and a few small artificial lakes. It leads in the richness of the forest (beech, oak, ash, etc.), as well as grassy vegetation (meadows and pastures) and herbs. On the mountain there is a large number of different species of large and small animals, birds, fish, and other biota (Stanić and Petrović 2011).

Geologic and geomorphological resources include the mountainous terrain of the mountain range Rudnik, the highest peak Veliki Šturac or Cvijićev vrh at 1132 m above sea level, and numerous other peaks more than 1000 m above sea level. The richness of rocks with minerals of lead, zinc, copper, and silver, more or less steep and shady slopes with the possibilities of summer and winter recreation, spacious and deep valleys between mountain peaks, picnic areas and viewpoints, caves, and other interesting and aesthetic beauties, rarities, and values that exclusively belong to the picnicking and mountain-climbing kind of recreation are all available. Hydrological resources highlight the richness of water in the form of Jasenica, Jarmenovačka River, Gruža, Despotovica, and other smaller rivers and streams, the small artificial lakes, and Svračkovačka and Stragarska Spa. As opportunities for tourism development in the area of this massif, the hydrologic characteristics, such as once numerous clean water streams in the hilly and mountainous zone, are seen as a dynamic and vivid landscape element, which can be an attractive tourist motivation and a significant element of summer recreation in terms of walks, fishing, swimming, and refreshment in natural whirlpools. Biogeographic resources include the richness in flora and fauna. The flora of Rudnik includes the woods (alder, willow, poplar, oak, ash, Turkey oak, sessile oak, beech), fruit trees, shrub species, valley and mountain meadows, and pastures as grassy vegetation with nearly 20 endemic and relict species, and herbs, mushrooms, agricultural, and vegetable plants. The fauna is represented by wild boar, rabbit, pheasant, partridge, quail, fox, badger, weasel, polecat, snakes, birds (vrtuša, short-tailed sparrow hawk, little owl, eagle-owl, jackdaw, magpie, hawk, raven, eagle, falcon), and numerous insects and other animal species (Štetić et al. 2011).

19.3 Cultural Heritage in the Area of Rudnik Mountain

The elements of the offer that often decisively influence choosing this journey destination are cultural attractions. The likelihood of discovering an aauthentic heritage is almost always on the list of motives for traveling. All the more importance is given to cultural and environmental contents in the tourist offer; regional differences are becoming more important (Vrtiprah 2006). Heritage and culture have long been accepted as key components of tourism. Whether we are talking about pilgrimages and visits to sacred objects, visits to various local communities, or developing other forms of spiritual activity, tourism has always been an important platform for such interactions (Gelbman and Amos 2009). Cultural monuments and heritage, depending on the degree of their recognition, generate economic activity and contribute to the development of the area in which they are located, and should be considered as valuable economic resources (Kunst 2009).

The rich, turbulent, and complex history of the Rudnik area left a legacy of extensive evidence of cultural and artistic activities of our ancestors, embodied by monuments. Of different types, origins, and age, these objects constitute an exceptionally well preserved heritage of great historic, cultural, scientific, pedagogical, and broader comprehensive social significance. Particularly in terms of the development of excursion tourism, cultural monuments of the past are a valuable component (Various authors 1987).

The cultural and historical heritage is a very important element of the tourist offerings. What is important for tourism is the level of cultural development both in countries of tourist demand and in countries of tourist offers. Culture and its qualities, especially in the countries with tourist offerings, very often represent a strong motive for the tourist industry. Also, the culture of a nation, its history, customs, and numerous cultural and historical monuments, are extremely important motives when choosing a tourist destination (Štetić et al. 2013a).

When considering archeological values as tourist potential in the area of Rudnik, it is important that it has preserved a number of testimonies of material culture from prehistoric and ancient times as well as from the medieval times and the Turkish period, which until this day remains as ruins of objects or sites where important archeological objects were found. Even though Rudnik has been a settlement since ancient times. The main characteristic of most of such settlements is that they are not explored enough and thus they are frequently unidentified. It can be assumed that there were centers of the Illyrian ethnic element, but the lack of archeological explorations means that traces of their lives are not reliably determined. Based on the findings acquired accidentally, for sites in the valleys of Dičina and Čemernica at the foot of Rudnik Mountain, it can be said to belong to a wider chronological framework of the Neolithic period. From the period of Roman occupation there were found many material remains that indicate a very developed life in the area of Rudnik Mountain. They include remains of a Roman temple, dedicated to Mother Earth, then a stone plaque with a preserved text that says the Roman Emperor Septimius Severus rebuilt the temple, the statue of the goddess Gaia, and others. Many sites with reliable identification from the early Middle Ages has been found. It is believed that certain old cemeteries, known as "Greek"or "Roman"or "Latin," may have originated from this period but that is still not proved by archeological explorations (Šimičević and Stanić 2012).

The monument of nature, *Ostrvica*, is a rare phenomenon of relief, both because of its unusual form and impressive massif and because of its origin. Its unusual volcanic cone with the remains of a medieval town on the top, rich history, and various endemic mountain flora, represent an attractive object for all nature lovers, tourists, and mountaineers. By origin, Ostrvica represents the remains of a destroyed volcanic cone. It is characterized by a distinct individuality, specific morphological physiognomy, and prominent height position relative to the surrounding environment. Because of its location and shape, Ostrvica was significant in the Middle Ages because it was located on a military fort, the remains of which can still be seen at the top. Ostrvica was, at the end of May 2009, declared a monument of nature. At the top of the monument of nature Ostrvica, there are the remains of its namesake medieval fortification, which protected the nearby mines of silver, copper, and lead, as well as mining settlements. There are assumptions that the city dates back to ancient times; however, history notes its first mention in the fourteenth century. According to historical data, merchants from Dubrovnik and miners from Rudnik had sought refuge in the city during the dynastic struggle between Stefan Dečanski and Vladislav, as well as after the death of King Milutin. Despot Đurađ Branković, around the year 1430, established Ostrvica again in defense against the Turks. There is a legend among the people that it was built by his wife, "cursed Jerina," which is why it is also known as Jerina's city. At the foot of Ostrvica, there was a medieval town-suburb in which there were representatives of "authorities of Ostrvica," artisans and merchants, including the people of Dubrovnik, who charged customs duty for goods that were exported to the coast or imported from there to supply the needs of Rudnik. Old Serbian annals say that Ostrvica was repeatedly occupied and destroyed by the Turks. In the translated Turkish defters from the fifteenth and sixteenth centuries, Ostrvica was referred to as the seat of nahija (district) and kadiluk (judicial centre) named Sivirdže Hisar. The famous Turkish traveler Evlija Čelebi visited Ostrvica in 1664 and noted that the fortified city and suburb were destroyed and deserted. Based on very few preserved remains, it is difficult to reconstruct the appearance of the former fortress. Today, it is an attractive tourist spot for climbers, cavers, and mountaineers but also for people looking for recreation in nature (Štetić et al. 2013b).

Gradovi represents the name of the remains of a Serbian medieval city, stationed on a slight incline of Veliki Šturac, about 3 km from the present settlement of

Rudnik. This city, which resembles a Roman castrum because of its foundation, is mentioned for the first time in the fourteenth century. Later it was held by the Turks and then by the Austrians. Prince Eugene of Savoy repaired and established it in 1737, but the Turks usurped it again in 1739 and burned it down. Karađorđe conquered it in 1804 and then in 1815 it was completely devastated when it was burned by the Serbs. *Misa* is the popular name given by the local residents of Rudnik for the remains of the former Catholic church that is thought to have existed a long time ago near Gradovi. Since the Saxons and people of Dubrovnik as well as people of Kotor and Split had their colonies in the Middle Ages in this known mining settlement, as there was a large Catholic population, a Catholic church was raised on the left side of the Jasenica River. The church was later turned into a mosque by the Turks. A cobbled street led from the city to this church or to this mosque. Recently, a sketch of Šanac on Rudnik Mountain from 1717 was found in the Vienna War Archive. Although Misa is now badly damaged, based on research conducted on the overall framework of existing architectural remains, in the assumed form of the roof and stone processing, it can be concluded that it is a type of mosque that appeared in this region in the second half of the fifteenth century, which corresponds to the data from the Turkish cadastral list. It is a structure with a rectangular basis that is almost a square and with a unique area for prayer, whose interior measures are 8.85 and 9.27 m. It is built from crushed local stone and mortar using wooden horizontally placed surrounds, and brick and tufa (a type of limestone) are occasionally used in the window frames. Its average wall width is 0.94–0.97 m with a properly made face on both sides. Judging by the shape which was visible before the exploration, as well as elements that are subsequently discovered, Misa was a one-storey building, spacious and with a minaret and a porch in front of the entrance. For now, there is no material information on the type of roof construction. The building was plastered twice with a grayish-white lime mortar. Surviving surfaces have no wall decorations. The building received light through the windows placed on all four walls. As are all Muslim places of worship, it is oriented in the direction northwest–southeast, toward Mecca. To the left of the portal, with the outer edge of the northeastern wall, the outer part of the stand for the miners was discovered, made of logs washed down with mortar. Based on all available data, it can be concluded that the Catholic Misa was, during the rule of the Turks, modified into the Turkish mosque, which is still crumbling away. The remains of the enigmatic Misa are located in the forest areas of Rudnik, as a mysterious witness of the past that reminds us of legends and stories of a bygone era and provokes curiosity about the junction of three cultures and religions in the same area. A few kilometers upstream along the River Srebrenica, which according to the legend got this name because the silver that was mined made the water silver as well, were preserved the remains of the medieval town of Srebrenica, which is dominated by a large tower, popularly known as Kulin. In the village Majdan are the remains of a structure that people called Crkvine, which probably dates from the Middle Ages. Majdan could also be a Turkish name for the mine. Excavations around it were carried out in 1930 with the desire to find the tomb of Despot Đurađ Branković who was allegedly buried somewhere around Kriva Reka, according to the legend, with large quantities of treasure, near the remains of the church in Jazine. There are foundations of four churches, the remains of the tower of Orlović Pavle, as well as many mining residues. It should be also noted that there are remains of churches in Ozrem, Leušići, and Grabovica (Šimičević and Stanić 2012).

The residence of Prince Miloš in Gornja Crnuća is located in this village on the slopes of Rudnik massif, only a few kilometers away from the Monastery Vraćevšnica in the extension of the road. Since Prince Miloš stayed there from the time of the Second Serbian Uprising until 1818 and operated from there, it can be said that this was the capital of recently liberated Serbia for 3 years. The residence is a representative example of wooden architecture of the early nineteenth century, with a large veranda in front and two rooms inside, where the permanent exhibition, which contains the history of the building and a brief overview of the events of the First and Second Serbian Uprising, through documents and photographs, preserves the authenticity. There is a legend about the said residence, that this was where the Princess Ljubica killed Petrija, the mistress of Miloš, punishing her unfaithful husband and a self-addressed prince of Serbia, who was rumored to be very fond of women. Above the village of Gornja Crnuća the hillsides of Rudnik and a known Gradina rise, with the remains of a medieval fortress, where coins from bygone eras can still be found during plowing of the fields. The village Crnuća, according to the legend, used to be called Belući and it was written under this name in the charter of the Monastery Vraćevšnica, but the name was changed after the Battle of Kosovo when, according to the legend, after all able men were killed in Kosovo the whole village was wrapped in black, hence the name Crnuće (Stanić 2009).

When it comes to architectural and artistic monuments, religious buildings, monasteries, and churches are inevitable; their high concentration in the Rudnik area existed during the period from the middle of the thirteenth until the end of the eighteenth century. Explorations have compiled data about the existence of more than 18 churches and monasteries, and these data are not considered final. Up to now, the preserved monasteries are Vraćevšnica, Voljavča, Nikolje, Blagoveštenje, and Petkovica as well as 4 parochial churches (St. Nikola in Ramaća, St. Arhangel Mihailo in Brezovac, St. Arhangel Gavrilo in Borč, and St. Ilija in the village Ba). Of the numerous foundations of religious buildings, 14 have been preserved, while traces of the rest, whose existence is testified by written sources and folk tradition, have disappeared from the face of the Earth. Therefore, the landscape of Rudnik Mountain is proudly called the “Holy Mountain in the heart of Šumadija” (Šimičević and Stanić 2012).

Vraćevšnica Monastery, with the church of St. Đorđe, is located on the southern slopes of Rudnik Mountain, on the road between Gornji Milanovac and Kragujevac. The monastery has a very turbulent history, as well as an important historical role during the Serbian warfare for freedom. The monastery was built in 1428, by Radič Postupović, a senior leader, son of the Duke of Gruža Milutin, who grew up in Bor and was brought up in the court of Prince Lazar in Kruševac. He was loved among the people because of his righteousness and wisdom, praised in folk songs such as “Oblačić Rade.” The name of the monastery itself is linked to the Battle of Kosovo, a common motif in name-giving in Serbia. According to the legend, leaving for the

Battle of Kosovo with his father, Duke Milutin Postupović, his son Radič prayed to St. Đorđe and promised to build him the church Vraćevšnica if he was kept alive and healthy and returned to his home. Radič fulfilled his promise, as can be seen in the patron composition, the fresco on the south wall of the temple, where he is shown handing over the model of the church to St. Đorđe and offers it as a gift to the Lord Jesus Christ. The last time the church was painted was in 1737 by Andro Andrejević with his brothers. The iconostasis is from 1754, except for four throne icons donated by Prince Miloš Obrenović. Vraćevšnica had a significant role in the history of the Serbian people, and for that reason was destroyed and devastated on several occasions (Stanić 2009).

Voljavča Monastery, hidden in a dense forest next to Voljavački stream, on the northeast slopes of Rudnik near Stragar and Voljavačka Spa, was built in the early fifteenth century on the foundations of an old church dating from 1050. According to a written document from the late eighteenth century, which is based on the original charters and deeds made by Haji Reuben (Hadži Ruvim), the patron of the monastery was Mihailo Končinović from Srebrenica, a nobleman of Despot Stefan. The monastery had a prominent role in the First Serbian Uprising. Karađorđe and his associates used it often for hiding, especially before the outbreak of the uprising. The monastery quarters, built in 1765, which are one of the most important and oldest living quarters in Serbia, in 1805 were also for a short time the seat of Praviteljstvujući sovjet serbski, the first government of Karađorđe, headed by Archpriest Mateja Nenadović. The leader of the First Serbian Uprising appointed the Monastery Voljavča to be the seat because it is situated in the hills, in a hidden place in the dense forests of Rudnik and away from the main roads (Marković and Popović 2001).

Nikolje Monastery is located near Oplenac, placed as a decoration of the dense forest of Rudnik around Donja Šatornja. There is not enough preserved written information about the period of the construction of the monastery, but it is believed that the church dedicated to St. Nikola was built in the late fourteenth or early fifteenth century, on the foundations of an older church that existed in this area. The patrons of the monastery were Despot Stefan Lazarević and nobleman Nikola Dorjanović, according to a record dating from around 1425. The monastery has survived in difficult times after the Turkish conquest. According to numerous inscriptions carved on the northern facade, a rich monastic life was led there during the fifteenth and early sixteenth century. It is not known when the monastery was first damaged, but it is believed that was before the beginning of the sixteenth century. During the eighteenth and early nineteenth century, Monastery Nikolje was as an important cultural and spiritual center of the region that was often under the attack of the Turks (Stanić 2009).

Blagoveštenje Monastery is located in the heart of Šumadija, on the eastern slopes of Rudnik mountain, near Jarmenovac. According to the legend, the monastery was built in the late thirteenth century, during the reign of King Dragutin, when the Rudnik area became part of the Serbian medieval state. If the monastery was indeed built then it was, by all accounts, destroyed throughout the wars during that and in the beginning of the following century, to be rebuilt by the end of the fourteenth century, probably during the reign of Despot Stefan Lazarević around 1400. The church that was then built was adorned with paintings, certain parts of which are preserved to this day. After the fall of Serbia under Turkish rule, during the fifteenth century, the monastery was seriously damaged during the Turkish invasions. As an important spiritual and cultural center during the seventeenth and eighteenth centuries, the monastery was constantly subjected to Turkish destruction (Petković 2004).

The monastery of the church of St. Petka, also called Petkovica Monastery, is located on the northeast slopes of Rudnik, 4 km from Stragar, in the small village Zlošnica, in a high clearing to which leads a narrow, steep path that has an incredibly beautiful view. The past of Petkovica Monastery is wrapped by the veil of darkness. It is not known who built it and when and to whom it was dedicated, but the people of this region attributed the construction of this church to King Dragutin. Based on the study of the stylistic features of the older layer of paintings, it is assumed that the church was built in the second half of the thirteenth century. However, the oldest information regarding the origin of the church is the inscription on a gravestone, found near the church, which indicates the burial of the monk Domentian in 1379, as well as the inscription on another gravestone about the death of the priestmonk Domentian in 1443, which confirms that the church was then a part of the monastery complex (Various authors 2004).

19.4 The Role of Cultural Heritage in the Development of Tourism in the Case of the Mountain Destination Rudnik

The convenient tourist and geographic position of Rudnik Mountain encourages the development of transit tourism because good traffic connections and the vicinity of larger cities as important emitting centers and the starting points of a great number of excursionists give the opportunity to develop excursions and recreational tourism. The preserved natural resources of Rudnik Mountain offer visitors fresh air, healthy food, clean water, and a lively landscape, which, depending on the season, creates opportunities for summer and winter visits. Depending on their affinities, tourists have a choice between mountain tourism products in either summer or winter, and the preserved cultural heritage in the Rudnik area contributes to a more eventful visit.

The most frequent summer activities of the visitors are hiking, biking, paragliding, kite flying, horseback riding, mountain climbing, visit to a rural household, birdwatching, collecting of mushrooms and herbs, sports activities, speleology, fishing, and other outdoor activities. The most frequent winter activities include hiking, sledding, skiing, skating, and hunting. Rudnik can qualify for both programs, summer and winter. It is regionally known as a year-round holiday destination and one of the potential sites of active relaxation and health in Serbia, which also has a rich cultural heritage of buildings from the past.

The concepts of culture and rural tourism are multidimensional and interrelated. Tourism is based on existing local amenities such as historical sites, natural beauty, and clean air, especially in rural areas. Efficiency in the development of attractions is increased, as well as the number of activities and educational programs in the natural environment, and historical landmarks and cultural experiences are emphasized (MacDonald and Jolliffe 2003).

The richness of anthropogenic tourist motives, the long and interesting history of the area, and numerous cultural and historical monuments raise possibilities for the development of cultural, cognitive, scientific, educational, religious, youth, and academic tourism. The variety of ethnological heritage, such as folklore, music, songs, games, costumes, cuisine, and traditional customs, as well as the specifics of the villages of Rudnik and the hospitality of the hosts, are a fertile ground for the development of event and rural tourism. Guests who head for this traditional picnic area have access to the path of health and areas suitable for walking and hiking, as well as numerous objects of cultural heritage. These latter include the remains of the castles and summerhouses of Roman rulers, Serbian despots from the family Branković and Turkish landowners; the Blagoveštenje, Vraševšnica, Voljavča, Nikolje, and Petkovica Monasteries; the residence of Prince Miloš; and other anthropogenic tourist motives that complete the tourist offerings on Rudnik.

So far, little attention has been paid to the territorial aspects of cultural heritage, as well as the changes in the physical, economic, and social environment arising under the influence of tourism. Studying the territorial cohesion of different elements of cultural heritage helps us to understand the cultural dynamics of a region or a town (Jansen-Verbeke 2008). Future research on Rudnik Mountain should be directed in this context.

19.5 Conclusions

Tourism as a branch of industry is experiencing a transformation in relation to the mass travel that marked the twentieth century. What is particularly sensitive in this context is tourist demand because a modern tourist today expects more from a tourist trip. Becoming tired of the traditional tourist offerings is a result of more sophisticated and demanding tourist customers. The classic tourist product is replaced with a new, unique, and specific one. A modern tourist expects and requires tourist programs through which he can become acquainted with the history of the visited area's preserved cultural heritage. The role of cultural heritage in the development of Rudnik Mountain as a tourist destination implies the promotion of specific forms of tourism that contribute to the preserved environment and to solving the problems of poverty, unemployment, and social tensions of the local community, as well as highlighting the satisfaction of the tourists staying in this tourist destination. In such a way, what is carried out is the positioning of Rudnik Mountain, as an environmental, still-undiscovered tourist destination with an abundance of preserved objects of cultural heritage, whose tourist product is marked by uniqueness, specificity, and authenticity.

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