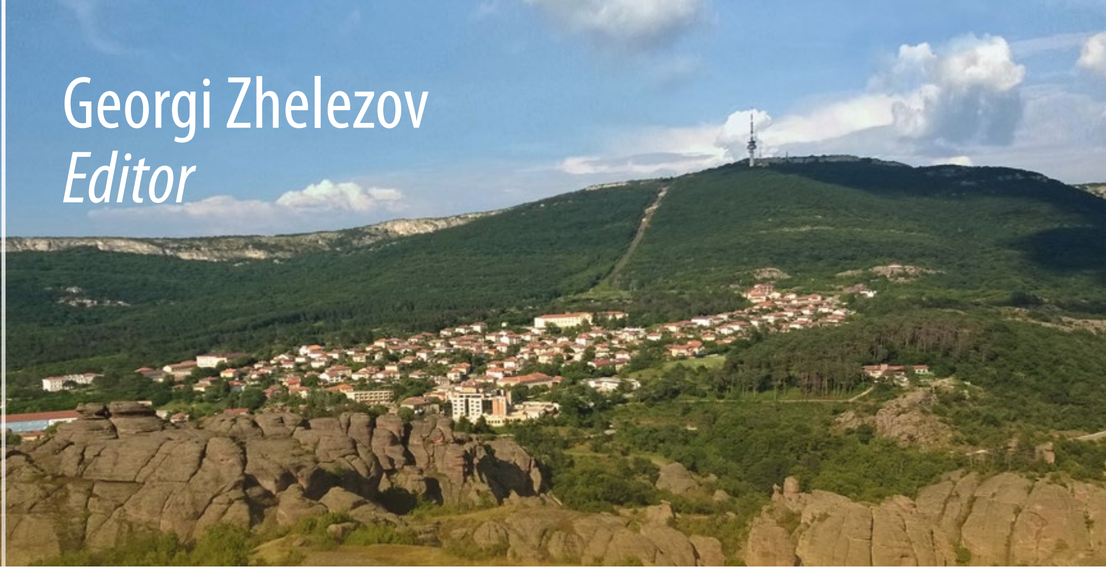

Georgi Zhelezov
Editor

Sustainable Development in Mountain Regions

Southeastern Europe

Second Edition

Springer

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Preface

The book *Sustainable Development in Mountain Regions: Southeastern Europe* integrates the scientific investigations and expertise of a number of researchers from the various countries in Southeastern Europe. This second edition of the book consists of updated information on the topics discussed in the first edition. It includes also five new chapters with analysis of the problems in the mountain regions of four more countries in the Southeastern European space.

The key topics for discussion are natural recourses and land use in mountain regions; sustainable social and economic development of the mountain regions; natural disasters and risk prevention; spatial modeling and planning; nature protection, monitoring, and conservation; politics and sustainable practices for development of mountain regions; and transborder and regional cooperation. The general themes in the book are summarized in five parts:

– Global problems and mountain regions
– Nature resources and land use in mountain regions
– Social, economic, and regional problems of mountain regions
– Nature protection, conservation, and monitoring
– Networks and strategies for mountain regions

Mountain regions are specific territories with unique landscape and biological diversity and great economic potential. Mountains cover 56 % of the geographic space in Southeastern Europe. In most of the countries located in this region, the mountains occupy more than 50 % of their territory. The mountain areas constitute a major ecological, economic, cultural, recreational, and living environment in Europe that is shared by numerous peoples and countries. Southeastern European mountain regions are an important reservoir for biodiversity, habitats, and ecosystem services. Many protected areas—national parks, nature parks, reserves, and nature monuments—are located in these regions.

The main parts of the mountain regions are observed to be the poorest areas in Southeastern European countries from the socioeconomic aspect, but these regions have potential for implementation of successful economic practices and activities. An opportunity exists to establish measures for development of the regions and, in particular, for transborder integration and cooperation. Regional cooperation is of paramount importance because EU integration differs among these countries, and synchronization of economic activity, originally triggered through the EU accession process, is needed to avoid future imbalance of development in border regions.

Positive examples such as the *Alpine Convention* or the *Carpathian Convention* do demonstrate the broad aspects and potential of local embedded processes that contribute to sustainable development of regional (also transborder) cooperation and the high economic potential of mutual learning. Development of these conventions provided the framework for cooperation and multi-sectoral policy coordination, a platform for joint strategies for sustainable development, and a forum for dialogue among all stakeholders involved. The development and implementation of both these conventions were triggered or assisted by researchers. Recent developments and the more stabilized and peaceful neighborhoods facilitate the preparation of a Balkan Convention on Mountainous Regions.

The initial directions and general aspects of the problems of mountain regions in Southeastern Europe have resulted from the work done at the international conference "Identifying the Research Basis for Sustainable Development of the Mountain Regions in Southeastern Europe" held in Borovets (Bulgaria), in April 2009, organized and supported by the Institute of Geography, Bulgarian Academy of Sciences and Austrian Science and Research Liaison Office–Ljubljana/Sofia, and the Federal Ministry of Science and Research of the Republic of Austria in the framework of its SEE (Sustainability, Energy and the Environment) science cooperation initiative.

Understanding the importance of development of mountain regions in Southeastern Europe, the participants in the 2009 scientific forum in Borovets decided to establish and develop a scientific network for the Mountain Regions of Southeastern Europe to advance research efforts in the field of global change and to support sustainable development in the region.

The scientific network was developed by realization of different projects on international and national levels and by several conferences: Timisoara, Romania (August 2010); Ankara, Turkey (July 2012); Sofia, Bulgaria (March 2013); and Borovets, Bulgaria (May 2015).

The common efforts of scientists in the future will be orientated toward intensification of the scientific partnership and integrated with the national and international institutions for foundation and development of a Balkan Convention for the mountain regions, based on the present experience of the Alpine and Carpathian conventions. Such integration, as based on the convention politics, is a sustainable platform for management and development of the mountain regions on the transnational level.

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Part I
Global Problems and Mountain Regions

Chapter 1
Scientific Research Basis for Sustainable Development of the Mountain Regions: Main Concepts and Basic Theories

Mariyana Nikolova

Abstract European policy concerning mountain regions aims at achieving sustainability by using cohesion and integration policies, as well as multi-sectoral and regional approaches. Under conditions of global change, the role of scientific research in the implementation of these policies acquires additional importance. Scientific understanding of the theoretical base and the concepts involved would best serve sustainable development policies in the mountain regions. This study provides an overview of definitions of fundamental concepts, such as "sustainability" and "sustainable development," "multi-disciplinarity," "inter-disciplinarity," and "trans-disciplinarity." Having in mind that diversity and complexity are typical characteristics of mountain areas, both socially and environmentally, this chapter discusses the advantages and drawbacks of implementation of the DPSIR (Driving forces, Pressures, State, Impact, Responses) model and the concepts of 'multidisciplinary,' 'interdisciplinary,' and 'transdisciplinary.' This analysis is expected to support the following conclusions: (1) sustainable development policies must be grounded in the basic concepts of economic theory, including "throughput," instead of "utility," and (2) mountain research necessitates transdisciplinary approaches.

Keywords Sustainable development • Mountains • Global change

1.1 Introduction

Thirty-five years after adoption of the concept of sustainability by the International Union for Conservation of Nature (IUCN), the Millennium Assessment (2008) provided evidence that the human capacity to destroy life-support systems continues to grow and the rate of human transformations of the Earth is increasing. Current

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relationships between humans and the biosphere have reached a critical state without analogy or precedence in past centuries. The Earth's capacity to provide resources and to support ecosystem services and human well-being is limited, which raises the question of the need to develop new thinking about sustainability and a new strategic approach to global sustainability, because "business as usual" is no longer an option. The mountains of the world need new knowledge-based approaches in this process both because of their high sensitivity to global change and because of the great diversity of goods and services that mountain regions provide to society. About 36 % of the territory of the European Union is a mountainous area that contains 18 % of the Union population. Mountain regions within Europe are important for the capture of water and its storage and delayed release to downstream areas. These regions are centers of biological diversity and are also economically and socially important as sites for tourism. Research and innovation are crucial to addressing some of the major issues facing the European Union (EU) and upholding an EU model based on economic growth, social responsibility, and sustainable development.

1.2 Research Base for Sustainable Development of Mountain Regions

There is no agreed definition of the extent to which sustainability is or is not being achieved in any policy program in spite of all the indicators developed during the years. It is already clear that we have to face the challenge and to shift the concept "sustainable development," which is an oxymoron, in a new direction that would be better expressed as "sustainability, well-being, and security." At the same time we have to seek better solutions for making trade-offs and synergy between different goals (between the interest of different social groups or different environmental outcomes, etc.). The three 'pillars' of sustainability, that is, environment, society, and economy, cannot be treated as if these are equivalent because the economy emerges from society differently in different environments and because the environment includes both society and economy.

The definition of sustainable development has been under critical analysis since it was proposed in the Brundtland Report (1987): "Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs." An important discussion on this definition was published by Herman Daly in 2001. He stresses the significant role of utility in this definition and the expectation that utility of future generations is to be sustained and nondeclining. According to the author, physical throughput should be sustained. Natural capital (the capacity of the ecosystem to yield both a flow of natural resources and a flux of natural services) is to be kept intact. Sustainable development as a concept of throughput requires increasing reliance on the renewable aspects of throughput and our willingness to share the nonrenewable part over many generations. The concept of throughput forces recognition of the constraints of physical laws on economics, and it also forces the recognition that 'sustainable' cannot mean using 'forever.'

Under the conventional development model, the 'good life' is defined in terms of access to goods and utilities. This formulation now seems to be inadequate and should be replaced by the concept of 'well-being' defined in terms of access to quality, diversity, a healthy environment, solidarity, and security. Research developments in the field of ecosystem services and innovations in so-called green technologies are crucial for the successful implementation of any strategy currently aiming for sustainability.

The EU Sustainable Development Strategy (SDS), which was renewed in June 2006, sets out a coherent approach to how the EU can more effectively live up to its long-standing commitment to meet the challenges of sustainable development. It reaffirms the overall aim of achieving continuous improvement of the quality of life and well-being on Earth for all present and future generations, through the creation of sustainable communities able to manage and use resources efficiently and to tap the ecological and social innovation potential of the economy, ensuring prosperity, environmental protection, and social cohesion.

The SDS requires the Commission to develop indicators at the appropriate level of detail to monitor progress with regard to each particular challenge. A first set of indicators was adopted by the Commission in 2005 and further reviewed in 2007 to adjust to the SDS. Sustainable Development Indicators (SDIs) are used to monitor the EU SDS in a report to be published by Eurostat every 2 years.

The SDI framework is based on ten themes, reflecting the seven key challenges of the strategy, as well as the key objective of economic prosperity, and guiding principles related to good governance. The themes follow a general gradient from the economic, to the social, and then to the environmental and institutional dimensions. They are further divided into subthemes to organize the set to reflect the operational objectives and actions of the sustainable development strategy.

To facilitate communication, the indicator set is built as a three-level pyramid. This distinction between the three levels of indicators reflects the structure of the renewed strategy (overall objectives, operational objectives, actions) and also responds to different kinds of user needs, with the headline indicators having the highest communication value.

The three levels are complemented with contextual indicators, which provide valuable background information but that do not directly monitor the strategy's objectives. The typology indicators proposed by the European Environmental Agency are divided into four types:

- Type A: *descriptive indicators* of what is happening to the environment or human health, such as emissions and concentrations of pollutants (nearly 60 of this type);
- Type B: *performance indicators* linked to a reference value or policy target, illustrating how far the indicator is from a desired level (more than 40 of this type);

- Type C: *efficiency indicators* illustrating the efficiency of production and consumption processes, such as energy consumption per unit of output (only 8 individual indicators);
- Type D: *total welfare indicators* that aggregate together economic, social, and environmental dimensions to illustrate whether welfare is increasing overall (none).

The remaining indicators are either contextual indicators or those ‘to be developed’ in the future (Eurostat 2007).

Sustainable development policy indicators should be based on the principles and objectives of the EU SDS aiming at development of a clear understanding of the additional headings of governance and global partnership directed to the policy priorities and organized within a thematic structure that would be readily understood by policy makers. The scientific basis on which sustainable development indicators are built needs to be also regionally tested and relevant to the specific environmental features of a given territory, such as mountain, coastal, or urban regions.

1.3 “Pressure, State, Response” (PSR) and DPSIR Models Require Trans-Disciplinarity

A number of models have been proposed for developing indicators and illustrating the links between issues, particularly for environmental indicators. The best known of these is the “pressure, state, response” (PSR) model developed originally by the Organisation for Economic Co-operation and Development (OECD). This model is also the basis of the United Nations Commission for Sustainable Development (UNCSD) framework of sustainable development indicators and has been adapted by the European Environment Agency into the “DPSIR” model (Driving Forces, Pressures, State, Impact, Responses).

As these models were developed primarily to help in understanding the interactions between the economy and the environment, they are not entirely appropriate for in terms of sustainable development. However, the concept of “ecosystem services (ESS)” essentially examines the link between biodiversity, ecosystems, and human well-being and is important in implementation of the DPRIR model in studies on sustainability.

According to DPSIR terminology, human developments (drivers, D) exert pressures (P) on the environment and, as a consequence, the state (S) of the environment changes (changes of ecosystems). This change has impacts (I) on humans and the society (by less or altered provision of ecosystems services), which may elicit a societal response (R). This response may target either the drivers, the pressures, the state, or the impacts on society via various mitigations, adaptations, or corrective actions. (Odermatt 2004)

The research basis for sustainable development requires implementation of methods and knowledge from different scientific disciplines incorporated into a multidisciplinary approach. The uniform understanding about the concepts we use in the research process of a given ecological target category, such as mountains, is of crucial importance for the successful integration of knowledge and the achievement of scientific results.

However, what we are going to do in the process of this integration? Answers are given in many publications from different authors.

- *Multidisciplinary* studies, joining together two or more disciplines without integration, have a wide range of subject matter and of conceptual frameworks, exploring the current state of mountain areas (Messerli and Ives 1997);
- *Interdisciplinary* studies is an academic process seeking to synthesize broad perspectives, knowledge, skills, interconnections, and epistemology to facilitate the study of subjects that have some coherence but which cannot be adequately understood from a single disciplinary perspective. Inter-disciplinarity is now a stand-alone discipline (Jones and Macdonald 2007)
- *Trans-disciplinarity* implies the interrelation of disciplinary-generated knowledge and nondisciplinary-generated knowledge and its application to complex problems and issues (Webster 2009).

The close relationship between sustainable development and trans-disciplinarity is that research for sustainable development has to be issue oriented and must reflect the diversity, complexity, and dynamics of the processes involved. It is possible therefore to examine complexity on a discipline-by discipline basis.

1.4 Conclusions

Studies on the sustainable development of mountain regions must be directed to successful implementation of the EU Sustainable Development Strategy, but also they must find implementation in policies for sustainable development grounded in an economic theory that includes throughput, ‘green’ technology innovations, and ecosystem services as its most basic concepts. Implementation of the DPSIR in studies on sustainability in mountain regions provides a good research basis for integration of the aforementioned goals and for the acquisition of knowledge.

Trans-disciplinarity is most relevant to the current dynamic processes under conditions of global change and to the study of sustainable development in mountain regions using the DPSIR model and SDI.

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Chapter 2
Solar Activity, Climate Change, and Natural Disasters in Mountain Regions

Milan Radovanovic

Abstract Contemporary science is burdened with contradictory, that is, severely opposed attitudes relating to climate changes issues such as global warming. What is undisputable is that if climate changes are more intensive, changes relating to stands of plants are also more intensive. Forest fires are one of the most drastic factors that influence changes of stands of plants in mountain terrains. The damage caused by forest fires destroying forests varies from case to case, but a significant problem occurs in irretrievable losses of soil because of increased erosion, as well as disturbances in underground water circulation. In contrast to plain terrains, mountains are far more sensitive to such disasters, especially when we consider losses in agricultural soil as well as of wildlife. The fact that a direct connection between any of the climate elements and the initial phase of a fire has not been established so far represents a special challenge to science. A new hypothesis is presented in this chapter, which attempts to link the processes on the sun, that is, charged particles (protons and electrons) as potential causes of forest fires of unknown origin.

Keywords Solar activity • Forest fires • Natural disasters

2.1 Background

According to the official Food and Agriculture Organization (FAO) data (2001, 2002), more than 20,000 forest fires of unknown origin occurred in some European countries in 1999–2001. For the period from 1950 to 1991, 40 % of fires with unknown cause were registered in Europe (http://www.feudeforet.org/english/forets_europe.htm#haut). Nikolov (2006) points out that Bulgaria had the highest percentage of fires of unknown cause (67.9 %) in the Balkans in the period from 1988 to 2004, whereas the Balkan countries had 37.9 % in the same period. Whether

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we are considering fires in mountainous terrains, foothills, or plains, the connection between meteorological, that is, climate, conditions and the initial phase of a fire is unclear. Every attempt at more complex research of this problem unavoidably leads to results contradictory to those that have been noticed in connection with climate changes.

In the past few decades many scientific papers have been published with severely opposed attitudes toward climate changes. Girardin et al. (2006) say: “Human-induced climate change could lead to an increase in forest fire activity in Ontario, owing to the increased frequency and severity of drought years, increased climatic variability and incidence of extreme climatic events, and increased spring and fall temperatures. Climate change therefore could cause longer fire seasons, with greater fire activity and greater incidence of extreme fire activity years.” The news is becoming worse, as they note: “Fire has also been recognized as a significant source of greenhouse gas emissions into the atmosphere. Most of this is in the form of carbon dioxide (CO_2), but quantities of carbon monoxide, methane, long-chain hydrocarbons, and carbon particulate matter are also emitted.”

In contrast to the emphasis on global warming, which especially has been supported in the media during the past recent years, there are more and more papers in which regional climate changes are stressed (Michaels 1998; Gray 2000; Landscheidt 2003; Komitov 2005; Radovanović et al. 2006). In that sense, the results have comments such as follows: “Just when you are starting to believe that variations in the amount of energy, which is coming from the sun, are not responsible for much of the observed surface warming during the past 20 years,” Scafetta and West (2006) conclude otherwise: “We estimate that the sun contributed as much as 45–50 % of the 1900–2000 global warming, and 25–35 % of the 1980–2000 global warming. These results, while confirming that anthropogenic-added climate forcing might have progressively played a dominant role in climate change during the last century, also suggest that the solar impact on climate change during the same period is significantly stronger than what some theoretical models have predicted” (http://www.worldclimatereport.com/index.php/category/climate-forcings/). In contrast to the interpretation that the cumulative buildup of greenhouse gases inevitably leads to a global increase in temperature, in the period 1996–2013 a global negative trend of temperature was measured (Radovanović et al. 2014). The authors note that this trend is statistically insignificant but still negative.

In situations when a number of localities appear with burning in several states, the question of intentionally or unintentionally caused fires simply cannot be taken into this discussion. As this chapter is limited in scope, only two figures are presented, illustrating the nonjustification of taking into consideration the anthropogenic effect on the phenomenon of the initial phase of fire in similar situations.

In reference to Fig. 2.1, it is necessary to emphasize that 2 days earlier many fires appeared on the southern banks of the Baltic Sea. It has been reported that at the end of March the destructive power of fires was spreading from the north of Central Europe toward the south of the Balkans and even to the south of the Apennines (Radovanovic and Gomes 2009).

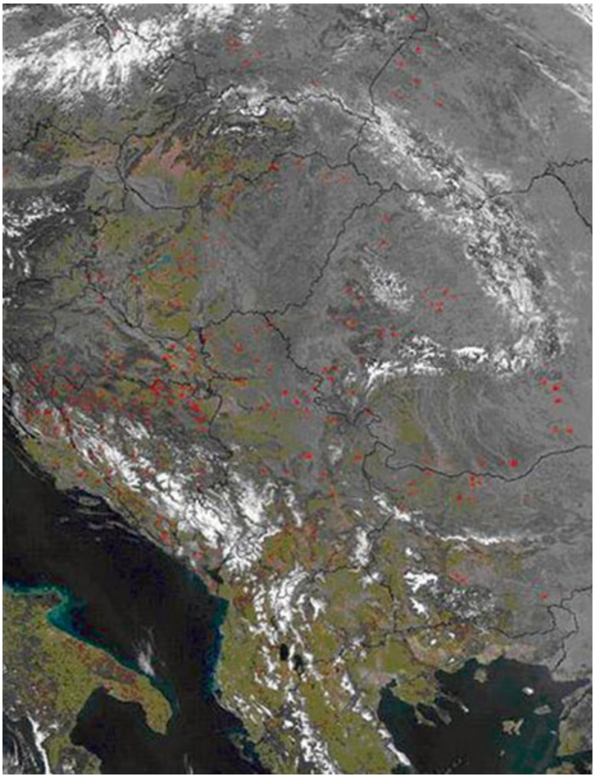

Fig. 2.1 A large number of fires was spreading from Italy over the Balkans, Hungary, Romania, Ukraine, Slovakia, and Poland on March 26, 2003 (http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=8620)

It is also necessary to mention that such images can be taken only when fire is already in its developed phase. In other words, the moment of the ignition certainly occurs a little earlier. Nevertheless, satellites cannot detect fires that cloak smaller surfaces (less than 1 km^2). Csiszar et al. (2005) wrote about the limitations of using satellites for the spatial detection of forest fires.

Fire overcoming locations throughout the Balkans can be seen in Fig. 2.2. Forests burned in the following mountains: Prokletije (Serbia, Albania), Sara (Macedonia), Pindus Mts. (Greece), the Carpathians (Romania), Stara Planina (Serbia, Bulgaria), and the Dinaric Alps (Montenegro, Croatia), but also in the lower terrains of the Mediterranean and the Black Sea coasts. The following quotation gives a concise description of the events in Bulgaria: "Emergency services were inundated with hundreds of calls from people suffering from heat stroke, dehydration and headache. In Sofia alone 140 people fainted in the streets on Saturday. At least eight deaths were directly attributed to the extreme temperatures. Most of the victims were elderly people suffering from chronic diseases. Six people were killed in the fires that started on Saturday and that continued well into the next week. There were an estimated 1530 cases of fire in just four days (Friday 20–Tuesday 24 July, 2007). That's three times the yearly average. Fires raged in almost every corner of the country but the largest fire was near Stara Zagora where 20 mile^2 (50 km^2) of pine

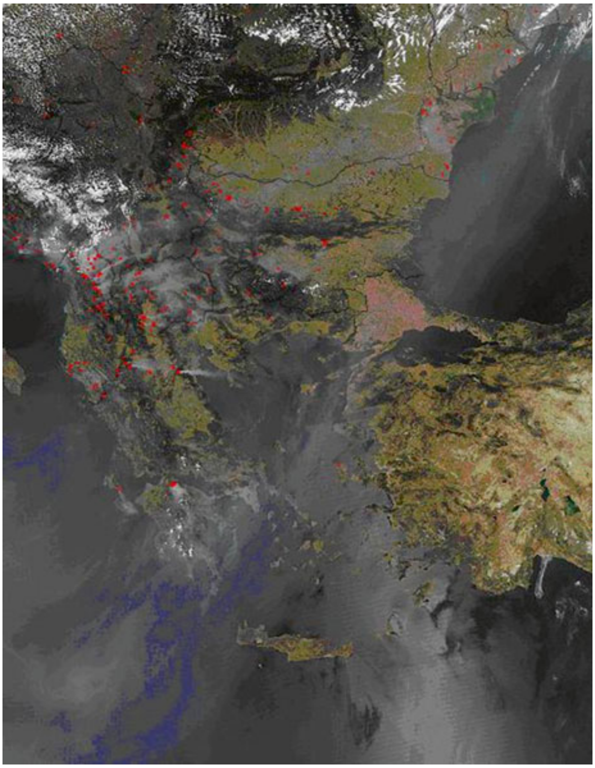

Fig. 2.2 Fires and smoke across the Balkan Peninsula. Satellite: Aqua, pixel size = 1 km; alternate pixel size =500 m/250 m 2007/206–07/25 at 11:15 UTC (http://modis.gsfc.nasa.gov/gallery/individual.php?db_date=2007-07-26)

forest burned uncontrollably for three days. Firefighters were unable to put out the fire by conventional means. Strong winds and the extremely dry air quickly sparked new fires and by Sunday the situation was out of control. The government turned for help to Russia and Be-200 amphibious water bomber flew in on Saturday to help fight the blaze near Stara Zagora. On Monday, more fires broke out but the one near Stara Zagora was contained. The fire caused extensive damage to the forest and wildlife. Estimates vary but this fire alone caused at least two million euros worth of damage. Temperatures in excess of 45 °C had never previously been recorded in Bulgaria. The country generally has a temperate climate. Although temperatures reach around 40 °C every summer this usually lasts for just a few days whereas this heat wave lasted for more than a week. Meteorologists from the national Institute of Meteorology and Hydrology announced 2007 to be the hottest year on record. However, they were careful to say that no clear link between global warming and the 2007 Bulgarian heatwave could be established" (http://en.wikipedia.org/wiki/2007_Bulgarian_heat_wave).

When discussing the eventual link of climate elements and fires, it is necessary to emphasize clearly that such connection has never been proved concretely. Namely, a minimum of 300 °C is necessary for flame to appear (Viegas 1998). As is well known, no temperature of the ground surface that has ever been measured is even close to this, not to mention air temperature. In the meantime the idea appears that lightning can represent a frequent potential cause of forest fires. Somehow there is a conviction that is easily ignored that, almost as a rule, rainfall appears with lightning and that should control fire spreading. It was established that "From 1990 to 1998, over 17,000 naturally ignited wildfires were observed in Arizona and New Mexico on U.S. federal land during the fire season of April through October. Lightning strikes associated with these fires accounted for less than 0.35 % of all recorded cloud-to-ground lightning strikes that occurred during the fire season during that time" (Hall 2007).

2.2 Heliocentric Hypothesis on Forest Fires

As far as it is known, Stevancevic (2004, 2006) for the first time presented the hypothesis on the possible connection between charged particles and forest fires. The author offers in his papers the explanation of the mechanism of the solar wind (SW) penetration through the magnetosphere and atmosphere of the Earth, concluding that protons and electrons can reach the topographic surface only in conditions of reduced air humidity and cloudiness (Malinovic-Milicevic et al. 2014). In contact with plant mass, the conditions are established for the initial phase of the fire to occur. Gomes and Radovanovic (2008), Radovanovic and Gomes (2009) have decided to confirm the justification of the presented hypothesis in 10 or 11 cases. Besides the fact that it was a research test, it seems that a few days before the forest fires occurred the coronary holes or energetic regions had been in a geo-effective position on the sun in all examined cases. Strong corpuscular energy was emitted from them toward the Earth, the speeds of which in some cases exceeded 800 km/s; particle temperature was more than 1,000,000 °C and particle density ranged to more than 50 p/cm^3. Having in mind that the number of samples is statistically insufficient (related to problems with data gathering), Todorovic et al. (2007), Radovanovic et al (2007), and Milenković et al. (2013) have also confirmed the justification of such an approach through some separate examples. As observed by regional geography, it can be said that where there are vegetation masses on our planet, there are fires too. Besides the reconnection (Radovanovic et al 2003; Stevancevic et al 2006), an especially intriguing explanation was offered on the southwest penetration mechanism through the atmosphere in tropical areas over a geomagnetic anomaly, that is, over the areas where the Earth's magnetic field is the weakest. At the same time, when fires occurred in the Balkans, numerous locations were also burning in Canada (Radovanovic et al. 2009). The SW stream, which is directed toward the tropics by the kinetic energy influence, in dependence on the existing situation in the atmosphere and angle under which it comes, moves toward certain parts of our planet, including the mountain regions. According to Stevancevic (2006), in each concrete situation when the particles penetrate deeply through the atmosphere, the SW stream disperses into several smaller components by increase of geomagnetic induction, B, and decrease of the radius of the SW particle circulation in accordance with the relationship $r=mV/qB$. The radius of the SW motion is proportional to mass m and speed V; it is inversely proportional to the electric load of particles, q, and the value of the magnetic induction, B.

The SW jet, which penetrates to the Earth, is becoming narrower because of the relationship in the aforementioned equation. The magnetic wall that surrounds the charged particles does not allow their dispersion. However, the increasing density of air and stronger geomagnetic field at relatively lower altitudes lead to increased friction and the weakening of the magnetic wall. At one point, that is, to a certain height (depending on the electromagnetic and physicochemical properties of the SW), it will come to the opening of the magnetic wall of the SW jet. A subsequent flow of particles, which means from other energy regions or coronal holes, is made easier to a large extent because of the already established routes of penetration. In any case, the stronger electromagnetic force of the SW, the more intense penetration to the surface, and thus the opening of the magnetic wall is closer to the ground. Radovanović (2010) points out that at that moment the particles disperse, in that the protons move to the left and the electrons move to the right in relationship to the dominant moving direction of the main jet. The possibility of reaching the ground, thus causing the initial phase of the flame, depends in addition to the aforementioned presence of humidity and cloud cover on the density of the particles, that is, their arrival. Keeping in mind that these protons are heavier in relationship to electrons, it can be observed that the fires resulting from their activities are spatially grouped and occupy a relatively small surface area. In contrast to these phenomena, a considerably broader dispersion can be observed at fires caused by the action of electrons. Depending on local, that is, regional conditions in certain situations, fires caused by the action of both particles may arise in a particular area. However, it often occurs that fires appear initiated by action of only protons or only electrons. In this manner the geographic distribution of fires could be explained, and on the basis of the spatial distribution it can be concluded what caused them. Thus, for example, on Mountain Povlen (south of Valjevo, Serbia) on 10 October 2012, a fire broke out at several sites at a height of 1,314 m. The former Interior Minister Dusan Mihajlovic reported this event (http://www.blic.rs/Vesti/Drustvo/347052/Bivsi-ministar-policije-Dusan-Mihajlovic-postavio-na-svoj-Fejsbuk-nalog-slike-pozara-na-Malom-Povlenu). Bearing in mind that there are no necessary astrophysical data for this specific case, it can be assumed that the cause relates to protons, given the relatively small number of vulnerable sites, as well as their surface. It is not necessary to emphasize that this case also had no formally specified cause.

In this way it could be explained why the charged particles can rarely be detected by the normal standard observations in the troposphere (Radovanović et al. 2015). Viewed in this manner, the locations in which they can be measured and therefore cause a burning of plant mass are never the same, especially if one takes into account a wide range of individual parameters of the SW. Radovanović et al. (2013) point out that in the example of the United States as opposed to indicators relating to the flow of protons and electrons in different energy ranges, the 10.7 cm solar flux, as an indicator of the overall solar activity levels, as well as the average daily solar wind speed point to the necessity of making prognostic models that will be based on these parameters. In other words, the Hurst coefficient was near 0.72–0.92, meaning that there was a long history of the number of small fires and 10.7 cm solar flux and average SW speed. The results are obtained on the basis of the determination of the correlation links on a daily level, as well as on the basis of the investigation of the phase move of 0–5 days. Irrespective of the foregoing guidelines, what can be carried out in a relatively short period of time refers to the making of the prognostic model based on adaptive neuro fuzzy inference system models. It follows that the general indicators show significantly better results on the level of statistics. In essence, this could be explained theoretically. The influx of protons and electrons that is measured in La Grange point does not necessarily mean that there will be a fire. However, in cases where some other causes are not included, it appears that it is not possible to expect the appearance of fire if there is no arrival of the charged particles.

At the moment it is difficult to make any quantitative assessment to what extent mountainous and submountainous terrains are threatened compared to the plains. Oxygen concentration is in general greater at lower altitudes, so that the presence of this gas as an extremely important factor of burning is linked with the advent of fire on areas with relatively lower altitudes.

Approximately 80 % of the total burned biomass is in tropical countries (http://earthobservatory.nasa.gov/Study/Fire/). The abundance of plant mass certainly influenced the previously mentioned extremely high value in this region. However, rarely inhabited terrains, as well as the presence of extremely high values of humidity in the air, should not be disregarded.

Which areas are going to be under the effect of the SW stream will depend on the angle (as well as other physicochemical characteristics) under which the SW stream penetrates toward the surface over the tropics. From the previously mentioned case, there has also been the time coincidence of air mass moving from the southwest toward the Balkans (Nikolić et al. 2010; Radovanović et al. 2010). It is very important to emphasize that before the destructive power of fires that occurred in southeastern Europe, a series of fires had occurred in northwestern Africa, as well as in many locations of the European Mediterranean (Gomes et al 2009).

Figure 2.3 shows mean wind speeds, approximately from the upper border of the troposphere to some mountain peaks. Yellow lines mark wind speeds, so that by following their location we can make some conclusions on dominant directions of air mass movements. The upper part of Fig. 2.3 relates to July 21 and the lower part to July 22, 2007. The same day when the satellite measured the sudden rise, that is, IMF approaching toward Earth, the isoclines of the increased mean wind speed (70 kts) were recorded in the area of the Mediterranean. According to heliocentric hypothesis, the penetration occurred over the Atlantic geomagnetic anomaly, so that a part of stream was directed toward Europe. Gomes and Radovanovic (2008) for the first time, in the case of Portugal, explained the idea according to which the air masses took hold in response to SW penetration over the Atlantic anomaly. Based on the available literature, it seems that research of the links between processes on the sun and physical geographic processes on Earth indicates a synchronized phenomenon of the SW particles and geomagnetic anomalies. “Therefore, we conclude

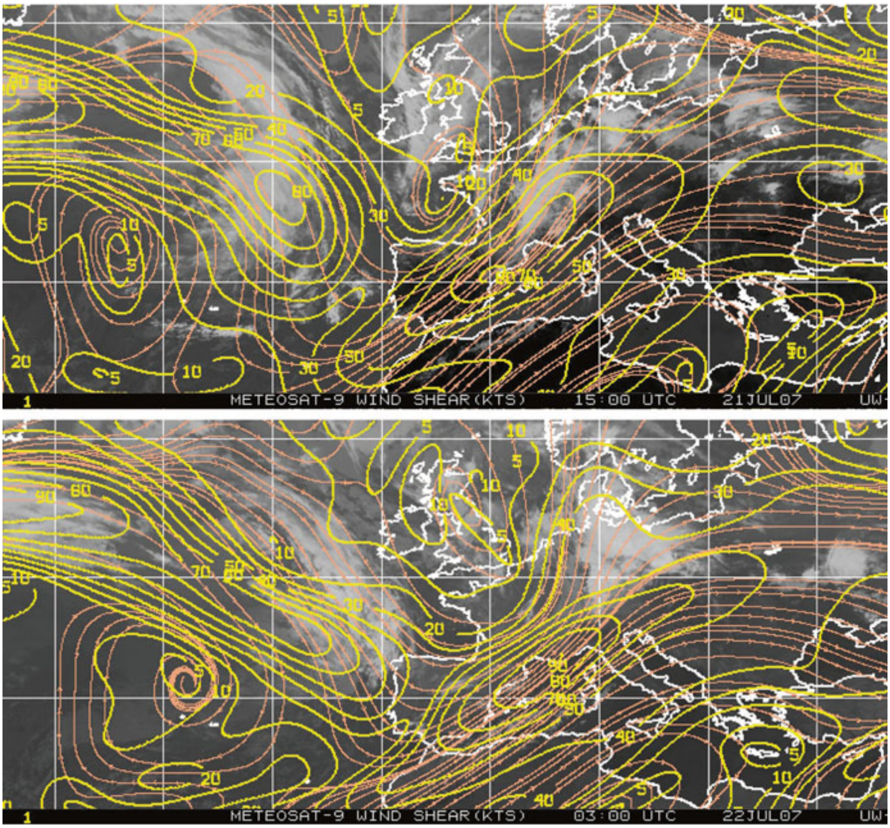

Fig. 2.3 Wind shear 150–300 mb layer mean minus 700–925 mb layer mean (http://cimss.ssec.wisc.edu/tropic/real-time/europe/winds/wm7shr.html)

that geomagnetic activity plays an important role in recent climate change, but that the mechanism behind this relationship needs further clarification" (Palamara and Bryant 2004) (Table 2.1).

On the basis of the data from this table, it can be seen that the number of protons in the range greater than 100 MeV practically did not decrease in the period from July 21 to 25, 2007. Until July 29, 2007 the number of protons of this range was decreasing but only on July 30, 2007 was it below the level in comparison with July 21, 2007. It should be stressed that even at the level of the average daily values, there are some (albeit in terms of statistics, primitive) indications as to the association of these processes. But in terms of sudden and powerful ejections of plasma from the energy regions from the sun, the influx of protons and electrons (and nucleons) of different chemical elements can vary within relatively large ranges even within 1 h.

On the basis of the available literature, it seems that cosmic radiation also has its pulsations, that is, it is not constant. It has been noticed that when the sun is more active the electromagnetic waves coming out of the solar system penetrate further

Table 2.1 Number of protons of certain energies during and after fires in Canada and the Mediterranean (protons/cm^2-day-sr)

Date	>1 MeV	>10 MeV	>100 MeV
2007 07 21	3.5e+05	1.7e+04	3.7e+03
2007 07 22	4.3e+05	1.7e+04	3.8e+03
2007 07 23	4.7e+05	1.7e+04	3.8e+03
2007 07 24	6.4e+05	1.7e+04	3.8e+03
2007 07 25	7.6e+05	1.7e+04	4.1e+03
2007 07 26	1.6e+06	1.8e+04	4.0e+03
2007 07 27	4.3e+05	1.7e+04	3.9e+03
2007 07 28	5.6e+05	1.8e+04	3.9e+03
2007 07 29	7.1e+05	1.7e+04	3.8e+03
2007 07 30	8.7e+05	1.6e+04	3.6e+03

Source: http://umtof.umd.edu/pm/crn/

toward the Earth and vice versa. However, in some cases, except the strengthened activity of the sun, the striking fronts of the cosmic particles are still coming toward us at certain moments. “Cosmic rays are different – and worse. Cosmic rays are super-charged subatomic particles coming mainly from outside our solar system. Sources include exploding stars, black holes and other characters that dwarf the sun in violence. Unlike solar protons, which are relatively easy to stop with materials such as aluminum or plastic, cosmic rays cannot be completely stopped by any known shielding technology” (http://science.nasa.gov/headlines/y2005/07oct_afraid.htm).

2.3 Conclusion

The hypothesis by which the charged particles from the sun and forest fires (of unknown origin) are considered as to connection needs experimental confirmation that would approximately simulate the contact between the plant mass and protons and electrons in laboratory conditions. It is also necessary to confirm the eventual causality in a much larger number of examples. That means, more concretely, that there are certain possibilities of prognostic modeling under the existing concepts. Therefore, at this moment it seems far simpler to prognosticate when forest fires are going to happen, but a considerably greater problem is to define where they are going to appear concretely. For the needs of modeling, particularly sensitive are the parts referring to the borderline values of the concentration of particles during the opening of the magnetic wall (approximately at the heights of 7–11 km), as well as their propagation to the ground in dependence of the local conditions. “…I think that these problems can only be solved by a joint interdisciplinary effort of open-minded scientists” (Landschieidt 2000).

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Chapter 3
Mass Movement Processes Under Changing Climatic and Socioeconomic Conditions

Karl Hagen and Peter Andrecs

Abstract In recent years, natural hazards have caused increasing damage to infrastructures and human beings in the alpine regions. At the same time, the global mean temperature is rising, but for mass movement processes, there exists no direct connection between these two facts. It is not evident that rising global temperatures will intensify the triggering effect of extreme precipitation everywhere. This will probably vary spatially. In Austria, socioeconomic development has brought about the increase of real values, and the impact of unsustainable land use has often caused higher susceptibilities. Thus, also without adverse "climate change effects," the risks caused by natural hazards are increasing as a consequence of socioeconomic development. Sustainable spatial planning is required to control further challenges. Databases and methods for hazard and risk assessment have to be adapted to meet its requirements.

Keywords Landslide • Climate change • Socioeconomic change • Natural hazards • Risk assessment

3.1 Introduction

In recent years, in Austria and in adjacent countries, natural hazards such as mass movement processes have increasingly caused damage to infrastructure, settlements and human beings, as lately seen in the Balkans in spring 2014, for example. Is this tendency caused by an increase in extreme precipitation events or is uncontrolled socioeconomic development responsible for this phenomenon? Which measures on the international, national, regional and local level are required to reduce the adverse effects? Based on investigations and actions in Austria, some recommendations with emphasis on spontaneous landslides and debris flows are given here.

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3.2 The Matrix of Mass Movement Processes and Triggering Parameters

3.2.1 Basics

In mountainous regions, several processes of mass movements appear, ranging from sediment transport in rivers to debris and mud flows to landslides, rock falls and avalanches. All these processes are triggered by varying combinations of parameters in different ways. For instance, rising temperatures mean rising snow lines, which probably increase the danger of flooding, especially during the winter season, but also may decrease the hazards of avalanches at lower altitudes (Perzl and Kammerlander 2010). This chapter focuses on the processes of spontaneous landslides and resulting debris and mud flows, but many of the conclusions may be figuratively valid also for other mass transport processes.

The *basic disposition* (Fig. 3.1) for gravitative transport processes, especially landslides and debris or mud flows in young fold mountains (e.g. the Alps), is comparatively high in this stage of "mountain development." Caused by topographic attributes (high gradients), erosion is a natural phenomenon. In the case of spontaneous, more or less shallow landslides and mud flows, basically tasks such as topography, parent rock material and the genesis of loose material (soils) are relevant to

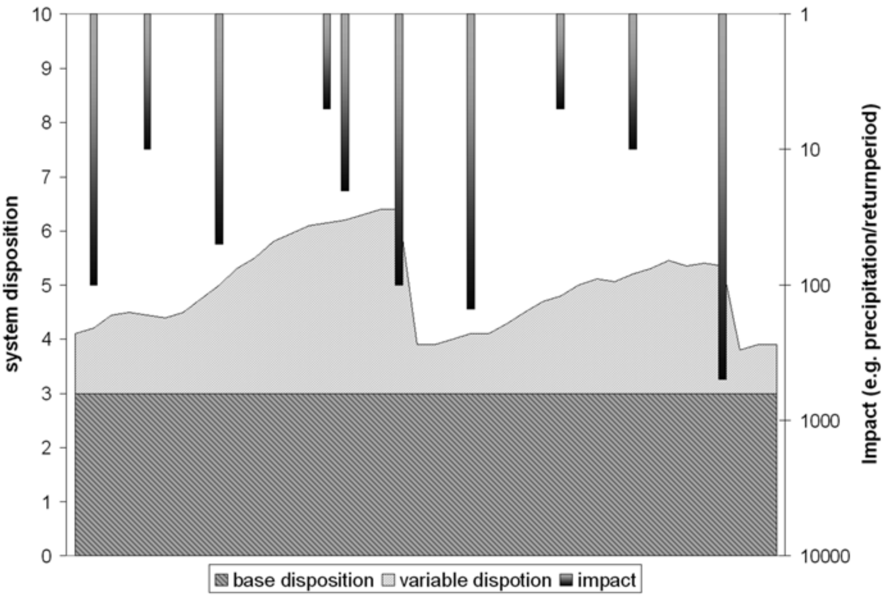

Fig. 3.1 Scheme: Frequency of mass transport processes (especially spontaneous landslides and debris flows). The amount and intensity of precipitation (shown by the return period) is only one triggering factor. The basic and the variable susceptibility of the area, reflected by selected parameters, have to be considered in this matter

assign the effects of gravitation (slope angle) and the countering forces (friction angle). They also affect the water regime (infiltration, water storage capacity).

The varying availability of material in the cycle of soil generation, erosion, and transport on slopes and in channels may be designated as *variable disposition* (Fig. 3.1) as well as the complex of land use and vegetation, which is often subject to the turn of the seasons. Also road construction, other building projects and protective measures such as drainage or construction in varying conditions are important factors.

Triggering effects of spontaneous, shallow landslides are predominantly heavy precipitation and earthquakes in seismic active zones. Depending on soil properties, the role of precipitation differs in amount and period. Debris or mud flows may be triggered by several factor combinations; the role of precipitation, intensity and amount varies accordingly. Usually, these flows are not directly caused by earthquakes, but they may emerge from seismically triggered landslides.

Except of the precipitation factor, none of these factors includes a time component. For this reason, it is hardly feasible to determine the *frequency* of occurrence and even less the changes in the frequency-magnitude function caused by climate change.

3.2.2 The Event of 2005 (Communities of Gasen and Haslau, Austria)

Between the 20th and 22nd of August 2005, an extreme precipitation event producing about 200 mm rainfall within 36 h (>100 years return period) triggered off several shallow landslides and mud flows (Fig. 3.2).

As an additional triggering factor, a high soil moisture content acting as a critical precondition was considered. The conjunction of these adverse climatic conditions can be assessed as very rare ($\gg$100 years return period; Andrecs et al. 2007).

The variable disposition for spontaneous landslides of the area may be considered all in all as high because of extensive road construction, especially for forestry measures. About two thirds of the surveyed landslides were triggered (or increased in magnitude) because of improper road slopes. Debris or mud flow events were not affected that adversely by road construction; in some cases, material deposition on the roads could even mitigate small debris flows.

In relationship to the part of the surface, agricultural areas were affected more seriously by landslides than forestry areas, although forestry areas are to be found predominantly in the steeper parts of the region (Tilch et al. 2011).

If they are affected, the woody debris will quite often cause problems by impairing protection measures (Fig. 3.3) and jamming channels.

The basic deposition of the area is also high because of the lack of glaciation during the last Ice Age. Therefore, thick soil and loose material horizons could develop.

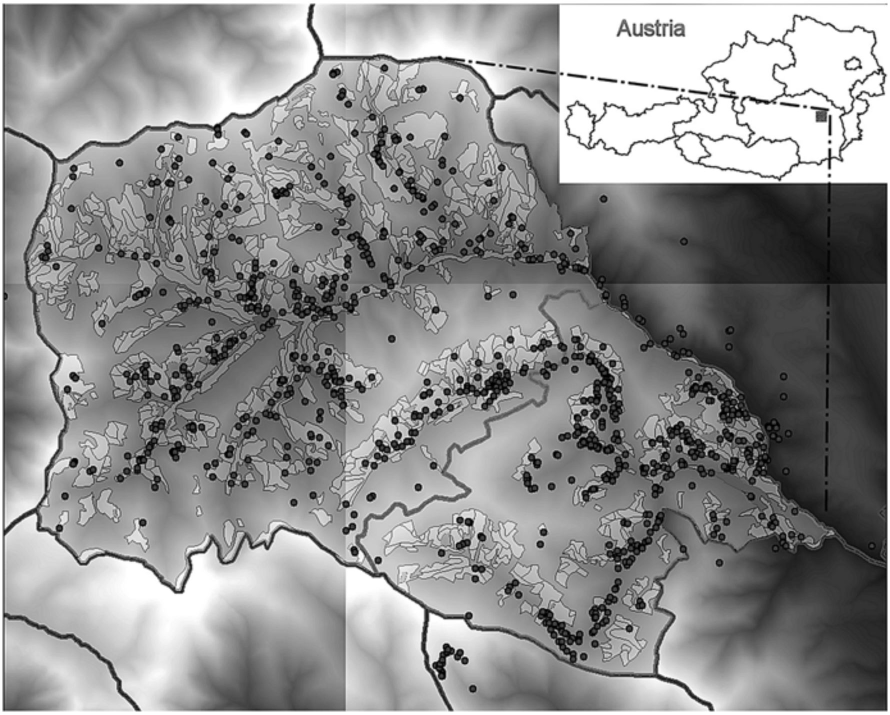

Fig. 3.2 In and around the communities of Gasen and Haslau, predominantly shallow landslides (about 700 on 60 km^2), often with ongoing debris flow, were documented (*points*) occurring during and shortly after the precipitation event of 20./21.8.2005 (Tilch et al. 2011; Hagen and Andrecs 2009)

Considering long periods, it seems that socioeconomic changes in the area have led to damage and to an increase of vulnerability, the extent of which had never been hitherto possible.

3.3 Climate Change: Facts and Assumptions

Looking back to earth's temperature history, we can take it as a fact that climate is not constant. Knowledge about other climate parameters such as precipitation is fragmentary. There have always been climate changes driven by such factors as continental drift, earth orbit parameters and even greenhouse gas concentrations, built up by feedback effects of the glacial stage, which influences earth albedo. The main task is to determine the intensity of change and its impact on society, which is not necessarily negative. Climate history can probably help us to understand and predict ongoing and further climatic development.

Fig. 3.3 Debris-sorting dam in the "Rauschergraben" (community of Gasen, Austria). Impaired function and overload because of "woody debris". The measure could avoid heavy losses in the settlement (photograph by WLV Styria, Ellmer)

The Fifth Assessment Report of IPCC (2013) found that global warming is already a fact and will continue in the twenty-first century, depending on the development of greenhouse gas emissions. According to the IPCC report, it is likely that heavy precipitation events have already increased over most areas in Europe. For Austria, Schöner et al. (2011) estimated the development on the basis of comprehensive climate data analysis as follows: precipitation will develop in spatially differentiated ways. Although winter precipitation will increase, especially in the northern parts of Austria, summer precipitation will rather decrease. The assumption from Christensen et al. (2007) that extreme precipitation events are likely to increase, based on the physical relationship that higher air temperature allows higher water content, are assessed as speculative.

However, although global warming is an established fact, regional and local effects of climate change are not that clear. To run AOGCMs (*Atmosphere–Ocean General Circulation Models*), it is necessary to use low spatial and temporal solutions and to reduce physical correlations. Although this is an appropriate method for global patterns, conclusions for higher solutions have become increasingly unreliable. Problems with simulating the hydrologic circle, especially convective processes at a small scale, make these simulations extremely difficult. Furthermore, existing datasets are improper for analyzing changes in short-duration events of extreme

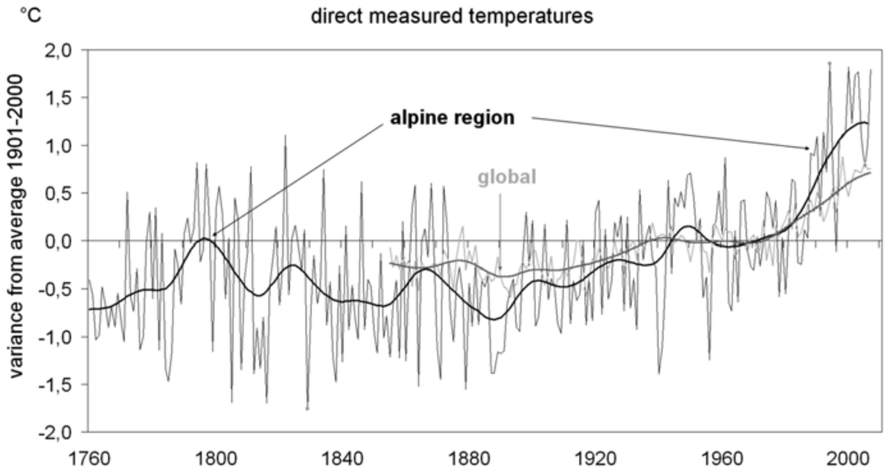

Fig. 3.4 The region of the Alps seems to be particularly susceptible to climatic impacts. The variance of temperature is more visible in this region than in the global trend (from HISTALP (Auer et al. 2007; Böhm et al. 2009))

precipitation (Böhm 2008). Considering this, we have to ask how we can predict future developments if we are hardly able to detect ongoing trends in this matter.

Reinhard Böhm (2009), an Austrian climate scientist, compared the "climate change situation" with the turbulent runoff in a torrent channel: *"…it is currently clear, that the water altogether flows downhill as it is clear that we are living in a time with global rising temperatures. But looking at all the details, we will detect places with still waters or with whirls which even cause "uphill flow" close to torrent flow…*". The fact of global warming and connected changes of precipitation behavior cannot be adopted on a one-to-one basis at a regional or local scale (Fig. 3.4).

For the region of Gasen and Haslau, the precipitation event (including the high preprecipitation amount) must be considered as not having been measured previously, which means a period of about 120 years. Although this was an extreme event, it is not acceptable to draw conclusions from this single event to an ongoing climate change. Linked with other extreme events, it might be a small part of the "Global Puzzle."

The damages and losses caused by extreme precipitation events in the past years combined with the change of climatic conditions obliged authorities in the alpine space to compile adaption strategies. The "Austrian strategy for adaption to the Climate Change – recommendations for action" (BMLFUW 2012) for example, focuses on the achievement of the hazard and risk awareness of the population in combination with a sustainable, risk-based spatial planning and accompanying specific research.

3.4 Socioeconomic Development and Rising Disadvantages

We cannot get rid of the feeling that losses caused by natural hazards ranging from storms to flood events and mass movements are increasing. And yes, it is not just the nowadays excessive reporting in our "global village" or psychologically reasoned influences. Looking at worldwide statistics, there is no doubt that there is an increasing number of natural catastrophes, defined as the region's ability to help itself being clearly overstretched etc. (Munich Re Group 2008). In 2007, there were 960 natural catastrophes following this definition, whereas 400 events occurred on average in the 1980s, 630 in the 1990s, and 730 in the last 10 years. Depending on the rising number, also the losses of natural catastrophes have increased, to US$ 82 billion (Munich Re Group 2008).

The definition of natural catastrophes as shown indicates that socioeconomic factors are the crucial tasks between hazard and risk (risk = hazard * vulnerability), although these two terms are often used synonymously. Increasing losses can be caused by increasing hazards as well as by increasing society's vulnerability (Fig. 3.5).

Calculating vulnerability means to determine the number of affected objects and their resistance against potential damage. Figure 3.6 shows the increase of buildings in Austria from 1951 to 2001 (from 916,448 to 2,047,712 buildings). These data indicate that, in Austria, socioeconomic development is probably more responsible than effects of climate change for increasing losses.

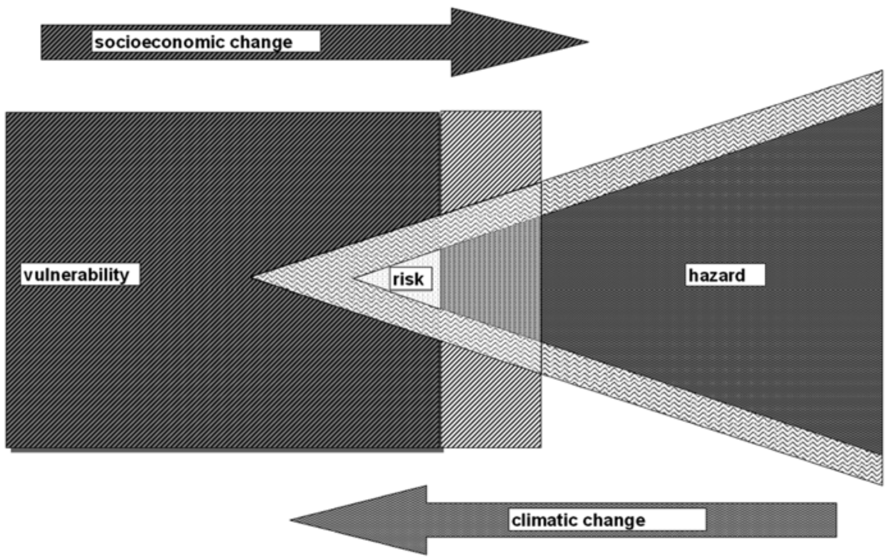

Fig. 3.5 Schematic relationship between risk, hazard and vulnerability. Changes of hazard as well as vulnerability (caused by socioeconomic development) may abate or increase the risk

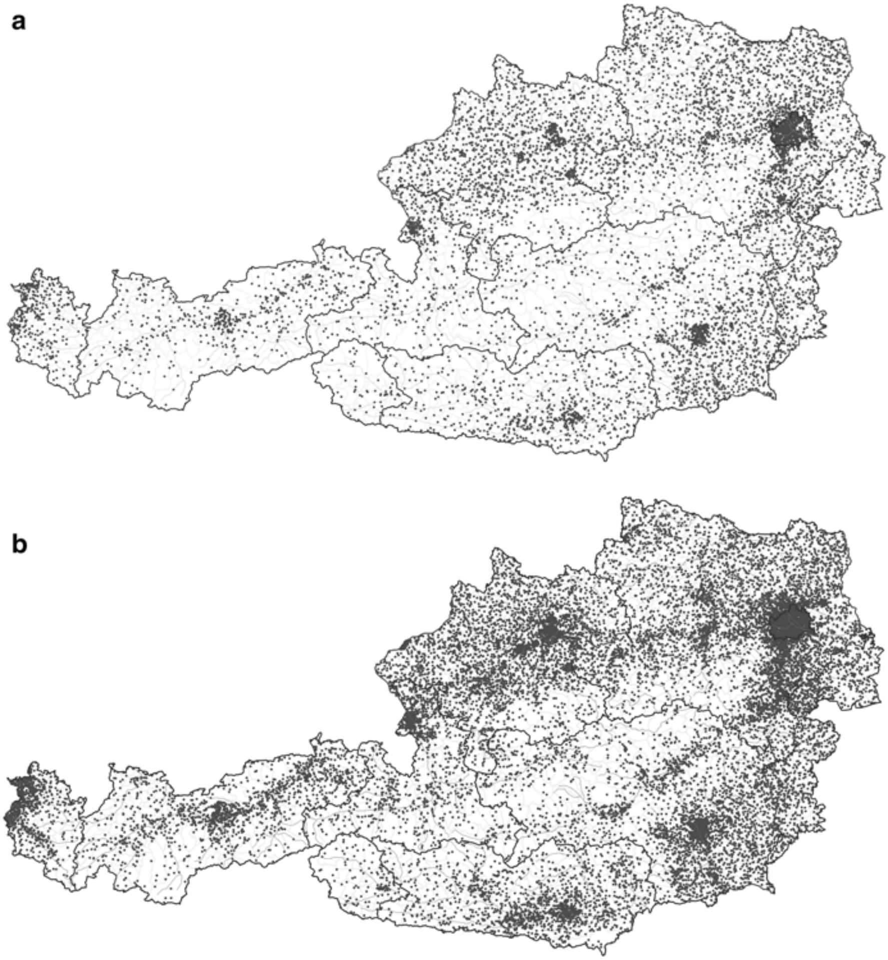

Fig. 3.6 Building census, Austria 1951–2001; every *point* represents 100 buildings (from WIFO 2008, based on Statistics Austria)

In terms of sustainability and risk management strategies, it is necessary to quantify not only the absolute monetary losses, but also the consequences of these losses for the community, which are strongly related to the stage of development of the community. An example is given next.

As a consequence of the ruined potato crop in Ireland in 1845–1848, more than 1 million persons starved and nearly 2 million persons were forced by their government to emigrate to America or Australia. These extreme effects on a community came along with comparatively marginal monetary losses (loss of potato crop). Nowadays, highly developed countries are able to overcome enormous monetary losses caused by natural disasters. For example, Hurricane Katrina caused damages of 138.000 million US $ in total, but nearly 50 % of this sum was covered by insurance (Munich Re Group 2008), so detrimental effects on the society have been comparatively low.

The GDP (gross domestic product) is a very common parameter of describing effects of losses caused by natural disasters for countries. Investigations of the WIFO (2008) have shown that the flood disasters in Austria in 2005 (monetary losses of about 500 million €) have not influenced the GDP importantly. Two facts are responsible for this—in the first moment—incomprehensible result: Soon after the disaster, positive (!) effects on the GDP activated by capital investments for rebuilding projects became operative. These positive effects have been more than balanced out by decreasing private consumption in the following years. The other important factor leading to the WIFO result is that the GDP contains current values (rebuilding investigations after a disaster are part of the GDP account) but not inventory values.

Summing up these recommendations, it is evident that defining measured values to describe the magnitude of natural disasters related to socioeconomic effects is problematic. Natural catastrophes have to be considered not as a whole but separated into relevant processes. Events have to be analyzed in terms of "climate change tasks" as well as in terms of different vulnerability factors and different approaches of rating their effects. Considering the supposed adverse effects of climate change, emphasis should be placed on documenting and analyzing the different triggering effects.

Scaling down these general conclusions to the regional scale of the communities of Gasen and Haslau, no comparable losses are documented, although in past centuries the area was populated more densely than nowadays. Despite the moderate development in this region, there is additional demand for infrastructure and settlements with increasing property values. Whatever the conclusion, it is not true to claim that there have not been similar precipitation events in the area before: they simply did not cause that much damage. Maybe because there were fewer roads (impact of road constructions to landslide susceptibility; compare Sect. 3.2.2), or people had a better understanding of natural contexts and inherent hazards and property values were much lower. Also, one cannot exclude the chance that historic documents describing such events were lost over the years.

The landslides that occurred in 2005 in the communities of Gasen and Haslau are well documented and allowed extensive analysis in terms of landslide–hazard assessment. Within the project AdaptAlp [Interreg IIIB Alpine Space Programme of the EU, co-funding: Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)], innovative data sources have been generated and tested in terms of cost and benefit. Methods to determine the disposition for shallow landslides have been compared and validated. An approach to determine the process area (Fig. 3.7) was developed. Last but not least the changes in environmental conditions (land use, change of precipitation) and their effects have been assessed. The overall aim was to provide recommendations for appropriate methods under certain conditions for certain aims (costs, value, scale, required results; Tilch et al. 2011).

3.5 Working with Scenarios: An Approach

As the further increase of frequency and magnitude of extreme precipitation events at a regional and local scale is still uncertain, scenario techniques will help to describe the frame of assumed developments. These scenarios should not cover only climate but also socioeconomic changes. Land use planning, agriculture and forestry should be considered as well as damage limitation and preventive measures. To be able to calculate the further impact of events on economy and society, it will be necessary to assess the vulnerability of communities.

As a first step, scenarios need to be developed separately for each process, showing the effects of changing frame conditions to triggering, transport and deposition processes. As a second step, interaction between the processes should be considered, as it can build up or mitigate adverse effects.

Scenario modeling is a common approach operating with insecure further developments. In the case of gravitational natural hazards there are some hurdles to clear. The crucial point is the fragmentary database covering current hazards and

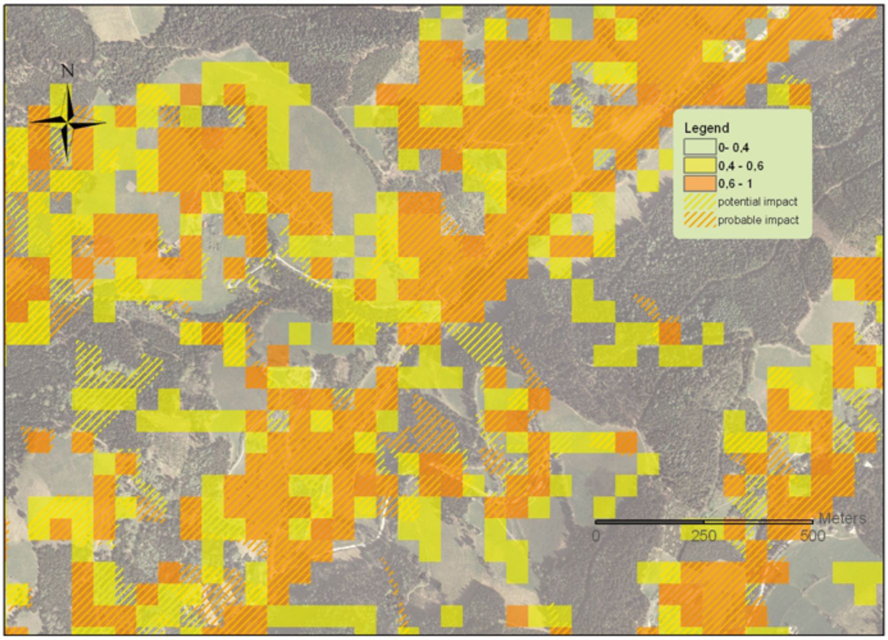

Fig. 3.7 Example of an area-wide assessment of the susceptibility for shallow landslides including the estimation of the process area (*striped*, clip: Gasen, Austria) (Compilation and presentation according to the suggestions of ÖROK 2015)

risks. Up to now hazard (index) maps in Austria are not homogeneous and are only partially available. Area information is often poor, which affects the method of compilation and of course the quality of results.

Although knowledge about triggering factors and processes is already available on a rather satisfying level, the issue of the frequency and magnitude of spontaneous, shallow landslides and debris flow has not been solved so far.

Classical frequency functions are based on series of measurements using statistical approaches, assuming that extreme events are independent from each other; this might be more or less true for precipitation and resulting floods but not for mass movements. Thus, other solutions must be found to estimate the frequency and magnitude of the events (Van den Eeckhaut et al. 2009), as this is a precondition for risk analysis and continuing prognostic evaluation and evidence of changes.

3.6 Conclusions

Climate change is a reality: the direct effects on gravitational natural hazards such as landslides and debris flow are questionable. The strategy to handle this situation is to be prepared for different scenarios of assumed further climatic development and its supposed impacts. This goal can be achieved on the one hand by designing scenarios including analysis and evaluations of their impacts and on the other hand by adapting monitoring systems and scientific monitoring.

It is evident that the impacts of changes are closely related to socioeconomic development. An effective spatial planning based on up-to-date, adequate, area-wide hazard (or even better, risk) maps promises a significant reduction of the damage potential. However, the quality of these maps depends primarily on the quality of the basic data, namely, process data (adequate, homogeneous documentation of events) and area information (adequate DEM-Digital Elevation Model, geological maps etc.). The choice of approaches to identify the susceptibility of slopes (heuristic, statistically based, process orientated) is predetermined by these frame conditions. For Austria, the ÖROK task force for gravitative natural hazards (ÖROK 2015) suggests a "top-down strategy." Analyses should start on a (supra)regional scale to identify potential "hot spots." Only these hot spots should be examined in more detail.

Considering the effects of climate change on hazards means that existing hazard maps will become outdated over time. This problem is not new, and is arising not only in terms of climate change but also with socioeconomic developments such as land use and construction measures. There is a strong need to increase resources to maintain these maps updated with or without impacts of climate change on natural hazards.

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Part II
Nature Resources and Land Use in Mountain Regions

Chapter 4
Mountains and Mountain Regions in Bulgaria

Yulia Kroumova

Abstract The mountains in Bulgaria occupy almost half of its area (47.54 %). The geographic situation of the country, the present-day differentiation and variety of the relief, and its combination with other natural components affect the economic management of the mountain regions. This research provides a comparative analysis of the changes in the territorial extension of the mountain regions according to the criteria approved in recent years [before and after Bulgaria's accession to the European Union (EU)]. According to the EU Regulations, the mountain regions are defined as unfavorable, with limited capacities for land use and with higher costs for performing agricultural activities. Among the groups of criteria, set in different normative documents and projects, special attention is paid to the criterion *above sea level altitude*. The mosaic nature of relief and the great number of landscape types in Bulgaria require that the complex impact of the physical geographic factors should be taken into consideration while determining the lower boundary of the mountain regions. In research work, however, to be in compliance with the aims of each investigation and to achieve unbiased scientific results, we have to observe either the boundaries already specified in the normative documents or the physical geographic borders.

Keywords Mountain • Mountain regions • Morphometry • Sustainable development

4.1 Introduction

The mountain regions as areas with natural limitations for economic activities have become the focus of research, aiming at efficient land use, sustainable economic development, and preservation of the ecosystems. The identification of their borders

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and of the whole set of relief features enables the development of efficient regional development strategies.

We recognize 38 mountains in Bulgaria. They occupy an area of 52,774.6 km^2 (Mihaylov 1989), 47.54 % of the country's area. Eight of the mountains are more than 2000 m high, 19 are from 1000 to 2000 m high, and only 2 are less than 1000 m. The highest mountain both in Bulgaria and on the Balkan Peninsula is Rila Mt. (Mussala peak, 2925 m); the lowest one is Strandzha (Gradishte peak, 710 m) (Fig. 4.1). The wide variety of relief forms has an impact on the economic development of the mountain areas.

These areas are among the least developed in the country, but nevertheless they possess a huge biological and natural potential, capable of sustaining long-term growth. Bulgaria combines three biogeographic regions: the mid-European forests, the Eurasian plains, and the Mediterranean, which overlap and favor climatological and biological diversity. For example, the Bulgarian flora includes 3,550 species, of which 2,137 are found at altitudes between 500 and 1000 m; 389 plants of the latter and 437 animal species are protected, and the preservation area was increased by 2.5 % after 1991 and reached 4.5 % of the area of the country in 2001 (Nikolova 2001).

The governmental policy of mountain region management has always tried to take into consideration these natural geographic peculiarities, but at the same time it is based upon their demographic and economic geographic potential. Different indicators and criteria have been accepted to determine the mountain regions in which a specific policy is needed to guarantee their sustainable development. The mountain regions, delineated on the basis of these criteria, do not always coincide with their physical geographic boundaries. Therefore, different statistical figures are published about the area of the mountain regions in Bulgaria, about their share of the country's area as well as about the number of mountain municipalities.

This research provides a comparative analysis of the changes in the territorial extension of mountain regions according to the criteria approved in recent years (before and after Bulgaria's accession to the EU). We stress that to achieve unbiased scientific results, we have to consider either the new boundaries or the physical geographic ones, depending on the research goals.

4.2 Arguments

The policy of mountain region development in Bulgaria after 2007 is carried out in accordance with the relevant policy of the EU.

Chapter Five of Regulations 1257/99 of the EU focuses attention on the unfavorable regions and the regions with ecological restrictions, divided into three groups, which every country has the right to define. The mountain territories represent one of these groups. Article 18 specifies the factors according to which these territories are not favored from the aspect of restrictions in land use and growth of production costs:

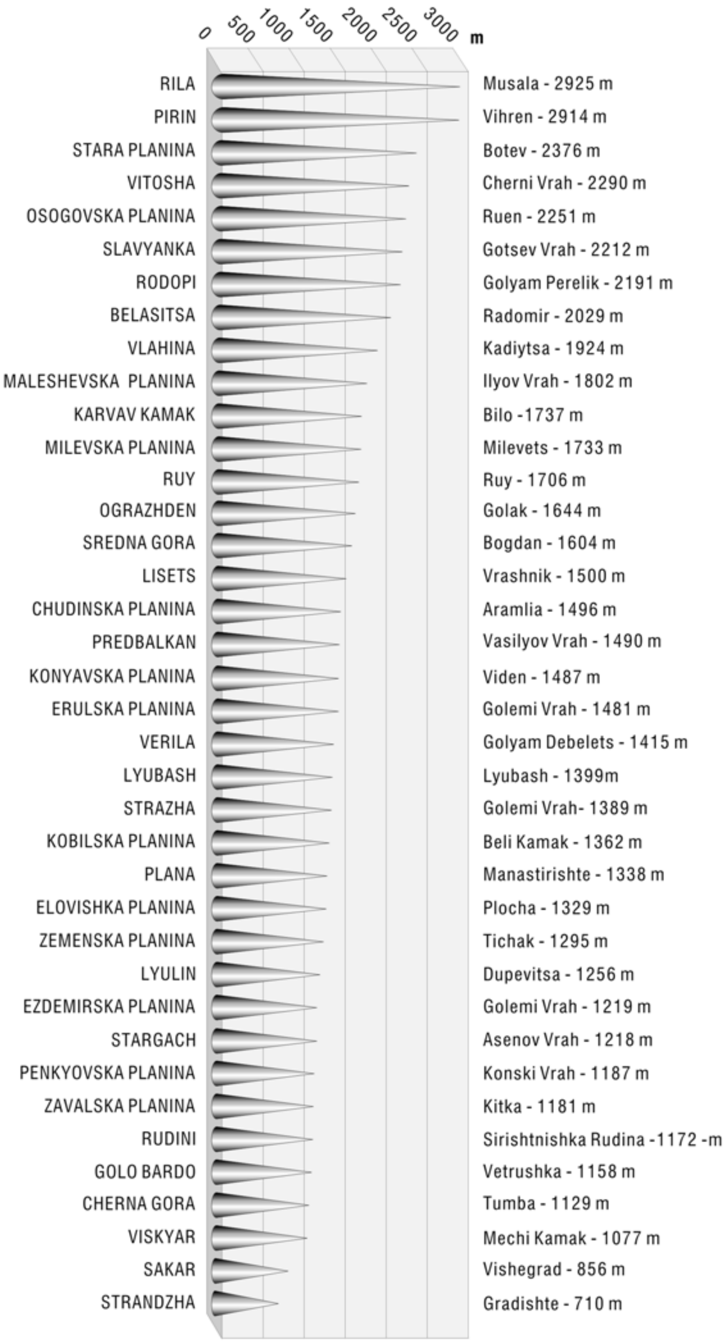

Fig. 4.1 The highest peaks of Bulgarian mountains

- *Altitude*: as a factor for unfavorable climatic conditions, leading to shortening the vegetation period of agricultural crops;
- *Steep terrain* (regardless of the lower altitude): hampering the use of agricultural machinery and requiring greater expense for specialized equipment;
- A combination of the aforementioned two factors, which individually do not provoke any difficulties;
- Regions to the north of the 62nd parallel.

The European legislation has issued guidelines for the selection of criteria that are to help in defining the mountain regions. The aim is to achieve a better synchronization of the joint research, carried out by different European countries, which concerns these categories of unfavorable regions. They underlie the Bulgarian normative documents and projects.

- Regulation 14 from 1 April 2003, on determination of the settlements within the rural and mountain regions, issued by the Ministry of Agriculture and Forests and the Ministry of Regional Development and Public Works;
- A scientific project of regulation on defining the unfavorable regions in Bulgaria (joint research, conducted by the Institute of Agricultural Economics, the Ministry of Agriculture and Forests, the Bulgarian Academy of Sciences, etc., 2006);
- Decree 30 from 15 February 2008, on adoption of a regulation concerning the identification of the criteria about unfavorable regions and their boundaries.

4.3 Criteria

Although the criteria in these normative documents for defining the mountain regions are scientifically substantiated, they are too diverse, which implies that mechanisms have been suggested for selection of certain areas rather than scientifically grounded criteria for their determination.

Thus, for example, the criteria for identification of mountain regions in compliance with Regulation 14 from 14 April 2003, on determination of the settlements in rural and mountain regions, are as follows:

- Altitude above 600 m;
- Altitude below 600 m with vertical dissection of relief greater than 200 m/km^2, drainage density greater than 2 km/km^2, and slope of the terrain more than 12°;
- The municipalities are defined as mountainous if more than half of the area adjacent to the settlements belong to mountain regions.

According to a scientific project on the Regulation specifying the identification of the unfavorable regions in Bulgaria, the criteria for defining the mountain regions in the country are as follows (Yanakieva and Velev 2006):

- Average weighted altitude of the municipality territory not less than 600 m;
- Average weighted slope of the terrain 10° (17.6 %), and average altitude for the territory of the municipality not less than 600 m;
- Average altitude for the territory of the municipality within the range of 500 m to 600 m, combined with an average slope of the terrain of 7° (12.3 %);
- In the attempt to homogenize the region, municipalities may be included in which at least one of the first two criteria shows significant height differences.

In the process of determination of the unfavorable regions (2005), the lowest level of administrative division of the country is the municipality. The major arguments in the selection of the groups of criteria for mountain region definition are these:

- Achievement of maximum range for the country;
- Compatibility of the criteria with the respective ones of the EU countries;
- Dependence of criteria selection on the databases available for the country.

On the basis of this group of criteria, the mountain regions occupy 49 % of the country's territory and 43 % of the agricultural fund. They embrace about 95 % of the forest fund and cover the territory of 130 municipalities, of which 88 are at an altitude exceeding 600 m, 25 with a slope exceeding 10°; 1 meets the requirements of a combined criterion, and 16 correspond to the principle of homogenization of the mountain regions.

All these documents take into account the natural characteristics of the country and accept the altitude of 600 m as the lower boundary of the mountain regions. Nevertheless, according to Regulation No. 30 of the Council of Ministers from February 15, 2008, the mountain territories, defined as unfavorable territories, include the lands of settlements that meet at least one of the following criteria:

- Average altitude of minimum 700 m;
- Average slope of the terrain of minimum 20 %;
- Average altitude of minimum 500 m in combination with an average terrain slope of minimum 15 %.

4.4 Results

By comparing the two divisions, the one from 2003 (2172 settlement areas incorporated in 138 municipalities) and that from 2008 (1714 settlement areas belonging to 144 municipalities), it became possible to draw an analytical map of the mountain municipalities (Fig. 4.2). The comparison clearly shows the newly established municipalities (13) in the 2008 division and those (7) that dropped out of the 2003 division. They all are presented with a limited number of adjacent mountain land plots (1 or 2).

Fig. 4.2 Municipalities in the mountain regions in Bulgaria

4.5 Conclusion

According to the criteria accepted in 2008, the mountain regions in Bulgaria include 41 % of the settlement network and 25 % of the population. Of the 264 municipalities in Bulgaria, 144 incorporate the adjacent areas of settlements that belong to mountain regions.

The question about the lower boundary of the mountain regions in Bulgaria is still debatable. From the physical geographic aspect, the mosaic relief, dominated by mountain and basin landscapes that reach to the southern state border, and the restricted Mediterranean influence only in the lowest parts, are the main reasons to define the altitude of 600 m as a boundary above which there are relatively poor potentials for utilization of the territory.

As a member of the EU, Bulgaria needs a unified national policy that will regulate the development of mountain regions and which will be tailored to local resources, potentials, and limitations. The investments will facilitate the solution of some serious infrastructural, communication, and organizational problems, in conformity with the principles of sustainable development and environmental protection. Such a balanced approach to mountain region management will ensure the long-term prosperity of these areas and therefore needs a solid legislative basis.

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Chapter 5
The Nature Potential of Mountains in Bulgaria and Its Sustainable Use

Marina Yordanova and Zoya Mateeva

Abstract Mountain territories, with their inherent various and rich nature conditions and resources, have always been the object not only of scientific but especially of economic interest. They are an object of attention also from the legal-normative point of view, as in both national and international aspects, especially regarding the possibilities for their sustainable development. The rate of their nature potential is determined as a quantitative expression of the combination of conditions and resources that are favorable for the all-around activity of society. Their importance for Bulgaria results not only from the large ratio of the area which they occupy of its whole territory—more than 40 % or even 50 %, according to their boundaries as outlined in the investigations of different authors—but also from their large nature potential. The mountains dominate the country's ratio of mineral resources (fuel, metal, and non-metalliferous) at more than 80 %; of water resources, at more than 80 %, as well as 70 % from the storage water capacity in a total of 700 large, middle-sized, and small dams, and more than 70 % of the mineral water fields; the forest resources, more than 70 %, as well as two thirds of the plants in Bulgaria; and also considerable resources of game, wild fruits, herbs, mushrooms, etc. The mountain space of Bulgaria also contains a large ratio of the demographic settlement and economic land structures; for example, about 30 % from the population and more than 55 % from the settlements, as the number of municipalities in the mountain regions is more than 140 (from a total of 260 in Bulgaria); about 65 % from the areas for cultivation of tobacco and potatoes; more than 85 % of the meadow areas; and more than 70 % of pasture grounds in the country, etc.

Keywords Bulgarian mountains • Nature resources • Relief • Climate • Waters • Soils • Vegetation • Animals • Landscapes • Assessment • Sustainable usage

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The evaluation of the nature potential of the mountains is related to the quantitative and qualitative characteristics of the basic nature components (relief and texture, climate, waters, soils, flora and fauna), and this evaluation is concerned with two points of view: as resources and as conditions. In this respect the climatic characteristics are usually identification for overall conditions, but their assessment as a resource, especially as a renewable one, becomes more and more definite. The total integral nature potential is detailed by so-called partial potentials of which each specifically is dependent on the specific corresponding economic activity for the purpose for which they are intended; for instance, industry, minerals, water, forest, energy potential, building potential, recreation, etc. Special importance is given to the assessment of such aspects of the partial potentials that are related to the state and tendencies to change of the nature components under conditions of anthropogenic pressure, such as clearing, regeneration, changeability, stability, etc. At the same time the attention is paid to the possibility for revealing degradation processes provoked by anthropogenic activity, by so-called physiognomic landscape components, grounded on the specific mountain landscape spectrums typical for large morphographic units. On the basis of these analyses, the concept of optimizing interactions in the system "Nature—Society—Economy," is discussed, with emphasis on priority economic activities allowing the protection of nature, in mountain territories, according to the principles of sustainable development.

5.1 Former Studies on the Natural Potential of the Mountains in Bulgaria

The nature potential of the mountains in Bulgaria has been the aim and object of a specialized complex interdisciplinary investigation in the 1980s by different institutes from the group of natural sciences in the system of the Bulgarian Academy of Sciences (BAS) under the leadership of the Institute of Geography. It was realized within the framework of the national plan for fundamental research in Bulgaria in the scientific sphere "Scientific bases of preserving and reproducing the environment," including in all 14 scientific problems (on a government level). The results of this investigation were summarized in the first of two volumes of the monograph *The Nature and Economic Potential of the Mountains in Bulgaria*: volume I, *Nature and Resources*.

The specialized study aimed at determining the boundaries of the mountain regions in connection with the preparation of a law for these regions was made in the mid-1990s, also in the Institute of Geography of BAS. The results were presented in several scientific publications, one of them being the fundamental principles, methodological, information, empirical importance: "The Mountain Regions in the Legislation Policy of Bulgaria" (Geshev et al. 1995). The morphometric characteristics of the relief were used as defining criteria: altitude above 600 m, and for the low mountains (Fore-Balkan, East Stara Planina, Strandzha, Sakar, Sarnena

Gora, and East Rhodopes, above 250–300 m); depth of dismemberment, above 200 m/km^2; slope inclination, above 120, etc. On the basis of this empirical work, together with NCTDRP (former National Center on Territorial Development and Residential Policy of the Ministry of Regional Development and Public Works), a methodological approach was substantiated for classification of the mountain settlements in Bulgaria (Methodological … 1996), according to which about 2200 settlements in the country correspond to the adopted criteria for mountain settlements (Kopralev: In: Geography of Bulgaria 2002).

The mountain territories are also the object of consideration from the legal normative aspect by a number of national and international documents: Law for Mountain Regions in the Republic of Bulgaria, developed and discussed at first reading in the National Assembly in the middle of the 1990s, but still not approved; European Chart for the Mountain Regions, developed also in the 1990s; Guiding Principles for Sustainable Spatial Development of the European Continent (including also mountain regions), accepted at the 12th session of CEMAT, Hanover, September 7–8, 2000, etc. According to these principles, the mountain regions, with their ecological, economic, and sociocultural functions, are accepted as having exceptional national and European potential, and it is respectively considered that they should be an especially important part of the integrated European territorial arrangement (spatial planning) policy. Taking into account that the state mainland borders of Bulgaria are almost entirely in mountain territories (with the exception of the northeastern one with Romania), the formulated principles for the boundary regions are also valid for them, including for transboundary, transnational, and interregional cooperation. These concern also the region of the Black Sea and the Caucasus countries, having in mind the so-called Pan-European transport corridors and zones, crossing and respectively including parts of our mountain borders.

The themes concerning the boundary mountain space occupy a more special place in the geographic investigations on the territory of Bulgaria. Such particular scientific, as well as complex, studies, were carried out as early as in the end of the nineteenth century, initially by west European scientists and some scientists from the Balkan countries (Ami Boué, Auguste Viquesnel, Jovan Zvijić), and later also by a number of Bulgarian scientists and geographers (Anastas Ishirkov, Yordan Zahariev, Ivan Batakliev, Dimitar Yaranov, Ilia Ivanov, Zhivko Galabov, and others). They are dominated first of all by the geomorphological and landscape character, in the spirit of the German school at that time, or were with ethnographic direction. In more recent times complex geographic research was carried out both within the framework of general studies of the country, for example "The Natural and Economic Potential of the Mountains in Bulgaria," and in regional studies: "Sakar–Strandzha," "Rhodopes," "Blagoevgrad District," etc. Specialized complex geographic investigations of the mountain territories along the southern and western borders of Bulgaria were realized in the 1990s within the scope of two scientific projects, financially supported by the National Science Fund of the Ministry of Education and Science (NSF-MES): H3-38/91 and H3-502/95. They were directed precisely toward revealing and evaluating not only the particular and general natural resource potential, but also the demographic, social-economic, and recreation-tourist potential. The aim is to intensify the wholesome development of these regions, which are boundaries and at the same time peripheral for the country, in the context of the "opening" of the national space, both within the framework of Balkan neighborhoods and in the Pan-European and global scale. A number of scientific publications in the different physical- and economic geographic aspects were issued on the results of these investigations. A substantial contribution in this respect was made by the publications concerning the transboundary communication systems with neighboring countries (Nikolov and Yordanova 1996) and the broader range of the Black Sea region with an emphasis on transport corridor VIII (Terziiska and Tarakanov 2000).

The nature potential of various resources (mineral/raw material, forest, water, etc.) in every territory, and especially those with mountain character, is a regular consequence of the conditions for its formation in connection, first of all, with the location in spatial or territorial structures with a broader range. This potential bears the specific features of common morphotectonic evolution of the foundation and common planetary-determined zonal belt peculiarities of the dynamic components. The individual specificity of this general background is related to the local manifestation of regularities of the so-called exchange of substances, energy, and information between the basic natural components during their continuous interaction and mutual penetration (e.g., water–air, in rocks, soils, biota, etc.). In this context, the mountain territories in Bulgaria, having in mind the position of the country in the South European mountain space, represent a part of the two mountain first-order macrostructures, entering the territory: large parts of the strongly faulted Macedonian-Thracian massif and the whole fold-chain Balkanide system of the Alpine orogen. In the hydroclimatic aspect, it is situated in the transition zone between the moderate and the subtropical belt, from the typically expressed moderate continental features in the Stara Planina Mt. portion through the transition continental features in the East Stara Planina, Kraishte-Sredna Gora, and Rila-West Rhodopes part to the typically expressed continental Mediterranean features in the Pirin-Slavyanka part, the East Rhodopes, Sakar, and Strandzha. This placement determines also the expressed transition features of the soil–vegetation characteristics, between the typical Middle European and the typical South European features. With increase in altitude, the hydroclimatic differences are gradually moderated, but soil–vegetation differences are increased and corresponding height zones are formed. In its turn, this is important for the creation of the typical altitude spectra of landscape belts for mountains differing in height, with their intrinsic characteristics of the natural resource potential and specific conditions of its reclamation.

When considering the evaluation of nature potential, renewable resources are usually implied, which are related first of all to the dynamic natural components (climate, water, biota, and soil, in part). However, evaluation is also made of the relief as a natural foundation of the geographic space (Mishev and Vaptsarov 1996). Such an approach has been adopted in the monograph *The Natural and Economic Potential of the Mountains in Bulgaria*, volume I, *Nature and Resources*.

5.2 Assessment of Nature Potential by Components for Various Economic Purposes

5.2.1 Assessment of Relief

The relief, representing the basic material surface (foundation) of the territory, is assumed as the basic natural component. It forms on the one hand its morphographic outlook by means of the Earth's surface forms, built of heterogeneous rock substrate (mountains, plains, plateaus, valleys, etc.). On the other hand it determines the features of the whole natural complex by the specificities of interaction between the rest of the components, more strongly or weakly dynamic natural, as well as anthropogenic. They depend on its morphometric characteristics (altitude, vertical and horizontal dismemberment, exposition, slopes) (Alexiev et al. 2005). It follows from here that its leading role as a natural component and as a natural factor is expressed mainly with respect to the conditions of the environment for existence and the economic activity of man and not so much in the aspect of a resource. Evaluated from this point of view, the mountains occupy a very important part of the territory, mainly with the "height change of the climatic conditions, the landscape diversity and the lower anthropogenic impact on nature, compared to that in the plains" (Danilova 1980).

The territories with differing heights in mountain relief in Bulgaria have almost zonal spread in the medium and southern parts of the country. In the hypsometric respect, six altitude belts are distinguished (Fig. 5.1, Table 5.1).

The extent in the middle of the country (and along the parallel) of the Stara Planina Mountain chain acts as a barrier for the inrushing of cold continental air masses from the north in winter and is accepted as a climatic boundary between the moderate continental climate to the north and the transitional continental climate to the south, and the high mountains of the Osogovo-Rhodopes massif represent a barrier for the warm air masses of marine origin inrushing from the south, their influence being more noticeable only along the meridional valleys of the Struma, Mesta, and Maritsa Rivers, as well as in the adjacent mountain slopes, especially in the Pirin, Slavyanka, East Rhodopes, Sakar, and Strandzha mountains.

Evaluation of the direct contribution of the relief to the natural environment formation is related first of all to the favorable or restricting conditions mainly for construction and agriculture from the aspect of terrain stability in the tectonic-seismic and lithological-petrographic respect and the sustainability or susceptibility of the soil cover to destruction–erosion processes in cases of larger dismemberment and slopes. The results from relief assessment in these two aspects with the use of rating estimates categorize the mountain territories as follows (Mihailov and Vaptsarov 1975):

- With unfavorable conditions for construction and agriculture: the main Stara Planina Mt. chain in the middle and western part and the Osogovo-Rhodopes

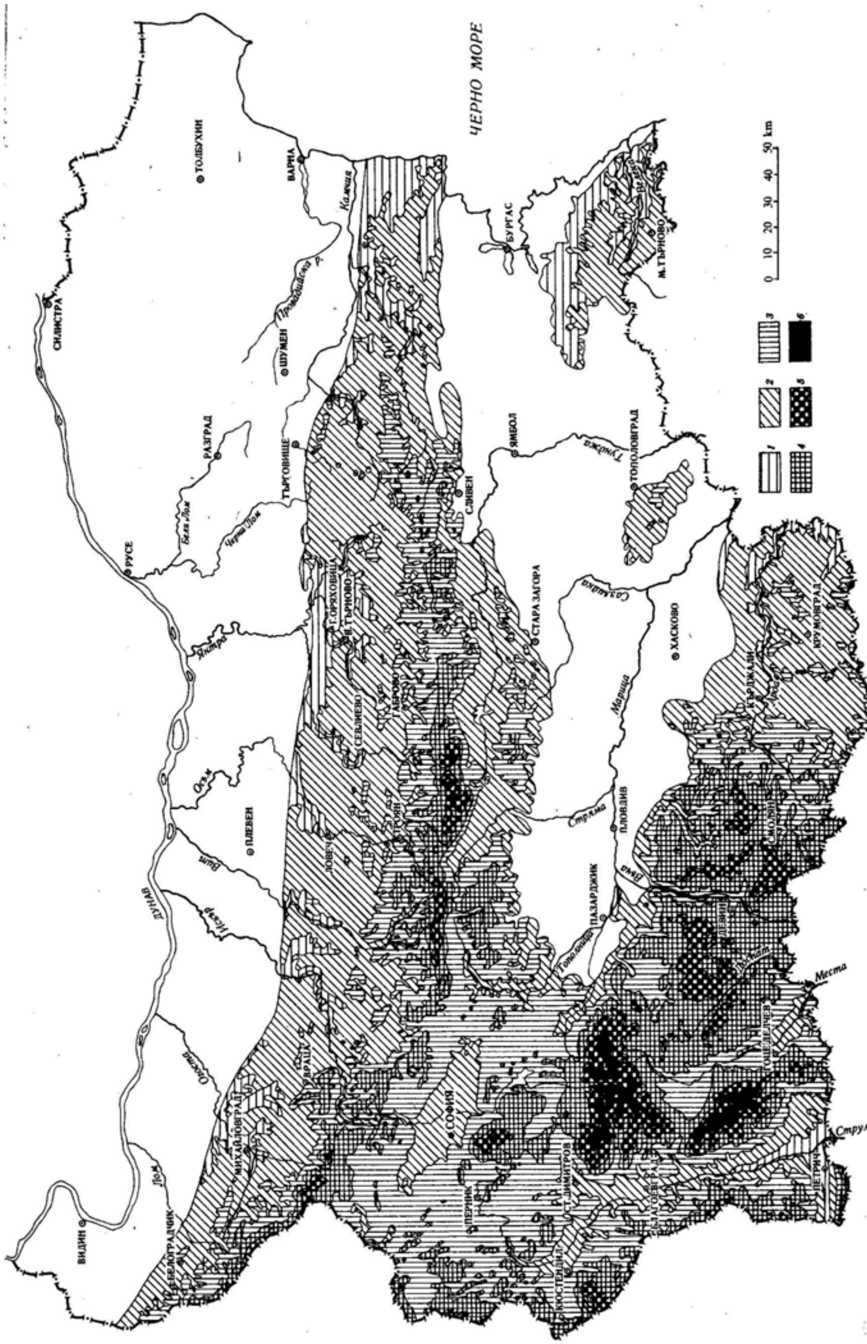

Fig. 5.1 Altitude belts (by Mihailov, in: The Nature and… 1989). *1* lowlands (<200 m), *2* hilly lands (200–600 m), *3* low mountains (600–1000 m), *4* mid-mountains (1000–1600 m), *5* high mountains (1600–2200), *6* alpine (>2200 m)

Table 5.1 Area (%) of altitude belts[a]

Altitude belts (m)	Mountain region			Total for all mountain regions
	Rila-and-Rodopy	Kraishte-Sredna Gora	Stara Planina	
Lowlands (0–200)	1.3	4.8	8.5	5.3
Hills (200–600)	27.7	39.4	57.0	43.3
Hilly lands (600–1000)	23.2	39.1	23.4	26.5
Mid-mountain (1000–1600)	35.1	15.9	9.7	19.8
High-mountain (1600–2200)	9.4	0.7	1.3	4.0
Alpine (>2200)	3.3	0.1	0.1	1.1
Total	100	100	100	100

Source: Mihailov, in The Nature and… (1989)

[a]Percentages express the ratio to the total area of the mountain regions

massif without the Middle Struma valley, the Gorna Arda basin, and the Haskovo hilly district;

- With medium favorable conditions: the Fore Balkan, Kraishte-Sredna Gora, Sakar-Strandzha, and the Middle Struma valley and the Gorna Arda basin;
- With favorable conditions: Haskovo hilly area.

The coincidence in the gradation of the single mountain units and whole areas with respect to their suitability for construction and agriculture is the result of the specificities of their broadly developed height zone belts, with their inherent morphometric characteristics and especially the altitude, dismemberment, and slopes. They are equally determinative both as prerequisites and constraints for these types of economic activities.

The assessments of the direct role of relief in the resource aspect are more specific, mainly from the aspects of recreation and tourism and partially from medical and geographic aspects.

The recreation-tourism aspect of the relief ensues from the necessity of available geomorphological objects with suitable properties for generating certain tourist demand and realization of respective tourist products for the different forms of tourism (Alexiev et al. 2005). Usually these are objects of high attractiveness, related to the specificity of the respective morphosculptural generic type of relief: for example, karst —caves, dolines, backsets, canyons, abysses, ledges, crowns, travertine terraces, sinter pans, etc. (represented mainly in the Fore Balkan and the Rhodopes); erosion—gorges, doughs, canyons, meanders, waterfalls, erosion cauldrons, etc. (represented mainly in Stara Planina, Kraishte, the Rhodopes); glacial—cirques, carlings, trough valleys, moraines, stone fields, and others (Rila and Pirin). The so-called rock phenomena occupy a special place as products from specific morphogenetic processes. They depend on the stability of the bedrock and its selective destruction, provisionally typified in the following three groups:

- Erosion-deflation: earth pyramids, rock mushrooms, etc. (e.g., Katina, Stob, Melnik, Zimzelen);

- Karst-erosion: rock arcs, bridges, windows, pits, etc. [e.g., Chudnite Mostove (the Wonder Bridges) in the Rhodopes, Chudnite Skali (Wonder Rocks) in Stara Planina];
- Lithological-destructive: prismatic basalt pillars (near the Studen Kladenets dam at the Arda River), vertical riolite walls and needles (in the region of Smolyan), spherical moraine-like blocks of massive rocks (in Vitosha), figures with outlines of rock castles, obelisks, people, animals (Belogradchik rocks), etc.

The deposits of interesting natural specimens of the so-called Geological Heritage (rocks, minerals, crystals, fossils, etc.) may be also connected to a significant extent with the rock phenomena. Relief forms such as ridges and peaks with panoramic views, slope steps, river terraces, and structural platforms may also possess a certain tourist attractiveness. It has to be mentioned that for the specialized types of tourism, for example, for many types of sport tourism related to the relief characteristics (climbing, descents, ski paths, cycling routes, rafting, etc.), the evaluation parameters are to a great extent measurable by concrete parameters, whereas for the mass forms of tourism, the attractiveness parameters are to a great extent subjective and are defined by the criteria for diversity, picturesqueness, uniqueness, exoticness, etc.

The tourist attractiveness of the different sites related to the relief is enhanced also by the presence of other, so-called physiognomic natural components such as vegetation, water, and animals: for example, steep bare rocks, inhabited by eagles or with edelweiss habitats, or deeply incised river valleys with thick forests or waterfalls. In the Bulgarian mountains there are many concentrations of sites significant for recreation and tourism resources of a geomorphological nature, which makes them attractive destinations not only on a national but especially recently on an international scale also. The rich resource potential of Rila, Pirin, the West Rhodopes is used for the creation of sport bases (Belmeken, Malyovitsa, and others), as well as of whole mountain complexes (Bansko, Borovets, Pamporovo). Naturally, parallel to the advantages of the relief, the entire landscape diversity, and especially the favorable climatic conditions for the formation of a thick and durable snow cover, have to be taken into account for winter sports specialization.

The medical geographic aspect of the resource assessment of relief is connected first of all with its individual properties (altitude, exposition, dismemberment, slopes), or by the effect of the properties of the other natural components indirectly influenced by it on the psychoemotional state of man, especially as moving along routes and encountering new and interesting sites.

At a greater height in the mountains, the human organism is also favorably affected by clean air because of the general lower bacterial pollution as well as higher ionization levels, especially noticeable around swift-flowing rivers and waterfalls (Danilova 1980).

The rugged terrain exerts definite health recovery and strengthening impacts during movement along routes on the so-called "health-paths," naturally taking under consideration certain norms for personal physiological loading.

In summary, as already pointed out, the assessment of mountain relief is expressed in two ways: on the one hand, with its role as a decisive factor for the hydroclimatic and soil–vegetation conditions on the territory and via them, for a number of economic activities, and on the other hand, with its role as a significant source of directly influencing human recreation-tourism resources, including also such with curative effects.

5.2.2 Climate Assessment

The thermal conditions of the mountains of Bulgarian territory with different situation and height vary within a broad range but in general according to altitude belts the differences are of the order of 10–20 °C, for each belt, both for the minimum average monthly temperatures in January and for the maximum average monthly temperatures in July. The average temperatures naturally decrease with height, in winter from 0–20 °C in the lowest belts to −80 to −100 °C in the highest, and in summer, respectively from more than 220 to less than 100, the annual temperature amplitude being almost unchanged (on the average 190–210 °C) (Table 5.2). There are greater differences in the extreme maximum temperatures, which are more than 30 ° to less than 10 °C in winter, and from more than 40 to about 15 °C in summer from the low toward the high parts, while the extreme minimum temperatures have approximately equal values everywhere, from −15 ° to −30 °C in winter and from −5 to +5 °C in summer, and in the transitional seasons they are −5 ° to −20 °C in autumn and −20 ° to −25 °C in spring, which outlines the spring season in the mountains as colder than the autumn one.

The duration of the period with a sustainable temperature of the air exceeding 100 °C represents a very indicative thermal characteristic for the conditions of vegetation of the natural and cultural plants (Fig. 5.2).

A basic climatic characteristic is also moisture in the most general sense, and especially precipitation, being the most important factor for life and human economic activities; it provides the basic contribution to the river basins in the formation of the vitally necessary water resources. It is also a source for ensuring soil moisture, especially necessary for agricultural crops during the vegetative period. The circumstance that all larger rivers form their runoff almost entirely in the mountain territories and to a great extent have only transit flow through the plains emphasizes the extremely important role of the higher amount of precipitation in their spring areas, where the annual precipitation sums exceed 1000 mm, then gradually decreasing to 500–550 mm toward the neighboring plain lands (Fig. 5.3).

Of course, all the other characteristics of climate (atmospheric pressure, air humidity, cloudiness, mists, icing, etc.) are rather important, especially from the point of view of habitation environment, transport, and production, but in the context of the present evaluation analysis they are not considered here.

Climate in the mountains is of great importance, both as a resource and as a condition for versatile human activity and as a factor for this activity, respectively, for improving the parameters of its sustainable development.

As a resource the climate finds application in power generation, climate-medical treatment, recreation, and tourism. In principle, all climatic resources are inexhaustible

Table 5.2 Mean and extreme air temperatures (t°C) by altitude belts[a]

Altitude belts (m)	Mean monthly t		Mean annual t	Temp. amplitude	Extreme temperatures							
					Maximal				Minimal			
	I/II	VII/VIII			Winter	Summer	Autumn	Spring	Winter	Summer	Autumn	Spring
0–200	1–2	>22	>12	19–21	30	>40	>30	>30	−15 to −30	−5 to +5	−5 to -20	−20 to −25
200–600	0–1	20–21	10–11		25	40	30	30				
600–1000	0 to −2	18–19	7–9		20	35	30	30				
1000–1600	−3 to −4	16–17	4–6		15	30	25	20				
1600–2200	−5 to −7	14–15	1–3		10	20	15	10				
>2200	< −7	<14	<0		<10	15	<15	<10				

[a]*Source*: Moraliiski and Gocheva, in: The Nature and …. 1989 (with additions)

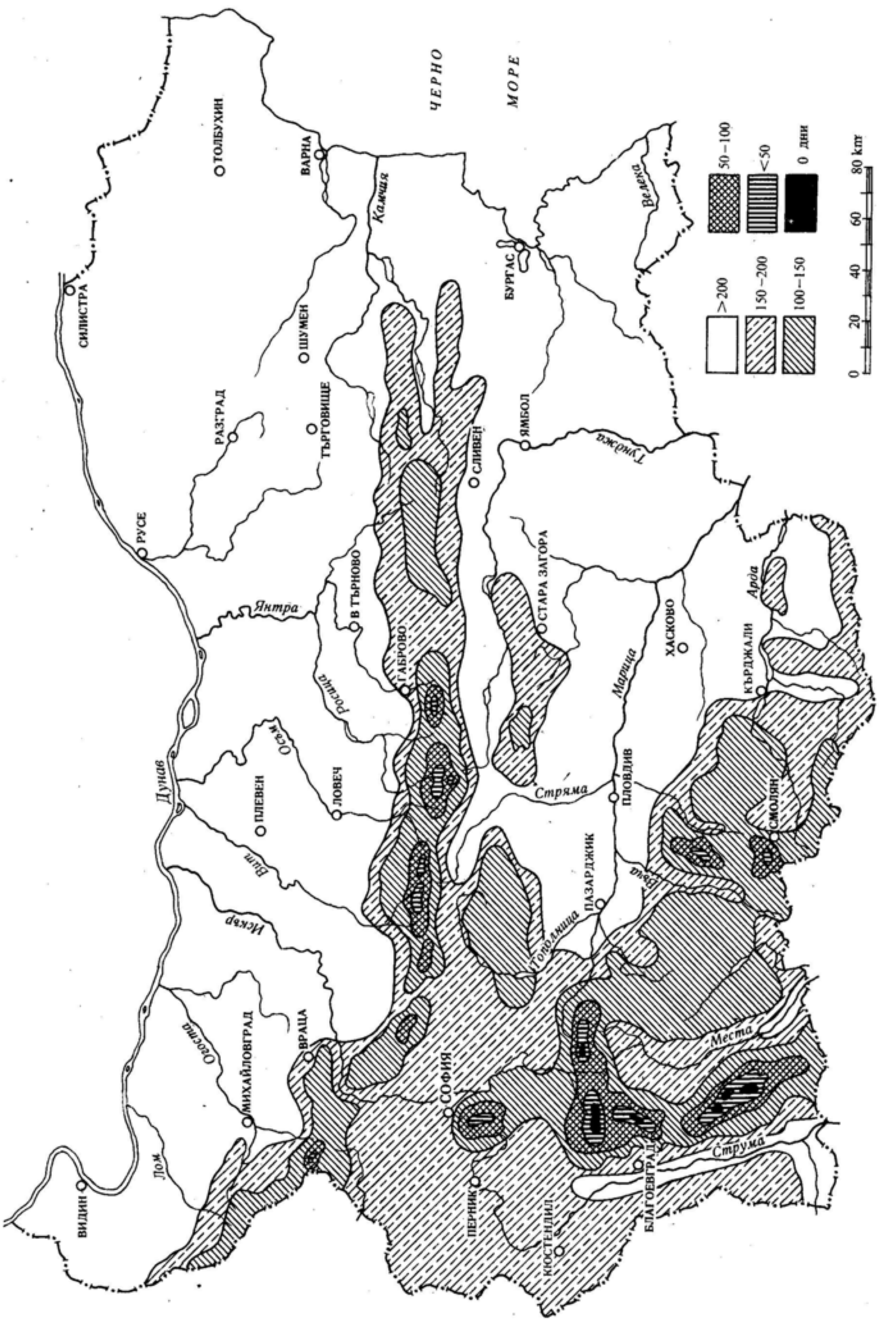

Fig. 5.2 Mean duration (days) of the period with sustainable temperature above 10°°C (From The Nature and… 1989): *>200* most favorable, *150–200* favorable, *100–150* medium favorable, *50–100* unfavorable, *<50* extremely unfavorable, *0* lack of vegetable period

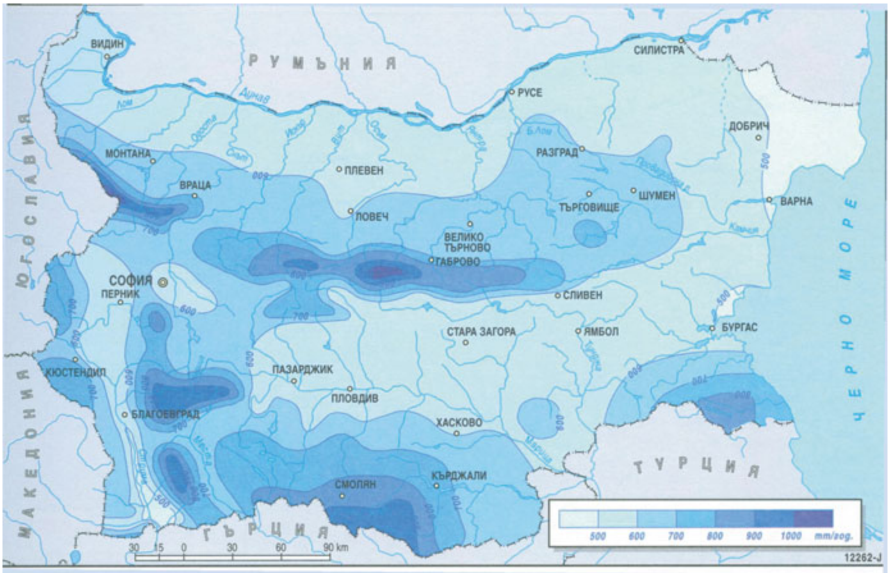

Fig. 5.3 Annual sum of precipitation (mm) for the period 1961–1990 (From Sharov, In: Geography of…. 2002)

and the more active is their utilization, or the higher is their share compared to the utilization of other, exhaustible natural resources, the more significant is the contribution of the respective human activity to sustainable social development.

In the sphere of power generation two climatic elements are used as resources: the sun and the wind. They are among the basic renewable energy sources, and it is expected that their relative share with respect to the utilization of conventional energy sources will be heavily enhanced not only in dimension but also in intensity. The mountain regions are one of the places with the most significant potential for these two climatic resources.

With respect to wind, the Bulgarian mountains are characterized by average annual values of about 800–1000 W/m^2. These values are on average about 300 W/m^2 for the low mountain regions and about 2000 W/m^2 in the high parts of the mountains. In this connection wind speed is the most important characteristic, which regularly increases with height, more intensively above 100 m, but with a different vertical gradient for separate mountains, higher for Stara Mt. and Vitosha in comparison to the Rila-Rhodopy massif. The bare and flattened mountain ridges, where single wind power generators or large-scale wind power parks may be situated, are most suitable for the purpose. However, this depends also on other important factors such as transport and electric power transfer accessibility, ecological admissibility, and land ownership.

With respect to the sun, the mountain regions are characterized by higher clarity and transparency of the atmosphere, and the mountain ridges by higher orographic bleakness, which is favorable for increasing solar intensity and the respective heliopower potential. However, at the same time the mountain regions exhibit more significant values of cloudiness, number of dark days, precipitation, and mist, which decrease the respective energy potential of these regions. On average the Bulgarian mountains are characterized by values of about 1800–2200 sunny hours per year, which is relatively favorable for the construction of solar parks. The capacity and effectiveness of these parks depend also on a number of other local factors, the orographic bleakness and southern exposure being especially important.

In the sphere of recreation and tourism the climate may be used as a resource for heliotherapy, aerotherapy, cryotherapy, and winter sports. The first three of these activities belong more closely to climate therapy and climate prophylaxis, which in our opinion are not sharply differentiated from the recreation-tourism activity, but rather represent its specific parts.

Heliotherapy is based on the physiological role of solar radiation on human organism, which is one of the most important, vitally necessary elements of climate for man. Its significance is expressed in two basic aspects: as a heat source, in the system of the thermal exchange between the human body and the environment, and as a source of ultraviolet radiation.

Ultraviolet radiation (UV), within the range of definite doses, exerts favorable effects on the cardiovascular and nervous system of the organism, the metabolism, and endocrine gland functions. The UV radiation annihilates harmful microbes and normalizes fat exchange, increasing the resistance of the organism against different diseases. The deficiency of UV leads to pathological states, known as “light hunger of the organism,” but the excess of UV exerts a blastomogenic impact. During 320 days of the year the territory of the country has the potential possibility of obtaining the necessary UV doses. However, under real conditions this possibility is reduced depending on the momentary thickness of the ozone layer in the high parts of the atmosphere, the transparency of the latter, the weather conditions, and in particular on the character of cloudiness (Mateeva 1999).

Aerotherapy is purposed for carrying out aero-procedures in air surroundings, saturated with specific components, of the type of some medicinal species phytoncides and other specific particles. Cryotherapy is used for stimulating the organism at minus temperatures.

Winter sports are directly dependent on the snow cover, which is formed annually in Bulgaria, but it is stable only in the mountains at an altitude exceeding 1100–1400 m. The basic factors for snow cover are snowfall as well as temperature of air and the underlying substrate. The snowfalls in the mountain regions of Bulgaria represent about 20 % (from the total sum of precipitation) in their low parts, between 20 % and 40 % in the medium high mountain parts, and more than 40 % in their high parts. The snow cover is formed first in the high-mountain belt, as early as in the second half of October, and in the middle- and low-mountain belt in November. The first snow cover in the mountains of Southeast Bulgaria, that is, Strandzha, Sakar, and the East Rhodopes, appears in the beginning of December. The last snow cover is observed from the end of March in the low-mountain belt until the end of May and even the beginning of June in altitudes above 1500–1700 m.

Except as a resource, the climate is of very high importance also as a condition, (environment), for all human activities that proceed in the open—from the numerous daily individual activities to economic activities as forestry and agriculture, construction, recreation and tourism, collection of herbs and mushrooms, hunting, fishing, etc. Here it has to be noted that with respect to recreation and tourism the climate is an important factor not only as a resource but also as an environment in which the recreation-tourism activity takes place, including the activity using as a resource the aforementioned specific elements of climate. The climatic environment exerts various effects on humans and their organism: physical (by means of precipitation, winds, mists, etc., which restrict in a purely mechanical manner the stay of people in the open, as well as by the aerosol, noise, odor, and pollen pollution of the air environment, and the UV-radiation) biotropic (by exchange of the air masses), psychoemotional (most often related with the degree of lighting, the duration of sunshine and of the day, cloudiness, visibility), and thermophysiological (Mateeva et al 2009). The latter occupy a special place among the climatic effects of the environment, because they affect the thermophysiological comfort of man and hence his general biostatus. For this reason they are determined as the most significant climatic factor of the environment.

The thermal environment exerts impact on the thermophysiological status of human organism by the thermal exchange, realized with it, which depends on the combination between the parameters of the air temperature, humidity, wind, solar and thermal radiation, and level of human activity and clothing and exposure. The assessment of this process is realized by the method of the heat balance of the human body. In conformity with the spatial and temporal regularities, the thermal balance parameters for Bulgaria show the following: during the warm half-year the transpirant exchange prevails, and in the cold half-year the turbulent thermal exchange is dominant; this results from the specificities of the wind regime, regardless of the characteristics of air temperature. With increasing altitude the structure of thermal exchange is subjected to significant alteration: regardless of the season, the turbulent thermal exchange is increased while the transpirant exchange is decreased. In the summer season this process is so clearly manifested that on the high parts a type of thermal exchange is formed, which is just the opposite of that in the low parts of the country. Concerning the heat balance of the human body and respectively its general physiological loading, occurring as a result from the impact of climatic conditions, the warm half-year is most favorable in the high mountain parts and the cold half in the plain parts in the interior of the country and in the low-mountain belt [Mateeva 2002].

The investigations of the mountain and fore-mountain regions in Bulgaria [Bioclimatic potential .... 1983] show that in a considerable part of these places the weather without restrictions for continuous stay of people in the open predominates all the year round (Fig. 5.4a). The frequent change of the various types of weather as well as the degree of contrast between the single changes, are also important criteria for human comfort. In this respect, the most contrast season in Bulgaria is winter, followed by spring and autumn, and the summer is distinguished by the highest stability of weather (Fig. 5.4b).

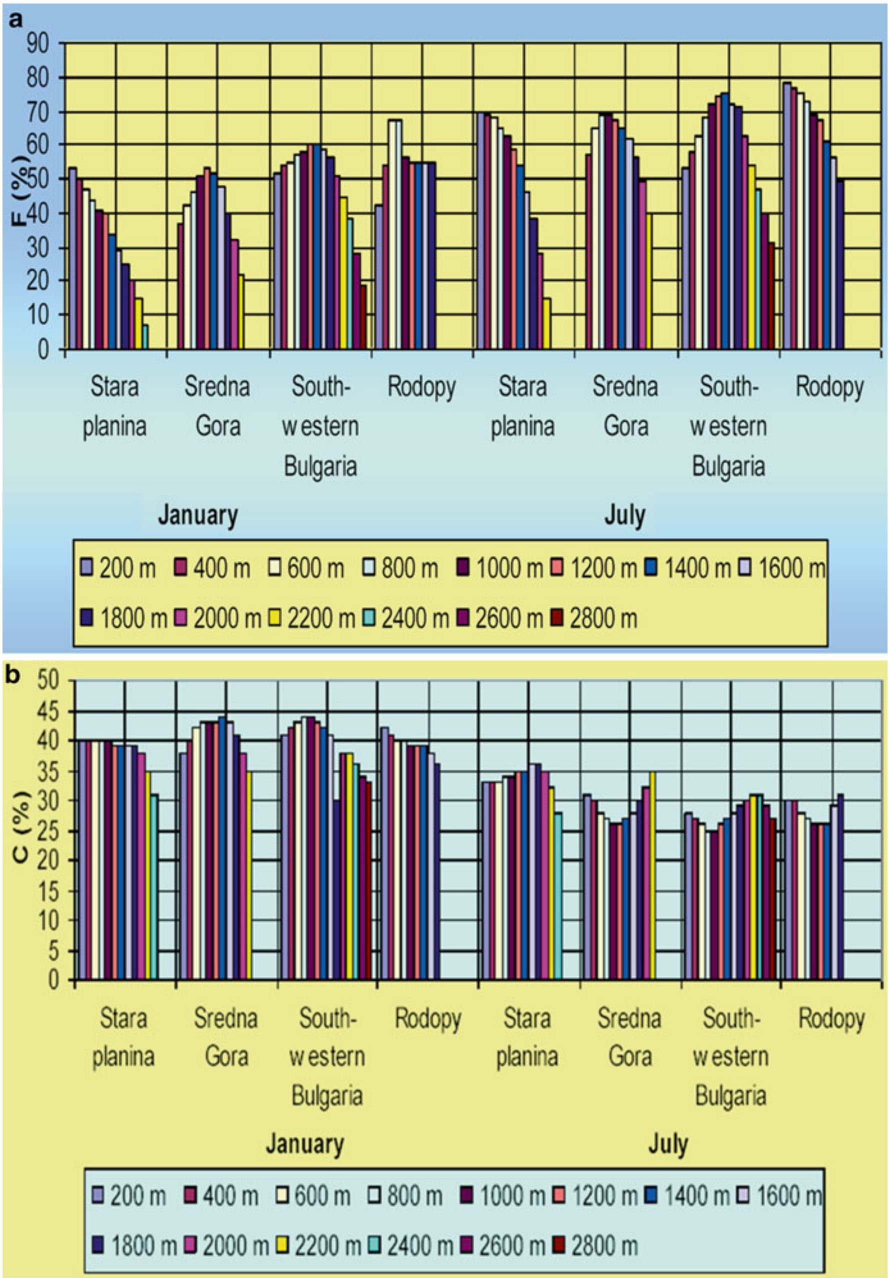

Fig. 5.4 (**a**) Frequency (*F*) of the cases with weather without limitations for a long stay in the open air at high levels of the mountains. (**b**) Frequency (*C*) of the contrasting changes of weather at high levels of the mountains

5.2.3 *Assessment of Water*

Having in mind the genetic formulation for the formation of water as a product of climate, it may be pointed out that the mountains receive the highest amount of precipitation. The mountains, with the conditions of restricted evaporation because of the relatively low temperatures, are the areas constantly generating water resources in Bulgaria. More than half the annual volume of river runoff is formed in the altitude belts above 600 m, and including the belt within the range 300–600 m, their share exceeds 80 % (Fig. 5.5). The highest water abundance belongs to the highest ridge parts: above 800 mm, for a runoff coefficient above 80 % with respect to precipitation in these areas, and the lowest (more than 300 mm) belongs to the low-mountainous and foothill areas, with a runoff coefficient above 50 % (Fig. 5.6). It has to be noted that with respect to precipitation and runoff conditions the East Rhodopes with their low altitude (on average, 330 m) are comparable with the medium- and even the high-mountainous parts (with an average altitude of about and above 1000 m) of West and Middle Stara Planina, the West Rhodopes, Rila, and Pirin; that is, this is one of the most water-bearing low-mountainous part of the territory of the country, with its occupied area of only about 4.5 %, more than 12 % of the water resources of the country are formed here (Physical geographic and … 1989). However, the river runoff has a strongly expressed inconstant regime, with extremely river high waves usually in the cold half-year and with continuous deep

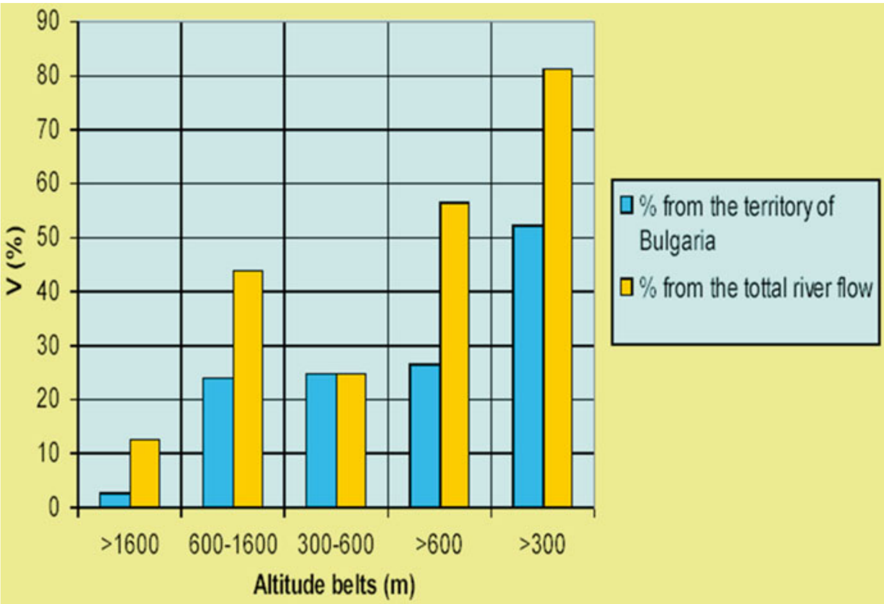

Fig. 5.5 Mean annual volume of river flow (*V*) by altitude belts (From table 71, in: The nature and …. 1989)

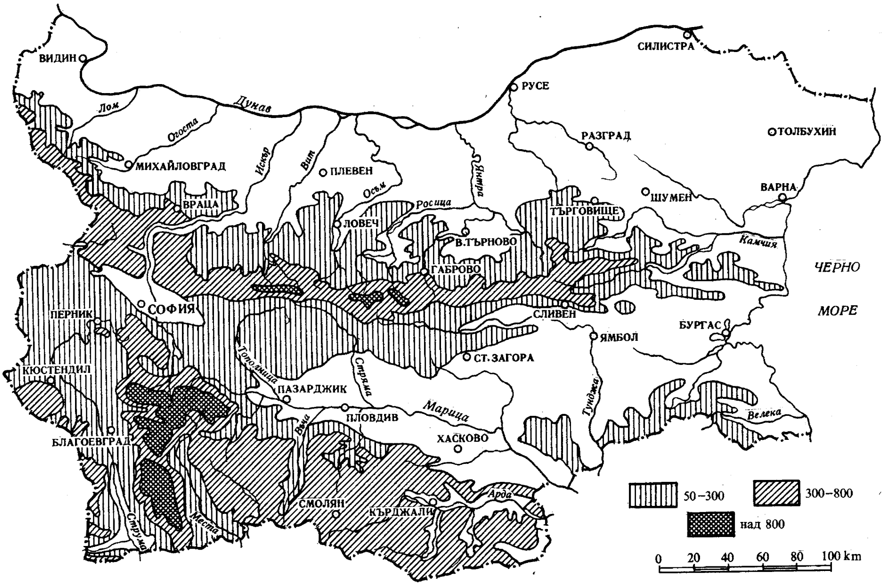

Fig. 5.6 Mean annual water flow (From Mandadjiev, in: The Nature and… 1989)

low water during the warm half-year, when even the larger rivers become dry. In contrast, river runoff in the high mountains is naturally regulated in the typical (for them) broadly spread ridge and slope flattened areas, often with peat cover, thick forests, thick and permanent snow cover, and not in the last place with lower evaporation even in the warm half-year.

In all, 700 water reservoirs have been built for utilization of the water potential of the mountains in Bulgaria for different purposes (water supply, irrigation, power generation), which are distributed irregularly in the height belts of the single mountains and regulate a significant volume of the river water formed in them. The volume of the artificially regulated river discharge in the water reservoirs of different size and location in mountains by altitude belts amounts approximately to about 5 billion m^3 and represents 70 % of the stored water volume in the country (Mandadjiev, in: The Nature and… 1989).

The technically usable hydraulic energy potential of the mountains is estimated to about 3400 MWt, and the potential actually used by construction until the end of the 1980s of about 70 hydropower plants (HPP) at the water reservoirs in the mountains is about 1900 MWt. It is seen that there is still significant unutilized hydraulic energy potential, which is one of the perspective renewable energy sources, together with the climatic sources, for solving problems of sustainable regional development in mountain territories and in the whole country. On the other hand, having in mind the relatively reduced water use for irrigation and industrial production related with the certain economic stagnation in the country during the past 20 years, it may be considered that a considerable water reserve is available for economic purposes and even for the needs of settlement water supply.

The recreation-tourism potential of the mountains, related to water, is extremely important. For example, sites that are usually appropriate for mass forms of recreation and tourism are the numerous mountain rivers, the hundreds of high-mountain lakes in Rila (140) and Pirin (119), and artificial water reservoirs in the lower zones of all mountains, as well as the numerous attractive waterfalls. Mineral water occupies a special place in the recreation-tourism activity; it is connected mainly with the fault zones in mountain areas, in total about 70 % of all the mineral water deposits in the country. This natural potential of the mountains is traditionally used in a number of outstanding balneological centers such as Hisarya, Pavel Banya, Narechen, Devin, Velingrad, Kyustendil, and Sandanski, as well as for production of bottled mineral water.

5.2.4 Assessment of the Soils, Vegetation, and Animal World

The soil potential of the mountains is formed on 3.71 million hectares and is evaluated by means of the forests and pastures, developed mainly on mountain soil types and partially of arable lands, amounting to about 1.64 million hectares (more than one third of the arable lands in the country, which occupy 4.5 million hectares). However, it has to be noted that the main part of the land abandoned during the past several decades, more than 1 million hectares of arable land, is in the mountain areas (Raykov, In: The nature and …. 1989). One of the major features of the soil cover in the Bulgarian mountains is the great soil diversity and the shallow profile of almost all soil types, distributed in the mountains. The respective soil belts are formed with increasing altitude and the regularly changing climatic conditions (lower temperatures and higher moisture).

The soil potential of the mountains, measured by soil fertility, represents the basis for the development of forestry and mountain agriculture. In the mountains are concentrated more than 70 % of the forest resources and about two thirds of the plant species and phytocenoses encountered in the country, about 65 % of the areas, suitable for growing oriental tobacco and potatoes, more than 85 % of the area of the meadows, more than 70 % of the common pastures and other pastures in the country, etc. (The mountain regions…1994).

The natural vegetation in the Bulgarian mountains, except with its high species diversity, is characterized also by high endemism and relictness. From the known about 250 species and subspecies of Bulgarian endemics more than 150 are in the mountains, mainly in the Rhodopes, Pirin, Rila and Stara Planina. Also, the predominating number of Balkan endemics is mainly in Bulgaria. The tertiary relicts are also typical. All this distinguishes the Bulgarian mountains as foci of flora species formation, not only on Bulgarian territory (Velchev et al, In: The Nature and … 1989).

The following vegetation zones are distinguished in the mountains with height: Mediterranean vegetation belt (up to 300–400/500 m), mainly with cenoses of *Quercus coccifera*, tree-like juniper (*Juniperus excelsa* Bieb.), etc., along the mountain slopes toward the Struma and Mesta River valleys and in the East Rhodopes; xerothermic oak forest belt (up to 600–700 m) developed in all mountains; hornbeam, common oak forest belt (between 600–700 and 900–1000 m), in all mountains; beech forest belt (between 900–1000 and 1300–1500 m), in all mountains without East Stara Planina and Strandzha; coniferous forest belt (between 1300–1500 and 2000–2100 m), in the Rhodopes, Rila, Pirin, Slavyanka, and fragmentarily Stara Planina, Osogovo, and Vlahina Mts.; subalpine thin forest belt, pine-scrub and juniper shrub cenoses (between 2000–2100 and 2500 m), in Rila and Pirin and more restricted in Stara Planina, Vitosha, Osogovo, and Belasitsa, at a lower height (less than 2000 m); alpine vegetation belt (above 2500 m), in Rila and Pirin (Velchev, In: Geography of Bulgaria 2002).

Parallel to its extremely important environment-forming function, the natural vegetation (tree, herbaceous, and shrub) is also traditionally used as an important source of diverse resources, such as wood, fodder, food, fruits, herbs, raw materials (tanning extracts, ethereal oils, resins, dyes, etc.), many plant species being also nectiferous (about 600) or with decorative features (more than 1000) (Velchev, In: Geography of Bulgaria 2002).

In the animal world, mainly birds and mammals represent an interest from the resource point of view. Their distribution is usually connected with the altitude vegetation belts, and the following types of fauna are distinguished: in the oak belt, in the beech belt, in the coniferous belt, and in the subalpine and alpine belt with typical representatives of each belt. The economically important species are those hunted, defined as game, representing a resource also for international hunting tourism. Fish fauna, related to the relatively pure water of both mountain rivers and the numerous natural lakes and artificial water reservoirs, are also important for the economy, especially for sport fishing.

5.2.5 Complex Assessment of Mountain Landscapes

The landscape-specific features are formed by the combination and mutual interaction of the individual natural components, with the leading role mainly of relief and climate, and with the physiognomic participation mainly of vegetation and partially of water. These features are expressed in the alternation of specific landscape belts with height. Six types of height landscape spectra are distinguished, differing with respect to location and height groups and single mountains in Bulgaria: Rila-Pirin, West Rhodopean, Stara Planina, Kraishte-Sredna Gora, Osogovo-Belasitsa, and East Bulgarian (Fig. 5.7). Each single type has an inherent set of height landscape belts, provisionally defined by the names of the hypsometric belts: low-mountainous, middle-mountainous, high-mountainous, and alpine; the so-called fore-mountain belt being distinguished in some of them. They have different height and area development in the single mountains depending on their morphographic peculiarities, as well as on their climatic differences, in connection with the macro-exposition of the mountain slopes, the boundaries of the landscape belts being 100–200 m lower on

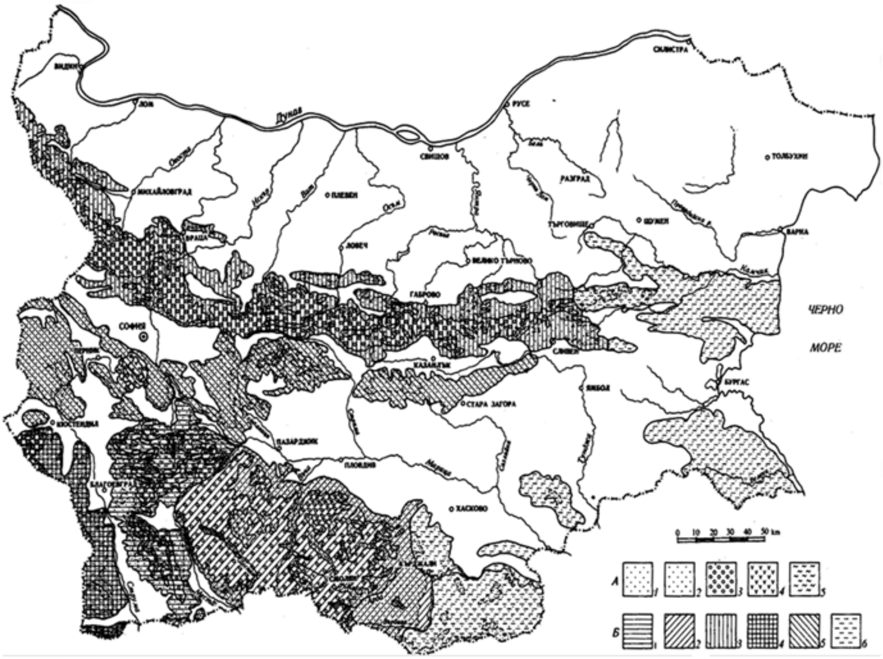

Fig. 5.7 Altitude landscape belts and types of spectrums (by The Nature and… 1989). (**a**) *Belts: 1 and 2* semi-mountains and low mountains, *3* mid-mountains, *4* high mountains, *5* alpean. (**b**) *Spectrums: 1* Rila-and-Pirin, *2* West-Rodopean, *3* Stara Planina, *4* Osogovo-and-Belasica, *5* Kraishte-and-Sredna Gora, *6* East-Bulgarian

the slopes with a northern component (Table 5.3). The differences are very well expressed in the high mountains: Stara Planina, Rila, Pirin, Vitosha.

Naturally, the Rila-Pirin type of height landscape spectrum is characterized by the highest number of landscape belts with the presence of an alpine belt with low-, middle-, and high-mountain zones. The smallest number of landscape belts, only one, is established for the so-called East Bulgarian type of landscape spectrum, typical for the lowest small mountains on the territory of Bulgaria, Sakar and Strandzha, and for a part of the larger mountain systems such as the East Stara Planina and the East Rhodopes (Fig. 5.7). Their distinguishment as a general independent type is determined both by the strongly expressed Mediterranean effect on almost all natural components and, especially, on the soil-vegetation cover.

The landscape features of the height belts are connected on the one hand with the natural resource six-component and complex potentials that are suitable for various target utilization, for example, industrial, power generation, forest, water resources, and potential for construction, recreation-tourism, etc. On the other hand the landscape features are connected with the dynamic processes of self-purification, recovery (regeneration), and degree of changeability during anthropogenic impact. It is much more important to take into consideration the possible manifestations of anthropogenically provoked or activated degradation processes.

Table 5.3 Altitude (m) of the landscape belt boundaries

Type of altitude landscape spectrum	Low-mountain	Mid-mountain	High-mountain	Alpine
Rila and Pirin	900–1400	1400–1900	1900–2300	>2300
	700/900–300/1500			
West Rodopean	300–900	900–1700	>1700	
Stara Planina	500–700	700–1800	>1800	
	500–900	900–1900	>1900	
Osogovo and Belasitca	700–1300/1400	1300/1400–1900	>1900	
Kraishte and Sredna Gora	600/700–1200/1400	1200/1400–1700/1800	>1700/1800	
East Bulgarian mountains	>300			

Source: The Nature and… (1989)

This provision especially concerns the output of resources and construction under conditions of higher dismemberment and slopes, typical for different high belts in the single mountains. It is necessary to precede the design and realization of any type of activity by comprehensive scientific analytical and synthetic investigations and classifications.

5.3 Assessment of the Possibilities for Sustainable Utilization of the Natural Potential of Mountains

The assessment of the nature potential of the mountains in Bulgaria as available resources and conditions is only the first but very important step toward ensuring the necessary prerequisites for sustainable development. The next steps are connected subsequently with determination of the needs of the various anthropogenic activities of the respective resource potential, the degree of its suitability or favorableness, its character and strength of impact, the direction and extent of its change, and, finally, the possibilities for optimizing its use with the view of its preservation.

The evaluation of the needs of suitable conditions and resources for different anthropogenic activities is directed toward meeting the specific requirements of each activity type with respect to particular quantitative and qualitative parameters of the resources and the environment; that is, the evaluation is subordinate to the so-called "subject–object relationships," the respective activity being implied as "subject." In addition, parallel evaluation is made of the integral and partial potentials; for example, if the landscape characteristics of all natural components are important for the broadly developed mass forms of tourism, only a few relief characteristics are sufficient for some specialized forms of tourism, such as rock structure and slopes (for alpinism, ski sports, etc.).

The evaluation of the degree of suitability or favorableness of the resource potential and the environment is also made in a differentiated manner according to partial potentials, but also in an integral way, by considering in detail the basic properties of the natural components, representing a special interest, and on their basis an integral assessment rating degree is attained for the territory. Rather often coefficients of significance or weight are introduced for the most important assessment parameters with the view of limiting the inevitable leveling of the integral assessments in the synthesis of the partial ones. The boundary conditions, connected with the given natural component, or its basic property, should be also subjected to assessment analysis, and the degree of its suitability is determined on the basis of the ratio between the positive and negative evaluations (Kantsebovskaya and Semenov 1968).

The evaluation of the character and strength of the impact of the single types of anthropogenic activity on the natural potential of the mountains is directly related to the criteria for sustainability in the context of the requirement for balanced anthropogenic loading in accordance with the "bearing capacity" (carrying capacity) of the natural components and landscapes. The impact is realized on the one hand by the "introduced" anthropogenic objects in the environment and on the other hand by their functioning according to their basic designation, as well as by pollution with liquid, solid, and gaseous substances. In this case it is important to know not only their direct reflection on the used natural component or its property (relief: for construction, water, wood, game, etc.) but also the character and strength of their mutual effect during their continuous interaction and mutual penetration as various media (rock–soil–air–water–biota), especially taking into account the multiplication effect in the exchange of pollutants.

The assessment of the direction and extent of change of the environment and the resources is a direct consequence of the impact and is subordinate to the principles of sustainable development, including the natural potential preservation. It is performed by determining the character of the occurring processes of degradation during anthropogenically activated unfavorable natural processes and phenomena, such as erosion, landslides, rock-falls, and damming of river flows, or anthropogenically provoked, as during construction, connected with slope cutting, excavations, forest cutdown, and extraction of minerals and other resources. Their identification is in the basis of the timely prevention of catastrophic consequences. The degree of change may be characterized by the stages of relief degradation (Rakovskaya 1982) as a foundation and a factor of landscape, which are in their turn the consequence of the observed still broader and uncontrolled loading, which neglects the bearing capacity of the natural environment.

The evaluation of the possibilities for optimizing the use of the resource potential with the view of its protection is in fact a step toward the realization of sustainability in the development of anthropogenic activity. It is manifested in several basic aspects. Conformity with the law in determining the potential for the needs of the respective anthropogenic activity and the possible boundaries of its development should be put in the first place, so that the use of resources beyond their "purpose" and with higher intensity than envisaged preliminarily is inadmissible. The system for monitoring, ensuring adherence to the requirements for maintaining ecological equilibrium, may be ranked in second place, and the normative regulations with exactly formulated standards for the degree of loading and alteration, as well as with strictly formulated sanctions for executed violations, should be put in the third, but not the last, place. Valuable activities in this respect were carried out in the course of harmonization of the Bulgarian ecological legislation with the European documents, but there are still some adverse practices.

5.4 Conclusion

In conclusion it may be pointed out that nature in the Bulgarian mountains is preserved to a significant extent in its virgin form, not only because of the nature protection status of large-range national and natural parks and numerous reserves and natural features in almost all the mountains, but also because of the organized activities of large groups of nature protectors, especially within the framework of the "Natura 2000" international program. The mountains in the border space with neighboring Balkan countries are relatively unaffected or slightly affected by anthropogenic activities as a result of the guarded regime in the border zones existing until recently, and the Rhodopes have been even stated to be one of the biggest so-called ecological bricks in Europe (Politische …. 1990). The opening of our boundary geographic space not only on a Balkan, but also on a European, and in a certain sense, on a world scale, provides the possibility of reviving these to a great extent economically underdeveloped peripheral regions of the country, and respectively of ensuring economic prosperity on the basis of their rich natural resource potential by the cooperation between countries, especially in the tourist and in the ecological spheres.

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Chapter 6
Morphometry and Land Use on High Mountains in the Republic of Macedonia

Ivica Milevski

Abstract In this chapter, basic morphometric (geomorphometric) characteristics and their influence on the land use of high mountains in the Republic of Macedonia are presented. Morphometric elements are computed from specially prepared 15-m DEM of the Republic of Macedonia instead of the 3″SRTM DEM (v4; Jarvis et al., 2008) model used in a previous edition. Special attention is given to hypsometry, slopes, and aspects that are characteristic for each mountain. Land use is calculated from Corine Land Cover (this time, CLC2006) data and the appropriate raster map with 100-m resolution, according to the CLC land cover categorization. Land use patterns on the high mountains are analyzed in respect to hypsometry, slopes, and aspects, finding large differences in all these elements. Some of these differences are the result of anthropogenic influences and human impact on the landscape, which is also highly influenced by topography. That fact must be taken into account considering the sustainable development of mountain areas, especially with regard to accelerated erosion and overall landscape degradation.

Keywords Geomorphometry • Land use • Remote sensing • High mountains • Human impact

6.1 Introduction

As a result of powerful local and regional geotectonic movements in the past, the landscape in the Republic of Macedonia (25.713 km^2) has a characteristic chess-like relief with frequent changes of mountains and depressions. In general, hilly–mountain areas highly dominate in the relief, covering 78.8 % of the country (Stojmilov 1981), although mountains only cover 12,254.5 km^2 or 47.7 % of the country (Markoski 1995, 2004). Of about 40 mountains, 13 are grouped as high mountains,

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extending more than 2000 m above sea level (a.s.l.) (Panov 1976; Stojmilov 1976); the highest, Korab, reaches 2753 m. According to the area that they occupy (29.3 %), high mountains have a large importance for the Republic of Macedonia. However, they are unequally distributed; most of them are located in the west and central part of the country, whereas only 2, Osogovo (2252 m) and Belasica (2029 m), are in the eastern part. Because of variable genesis and geomorphic evolution, high mountains have significant morphometric differences, clearly evident in their hypsometry, slopes, aspects, and contours (Milevski 2011). Although this is important for the physical geographic processes, mountain morphometry highly influences human activities as well. According to Markoski (1995), in 1961 the area of high mountains was populated with 136,217 inhabitants, and in 1981 with 124,250 inhabitants, of whom 37,760 were settled above 1000 m altitude (about 24,000 by latest estimation for 2014). The spatial distribution of this population and its activity in the mountain areas is closely related with topography. On the other side, topography with terrain morphometry largely determines land use structure, which is analyzed in this work through the Corine Land Cover 2006 (CLC2006) data. CLC2006 is used as a very representative and standardized source of data for the Republic of Macedonia, prepared as a part of the project of EEA (European Environment Agency), although there are other possibilities for remote sensing-based land use detection sources, such as Landsat ETM+ or ASTER (Milevski 2005b). There are 31 land use classes identified and mapped in the country with a unit resolution of 20 ha. It is interesting that CLC2006 very slightly differs from CLC2000 used in the previous edition (Milevski 2011). Joint analyses of morphometry and land use in this work show considerable differences of land use distribution by hypsometry, slopes, and aspects, which is significant for further sustainable development of mountain areas (Fig. 6.1).

6.2 Methodology

Regarding the purpose of this chapter, two basic analyses were made, one of mountain morphometry and the other of mountain area land use. First, high mountains are precisely bounded according to the cartographic (Markoski 1995, 2004) and morphological approach (Milevski 2011). However, there are problematic areas where mountains gradually pass into bottom flats through hilly terrain. In those cases, most logical hypsometric and morphological bounding is performed. Then, further analytical procedures were carried out.

The basic tool for morphometry (geomorphometry) analyses is the 5-m DEM provided by the Ministry of Agriculture, Forestry and Water Economy of the Republic of Macedonia (MAFWE), completed in 2010. Because of some shifts and artifacts, recently this 5-m TIN-like DEM of MAFWE is interpolated and filtered to “soft-surface” 15-m resolution. According to the results of geomorphometric calculations, the filtered 15-m model has high overall quality, much better than the formerly available 3″SRTM DEM and 1″ASTER GDEM (Milevski et al. 2013; Milevski 2014). In the following, only the mountain areas of interest were cut off

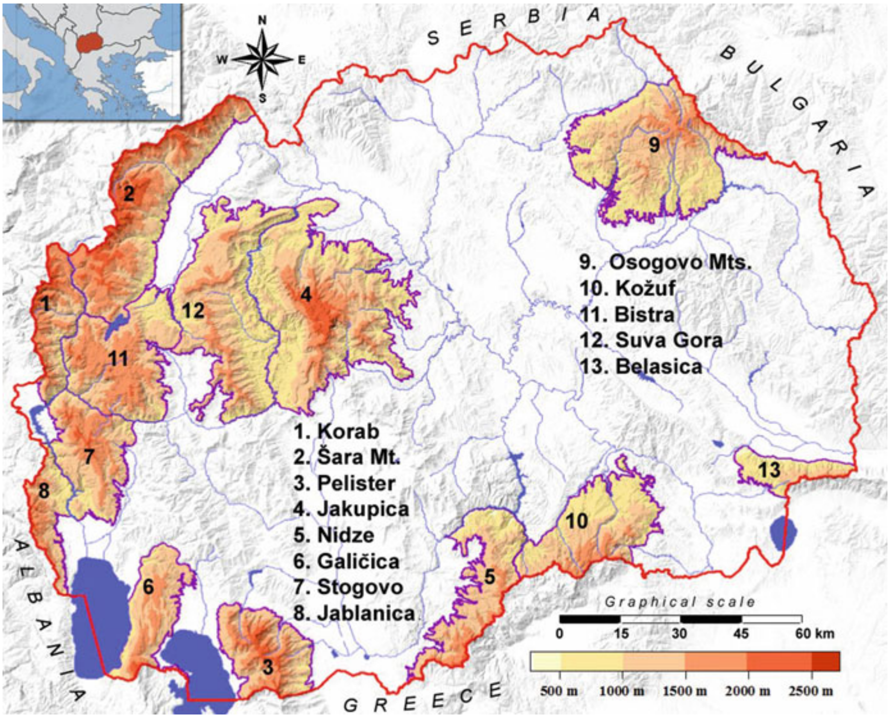

Fig. 6.1 Geographic locations of high mountains in the Republic of Macedonia

from the model to undergo further morphometric processing with SAGA GIS software.

Land use analyses were made from the previously checked Corine Land Cover 2006 raster data model. Some minor errors noted in the model were corrected with comparison of appropriate spectral bands on Landsat ETM+ satellite imagery (mostly by NDVI relationship). Then, the CLC2006 model was carefully resampled to 15-m resolution, the same as the DEM model, enabling joint identification, calculation, and quantification of land use areas with respect to the topographic elements. Finally, comparative analyses were made, showing some patterns of the influence of morphometry on land use.

6.3 Basic Morphometric Characteristics

The basic morphometric characteristics of the high mountains in the Republic of Macedonia are presented in Table 6.1: base point in foothill (Hmin), highest peak (Hmax), relative altitude (Hrel), mean altitude (Havr), area (P), and volume (V) of each mountain.

Table 6.1 Basic morphometric characteristics of the high mountains in the Republic of Macedonia*

No.	Mountain	Hmin	Hmax	Hrel	Havr m	P km^2	Vkm^3	iV/P
1.	Korab	589	2753	2164	1557.4	289.5	282.6	0.98
2.	Šara Mt.	590	2748	2158	1594.0	828.6	839.1	1.01
3.	Pelister	740	2601	1861	1478.3	396.6	293.7	0.74
4.	Jakupica	316	2540	2224	1126.9	1272.7	1032.4	0.81
5.	Nidže	272	2520	2248	1199.3	460.0	425.5	0.93
6.	Galičica	693	2288	1595	1293.7	346.3	208.2	0.60
7.	Stogovo	570	2268	1698	1344.3	458.0	355.3	0.78
8.	Jablanica	574	2256	1682	1309.1	207.6	153.6	0.74
9.	Osogovo	424	2252	1828	1070.2	981.0	638.5	0.65
10.	Kožuf	449	2165	1716	1061.3	543.9	331.6	0.61
11.	Bistra	587	2163	1576	1383.8	643.7	513.6	0.80
12.	Suva Gora	301	2061	1760	1069.4	923.4	710.8	0.77
13.	Belasica	268	2029	1761	846.4	167.5	96.3	0.57
	Average	490	2357	1867	1256.5	578.4	452.4	0.77
	Total	–	30,644	–	–	7518.8	5881.2	–

*Explanation of the terms in the text

Table 6.1 shows that 5 mountains are higher than 2500 m (Korab, Šara, Pelister, Jakupica, Nidže), and 4 mountains have a relative altitude higher than 2000 m (Nidže, Jakupica, Korab, Šara). Šara and Korab have the highest mean altitude (Hsr) and the highest index of volume (iV/P) according to their overall area. It is interesting that Bistra Mountain is 11th in peak altitude, but 4th in mean altitude and 5th in volume index, which is a consequence of its characteristic morphology. The mean altitude of all high mountains is 1256 m, which is 426 m higher than the mean altitude of Macedonia, which is 830 m (Milevski 2007). The average volume index of 0.77 indicates generally high mountains in respect to their area.

6.4 Basic Land Use Characteristics

As already expected, analyses of CLC2006 data (compared and corrected by Landsat ETM+ satellite imagery for 2005–2007) indicate the dominance of forests and shrubs on high mountains (Table 6.2). However, most of the forests are broadleaf, partly degraded, and with unsuitable structure and density.

According to the data in Table 6.3, on most of the 13 high mountains, broadleaf forests prevail, except on Nidže Mountain, where coniferous forests occupied a significant area. On Korab, Šara, and Galičica Mountains, instead of forests, scrubs dominate, partly because of the high altitude and partly as a result of forest clearing for increasing mountain pasture area. Osogovo Mountain is characterized as having large agricultural areas (274.9 km^2 or 28 %), most of which is land principally occupied by agriculture (101.1 km^2), pastures (56.5 km^2), and complex crops (55.3 km^2).

Table 6.2 General land use types (according to the CLC2006) on the high mountain in the Republic of Macedonia

Main type	Area (km^2)	Area (%)	Subtype	Area (km^2)	Area (%)	CLC code
Artificial	11.0	0.15	Industrial	1.9	0.03	121–124
			Mine, dumps	3.9	0.05	131–133
			Urban	5.2	0.07	112–142
Agriculture	916.0	12.18	Arable land	6.4	0.09	211–213
			Permanent	3.2	0.04	221–222
			Pastures	134.5	1.79	231
			Heterogenic	772.0	10.27	241–244
Forests and scrubs	6585.8	87.59	Broadleaf	3235.4	43.03	311
			Coniferous	500.1	6.65	312
			Mixed	461.7	6.14	313
			Scrub	2361.0	31.40	321–324
			Open space	27.7	0.37	331–335
Wetlands	2.3	0.03	Wetlands	2.3	0.03	411–412
Water bodies	3.6	0.05	Water bodies	3.6	0.05	511–512
Total	7518.7	100.00	–	7518.7	100.00	–

That characterization is a consequence of oak deforestation and the introduction of agriculture on terraces and flats below 1000 m.

6.4.1 Hypsometry and Land Use

Hypsometry of the high mountains in the Republic of Macedonia is derived from precise analysis of 15-m DEM, according to the standard altitude range of 500 m (accuracy shift, <0.2 %) (Table 6.4).

Obviously, there are large hypsometric differences between mountains. Thus, only Šara Mountain and Kožuf have significant area above 2000 m, 21.7 % and 14.6 %, respectively, after which is Pelister with 10.0 % of its total area. As already mentioned, in Macedonia, Belasica does not reach 2000 m, because the highest peak is in Bulgaria (Radomir, 2029 m). The majority of mountains have their largest areas in the hypsometric zone of 1000–1500 m, which corresponds to its mean altitude of 1248 m. Such hypsometric structure influences local climate (decrease of temperature, increase of precipitation), hydrography, vegetation, soil types, population density, human activities, and certainly land use patterns. Thus, according to the major land use classes on high mountains, agricultural areas prevail on lower altitudes, up to 1000–1500 m. Forests are especially dominant at 1000–2000 m (i.e., 800–1800 m), with the upper limit (anthropogenic) about 1800–2200 m. Above are natural grasslands and bare rocks, extending up to the mountain tops (Table 6.5).

It is interesting that the oak complex (as well as other forest types) on the lower mountain sides is significantly devastated by human impact (mostly by overcutting and clearing). Similarly, dense coniferous forests above 1800 m were destroyed in

Table 6.3 Main types of land use (according to the CLC2006) on each of the high mountains in the Republic of Macedonia

Mountain	Artificial	Agriculture	Broadleaf	Coniferous.	Mixed	Scrubs	Other	Wetlands	Water	Total
Korab	0.0	22.0	116.1	11.8	12.9	122.0	4.6	0.2	0.0	289.5
Šara Mt.	2.6	92.1	263.9	25.5	36.4	401.8	4.6	0.4	1.3	828.6
Pelister	0.5	30.4	183.1	30.7	24.6	125.5	1.7	0.0	0.0	396.6
Jakupica	0.0	109.6	492.9	90.0	99.5	473.8	6.9	0.1	0.1	1272.7
Nidže	0.0	30.6	131.5	154.5	65.0	77.7	0.8	0.0	0.0	460.1
Galičica	0.3	39.3	127.3	16.5	18.8	144.1	0.0	0.0	0.0	346.3
Stogovo	0.2	45.8	242.1	15.5	14.8	135.4	3.1	0.6	0.6	458.0
Jablanica	0.7	26.6	105.0	6.5	6.5	59.7	0.9	0.6	1.1	207.6
Osogovo	2.3	274.9	405.4	37.0	42.1	214.9	3.9	0.2	0.4	981.1
Kožuf	1.2	29.2	263.8	49.8	78.6	120.8	0.4	0.0	0.0	543.8
Bistra	2.2	41.4	371.0	24.7	25.8	177.2	0.8	0.3	0.3	643.6
Suva Gora	0.9	156.6	422.0	32.0	30.9	280.8	0.1	0.0	0.0	923.4
Belasica	0.2	17.7	111.1	5.5	5.8	27.2	0.0	0.0	0.0	167.5
Total	11.0	916.0	3235.4	500.1	461.7	2361.0	27.7	2.4	3.7	7518.8

Table 6.4 Hypsometry (in m) of high mountains in the Republic of Macedonia

Mountain	<500	500–1000	1000–1500	1500–2000	2000–2500	>2500	Total
Korab	0.0	25.4	97.0	124.9	40.5	1.7	289.5
Šara Mt.	0.0	104.7	224.7	319.4	171.1	8.7	828.6
Pelister	0.0	28.2	188.6	140.2	39.1	0.6	396.6
Jakupica	14.6	582.3	428.2	178.2	69.2	0.1	1272.7
Nidže	15.3	85.7	273.0	76.8	9.1	0.1	460.0
Galičica	0.0	48.7	205.8	84.7	7.1	0.0	346.3
Stogovo	0.0	78.3	226.2	138.5	15.0	0.0	458.0
Jablanica	0.0	47.7	92.2	60.2	7.5	0.0	207.6
Osogovo	3.8	432.8	427.6	114.2	2.6	0.0	981.0
Kožuf	1.6	270.6	199.3	70.6	1.8	0.0	543.9
Bistra	0.0	104.5	274.3	259.0	5.9	0.0	643.7
Suva Gora	15.0	393.2	409.5	105.5	0.2	0.0	923.4
Belasica	18.9	100.9	40.8	6.9	0.0	0.0	167.5
Total	69.1	2303.0	3087.2	1679.0	369.2	11.1	7518.7

Table 6.5 CLC2006 land use types (in km^2) with respect to hypsometry

Code	Type\slope	<1000 m	1000–1500 m	1500–2000 m	>2000 m	P km^2
2–11	Artificial	6.70	3.18	1.12	0.00	11.00
12–22	Agriculture (all)	562.56	340.09	13.35	0.00	916.00
18	Pastures	72.76	59.79	1.98	0.00	134.50
20	Complex crops	117.79	54.94	2.09	0.00	174.80
21	Land-agriculture	240.91	135.30	4.73	0.00	380.94
23	Broadleaf	905.54	1740.50	582.83	6.51	3235.40
24	Coniferous	114.99	232.71	146.51	5.88	500.10
25	Mixed forests	139.86	192.97	121.96	6.92	461.70
26	Natural grassland	111.11	155.29	539.66	276.88	1082.94
27	Moors, heathland	82.57	81.67	115.23	41.77	321.25
28	Sclerophyllous vegetation	118.18	104.85	52.10	8.46	283.59
29	Transitional	312.97	233.78	107.57	18.92	673.24
	Total (with other)	2372.10	3087.23	1679.03	380.34	7518.7

the past, transforming these areas to grasslands for pasturing. As a result, severe erosion occurs, especially at the mountain bottoms.

6.4.2 *Slopes and Land Use*

Slopes are a significant morphometric element that influences numerous natural and anthropogenic aspects. In this work, only slope angle is analyzed in detail, although slope length and slope curvature have considerable significance also. The slope

Table 6.6 Slope angle by area (km^2) on the high mountains in the Republic of Macedonia

Mountain	0–10	10–20	20–30	30–40	40–50	>50	P km^2	α°sr	LS
Korab	19.1	70.3	103.2	69.1	22.5	5.3	289.5	27.4	34.8
Šara Mt.	64.2	269.9	289.6	149.1	48.8	6.8	828.6	24.5	33.2
Pelister	27.8	95.7	165.8	100.3	6.5	0.4	396.6	25.3	32.0
Jakupica	187.6	403.9	405.3	221.0	45.8	9.1	1272.7	23.6	27.4
Nidže	56.6	162.2	163.3	67.8	9.4	0.6	460.0	23.6	25.2
Galičica	88.8	138.4	85.7	27.2	5.6	0.6	346.3	19.1	21.7
Stogovo	62.3	172.5	154.8	52.5	13.6	2.4	458.0	22.7	26.7
Jablanica	36.5	72.6	64.5	26.9	6.1	1.1	207.6	22.8	25.1
Osogovo	136.5	415.1	331.9	89.3	8.0	0.2	981.0	22.2	22.6
Kožuf	88.7	215.6	174.6	53.8	9.7	1.5	543.9	22.3	22.7
Bistra	119.6	242.8	180.4	69.3	23.8	7.8	643.7	22.1	24.7
Suva Gora	125.5	308.3	311.3	154.8	22.1	1.4	923.4	23.1	26.7
Belasica	30.7	50.9	49.7	30.2	5.8	0.3	167.5	24.6	26.7
Total	1044.0	2617.9	2480.2	1111.3	227.8	37.6	7518.7	27.4	26.9

angle of the high mountains in the Republic of Macedonia is derived from the 15-m DEM of MAFWE-RM (Table 6.6).

The data show that the highest mean slope (from 27.4° to 25.3°) is at Korab, Šara Mountain, and Pelister, which are also the highest mountains in the country. The causes for such high slopes are geotectonically predisposed steep sides and deeply incised river valleys. Jakupica and Suva Gora have moderate slopes, with steep sides but flattened karstified planes on top. Galičica Mountain has the lowest mean slope (only 19.1°), as a result of a very large flat-top surface with many shallow dolines, sinkholes, karst poljes. etc., on the central and north part. Overall, the average slope of the high mountains in Macedonia is 20.9°, which is significantly higher than the average slope of the country of 15.5° (Milevski 2014). It is interesting to stress that the average slope of most mountains sharply increases with altitude up to about 1000 m, after which the slope values fluctuate between 15° and 25° (because of morphological changes). At the highest altitudes, slope trends decrease, especially toward ridge and peak areas on the top.

A good slope indicator of the analyzed mountains is the LS (length–slope) factor, which is slope angle multiplied by length of constant slope. On Table 6.3 is evident that the three highest mountains have the greatest LS values (34.8–32.0), meaning long, steep slopes. Galičica has the lowest values because of relatively short, flat slopes on the large karstified top surface.

However, among the other, slopes directly or indirectly influenced land use pattern. Data from Table 6.7 show that on smaller slopes (0–20°), agricultural land prevails, especially areas with complex crops; that is logical, because agricultural activities are much more easily practiced on lower slopes and in that range are found most of the population and rural settlements. In contrast, forests are present on higher slopes, with significant areas even above 30°. Normally, bare rocks, sparse vegetation, etc. are present on all slopes with noteworthy percent above 30°.

Table 6.7 CLC2006 land use types (in %) with respect to slope categories (in degree, °)

Type\slope	0–10	10–20	20–30	30–40	40–50	>50	P%	P km²
Pastures	26.7	43.6	23.8	5.3	0.6	0.1	100.0	134.5
Annual crop	23.5	43.8	26.0	5.9	0.6	0.2	100.0	31.0
Complex crop	34.0	43.3	18.6	3.6	0.5	0.0	100.0	174.8
Land: agriculture	20.6	44.2	28.8	5.8	0.6	0.0	100.0	380.94
Agro-forestry	15.2	41.5	33.7	8.6	0.9	0.1	100.0	185.29
Broadleaf	8.5	31.6	37.6	18.2	3.6	0.5	100.0	3235.38
Coniferous	10.9	33.8	34.9	16.4	3.3	0.7	100.0	500.07
Mixed forests	12.0	34.6	33.3	15.4	3.8	1.0	100.0	461.68
Natural grassland	18.2	36.6	29.1	12.7	2.9	0.4	100.0	1082.94
Moors, heathland	17.3	34.4	31.0	14.0	2.8	0.5	100.0	321.25
Sclerophyllous vegetation	19.3	36.9	27.8	12.8	2.7	0.6	100.0	283.59
Transitional	18.4	36.5	27.7	13.6	3.2	0.6	100.0	673.24
Beaches	14.1	24.3	24.9	22.6	8.8	5.2	100.0	6.10
Bare rock	10.9	26.2	28.2	19.1	9.6	5.9	100.0	7.43
Sparsely	12.6	25.4	29.4	20.7	7.5	4.3	100.0	13.28

The significant presence of agriculture areas on slopes of 10–20° or even 20–30° (formerly broadleaf forests), which are usually on altitudes below 1000 m, cause land degradation and soil erosion. With time, part of that land will be abandoned and transformed to grasslands, pastures, or bare rocks.

6.4.3 Aspects and Land Use

Terrain aspects are also a very significant morphometric element on the high mountains in the Republic of Macedonia, resulting from geotectonic processes and geomorphic evolution. At the same time, these aspects have importance for the intensity of erosion processes, local climate and vegetation, and type of soils, as well as for anthropogenic activities.

Table 6.8 shows large differences in the structure of aspects between mountains from numerous causes: geotectonic and morphological elements, dominant directions of mountains, directions of valleys, position of the border mountains (which is analyzed only for areas in Macedonia), etc. Overall, west aspects dominate, as well as east aspects which is in line to the NW-SE (dinaric) directions of the mountains. Nidže, Kožuf, Osogovo, and Belasica are exceptions because of their E–W directions (consequence of N–S neotectonic extension; Milevski 2006). It is interesting that the largest aspects have lower and longer slopes than the least present, which have much steeper slopes, and vice versa (Milevski 2008).

Aspects have very significant influence on local climate, vegetation, hydrography, soils, and human activities in the space as well as on land use. It is known that at this latitude the north aspects are colder, wetter, with dense vegetation, deeper

Table 6.8 Aspects on the high mountains in the Republic of Macedonia

Mountain	NE	E	SE	S	SW	W	NW	N	Total
Korab	52.1	64.3	50.0	38.5	26.7	15.0	11.7	31.1	289.5
Šara Mt.	109.4	153.7	177.8	140.9	90.0	48.6	46.4	61.9	828.6
Pelister	50.7	54.3	50.0	32.1	40.8	54.9	51.5	62.3	396.6
Jakupica	171.5	181.8	143.0	131.4	160.7	191.9	154.2	138.2	1272.7
Nidže	66.6	42.8	33.0	35.2	54.9	75.4	76.5	75.5	460.0
Galičica	42.8	55.1	35.2	25.9	34.3	74.1	49.5	29.5	346.3
Stogovo	58.9	61.8	52.2	53.7	75.6	63.4	46.3	46.3	458.0
Jablanica	48.9	55.8	33.4	20.8	10.1	6.5	10.8	21.1	207.6
Osogovo	102.7	121.4	112.5	126.2	163.2	147.8	109.6	97.6	981.0
Kožuf	87.1	75.1	43.7	31.9	47.9	89.3	88.2	80.5	543.9
Bistra	93.6	93.2	75.0	67.4	72.0	81.5	79.9	81.1	643.7
Suva Gora	118.4	125.4	131.0	118.1	92.8	93.7	111.4	132.4	923.4
Belasica	27.5	14.9	7.4	11.6	19.1	22.3	26.4	38.4	167.5
Total	1030.3	1099.6	944.1	833.7	888.2	964.4	862.3	895.9	7518.7

Table 6.9 CLC2006 land use by aspects on the high mountains in the Republic of Macedonia

Code	Type\slope	E	S	W	N	P km^2
2–11	Artificial	3.35	4.08	2.17	1.39	11.00
12–22	Agriculture (all)	280.87	269.64	202.71	162.78	916.00
18	Pastures	36.28	41.18	34.29	22.75	134.50
19	Annual crops	8.47	9.58	7.67	5.29	31.00
20	Complex crops	58.78	52.79	37.12	26.12	174.80
21	Land: agriculture	121.65	111.93	79.39	67.97	380.94
22	Broadleaf	888.96	595.57	795.91	954.96	3235.40
23	Coniferous	106.02	87.19	163.32	143.58	500.10
24	Mixed forests	106.80	84.33	141.91	128.66	461.70
25	Natural grassland	357.06	292.72	230.13	203.03	1082.94
26	Moors, heathland	87.39	74.90	86.43	72.53	321.25
27	Sclerophyllous vegetation	84.28	79.78	69.10	50.44	283.59
28	Transitional	203.64	214.60	161.35	93.66	673.24
–	Other	13.93	9.69	8.27	1.57	33.46
	Total	2132.3	1712.5	1861.3	1812.6	7518.7

soils, and less human impact. The opposite occurs on south slopes, where because of intensive human impact severe land degradation and erosion usually occur. However, major types of land use patterns are presented here according to the four main aspects: east, south, west, and north (Table 6.9).

According to the CLC2006 data, artificial and agriculture land use types dominate on south, southeast, and east sides, where is the greatest distribution of population and human activities. For the same reasons, scrubs, especially grasslands, are more present on south aspects (relative to the percent of south areas) and east aspects. In contrast, forests occupy a smaller area on these sides, while these are much extended on north and west aspects. It is clear that human impact has a large influence on land use structure according to the aspects.

6.5 Conclusion

From the presented data, it is apparent that the topography of the high mountains has a large direct or indirect influence on land use. Thus, on lower altitudes with south aspects (with denser population and higher human impact), forests are usually degraded, destroyed, or replaced by cultivated vegetation. Because of that practice, accelerated soil erosion occurs, devastating the landscape. Calculations from the soil erosion map of the Republic of Macedonia (Djordjevic et al. 1993) show a high average soil erosion rate in the region of the high mountains of 724 m^3/km^2/year (786 m^3/km^2/year below 1000 m). Opposite are higher mountain regions, especially those with north aspects and steeper slopes; they are more unsuitable for human activities, which resulted in better preservation of natural areas. However, with infrastructure and transport modernization in recent times, the influence of morphometry on anthropogenic activities slowly decreases, followed by some land use shifting. That effect will become even more pronounced in future when climate change takes effect.

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Chapter 7
Usage of the Mountain Areas in the Republic of Macedonia

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Abstract According to the geomorphological structure of the relief in the Republic of Macedonia, mountain areas (along with the frontiers of displaced villages) cover about 47.6 % of the total area. Almost 25 % of the total number of village settlements in the country are in this territory, but only 9.5 % of the total village population recorded in 2002 in the Republic of Macedonia lives in the mountains. In the past 50 years, there has been a rapid decline of the population in mountain areas. As a result, in 2002, 47 village settlements in the mountains had been displaced, and the population density was barely 10 people per square kilometer (km^2). In favor of this is that in 2002 there had been 1.2 ha arable land per person, which is double in comparison to 1961. The negative usage of farmlands was seen especially in the villages of up to 300 people, with 5.2 ha per person. These villages have mostly single-person and aged households. At the same time, although mountainous areas have conditions to develop other activities, such as mining and various types of tourism, they are not adequately used.

Keywords Mountain areas • Population • Arable land • Usage • Resources

7.1 Introduction

No matter how paradoxical it sounds, there is truth in the claim that mountain areas are so rich and yet so poor. This saying results from the fact that mountain tracts have an abundance of diverse natural resources of regional and state significance, but these resources are not fully used.

To stress the degree of inadequate usage of mountain areas as well as potential possibilities for increased usage, several existing and planned activities that contribute or will contribute for more adequate usage of the areas are described in this chapter. Throughout the chapter, the main landmark for usage is the population, as the human resource is the main driving force in maintaining certain areas. At the

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same time, some other prerequisites for using the space as the corresponding linear and institutional infrastructure are indicated, because the infrastructure equipment can allow the unobstructed flow of the population and provide a comparative advantage in the area for economic activity and revitalization.

7.2 Methodology of Work and Data Sources

In relationship to the classification of the mountainous village settlements, the main indicator that is taken into account is the orography of the area (according to Panov M.1983, 1998).

The villages are examined in the frames of the region, according to NUTS 3 classification and by municipalities, according to the NUTS 4.
The NUTS (or NTES) Nomenclature has 5 levels as follows: (Official Gazette of the Republic of Macedonia No. 158/2007).

– At NUTS level 1 and NTES level 2 the whole territory of the country is one unit
– At NUTS level 3 there are statistical regions (8 units)

The Republic of Macedonia is consisted of eight non administrative units, statistical regions: Vardar, East, Southwest, Southeast, Pelagonia, Polog, Northeast and Skopje region.

– At NUTS level 4 there are municipalities (84 units)
– At NUTS level 5 there are settlements (1776 units)

As a result of the implementation of the Law on Territorial Organisation of the Local Self-Government in the Republic of Macedonia, according to which the municipalities Zajas, Oslomej, Drugovo and Vranestica became part of the municipality Kichevo, the Government of the Republic of Macedonia adopted a Decision amending the Decision on the establishment of the Nomenclature of Territorial Units for Statistics – NTES (“Official Gazette” No. 10 of 20.01.2014). The amendments relate to NTES level 4 and NTES level 5.

For all village settlements, statistical data from the censuses in 1948, 1953, 1961, 1971, 1981, 1994, and 2002 are used.

Because of an unimplemented census in the past 12 years, there are no more recent data of the population to be used. The current annual estimates of the population, regularly published by the SSO of the Republic of Macedonia, concern only the regions and do not allow analysis and allocation of mountain villages. Therefore, comments on current conditions are attached to the immediate knowledge of field research.

7.3 Population as a Precondition for Area Usage

As a result of the powerful and quite intense socioeconomic changes in the last period, with emphasized industrialization and urbanization of the city centers, and large migration movements of the population toward larger, more attractive

Table 7.1 Population numbers in mountain villages

Census year	Population, total	1948 = 100	Chain index
1948	164.937	100	100
1953	176.157	106.8	106.8
1961	149.122	90.4	84.7
1971	128.850	78.1	86.4
1981	104.195	63.2	80.9
1994	83.123	50.4	79.8
2002	74.453	45.1	89.6

Source: Census of the population and households, according to settlements in 1948–2002

Table 7.2 Structure of the total population in mountain areas, according to regions (in %)

Region	1948	1953	1961	1971	1981	1994	2002
Skopje	7.1	7.3	7.1	6.1	6.5	8.2	7.2
Vardar	7.5	7.2	5.6	3.8	2.9	3.5	4.2
Northeast	15.1	15.2	15.7	15.4	11.8	8.9	7.2
East	10.3	10.8	10.6	10.9	9.4	8.8	7.8
Southeast	3.8	3.7	2.3	2.1	2.0	1.8	2.0
Pelagonia	13.6	13.1	13.2	11.9	11.6	5.8	5.6
Southwest	22.2	21.7	22.2	21.4	20.1	21.4	20.2
Polog	20.5	20.9	23.3	28.3	35.6	41.5	45.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Census of the population and households, according to settlements in 1948–2002

settlements located in the lower regions of the country, there are evident changes in the mountain village settlements in the Republic of Macedonia. The main characteristic of their population–geographic development is the change in the number of the population that lives in the settlements in the mountain areas of the country. In just a few decades, villages that were once significantly stronger in population and economic structure have been transformed to settlements of smaller aging populations with impaired economic structure, as well as a number of Apostolovska Toshevska and Madzevic sustainable development (Apostolovska Toshevska and Madzevic 2013). Those unfavorable changes in the development of the settlements were confirmed by the statistics of the censuses of population and households in the second half of the twentieth century, as well as by the numerous scientific studies and fieldwork in the area where the mountain villages are located. From the data presented in the following tables, we can see the dynamics with which the number of the population in the mountain villages has been changing (Tables 7.1 and 7.2).

In 2002, the largest part of the population, or 45.8 %, lived in the region of Polog, followed by the southwest region with 29.2 %. Following all census years, it is obvious that the biggest part of the population in mountain areas was concentrated in the west part of the Republic of Macedonia. At the same time, in contrast to the trend of population decline in mountain villages of other regions, or certain variations in the southwest region, the region of Polog after 1953 records an increase. This increase occurred partly because, in parallel to the decline of the absolute number of village populations in other regions, in the region of Polog the general part of the population was retained as a result of the high population birth rate, mostly consisting of Macedonian Albanians.

The period after World War II was the so-called compensation period when there were no large economic developments in the towns to draw population from the rural surroundings. Immediately after the war, the population numbers in these village settlements increased by 6.8 % in a period of 5 years. In fact, in that period, the number increased to 11,220 people, an average of 2244 people per year. Consequently, a period follows that is characterized by the permanent reduction of the population. As a result, in only 8 years, between 1953 and 1961, these villages had lost more than 27,000 people, an average of 3380 people per year, which decreased the population mass by 15.3 %. This decrease continued in the following period between 1961 and 1971 when a contingent of 20,272 people had resettled, an average of more than 2000 people per year.

In the period of 1971–1981, the greatest changes occurred. The migration process continued with greater intensity, which led to a reduction in the number of people in these villages by 24,655 people or a decrease of one fifth of the population. In subsequent years, because much of the population already moved away from these villages, the decrease proceeded with a somewhat slower pace, but it was still noticeable. Permanent reduction of the population in these villages led, in 2002, to a decrease in the population of nearly 102,000 people, or 57.7 %, in comparison to 1953. This change indicates that, apart from the constant population of the researched villages, the entire population growth was misplaced. In fact, of the various reasons for this happening, the most frequent is that whole households migrated; very seldom did only individual members of a household move.

The illustrated changes in the number of the population are associated with the powerful socioeconomic changes that had taken place in the country, with uneven regional development, neglected development in the rural surroundings, and the insufficient infrastructure and institutional equipment of these villages, as well as many other factors. The situation would have been much worse for this group of mountain villages if it had not been for those several settlements that record an increase in their population. Here, we have higher population growth in villages such as those in the area of Shar Mountain. These changes have led to certain problems, especially the restricted use of the areas and the insufficient use of natural resources.

7.4 Size of Villages According to Population Number

To have a detailed and more complex understanding of the population changes of those villages defined as mountain villages, it is essential to recognize the changes that have happened in their population size. The negative tendency of the number variation of the total population directly reflected the size of the villages according to population number and the coverage of certain population groups of villages.

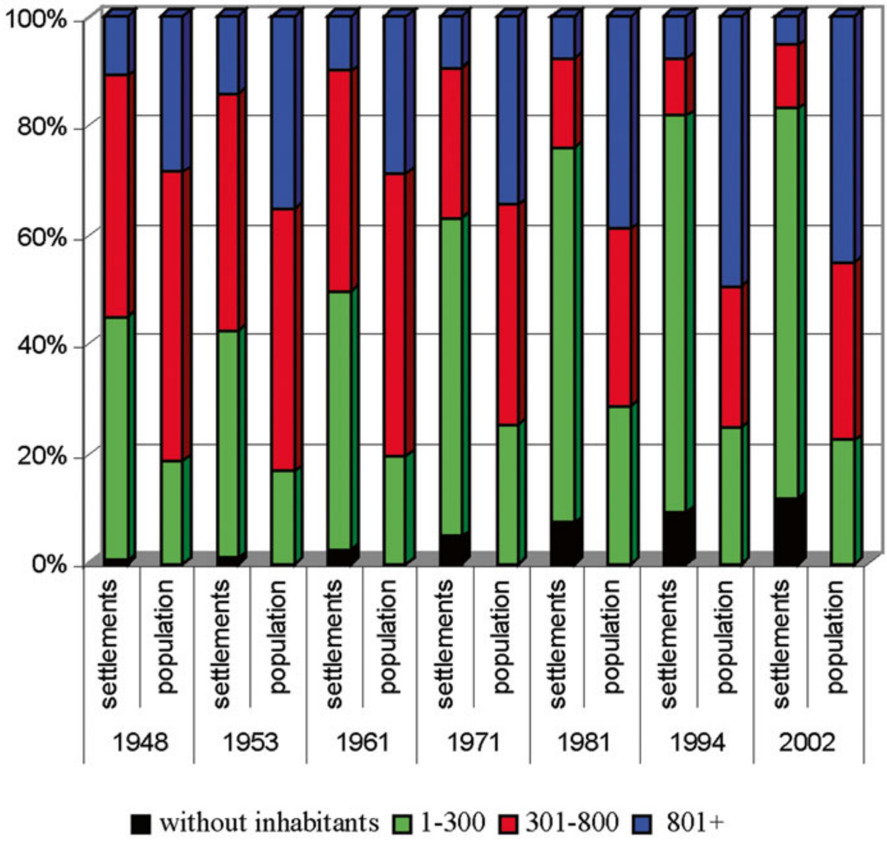

Fig. 7.1 Settlements according to population size

According to the elaborated in detail data, we obtain more information about the current changes. The main change is the one where population reduction of the mountain areas led to reorganization of the villages according to their size and the shift from one group to another.

From the total of 391 villages that are subjects of research, it is evident that dominant villages are those small in population. The villages with a size from 1 to 300 people are most frequent, and their number increased permanently. Therefore, increase by 59.8 % had been noticed in the whole analyzed period. In fact, of 174 villages in 1948, by 2002 that number increased to 278 villages, which represent 71.1 % of the mountain villages (Madzevic and Apostolovska Toshevska 2011) (Fig. 7.1).

Analogous to the changes in number of total population, villages of 1 to 300 inhabitants recorded 46 % reduction in population in the period between 1948 and 2002. Then again, a special characteristic of these villages, in terms of percentages, is the evident increase in the population number that lived in those villages, which varied from 18.8 % in 1948 and 28.7 % in 1981 to less than 25.0 % in the last census. This group of villages is the only one where the average size of the settlements reduced from 179 people in 1948 to 60 people in 2002. This group also includes the smaller villages of up to 100 people. Their participation in the total number of mountain villages increased by 8.2 % in 1948 and 56.3 % in 2002, which shows that half the mountain villages are very small. Only a small part of the population of mountain villages, which is less than one tenth, lives in villages of up to 100 settlers.

Villages of 301 to 800 inhabitants, which are considered as mid-size villages, show a noticeable decline in their number of −73.8 % in the whole analysis period. Their representation on the network of settlements was relatively stable until the 1960s, and they had participated with around two quarters in the total number of mountain villages. Powerful migration processes that had affected these and other villages are the reason for their drop in number, from 107 villages in 1961 to 45 villages in 2002. In that sense, their participation in percentage terms had been decreased from 27.4 % in 1961 to 11.5 % in 2002. In these villages there was a decline in the population number of −72.2 %. The biggest concentration of population was in the average-size mountain villages up until 1971. The average size of these villages rose from 504 people in 1948 to 535 people in 2002.

Villages that have more than 800 inhabitants are categorized in the group of large villages. Their number in the last period halved; in other words, the number decreased from 55 villages in 1953 to 30 villages in the period between 1981 and 1994, and to 21 settlements in the last census. At the same time, there was a 28.8 % reduction in the population that had lived in it in the period between 1948 and 2002. The population number in terms of percentages varied slightly, with 28.6 % in 1953 and 49.3 % in 1994, or 45 % in 2002. From 1981 onward the largest part of the population of the mountain villages has been concentrated in this group of villages. Much of the contribution to that is the participation of the larger villages of more than 800 people, which numbers record some significant oscillations and decrease in the past 30 years, and yet part of the larger villages maintain their population and continue to increase. The villages of more than 800 people record a rise in the number of the population of 1097 people in 1948 to 1560 people in 2002, which is an increase of 45.8 %.

Considering the general relief features and reallocation of mountain areas within the Republic of Macedonia, in terms of different demographic development, specifics are discernible in the spatial distribution of mountain villages, especially those in the group of large villages with more than 800 inhabitants.

Their regional distribution is such that a pronounced concentration in regions where mountainous areas occupy a significant part of the territory of the region. Of 21 large villages, more than half are concentrated in the Polog region, where the slopes of the Mountain Shara and other mountains are formed and have developed a large population settlement.

Most of the larger villages are situated in the Tetovo area, where 11 villages are situated, and next is the Gostivar region with 3 large villages. Another important area with a greater number of large villages in the mountain area of the Southwest region is Debar, where 4 such villages are located. In the other regions are noted

1 or 2 major mountain villages, whereas in the Southeast region such villages are not observed at all.

Among the villages in the mountainous area, although the life conditions are not exactly the best, some are emphasized because of size, counting a large number of residents, according to the 2002 census, ranged from more than 2000 residents (Podgorci, Shipkovica, et al.) to more than 4000 residents, as Gradec, in the Gostivar area.

Another problem of these villages appears to be the lack of institutional infrastructure and equipment and of opportunities for improvement of living conditions.

In such large villages, in terms of the vital population and higher participation of young people of working age, taking into consideration the limited opportunities of the local environment, the question of their inclusion in the labor market can be raised.

A fact of concern about the size of mountain villages is the negative change of the population number, which is followed by the constant increase of the number of displaced villagers. The number of the population of only 2 villages in 1948 increased to 47 settlements in 2002, and they represent 12 % of the total number of mountain settlements.

The presented changes concerning the size of the villages imply the need for resolving the problems related to their development. Demographic problems and unsuitable conditions affect their future population, as well as economic development. Taking into consideration that we are talking about a relatively large number of settlements, and that to all of these belong different resources that are not sufficient and are inadequately used, it is essential to include relevant factors for directing their revitalization and sustainable development.

7.5 Usage of the Areas of Mountain Villages

The largest number of mountain villages occurs in the west part of the Republic of Macedonia, to be precise, in the region of Polog and the Southwest region, which area is around 40 % of the total land of mountain villages. A large number of these villages are spread along the border area; in the future a collaborative interneighbor endeavor for economic development of the mountain tracts should be used as a positive developing predisposition and not as an idiosyncratic handicap along the borders (Table 7.3).

In land structure, the forest areas are predominant with 46.6 %, which represents 32.2 % of the total forest areas in the country. According to the percentile presence of forest, a part of the area is used for the needs of forestry. The work force involved in wood cutting and transportation is from the local region. A good part of the population lives on illegal woodcutting, which is a characteristic of the whole mountain area in the Republic of Macedonia. This chosen existential alternative is certainly not to be supported from the aspect of suitable development of the mountain area and forest, but that kind of existence is provoked by the constant poor policy of economic development of the mountain areas.

Table 7.3 Land structure of mountain villages in the Republic of Macedonia according to regions (in %)

Region	Area	Arable land	Pasturelands	Forest
Polog	20.6	14.2	23.8	14.6
Southwest	19.8	17.5	18.1	22.2
Pelagonia	15.4	18.3	22.2	12.1
Skopje	6.9	8.0	7.4	7.2
Vardar	8.4	5.1	5.4	11.1
Southeast	6.1	2.7	2.9	9.8
East	12.1	13.2	10.8	13.6
Northeast	10.7	20.9	9.5	9.3
Total	100	100	100	100

Source: DGU (1984): Macedonia through Cadastre evidence, Skopje

Although only a few, there are some examples of small productive facilities for primary wood processing (sawmills), as well as for production of wooden packing.

Pastures are involved with nearly one third of the total pasturelands. The largest areas of mountainous pasturelands extend over Shar Mountain, Karadjica, Bistra, and Osogovo Mountains (Milenkovski 1981). These mountains contain almost two thirds of pasturelands below the mountainous areas in the country. According to the size of the pasturelands, next in line are the mountainous areas of Pelister, Korab, and Stogovo. Pastureland nutrition of the livestock, considering the necessary effort and measures (besides being a characteristic of the extensive form of stockbreeding), represents the cheapest way of feeding the livestock. Hence, pasturelands are a suitable predisposition for development of stockbreeding. However, parallel with the continuous decline in the number of livestock fund, and this is especially true for the number of sheep, it is apparent that there is decreased use of the pasturelands. The most intensively used are the areas of Shar Mountain, Korab, Bistra, Osogovo Mountains, and Maleshevo Mountains where the largest number of sheep, 1,500,000, is bred, as was recorded in the last agricultural census in 2007.

Large numbers of sheepfolds are located in these areas, where their characteristic cheese and yellow cheeses (Berovsko, Mariovsko, Galichko) are made. In the past 10 years there has been a positive increase in the breeding of goats. Nonetheless, the records show that stockbreeding in the mountain tracts provides low incomes (cow lactation is no greater than 1200 l per year and sheep lactation is 50 l per year). The low strive for change of agro- and zoo-technical measures, parallel to the decline of the population of the villages, results in diminishing possibilities for optimum usage of pasturelands.

Arable land is involved with only 15 % of the total land (Tables 7.4 and 7.5).

These areas also have possibilities for intensification of orcharding. The areas that are not appropriate for cultivating other crops can be used for the development of orchards. Market demand and the processing industry, as well as the possibilities for export, should be taken into consideration in the structural placement of the orchards.

Generally, the basis for the increase of the income is redirection of this agricultural production, in which everything and anything is now being grown, toward

Table 7.4 Structure of the usage of arable land presented as hectares (ha) farmland per person

Region	1948	1953	1961	1971	1981	1994	2002
Skopje	0.6	0.6	0.7	0.9	1.1	1.1	1.4
Vardar	0.4	0.4	0.6	0.9	1.6	1.6	1.5
Northeast	0.8	0.7	0.8	1.0	1.6	2.6	3.6
East	0.7	0.6	0.8	0.9	1.2	1.7	2.1
Southeast	0.4	0.4	0.7	0.9	1.2	1.6	1.7
Pelagonia	0.8	0.7	0.9	1.1	1.4	3.5	4.1
Southwest	0.4	0.4	0.5	0.6	0.8	0.9	1.1
Polog	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total	0.6	0.5	0.6	0.7	0.9	1.1	1.2

Source: Author's calculations according to DGU (1984): Macedonia through cadastre evidence, Skopje, and census of the population and households according to settlements 1948–2002

Table 7.5 Structure of the usage of arable land presented through hectares (ha) farmland per person in different size settlements

Region	Size of the settlements	1961	2002	Region	Size of the settlements	1961	2002
Pelagonia region	1–300	1.1	5.2	Southwest region	1–300	0.5	3.4
	301–800	0.7	1.1		301–800	0.5	0.4
	800 +	0.9			800 +	0.3	0.1
	Total	0.9	4.1		Total	0.5	1.1
Polog region	1–300	0.4	1.6	Southeast region	1–300	0.8	3.0
	301–800	0.4	0.5		301–800	0.7	0.6
	800 +	0.3	0.2		800 +		
	Total	0.4	0.4		Total	0.7	1.7
Vardar region	1–300	0.8	5.2	East region	1–300	0.8	4.0
	301–800	0.6	0.3		301–800	0.8	1.3
	800 +	0.3	0.1		800 +	0.7	1.1
	Total	0.6	1.5		Total	0.8	2.1
Skopje region	1–300	1.6	4.2	Northeast region	1–300	1.0	4.5
	301–800	0.7	0.9		301–800	0.8	1.9
	800 +	0.6	0.4		800 +	0.9	
	Total	0.7	1.4		Total	0.8	3.6

Source: Author's calculations according to DGU (1984): Macedonia through cadastre evidence, Skopje, and census of the population and households according to settlements 1961–2002

agriculture that will agree with market demands. The main point should be directed toward finding adequate solutions for better placement on the market. Some products may have to be left out, and new ones, that are suitable for the new market demands, should be introduced. Although agriculture in the mountain areas provides low income, it is wrong to believe that the situation will improve only by providing means for the community. Instead, the solution should be found in the possibilities of interrelationships and help from the other areas based on mutual interest, considering that there is a need for these to complement and link each other. (Azderski et al. 2003). Of course, the social factors and the whole community need to be involved in this, but the intervention of the community is of secondary importance.

In agreement with the country policy, in past years there has been striving for development of small businesses, for starting your own business and self-employment. Parts of these initiatives are being realized within the village boundaries. Although some have seasonal character, they are still of great importance for the sustainable development of the area. Examples of that are the already existing drying rooms for wild berries, drying rooms for mushrooms of local geographic origin, and the participation of the local population in the gathering of these wild berries and mushrooms. According to data from field research, whole families from the villages below Shara Mountain, the villages of Osogovo Mountain, and the mountainside of Jakupica, exist on the gathering of mushrooms, wild berries, and remedial plants.

Large mine resources are concentrated in the mountain areas and for that reason mining is existent in the villages. An example is the boundaries of the village Sasa in the Osogovo Mounatins (where there is a lead and zinc mine), as well as the surroundings of Rzhanovo where there is nickel and iron ore. These natural resources are the foundations of ferrous and nonferrous metallurgy in the Republic of Macedonia. Here we also mention the abundance in the mountainous tract of Kohzuf where the mine Alshar is located and where the rare loran can be found.

Mountain areas are the only expanses that have better water potentials. Very often, these are captured as the water supply of the local population as well as the population in the surrounding areas. Large numbers of rivers abound in hydroelectric power potential, but this potential is used minimally. Around 100 big springs are registered on Shar Mountain, among which is Vrutok with a lavish 1500 l/s. Also, there are about around 20 large mountain rivers, flowing in fast and clear watercourses. The largest are Pena, Mazdrcha, Leshochka River, Tearchanka, Bistrica, and others. A characteristic for Pelister are the 23 rivers with a total length of 212 km, which are abundant with trout, etc. (Stojmilov 2003). Some of these mountain rivers are used as fishponds for raising trout and carp. One part associates this activity with catering, which accentuates the attractiveness of the area, and the income is significantly higher (e.g., the fish pond in the village Nezhilovo, on the upper flow of the River Babuna) (Madzevik and Apostolovska Toshevska 2007).

Tourism as a peculiar form of usage of the rural area, although outwardly unpretentious, is slowly being enlivened. This usage of mountain areas highlights the possibility of usage of natural and anthropogenic tourist motives. The possibility for usage that is based on the development of many types of tourism, such as village inns, eco-tourism, sports, and hunting (mountain hunting grounds at Osogovo, Bistra, and Shar Mountain) and fishing tourism, should be especially emphasized, as well as the opportunities for mountain climbing, alpinism, etc. Furthermore, using tourism for promoting areas where healthy food is produced, where the positive experiences of the Beluno region should be taken into consideration and a so-called cheese road should be created. “This project has included vertical structures, from mountain grassland and cattle pasturing to producers on village estate," (Šiljkovič 2013). At the same time, it should be followed up by village manifestations and folk traditions, creating of ethno-parks, etc. In some villages in the Republic of Macedonia certain celebrations have taken place for a long time, such as the Galichka wedding in the village of Galichnik, on 12 July each year, on St. Peter's Day; also there are manifestations in Gari and Lazaropole. Churches and monasteries built seven, eight, or more centuries ago also favor of tourism. Especially distinguishable are the monastery above the village of Matejche (1005 m), the monastery St. Prechista on the hillside of Vrvoj (920 m), St. Joakim Osogovski at the Osogovo Mountains (825 m), St. Preobrazdenie in Krushevo (1500 m), and others. In these monasteries there are lodgings in which guests can stay overnight (Panov N. 1998)

Specially organized types of usage of the mountain areas are the national parks (Pelister, Mavrovo, and Galichica), as well as some nature reserves (e.g., Jasen), which provide opportunities for the development of different types of tourism.

To have even better exploitation, mountain areas should be used for educational purposes. The idea is to place educational centers and natural laboratories designed for students of different ages in certain mountain areas that abound with prominent characteristic natural geographic elements.

Of course, all these features can be put into operation on sustainable development in mountain villages only if there is an adequate transport infrastructure, because "The traffic infrastructure has an important vital function in the purpose of rational territorial integration of all activities and contents in the area," (Stojmenov et al. 1998). It is an important factor in sizing of the spatial framework for all activities in the economic and geographic development. An adequate infrastructure enables the use of natural resources, exchange of goods between the settlements and wider territorial mobility of the population, with opportunities for information and innovation penetration, and enables sustainable economic development, economic benefits, and improvement in the investment climate, increases the competitiveness of the area to develop certain economic activities more than other areas, and increases the number of jobs, improving the quality of life. The extent of the development, as well as spatial and temporal consistency, is a reliable indicator of the entire local economic-geographic development of the village settlements. Therefore, the displacement of the location of certain village settlements near roads as a significant attractive economic, developing, and social element is clear (Apostolovska Toshevska and Iliev 2013). The general impression is that efforts for better organization of the local road network occurred later, at the same time when the villages were weakened in numbers of population and were unable to respond to current challenges and opportunities for economic development on a larger scale. Even under present conditions, in some of the large mountain villages located at high altitude, such as in the Skopje region, despite the relative proximity of the city, poor road connectivity is one of the main obstacles to proper utilization of the potential of the space and opportunity for development of socioeconomic sustainable development. Despite the fact that activities in the planning of the traffic infrastructure took place late, the positive effects of the improved traffic infrastructure were certainly not left out. More precisely, paving of roads, especially in the upper course of River Babuna (to the villages Oreshe, Papradishte, and Nezilovo) was crucial for promoting certain forms of tourism based on a series of natural tourism attributes that were the reason for construction of accommodation facilities and tourist activation of the area (Apostolovska Toshevska and Iliev 2013).

Also, there is a limitation of infrastructural facilities that would have importance in the development of populated areas, as, for example, the lack of sewage systems, agricultural cooperatives, purchasing points, and health facilities.

A special problem occurs in areas where, according to the area configuration, a disrupted type of villages developed, mainly in the Osogovo region, whose physical infrastructure design and modeling is significantly difficult.

However, for almost all mountain villages, it is a fact that "population in mountain areas is distant from the centre of political power and does not represent the critical mass important for political parties and government" (SARD, 2004 through Šiljkovič Ž 2013). Therefore, the need of a different territorial organization that will provide economic empowerment of certain rural centers and their economically revitalizing effect on marginal mountain areas and populations is necessary.

7.6 Conclusion

For a period of more than 60 years, significant reduction of the population in mountainous areas has been typical, mostly because of inability to maintain the population and to secure it economically. One cause is the inadequate infrastructure and its inability to be competitive to all opportunities and economic challenges offered by cities during rapid industrial development. At the same time, it does not provide equal development opportunities and benefits for living for the existing population, which when correlated with economic insecurity is a strong argument for continued migration.

From all the foregoing points, we perceive usage of mountain areas is far from optimal. One of the measures that would be considered prolific is a stimulating tax policy and infrastructural adjustment of the area. This kind of investment by the state would be minimal in comparison to the positive effects that are likely to be achieved. First of all, the area is being established as attractive for investment, primarily for the development of agriculture and tourism. The area becomes attractive for the young population, which, if unemployed, in the Republic of Macedonia may secure their existence. The natural production is oriented toward market production, which results in higher income, and the higher income is a precondition for a bigger investment. In that way, conditions for further self-revitalization and economic strengthening of the area are being created.

The effects of efforts for rural businesses remain to be seen, which, of course, is an opportunity for greater utilization of resources in mountainous areas.

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Chapter 8
Physical Geographic Characteristics and Sustainable Development of the Mountain Area in Montenegro

Predrag Djurović and Mirela Djurović

Abstract Montenegro is located in the Balkan Penninsula, which is extremely mountainous country. More than two thirds of the total area is mountainous. There are four macro relief units in the mountain area: mountain plains, valleys (canyons and gorges), basins, and mountains. A very dynamic physical geographic basis (geology, geomorphology, climate, hydrology) enabled the diversity and rich natural potential resorts to be formed in the mountain area in Montenegro. In the past 50 years, new industries have appeared: mining, metallurgy, energy production, traffic, and tourism, and their development has led to endangered, devastated, and polluted environments in the mountain area of Montenegro.

Keywords Mountain area • Physical geography • Relief • Sustainable development • Montenegro

8.1 Introduction

Montenegro occupies the southwestern part of the Balkan Peninsula. Although Mediterranean, it is mostly a mountainous country. The land portion includes 13,812 km^2, and that under the sea is 4800 km^2. Montenegro extends in meridian line approximately 200 km (between latitudes 41°39′ and 43°44′N), and the distance between the easternmost and the westernmost point is 173 km (between longitudes 18°26′ and 20°21′E) (Radojičić 1996). The recently conducted census in 2011 showed a population of 620,029 in Montenegro, which currently encompasses 23 municipalities, each of which is partly mountainous.

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8.2 Borders and Division of the Mountain Terrain

Determination of boundaries in the mountain area is a very difficult and complex procedure (Rasemann et al. 2004) because various qualitative and quantitative criteria have been used in their definition. Quantitative (hypsometric) criteria rely on relief and its elevation (Zevenbergen and Thore 1987), the simplest and the most applicable method. Additional criteria, besides absolute height, include slope angle, relative height, etc. (Barsch and Caine 1984).

According to the accepted division of relief based on elevation in the given part of southwestern Europe (Mladenović 1984), the altitude of 500 m a.s.l. is established as the lower boundary of the mountain area in Montenegro. The influence of Mediterranean climate is strong, also affecting the hinterland. Consequently, some mountainous regions that display such mild climate and corresponding biogeography could not be classified as mountains. However, in spite of a possible although small inconsistency, the mountain area in Montenegro is assigned to the region above 500 m a.s.l. (Table 8.1).

The mountain area encloses the largest part of Montenegro. Regions above 500 m a.s.l. include 83.8 % of the total area of this country, that is, 11,596 km^2. Division of the mountain area is based on hypsometric, climate, geomorphological, and biogeographical characteristics.

The mountain area is divided into three elevation regions. The lower mountain region (500–1000 m a.s.l.) occupies 32.4 % of the total mountain area and has the most appropriate climate, floral diversity, and highest population density. The mid-mountain region (1000–1500 m a.s.l.) includes 46.4 % of the total mountain area. Climate and relief in this area are unsuitable although its upper boundary represents the boundary of habitation and continual forest extent. The high mountain region (exceeding 1500 m a.s.l.) as regards climate, relief, flora, etc. is the most limited region; it covers 21.2 % of the total mountain area in Montenegro.

The biggest part of Montenegro is mountainous, excluding the narrow coastal area, Skadar Lake basin, and the Zetsko-bjelopavlićka plain (Fig. 8.1). Within the mountainous area have been distinguished four macro relief units: mountain plains, valleys (canyons and gorges), basins, and mountains.

Table 8.1 Elevation regions in the mountain area (Mladenović 1984)

Elevation region	Spatial area (km^2)	Percent (%)
0–200 plains	1425	10.4
200–500 hills	791	5.8
500–1000 lower mountain regions	3763	27.1
1000–1500 mid-mountain regions	5378	38.9
>1500 high mountain regions	2455	17.8
Total	13,812	100

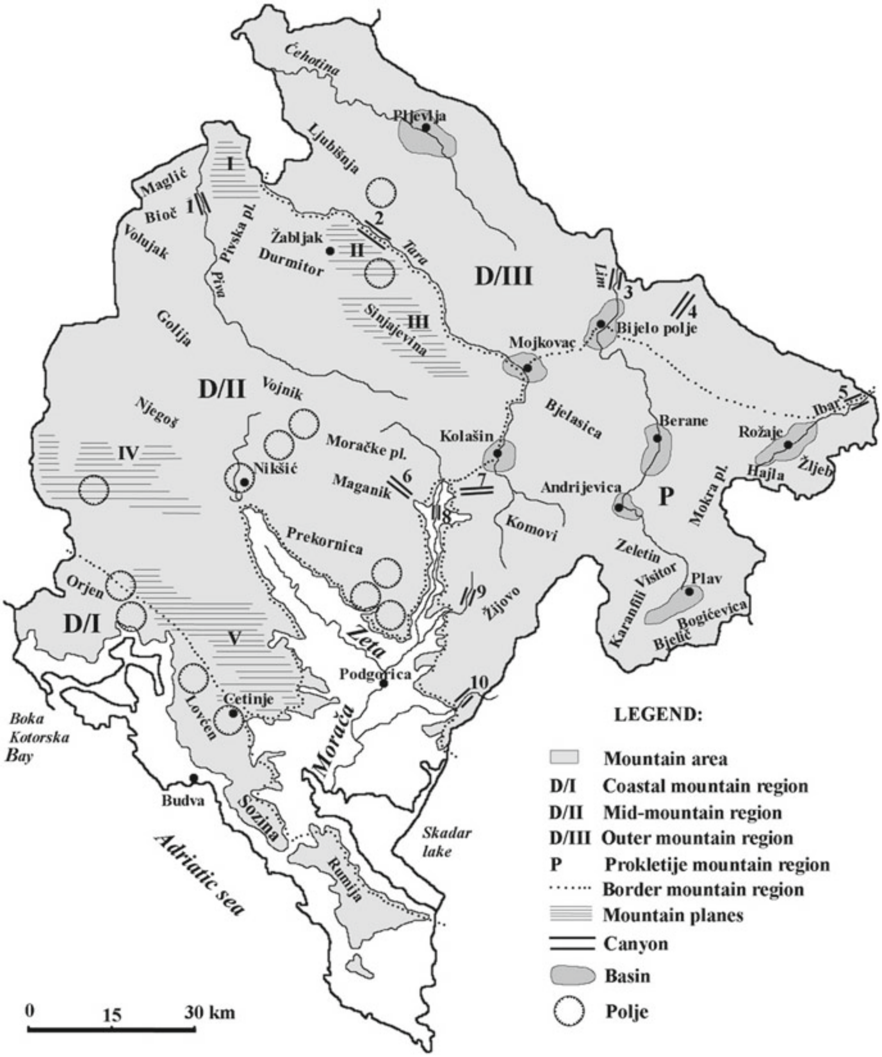

Fig. 8.1 Relief units of mountain area

Mountain plains are parts of the mountain area that formed in the very early geomorphological past. They occur at different elevations, from 700 m a.s.l. (Katunska plain between the Bay of Boka Kotorska and Podgorička ravine), above 1200 m a.s.l. (plain of Sinjajevina between Durmitor and Bjelasica and Pivska plain above the Piva canyon), to 1450 m a.s.l. (Jezerska plain surrounding Durmitor, etc.). They were created under fluvial-denudation processes that took part during a long and, regarding tectonics, a peaceful period since Miocene to Pliocene (Cvijić 1926).

Plains are, as a rule, intensively karstified and represent suitable area for holokarst to be developed.

Valleys are steeply incised into the mountain area in Montenegro. The least number of valleys is in areas composed of carbonate rocks. Here they are commonly very deep and narrow, considered to be canyons. Valleys are more abundant, considerably wider, and with alluvial plains transiting sporadically into basins, particularly in areas of noncarbonate rocks.

There are many quite long and very deep canyons in the mountain area in Montenegro (Table 8.2). Some of them exceed 1000 m in depth. Various characteristics of river courses and their changes during longer periods of time have influenced the formation of three types of canyons: canyons formed directly by glacial, meltwater streams; canyons formed by river courses with glacial-nival regime; and canyons formed by torrent streams (Djurović and Petrović 2007).

Basins are located in the mountain area composed of rocks other than carbonate. Basins occur along river flows separating gorges. These are the most fertile parts of the mountain area, with a mild climate. They are intensively inhabited for reasons of the broadest agricultural fields and the best traffic infrastructure. The most important basins are in the valleys of these rivers: Lim: Gusinjsko-plavska (about 900 m a.s.l.), Andrijevica (about 740 m a.s.l.), Berane (at approximately 660 m a.s.l.), Bijelo Polje (at about 560 m a.s.l.); Ibar: Rožaje (at about 990 m a.s.l.); Tara: Kolašin (at 940 m a.s.l.), Mojkovac (at about 790 m a.s.l.); and Ćehotina: Pljevalja (at about 760 m a.s.l.).

Different geologic backgrounds, intensive and long-lasting tectonic movements, and diverse geomorphological evolution of the mountain area resulted in formation of numerous and various mountains. Mountains in Montenegro are included in two extensive mountain ranges: the Dinaric Alps and Prokletije. Their boundary is yet unclear. Investigations conducted at the end of the nineteenth century (Cvijić 1899), along with later research (Bošnjak 1938; Milojević 1937; Bešić et al. 1985; Lakušić et al. 1985; Petrović 1985) indicated and confirmed the individuality of Prokletije as an independent mountain range. It stretches almost perpendicular to the direction of the Dinaric Alps and displays different geologic (diversity and age of rocks) and

Table 8.2 The most significant canyons in Montenegro

Number	Name of the canyon	River	Length (m)	Depth (m)
1	Piva canyon	Piva	31,240	1034
2	Tara canyon	Tara	79,400	1341
3	Lim canyon	Lim	3005	517
4	Djalovića canyon	Bistrica	8520	627
5	Ibar canyon	Ibar	7100	151
6	Mrtvica canyon	Mrtvica	6667	1247
7	Kruševački potok canyon	Kruševački potok	4400	1008
8	Morača canyon	Morača	31,676	1168
9	Mala Rijeka canyon	Mala Rijeka	11,391	814
10	Cijevna canyon	Cijevna	12,400	903

geomorphological features. Additionally, different floral-vegetation species and its general ecological diversity distinguish Prokletije Mt. as the distinct mountain system at the Balkan Peninsula. Prokletije is located between the Dinaric Alps in the northwest, the Šar-Pindus system on the east, and the Skadar basin in the southeast; the Kosovo-Metohija basin borders it on the northeast.

According to geologic, climate, and relief differences, in the Dinaric Alps in Montenegro were distinguished three mountain regions: coastal, middle, and outer (Fig. 8.1).

The coastal mountain region (Fig. 8.2) stretches, as do the Dinaric Alps (NW–SE), as a narrow belt parallel to the coastline. Mountains rise abruptly from sea level as rocky cliffs reaching from a few hundred meters to 1000 m in altitude. This mountain region extends from the border with Bosnia and Herzegovina to the valley of River Bojana and is about 100 km long. The region varies in width from 10 to 20 km, including several mountains: Orjen (1894 m a.s.l.), Lovćen (1749 m a.s.l.), Sozina (780 m a.s.l.), and Rumija (1594 m a.s.l.). Its northeastern part meets the mid-mountain region.

The mid-mountain region (Fig. 8.3) includes the central part of Montenegro between the coastal and the outer region, from the border with Bosnia and Herzegovina to Podgorička basin and the valley of River Morača, which separates it from the Prokletije mountain range. It stretches as do the Dinaric Alps. The broad-

Fig. 8.2 The coastal mountain region: (**a**) Cetinjsko polje, (**b**) Njeguško polje, (**c**) rural architecture, (**d**) tourist center on Mt. Lovćenu (Photographs by P. Djurović)

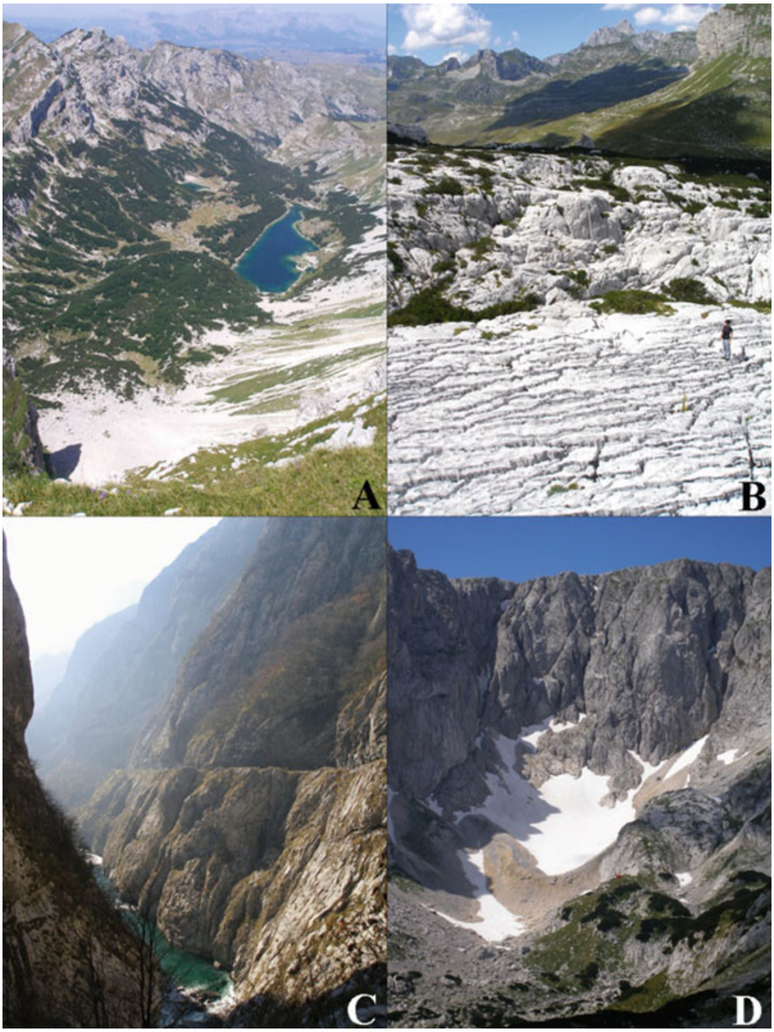

Fig. 8.3 The mid-mountain region: (**a**) glacial relief on Durmitor Mt., (**b**) high mountain karst on Durmitor Mt., (**c**) the River Morača canyon, (**d**) the Debeli Namet glacier (Photographs by P. Djurović)

est mountain region, it includes mountains that rise from old Mio-Pliocene plains and has been referred to by Cvijić as the region of "plains and hills"(Cvijić 1926). It is dominantly built of carbonate rocks that support intensive karst processes with features of holokarst. Mountains in this region are Prekornica (1927 m a.s.l.), Maganik (2139 m a.s.l.), Vojnik (1998 m a.s.l.), Sinjajevina (2277 m a.s.l.), Golija (1935 m a.s.l.), and Durmitor (2523 m a.s.l.). Deeply incised canyons occur sporadically (such as Tara, Mrtvica, Morača, Komarnica, and Piva).

The outer mountain region encloses the region from the River Tara Canyon to the border of Montenegro and Serbia, and from the border with Bosnia and Herzegovina to the Bijelo Polje basin and the River Ibar canyon. The most remarkable mountain in this region is Ljubišnja (2238 m a.s.l.); the others are of moderate height (about 1500 m a.s.l.). The valley of River Ćehotina is a remarkable fluvial form in this region; here is located Pljevlja's basin.

The Prokletije mountain range (Fig. 8.4) in Montenegro encloses the region between the River Morača canyon, Kolašin and Mojkovac basin, Bijelo Polje basin, and the River Ibar canyon to the border of Montenegro with Albania. The River Lim valley divides this region into two parts. The northwestern part consists of mountains: Žijovo (2131 m a.s.l.), Komovi (2487 m a.s.l.), Visitor (2211 m a.s.l.), and Bjelasica (2139 m a.s.l.), and the southeastern part comprises Karanfili (2119 m a.s.l.), Bjelič (2556 m a.s.l.), Bogićevica (2374 m a.s.l.), Zeletin (2126 m a.s.l.), Mokra planina (1968 m a.s.l.), Hajla (2403 m a.s.l.), and Žljeb (2356 m a.s.l.).

Fig. 8.4 The Prokletije mountain region: (**a**) Lake Hridsko, (**b**) the Skakavac waterfall, (**c**) Komovi Mt., (**d**) Kotlovi on Karanfili Mt. (Photographs by P. Djurović)

8.3 Geologic Background

The geologic background of the mountain area in Montenegro is complex. Some parts are dominantly built of carbonate complexes and others are built of noncarbonate rocks. These differences have had, and still have, significant influence on geomorphological processes and the type of relief. The mountain area in Montenegro mostly contains different rocks of Mesozoic age. Cenozoic rocks are less abundant, and rocks of Paleozoic age occur only sporadically. In the sense of petrology, carbonate rocks dominate (limestone and dolomite); clastic sedimentary rocks (sandstone) and schists are less abundant, and igneous rocks (andesite, dacite) occur sporadically (Radojičić 1996).

The Dinaric Alps mountain range is mostly built of rocks of Mesozoic age (Bešić 1975, 1980, 1983). The lowest levels of the coastal mountain region are of Cretaceous-Eocene rocks (flysch, limestone), and its medium level and the highest parts are of Mesozoic limestones. Limestones range in thickness from a few hundred meters to more than 1500 m. Mesozoic carbonate rocks (limestone and notably less abundant dolomite) dominate in the mid-mountain region, exceeding 2000 m in thickness. Carbonate complex has been cut in places (thrust sheets zone) by narrow and long belts of Paleogene flysch. Igneous rocks are exposed sporadically, commonly in the piedmont of mountains (e.g., Sinjajevina, Durmitor, Volujak, Pivska planina). The outer mountain zone comprises rocks of various age and composition. Carbonate rocks are not exposed as much as in the previous two zones. They are still abundant, but the very large, wide complexes are lacking. Limestone outcrops exceed 1000 m only locally (proximity of the River Tara canyon). The alternation of carbonate and noncarbonate complexes is common (“mosaic structure”). The latter includes Triassic sandstones, andesite and dacite, Paleozoic schists and sandstones, as well as Neogene sediments. In the southeastern parts of this region (toward the Prokletije mountain range) occur larger complexes of Permian sandstones, schists, and marlstones.

The Prokletije mountain system is the most diverse mountain area in Montenegro as regards geology. Mountains are largely built from rocks other than Mesozoic carbonate rocks. In most of the mountains, carbonate rocks build their highest levels (Bjelasica, Komovi, Visitor). Marginal parts of mountains are composed of Jurassic schists, diabase, and marlstone together with Triassic dacite, andesite, and tuffs. Carbonate rocks vary in width, but in the most cases attain a few hundred meters. Hence, they are not wide as in the mountains in the Dinaric Alps. The Bjelič Mt. is prominent with the noteworthy thickness (1000–1500 m) of the dominant carbonate rocks. Recall the mountains, which lack carbonate rocks: Greben 2196 m a.s.l., with Jurassic schists, diabase, and marlstone with Triassic dacite, andesite, and tuffs, and Bogićevica from Paleozoic phyllite, and Permian–Triassic conglomerate.

8.4 Climate Conditions

The mountain area in Montenegro exhibits extraordinary climate diversity as the consequence of variable elevation, distance from the sea, and desiccation of the mountain area. It has not been uniformly monitored instrumentally. Monitoring takes place up to about 1500 m a.s.l.; thus, the higher elevations require calculations and various modeling.

The greatest importance for air temperature differences is the difference in elevation, reaching almost 2000 m (from the lowermost point to the highest summit). In Žabljak meteorological station (eastern foothill of the Durmitor Mt., 1450 m a.s.l.), the average annual temperature of 4.6 °C for the period 1961–1990 of 4.7 °C was determined (Djurović 1996, 2011; Burić et al. 2011, 2012). The average annual temperature of the air has been decreasing since 1960 until the end of 1970 and at the beginning of the 1980s when the lowest value of 3.7 °C was recorded (Djurović 2011). Since then, an increasing trend of average annual temperature has occurred. Within the period of instrumental measuring (1958–2014), the average annual temperature reached a maximum of 7.1 °C in 2014 (Republic Hydro-meteorological Service of Montenegro).

The average annual temperature of air for the high mountain elevations in the Durmitor Mountain was established in terms of their vertical temperature gradients during 1958 to 1993 (Djurović 2011). Such value obtained at 2050 m a.s.l. altitude is 1.6 °C, and for 2550 m a.s.l. is 0.1 °C (Djurović 2011). The average annual temperature of air at other higher elevations of the mountain area in Montenegro has also been calculated.

Annual precipitation rate for the whole Montenegro is approximately 1798 mm/year; during winter (October–March) it is 1223 mm (68 %), and in summer (April–September) it is 575 mm (32 %). The absolute value for average precipitation in Montenegro is $24{,}834 \times 10^6$ m^3/year (Radojičić 1996).

The annual amount of precipitation in mountain areas is significantly influenced by the distance from the sea, elevation, and orography. Lack of precipitation stations at higher elevations also caused problems in this region. Therefore, the average precipitation at elevations exceeding 1500 m was calculated concerning the precipitation coefficient. The highest annual precipitation rates occur in mountain regions that are nearest to the Adriatic Sea.

In the coastal mountain region of the Dinaric Alps is recorded an annual precipitation of 4604 mm (1961–1990) on Crkvice (937 m a.s.l.) (Krivošije). The highest annual precipitation rate, 7067 mm, was recorded in 1979 (Republic Hydro-meteorological Service of Montenegro). In the same period, Cetinje (640 m a.s.l.) received 3236 mm (Burić et al. 2012).

An average annual precipitation rate of 1453 mm (1958–1993), that is, 1473 mm (1961–1990), has been instrumentally determined at the meteorological station Žabljak (Djurović 1996, 2011; Burić et al. 2012). According to results obtained in 11 stations (located from 446 m a.s.l. to 1450 m a.s.l.) the precipitation gradient was calculated, and afterward, an isohyetal map based on it was prepared for Durmitor.

This map indicated annual precipitation from 2200 to maximally 2600 mm in the highest elevations on the Durmitor Mt. (Djurović 2012).

The largest distance from the sea and the highest elevations of mountains exposed between the outer mountain region and the Adriatic Sea caused the lowest annual precipitation. In the Pljevlja basin (784 m a.s.l.) annual precipitation is 802 mm (1961–1990), whereas in the Cetinjsko polje (640 m a.s.l.) synchronous precipitation is 3236 mm.

The mountainous region in the Prokletije mountain range, for the same reasons, has a lower precipitation rate despite the highest altitudes. Annual precipitation in the Bijelo Polje basin (606 m a.s.l.) is 908 mm and 1985 mm in Nikšićko polje (647 m a.s.l.). Average annual precipitation ranges from 1000 to 1400 mm (Burić et al. 2012).

8.5 Hydrologic Characteristics

The hydrologic characteristics of the mountain area in Montenegro are complex and include numerous hydrologic events. Such characteristics arose from the geologic background, climate differences, and relief features.

The coastal mountain region is lacking in big rivers. A small number of river flows discharge directly into the Adriatic Sea or the Skadar Lake. High slopes give a torrential character to water flows, whereas the carbonate basement slows water to be retained during the year. Disappearing rivers occur sporadically in karst poljes (Grahovsko, Dragaljsko, Njeguško, and Cetinjsko).

Rivers from the mid-mountain region empty into two sea drainage basins: Adriatic (Morača with Zeta) and the Black Sea (Tara and Piva). The mean annual discharge of the River Morača (1961–2001) was 156 m^3/s (from 95 m^3/s in 1983 to 255 m^3/s in 1979) (Knežević 2009). The mean annual discharge of the River Piva is 75 m^3/s, and that of Tara 79 m^3 (Prohaska et al. 2004). Specific spatial distribution of carbonate rocks causes the lack of surface flows and the domination of underground flows. The powerful karst springs Vukovo vrelo, Vidrovana, Gornjepoljski vir (Nikšićko polje), Ljutica (Canyon Tara), and Pivsko (about 20 m^3/s; Canyon of Piva) emerge in such areas (Prohaska et al. 2004). Hydrologic curiosities include intermittent springs (Vidov potok, Šavnička glava, and Zaslapnica), as well as estavelles (Gornjopoljski vir).

Lakes in mountain area were formed either inside the Pleistocene cirques (Lake Manito jezero on the Moračke mountains, Trnovačko Lake in the base of the Volujak Mt. and Bioč, Jablan Lake, Zeleni vir, Veliko and Malo Škrčko Lake on Mount Durmitor, etc.) or in glacier valleys (Crno, Modro, Valovito, and Zminje Lake on Mount Durmitor, Veliko and Malo Stabanjsko Lake on the Bioč, Kapetanovo Lake on the Moračke mountains, etc.) (Stanković 1975). Artificial lakes were formed by dams in river valleys (such as Pivsko Lake in the River Piva canyon: the dam is 220 m in height and volume is 800 million m^3) (Prohaska et al. 2004), or in karst poljes (Lakes Krupac, Slano, and Vrtac in Nikšićko polje). The most distinctive property of this area is the existence of the Debeli Namet glacier (Djurović 1996, 2012; Hughes 2007, 2008). It is situated on the Durmitor Mt., at elevations from 2050 to 2150 m a.s.l., and covers an area of 1.8 to 2.6 ha.

In the outer mountain region are most of the water draining rivers: Ćehotina (average annual discharge, 18 m^3) (Prohaska et al. 2004) and Tara, and to a lesser extent the River Lim. When compared with the two previous regions, as the consequence of less exposed carbonate rocks, the river catchments are better developed. Otilovića Lake was formed by enclosing the valley of the River Ćehotina for the purpose of of thermoelectric power ("Pljevlja").

River catchments are better developed in the Prokletije mountain range than in the Dinaric Alps. The Rivers Lim (average annual discharge, 112 m^3/s) and Ibar drain into the Black Sea and the River Cijevna empties into the Adriatic Sea. Powerful springs create the Rivers Vruja (Alipašini springs) and Ibar (Glava Ibra). Not less powerful springs come from caves (Glava Bistrice) (Djurović and Lješević 1994). Glacial lakes on the Prokletije Mt. include Ridsko, Ropojansko, and Rikavičko. Lakes form in basins left by accumulation of glacial material; such are Plavsko (the largest lake in the mountain area of Montenegro, ~2 km^2) and Biogradsko Lakes.

8.6 Geomorphological Characteristics

The relief in the mountain area in Montenegro has been created from different geologic backgrounds and under different climate impacts. Karst processes dominate in the largest area, and fluvial processes are important in terrains composed of non-carbonate rocks. The area above 1800 m a.s.l. is under the influence of cryo-nivation processes (Milivojević and Djurović 2010). In the mountain area, preserved forms of Pleistocene glacial relief remain. They are presented in terms of their genesis instead of their location within a certain mountain region with the aim of better insight.

Karst relief in mountain area is well developed and is represented by surface as well as underground karst landforms. The former includes from the smallest (kamenitze) to the largest (polje) forms. Kamenitzes with diameter exceeding 2 m are found on the Durmitor Mt. (Bolj) at about 1800 m a.s.l. (Djurović 1996). Widespread karrens often reveal impassable terrains; the most remarkable karrens are on the Orjen, Lovćen, Durmitor (Bolj), Maganik, and Bjelič mountains. The most abundant karst forms are sinkholes, found at different elevations, displaying a variety of forms and sizes. They are referred to as limestone pavement when densely clustered (Pivska Mountain, Komarnica). Uvalas are also very common. Their bottoms, covered by sediments, make them larger agricultural karst surfaces. Most frequently they represent karstified dolinas, whereas those at higher elevations represent transformed Pleistocene cirques and glacier valleys (Djurović 2011; Djurović et al. 2010). Karst pedestals are characteristic for this region. According to results obtained during their research on the Durmitor (Bolj), a decrease of spatial distribution of limestones of 0.014 mm per year was deduced (Djurović and Djurović 2011).

The majority of poljes are located in the mountain area. They are, excluding Nikšićko polje, of small dimensions. The most frequent are in the River Zeta watershed. Their bottoms are flattened and covered with gravelly-sandy sediments. Pleistocene glaciation is the most responsible for such patterns. Glaciers advanced until certain poljes and deposited moraines: Dragaljsko, Njeguško, Ivanjsko, Drobnjačko (Menković and Djurović 1993). Most poljes survived the shrinking of bottoms during retransporting moraine material from poljes from higher elevations into the lower ones (Lukovsko, Nikšićko). Accumulation was not so significant where the influence of glaciation was not prominent (Velimsko polje) or was related to fluvial processes (Bitinsko polje). Significant amounts of sediments and water caused certain poljes to be flooded (Nikšićko, Dragaljsko, Grahovsko, etc.).

Underground karst relief includes a few thousand caves, with some reaching the depth of a few hundred meters. They vary in shape, dimension, and origin. In the mountain area, vertical objects dominate and horizontal formations are less abundant. The significant thickness of limestone, along with tectonic susceptibility, deep canyons, large amounts of precipitation, and Pleistocene glaciation, created ideal conditions for cave formation. Caves at lower elevations were formed by past rivers that represented surface flows before karstification (Jama Duboki do, the River Njeguška; cave Lipska pećina, the River Cetinjska (Djurovic et al. 2002). The deepest cave, Iron Cave on Maganik, is 1162 m deep.

Fluvial relief in the mountain area is represented by different dolines. The deepest canyons are in regions built of carbonate rocks. Such canyons were incised by allothigenous flows that come from non-carbonaceous water-rich terrain. In such regions dolines are shallower, but more abundant and diverse. Huge accumulations of fluvial material apart from the erosion landforms should be mentioned. These materials were deposited in basins (reaching in thickness a few tens of meters: Andrijevica, Berane, Bijelo Polje, etc.) in which the rivers have incised two series of terraces. Accumulation of fluvial material also occurred in the canyons themselves (up to 120 m thick: canyons of Tara, Morača).

Periglacial relief is developed only in the highest parts in the mountain area, that is, above 1800 m a.s.l. (Milivojević and Djurović 2010). The arc ridges, the protalus rampart, forms by rock falls that are produced by long-retained snow on carbonate material, whereas rock glaciers form in non-carbonate rocks.

Pleistocene glacial relief is well preserved (Cvijić 1903; Djurović 2009; Stepišnik and Žebre 2011; Hughes et al. 2010, 2011) and is related to the highest mountain area. It commonly includes cirques, glacier valleys, glacial shoulders, roche moutonné, etc. Accumulation landforms, such as moraine, also stayed preserved apart from the erosion forms. These forms are highly transformed, even destroyed, on being exposed to deluvial and fluvial processes during the postglacial stage.

Coluvial processes are the most intensive in the highest parts in the mountain area resulting from the strong impact of low temperatures and increased precipitation. The most impressive talus cone, approximately 1.5 km in length, occurs at Komovi Mt. The coluvial process is important at lower altitudes and may be of significant intensity. In 2006, in the beginning of the canyon Tara (Bistrica locality), a severe landfall caused partition of the canyon. A lake 2 km long formed above the dam, and the River Tara has stopped flowing downstream from the dam. After digging, the lake has mostly disappeared.

8.7 Geoheritage and Environmental Protection

According to the classification proposed by ProGeo (Wimbledon 1996, 1999), a preliminary list of the geoheritage objects of Montenegro was made (Djurović and Djurović 2010a). The list includes nine main categories: objects of historical-geologic and stratigraphic heritage, structural objects, petrological objects, objects of geomorphological heritage, objects of neotectonic activity, speleological objects of geoheritage, objects of hydrologic-hydrogeologic importance, pedological objects, and archeological geoheritage objects. The majority of 217 distinguished geoheritage objects is located in mountain area 170 (Djurović and Djurović 2010b).

The most valuable regions in the mountain area are designated by law as areas of extraordinary natural worth areas and put under various protection regimes. Four of five National Parks are in the mountain area (NP “Lovćen,” “Durmitor,” “Biogradska gora,” and “Prokletije”).

8.8 Potentials and Limitations for the Application of the Concept of Sustainable Development

Agriculture and forestry are traditional economic activities in mountain areas. However, in the past 50 years some new industries have occurred: mining, metallurgy, energetics, traffic, and tourism (Fig. 8.5). Their development led to an endangered, devastated, and polluted environment. The concept of sustainable development, which looks for the balance between economic, social, and ecological requirements, that is, to satisfy needs of the present generation without putting them in danger for the future generations, arose as the solution for problems caused by economic and social development (Brundtland Commission WCED 1987). The main task of sustainable development is continual social development in accordance with environmental protection.

The state of Montenegro has determined the strategy for future development in accordance with principles and rules of sustainable development with the “Declaration of ecological country Montenegro” in 1991. Montenegro has been an ecological state since the Constitution in 1992. The strategic document “Directions for development of Montenegro as an ecological state,” from 2000, established basic criteria for realization of sustainable development. “National Strategy of sustainable development” has to guide the proposed tasks of the “Declaration of

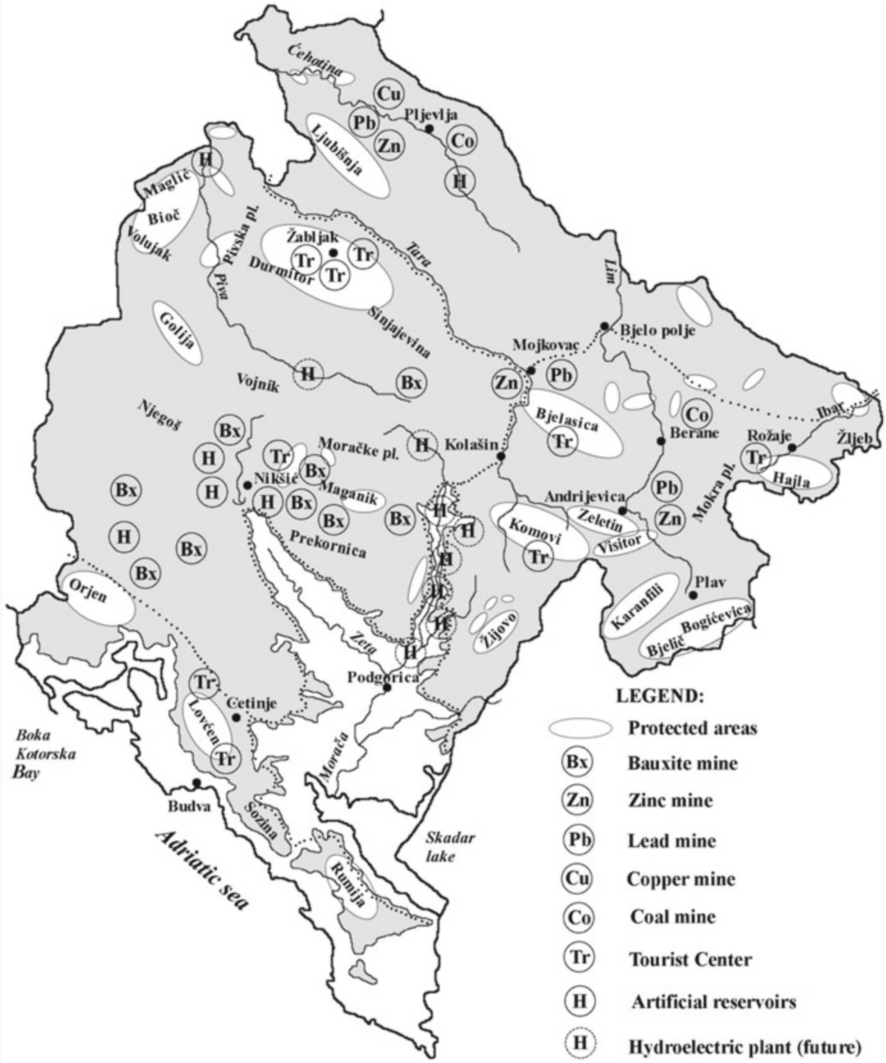

Fig. 8.5 Protected, potentially endangered, and endangered areas in the mountain area

ecological country Montenegro," as well as its principles for progress. This strategy is one of the elements of implementation of the "Mediterranean strategy of sustainable development"; hence it is a part of the world's national strategies in sustainable development, which are supported by the UN Commission for Sustainable Development.

"National strategy for sustainable development in Montenegro" is based on generally established principles on sustainable development that were proclaimed by the "Declaration in Rio" and by "Agenda 21," "Declaration and Plan for implementation from Johannesburg," and "Millennium declaration of UN." Montenegro is decisive in following the National Strategy for sustainable development, but similar to many countries in Southeast Europe meets with numerous complex problems. Some of the most important problems are balanced economic development, improvement of life standards, and poverty reduction, as well as the increased awareness of the inevitability and necessity of the sustainable development concept (Nacionalna strategija održivog razvoja Crne Gore 2007).

The spatial plan for Montenegro up to 2020 established priorities. Based on available resources and potentials on one side and limitations and conflicts on another, the main development paths were recognized, considering the principles of sustainable development; regardless, conflict has remained between economic development and environmental protection (Fig. 8.6).

The proximity of coastal tourist centers directly impacts the number of visitors, increasing it in the coastal mountainous region (complementary tourism). Expansion of tourist centers within the mountain area (Ivanova korita and Njeguši on Lovćen), the construction of the new magistral road Nikšić–Risan and the planned Adriatic–Ionian highway will additionally affect nature and the environment in the mountain areas. Considering the carbonate basement in this area, elevation, and the lack of wastewater treatment plants, the possibility of permanent pollution of underground karst features becomes real. One of the main tasks of environmental protection is

Fig. 8.6 Endangered areas: (a) tourism development (Žabljak), (b) mining (Pljevlja), (c) hydropower (Piva), (d) unregulated landfill (dump) (Tara) (Photographs by P. Djurović P.)

the solution of temporary floods in the Cetinjsko polje, adequate carrying away of atmospheric waters and wastewaters, and implementation of wastewater treatment. Considering the main courses of groundwater (Lovćen–Njeguši–Bay of Boka Kotorska, Lovćen–Cetinjsko polje–Skadar Lake), the pollution of a wide area is inevitable. The construction of ski centers is planned on mounts Orjen and Lovćen where conditions for winter sports are favorable. The foundation of the second national park (on Mount Orjen), the declaration and protection of the Rumija mountain (regional park), and its planned connection with the National Park Skadar Lake will considerably contribute to the quality and improvement of environmental protection (Prostorni plan Crne Gore do 2020 2008).

A few factors in the mid-mountainous region limit sustainable development, as particularly concerns the steel industry, food industries, wastewaters, and communal waste in Nikšićko polje. In three municipalities in this area (Nikšić, Plužine, Šavnik: 82,501 inhabitants), 18,200 tons of communal waste was produced in 2004 (Mapa resursa 2011). The construction of five artificial lakes led to significant environmental changes in this part of the mountain area. Many open and underground bauxite pits have severely devastated the environment. The construction of hydropower dams, planned on the Rivers Komarnica (1) and Morača (4), will also have harmful environmental impacts. Hydroelectric plants on Morača would produce annually 706 GW. In the hydroelectric plant Andrijevo (height of dam, 150 m; capacity, 250,000,000 m^3) is planned a 10-h average workday with the installed stream flow of 120 m^3/s. Minimal stream flow down of the dam is calculated as 10 m^3/s. The construction of 11 accumulation-derivation electric plants is additionally planned on tributaries of the River Morača (height of dams, 39–140 m) with total annual production of 520 GW (DPP za prostor visenamjenskih akumulacija na rijeci Morači 2010). Their construction will undoubtedly have a serious environmental impact on this part of the mountain terrain. Natural diversity allows many kinds of sport to develop throughout the year (mountaineering, canyoning, skiing). Ski centers Durmitor and Vučje are the base for further development of winter sports. Suggested declaration of the regional parks Bioč, Maglić, and Volujak will provide, along with their connection with the National Park "Sutjeska" in Bosnia and Herzegovina, support for the foundation of overbordered protected areas. Formation of a regional park on Mount Sinjajevina is also planned.

Disposal of the waste from the lead-zinc mine Brskovo, as well as its possible reactivation, are serious challenges for water quality in the River Tara (Prostroni plan Crne Gore do 2020 2008).

The outer mountain region has well-developed mining (exploitation of coal and lead-zinc ore) and energy production (thermoelectric power plant Pljevlja), including the earlier cement production. All together contributed to significant environmental degradation of surface water and groundwater and resulted in polluted air in Montenegro (Pljevlja City). The exploitation of various mineral resources in Montenegro annually leaves behind about 25,000 m^3 of tailings. The largest part is disposed in the mountain area (Nacionalna strategija održivog razvoja 2007). The obtained annual waste is from 1,084,000 t, whereas the energy production release is 350,000 t. (lit. 14). In the municipalities Pljevlja and Žabljak (40,010 inhabitants)

7100 t of communal waste was produced in 2004. The planned protection of the Ljubišnja Mountain as a Regional Park will contribute to environmental protection in the given area (Prostorni plan Crne Gore do 2020 2008).

The Prokletije mountain system has remained preserved because of weakly developed industry and its distance, that is, its isolation. Lack of an efficient system for waste control and a number of wild deponies in lower as well as in higher elevated areas at this mountain have considerably environmental impact, affecting human health. In Berane, Plav, Andrijevica, and Rožaje (77,351 inhabitants) in 2004 8350 tons of municipal waste were inadequately deposited. Exploitation of brown coal and the construction of thermoelectric power in the middle of the River Lim valley (Berane) will significantly degrade the human environment. The planned route of the highway Bar–Boljare passes for most of its length through the mountain area; hence, growing pollution of the air and water, devastated relief, and noise is expected. The formation of the regional park Komovi and its connection with the National Park Biogradska gora, with the newly declared National Park Prokletije and the regional park Turjak with Hajla, provides a basis for better environmental protection and preservation of this part of the mountain area. Diverse protection grades are adequate issues for the harmful impacts of increasing numbers of visitors (Prostorni plan Crne Gore do 2020 2008).

The development of mountain tourism offers one of the best solutions for the concept of sustainable development in the mountain area. Following the promoted program for benefits, an increasing number of night stays from 160,000 in 2005 to 4,200,000 in 2020 is inferred. The number of accommodations in family hotels, pensions, and apartments, increasing from 3500 in 2005, is planned to reach 35,500 in 2020. The number of employees, from 1500 in 2005, is expect to increase to 11,100 in 2020. Such large changes in the number of tourists inevitably will affect the mountain environment (Program razvoja planinskog turizma 2005).

8.9 Conclusion

A diverse physical-geographic basis (geology, geomorphology, climate, hydrology) enabled the diversity and rich natural potential resorts to be formed in the mountain terrain in Montenegro. Two mountain systems (Dinaric Alps and Prokletije Alps) include several naturally distinguished mountain regions. The outstanding geomorphological diversity resulted from the dominantly carbonate basement, which occasionally alternates with noncarbonate rock complexes. High mountains, deep valleys (canyons), broad mountain plains, and basins give this area astonishing dynamics. High precipitation (particularly as snow) allowed creation of specific landscapes (high-mountain karst, long-lasting snow, as snow pack and ice sheets), including various hydrologic occurrences (streams, disappearing rivers, rivers, lakes). A conflict between the highly vulnerable mountain area and necessary economic and social development should be overcome by implementation of the sustainable development concept. In spite of all efforts, certain economic activities are still unsolved problems, particularly as concerns the exploitation and use of mineral resources (lead-zinc ore, bauxite, coal) and energy resources (thermoelectric power plants). Inadequate disposal of communal and other waste is still a large and significant problem. Unlimited and unplanned tourism development, although one of the least harmful and in terms of ecology the most acceptable economic activities, may in the future considerably impact and devastate the most important and the most valuable places in the mountain areas of Montenegro.

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Chapter 9
Climate Variability, Soil, and Forest Ecosystem Diversity of the Dinaric Mountains

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Abstract The Dinaric mountains in Croatia present one of the hot spots of European biodiversity, possessing a very large number of species and hosting most endemics. The Dinaric mountains in Croatia strongly affect the climate of the Adriatic region, making a distinct boundary between the maritime and a continental climate. In this chapter, an overview of climatic conditions of the Dinaric area is provided, including observed climatic changes of temperatures and precipitation in the last century. Existing soil types were assessed and described, in particular with respect to soil-forming processes. The role of climate as a dominant factor of soil formation was evaluated in relationship to other factors such as lithology and topography. Also, the occurrence of a specific broad range of forest associations in Dinarides was presented. We examined the correspondence between forest vegetation, soil, and climatic properties in the Dinaric area. As a finale, some future, very possible scenarios of regional climatic development are presented as a serious hazard to the sustainability of natural forest resources. We determined the variety of soil types, ranging from soils that are characteristic for Mediterranean (on limestone) such as Terra rossa with intensive red color, calcomelanosols and calcicambisols in high karst, to soils characteristic for continental climate (on flint or silica) such as dystric cambisols and luvisols. The forest vegetation of the Dinaric mountains constitutes 54 diverse forest ecosystem types, encompassing specific combinations of soil and phytocoenoses. Existing ecosystems form nine broader groups, that is, bioclimates, which are typical for Dinarides.

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9.1 Introduction

The Dinaric mountain system is an area that extends from Italy and Austria in the northwest to northern Albania in the southeast along the Adriatic coastline. Named by Dinara Mountain, on the Croatian–Bosnian border, it is among the most impressive karst entities in the world, with distinctive geologic, geomorphological, and hydrologic traits. Karst is defined as terrain underlain by limestone or dolomite in which the topography is chiefly formed by the dissolving of rock, and which is characterised by sinkholes, sinking streams, closed depressions, subterranean drainage, and caves (Field 2002). The geologic substrate is dominated by very thick (up to 8 km) carbonate Mesozoic sediment: limestone and dolomite rock. Emphasized tectonic fragmentation affects an equal number of horizontal and vertical (caves) karst morphological forms.

In the western Balkans, the Dinaric karst is recognized as the hot spot of European biodiversity (Gaston and David 1994), possessing not only the largest number of species but also hosting most endemics. Although in Central and Northern Europe, during the Pleistocene, life was either entirely extirpated by the advance of ice sheets, or vegetation was transformed into tundras or cold steppes, the southern and western parts of the Balkans offered buffered conditions, allowing even temperate tree species to survive the cold stages (Hewitt 1999). Although the biological diversity of this region is the primary work of nature, human impact over the centuries turned a uniform landscape (flooded karst fields, mountain forests) into a seminatural biome, rich in different habitats and flora and fauna.

In Croatia, the Dinaric karst region is southern from the Karlovac depression to Adriatic Sea; it includes the Adriatic coast and islands, but also the highest mountains such as Dinara (Dinara 1,831 m), Kamešnica (Kamešnica 1,810 m), Biokovo (Sv. Jure 1,762 m), Velebit (Vaganski vrh 1,758 m), Plješivica (Ozeblin 1,657 m), Velika Kapela (Bjelolasica 1,533 m), Risnjak (Risnjak 1,528 m), Svilaja (Svilaja 1,508 m), and Snježnik (Snježnik 1,506 m). Mountains such as Biokovo and Velebit represent the center of Croatian endemism. Among 38,000 known species in Croatia (nearly 9000 plant species), more than 1000 are endemic, of which more than 500 are plants! Because of their inaccessibility, the Dinaric mountains present the habitat of some relict forest communities (lime and yew forests, *Tillio–Taxetum*; Scots pine and black hellebore forests on dolomite, *Helleboro–Pinetum*; and black pine forests, *Cotoneastro–Pinetum nigrae*).

Generally, there are two types of karst in the Croatian Dinaric region:

– The so-called bare karst or uncovered karst has only a few surface watercourses because water quickly sinks underground into the crevices and cavities in the limestone; it has many characteristic geomorphological and speleological features and sparse forest vegetation in mostly degraded forms (maquis, garrigue), of grassland;

– The green or covered karst is so called because the karstic processes take place under the layer of humus/soil and vegetation. On high karstic plateaus or eastern faces of the mountains, there are regions of huge expanses of forests throughout the Dinaric range. Beech, the predominant tree species in Croatia, forms a number of different forest communities in this region, from sub-Mediterranean to the subalpine vegetation belt (Vukelić and Rauš 1997).

Karst is an extremely fragile natural environment. The geologic, morphological, hydrologic, and hydrogeologic features of karst determine an overall high vulnerability to a number of potentially dangerous events (White 1988; Ford and Williams 2007; Parise and Gunn 2007). The delicate equilibrium of karst ecosystems can be, therefore, changed very easily, sometimes dramatically and irreversibly, up to its destruction that may occur as a consequence of both natural and anthropogenic impacts.

The Dinaric system in Croatia has a long-time tradition of hosting botanical and vegetation studies as well as studies related to disclosing interactions of the soil–vegetation properties of forest and scrublands. Comprehensive overviews of plant communities of forests in Croatia and neighboring countries were initially undertaken by Horvat (1938, 1950). Gračanin (1950) associated the soil-related surveys to existing phytocenological studies to gain insight into the ecology of forest communities, their natural development, and the mutual genetic relationships. According to Gračanin (1950), the development of forest communities is the function of various factors, primarily edaphic (related to soils) and climatic. However, forest communities and soils develop in correspondence on a particular site under the influence of similar environmental factors (climate, organisms, parent material, topography, and time). There is also mutual dependence in the genesis of soils and vegetation.

Performance of environmental factors in the long term can generate vegetation succession and regional variations in soils and floristic composition. According to the existing theories, by responding to climate and other edaphic factors, vegetation throughout development converges into the final stage, termed the climax or climazonal forest community. In most cases, the existing composition of forest cover in Dinarides reflects climazonal vegetation development in prevailing climatic conditions in the long term. These principles are incorporated into the typological delineation of Croatian forests (Bertović 1961), which has also become the basis for the evaluation of forest ecosystem functions, forest valuation, or the creation of management plans for specially protected areas. Bertović (1961) provides major differentiation within the ecological conditions across Croatia by defined bioclimates as broad vegetation tiers, taking into account the gradient of vertical and horizontal zoning of vegetation, and edaphic categories, reflecting a gradient of trophic conditions and ecohydrologic properties.

During the past century, the phenomenon of climate change has become evident, which has been particularly intensified in the past decade. Climatic change as a major driver will most probably result in a stronger precipitation gradient from (north)western to (south)eastern Europe, corresponding to the amplification of an already given gradient (Bredemeier 2011). The transitional region of (south)eastern Europe and Mediterranean (the Balkan peninsula) presents one of the most vulnerable hot spots in the given gradient, with expected intensification of severity and duration of droughts and heat waves, together with more intensive precipitation events and flooding. This region is faced with the highest frequency of drought events in Europe; after 2000, significant droughts and heat waves were observed in 2002, 2003, 2007–2008, 2011, and 2012 (EEA 2012). There are certain proofs that climate change in the past century has affected the phenology of organisms, the range and distribution of species, and the composition and dynamics of communities (Walther et al. 2002). The impact of climate change on soil formation and its properties is still unknown. However, climate change in the Dinaric region could be considered as one of the most significant threats to established terminal stages of development of forest communities and the overall biodiversity of this region. At the present stage of knowledge, it is quite uncertain how climate change will affect this region and what will be the consequences in relationship to ecosystem functioning.

With respect to the aforementioned, this study aims to provide insights and a better understanding of climate properties, of regional spatial and temporal climatic variations and their influence as a driving force of the formation of soils and forest vegetation in Dinarides. First, we provide a description of prevailing climatic properties of the Dinaric area, including observed climatic changes in the last century. Second, existing soil types were analyzed together with their abundance. The role of climate as a dominant factor of soil formation was evaluated in relationship to the other factors such as lithology and topography. Third, the occurrence of a specific broad range of forest associations in Dinarides is presented. We examined correspondence between forest vegetation, soil, and climatic properties in the region. As a finale, future, very possible scenarios of regional climatic development are presented, providing a serious hazard to sustainability of natural forest resources in this area.

9.2 Climate Characteristics and Observed Climate Change in Dinarides

The Dinarides are characterized by the mountain climate with large spatial temperature change in this area resulting from the great changes in this altitude and temperature dependence on altitude. The air temperature gradient (Fig. 9.1a) is higher on the coastal side (0.7 °C/100 m) than on the mainland (0.5 °C/100 m). An isotherm of 10 °C is situated at an altitude of 600–700 m above sea level on the southwestern side of the mountain range, whereas it is, on average, at an altitude of 200–300 m above sea level on the northeastern side (Zaninović et al. 2008). The average annual temperature ranges from 3.5 °C at the highest station on the Velebit

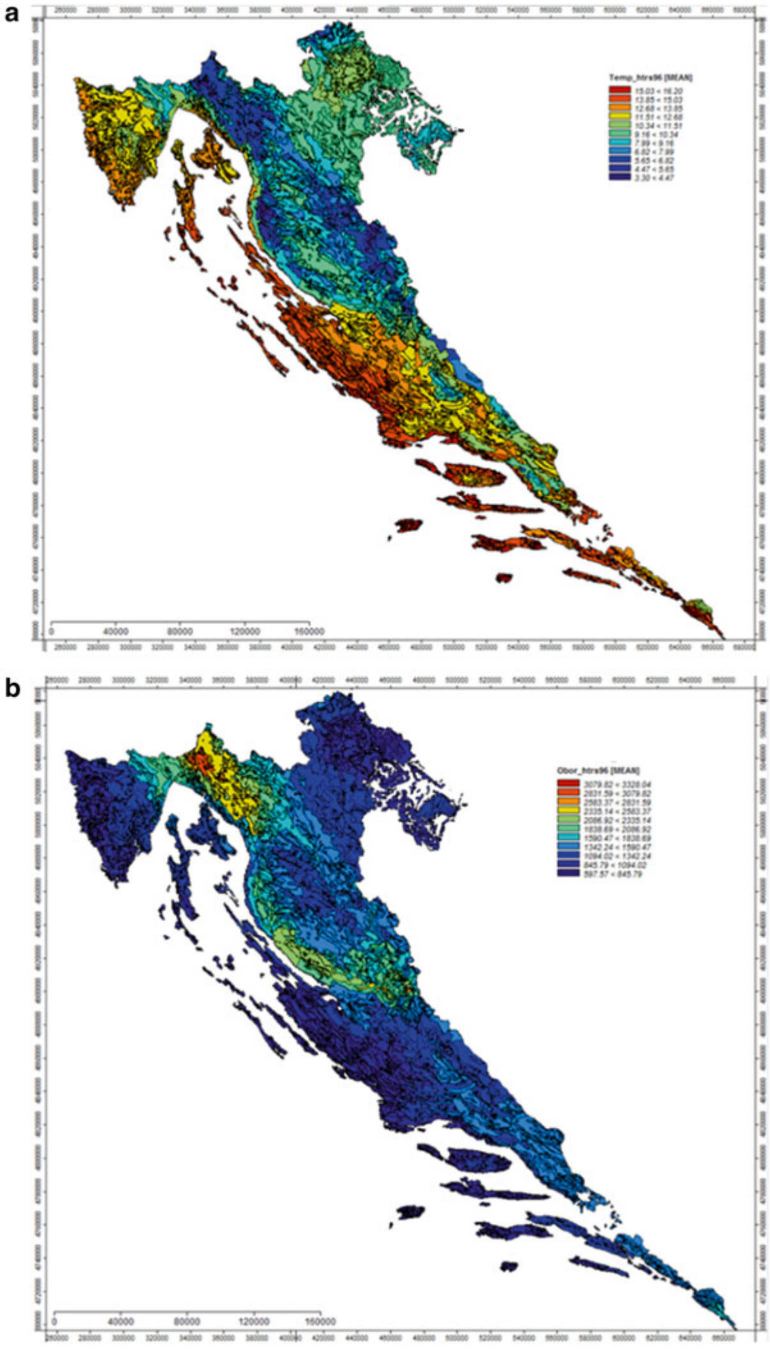

Fig. 9.1 (**a**) Mean annual air temperature based on measurements from 152 main and climatological stations. (**b**) Mean annual precipitation for 1961–1961, based on measurements of mean daily precipitation from 567 main, climatological, and rain-gauging stations in Croatia

Mountain (Zavižan; h = 1594 m) to 8.4 °C at the Lika plateau (e.g., Gospić; h = 564 m). The coldest temperatures (averages from −3.8 °C to −0.6 °C) are recorded during the winter (DJF) and the maxima (averages from 11.3 °C to 17.1 °C) during the summer (JJA). Steep orography and a strong north Mediterranean cyclogenesis effect cause abundant precipitation: the largest annual amounts, from 3000 mm to more than 3500 mm, fall over the peaks on the Velebit Mountain and in Gorski kotar. The precipitation vertical gradients (Fig. 9.1b) range between 57 mm/100 m and 151 mm/100 m, depending on the mountain (Bajić et al. 2003; Gajić-Čapka et al. 2003). The monthly precipitation maxima are recorded in the autumn (SON) and December. The mountain slopes that are oriented to the seaside receive more precipitation than the leeward slopes. Therefore, mountains in Croatia strongly affect the climate of the Adriatic region, making a distinct boundary between the maritime and the continental climate.

In this subsection, a brief overview of detected changes in precipitation amounts and air temperature values in the Croatian highlands is given. It can be a useful starting point in assessing the risk of climate change impacts in many sectors (e.g., water resource management, agriculture, forestry, transportation, and tourism).

Trends in mean seasonal and mean annual air temperature and total seasonal and annual precipitation amounts, estimated by Kendall's tau method (Sen 1968) and expressed as decadal values, are presented for the 1961–2010 period. The statistical significance of trends is determined by the nonparametric Mann–Kendall test (Gilbert 1987).

During the recent 50-year period, a significant increase in mean annual temperature values (from 0.2 °C to 0.4 °C per decade) is found in the Croatian highlands. The overall (annual) positive trend is mainly the result of significant positive summer and spring trends (from 0.3 °C to 0.5 °C per decade). As an example, annual and summertime series with corresponding trend lines are shown for the two stations in the Croatian Dinaric Alps (Gospić and Zavižan; Fig. 9.2).

For precipitation, the prevailing trends in the highlands are negative (from −17 mm/10 year to −11 mm/10 year), except at the highest altitude station where the prevailing trend is positive (32 mm/10 year), although not significant. However, an analysis of precipitation climate made by Gajić-Čapka et al. (2014), based on a dense network of rain-gauge stations in Croatia, reveals a significant decrease of the total annual precipitation amounts of −50.6 mm/10 year in the mountainous regions. The annual trend is mainly governed by a significant summer decrease, and, in the northern part, also partly by a spring decrease. In other seasons, a combination of statistically insignificant trend signs is found. Figure 9.3 provides an example of the annual and summertime series with associated trend lines for the Parg station (h = 863 m) in the mountainous district of Gorski kotar.

Based on available literature and the foregoing results, it can be concluded that the warming of climate in Croatian highlands is currently present, which is particularly apparent during the warm half-year (spring and summer). This warming goes together with drying trends, thus indicating that the mountainous regions in Croatia are prone to significant climate change. The next subsection provides the results on the projection of the near-future climate in the twenty-first century.

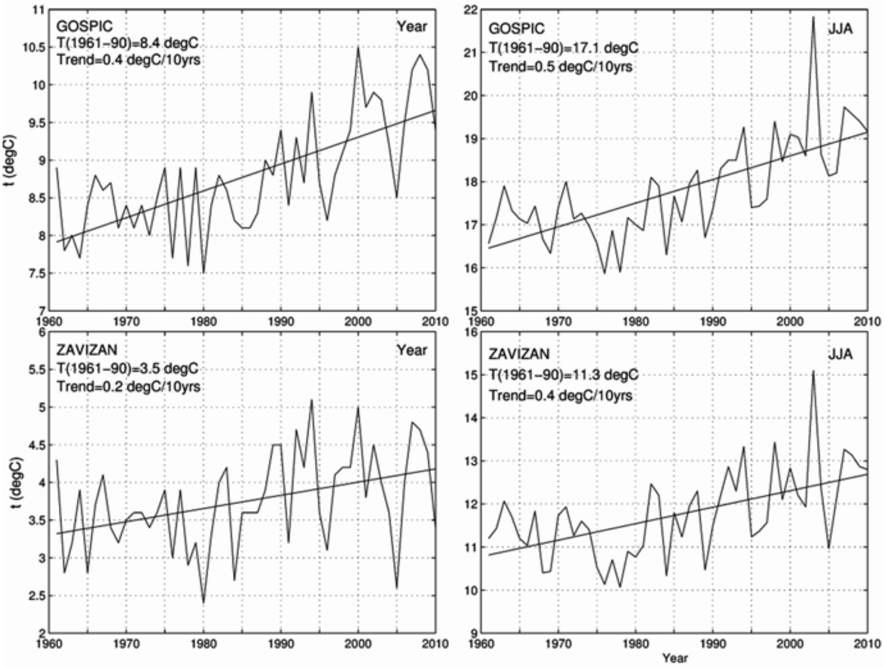

Fig. 9.2 Time-series of the mean annual (Year) and the mean summer (JJA) air temperature values with the associated trend lines for the Gospić and Zavižan stations in Croatia. The average 1961–1990 temperature values (*T*) and decadal trend (*Trend*) from 1961 to 2010 are given in the *upper-left corner* of each panel

9.3 Main Soil-Forming Factors

Soil presents a vital functional part of the ecosystems, that is, the substrate for various plant communities and living organisms. Soil can be considered as a natural body, differentiated into horizons of mineral and organic constituents, usually unconsolidated, of variable depth, which differs from the parent material below in morphology, physical properties and constitution, chemical properties and composition, and biological characteristics. Soils perform five key functions in the global ecosystem: they serve as the medium for plant growth, regulator of water supplies, recycler of raw materials, habitat for soil organisms, and a landscaping and engineering medium. Five principal soil-forming factors (Jenny 1941) completely define the soil system: climate, organisms, topography, parent material, and time. Soils in Dinarides are in particular influenced by interchange of climatic properties at a relatively short spatial extent.

The parent material in Dinarides is a relatively homogeneous soil-forming factor (Čubrilović et al. 1967). The most abundant are limestones and dolomites, prevailingly Mesozoic marine sediments, limestone breccias, marly limestones, and marlstones. The parent material affects the formation of soil through its mineralogical

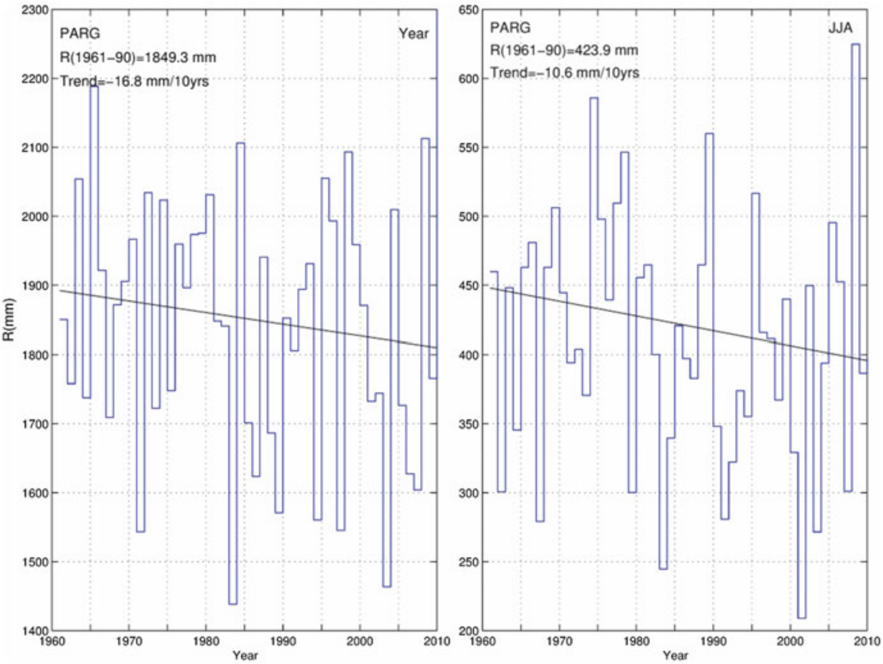

Fig. 9.3 Time-series of the total annual (Year) and summer (JJA) precipitation amounts with the associated trend lines for the Parg station in Croatia. The average 1961–1990 precipitation amounts (*R*) and decadal trend (*Trend*) from 1961 to 2010 period are given in the *upper-left corner* of each panel

composition, coherence, and water permeability. Mineralogical composition causes the amount, type, and texture of the substrate in which soil is created, the coherence or strength determines the resistance to degradation and the rate of decomposition, and the permeability effect depends on the intensity of the physical and chemical transformations of residual rocks. The largest variations in properties of the parent material come from different types of weathering of limestone (chemical weathering) and dolomites (physical disintegration).

Topography has a distinctive function in hilly and mountainous terrain because it governs the dynamic processes of runoff and erosion of accumulated material. The soils in lower positions and depressions receive an additional amount of water that runs off from the adjacent higher lands. The translocation of soil-forming material is nonexistent under dense vegetation cover consisting of grass or forest vegetation. However, in conditions of bare soil surfaces, material is removed from the upper portions of the slope and deposited on the lower parts. As the result of translocation of the material, there is great variability of soil depth. Especially, very deep soils can be found in karstic sinkholes opposite to very shallow soils on mountain ridges.

Climate is the prevailing factor for soil formation and is credited for variations in soil properties and types. Climate influences processes in both solid and porous phases in soils. Two main components of the solid phase, mineral and organic, are influenced by climatic properties in specific ways. The sharp mountainous climate is characterized by high temperature variations, high precipitation, freezing and thawing, and strong winds, which accelerate physical soil weathering. During the day, the surface layer of rocks warms up and widens, and during the night it cools down and shrinks. In this way, cracks are created in the rocks, and the surface layer becomes slowly mechanically crushed. Water supports this process in that it penetrates and places pressure on the walls of the pores. When freezing turns water into ice, water increases in volume and promotes the expansion of the pores, causing crushing and weathering of rocks. This physical weathering is supported by plants (grass, shrubs, trees), the roots of which often penetrate into the cracks of rocks to cause secondary broadening, which places additional pressure on the walls of the cracks.

The climate, temperature, and moisture regime influence the organic component of soil by affecting primary production of material and the decomposition of organic residues. In the cold mountainous climate and on grasslands above the limits of forest vegetation, there is a continuous accumulation of organic matter that prevails in decomposition. Accumulation as a consequence creates a relatively thick and dark organic soil layer.

Soils in the littoral zone of Dinarides are the typical types of soils formed in the Mediterranean climate, which is characterized by alternation of wet and cold periods during the winter and hot, dry summers. The Mediterranean climate also determines the soil water regime because most of the rainfall occurs during the winter and dry periods occur during the summer. The temperature regime is characterized by mean temperatures between 15 °C and 22 °C and in some places (sub-Mediterranean) between 8 °C and 15 °C. In that condition, pedogenetic processes are most pronounced during the winter rainy season when the optimal conditions exist for dissolution and leaching of $CaCO_3$ and other easily soluble elements as clay particles. Dissolution of $CaCO_3$ causes lowering of pH from 8.0–8.2 to 7.0–7.2 and shows a tendency of for desaturation of the cation-exchange complex. During dry periods, the retarded processes as a consequence stop the process of dissolution, leaching, and migration of clay. This phase causes significant periodic variations in soil acidity and even to a degree on the pH scale in soils with higher organic matter content. In summer conditions, the prevailing process is the oxidation of iron, creating an intense red color (rubification).

9.4 Characteristic Soil Types

In the area of Dinarides (Komlenović et al. 1997; Martinović 2003), automorphic soils (Table 9.1) dominate, ranging from types with humus-accumulative undeveloped horizon such as litosols (leptosols, lithic, hyperskeletic; WRB), to soils with developed stratigraphy such as luvisols with signs of brunification and eluviation-illuviation processes. The occurrence of a particular soil type is related to the prevalence of specific soil-forming factors. On the limestone slopes, with dynamic processes of mechanical disintegration of rocks, debris accumulates with formation of soil types with an initial organic horizon. A very shallow organic horizon, only a few centimeters deep, is dispersed inside cracks in the debris. Lithosols covers about 2 % of the area in Dinarides. Another type of soil in the initial phase is regosol (regosol, leptic), which develops on finer rock debris (flisch, shale, dolomite, sandstone). Regosols as compared to lithosols possess a better substrate for plant growth because of the higher water retention properties.

On the very hard limestones with more than 98 % $CaCO_3$, calcomelanosol (leptosol, lithic, hyperskeletic, molic, humic) is the primary soil formation. The dominant processes of its formation are accumulation of organic matter and clay. Initial forms of calcomelanosol have a very high content of organic matter with formation of organic forms of calcomelanosol. However, long-term evolution causes an increase of clay content and creation of the mineral form of this soil type. Calcomelanosols cover 10.34 % of the area in the Dinarides (Figs. 9.4 and 9.5).

Rankers are soil types very similar to calcomelanosol, but they form on silicate substrates, which are very scarce and uncommon in the Dinarides. Therefore, ranker forms only in small negligible pockets, 0.07 % of the area. On the calcareous parent material (more than 10 % of $CaCO_3$) such as flisch, sand, and dolomite, rendzina (leptosol, rendzic, hyperskeletic, calcaric) is formed on 14.69 % of the area. Further soil development from calcomelanosol on hard and pure limestones and dolomites present calcocambisol (cambisol, leptic, hyperskeletic), which covers 40.55 % of

Table 9.1 Soil types and their spatial abundance in Dinarides

Soil type	Soil type (WRB)	Area (ha)	Area (%)
Calcomelanosol	Leptosol, lithic, molic	425,296.54	10.34
Dystric cambisol	Cambisol, dystric	373,801.63	9.09
Eutric cambisol	Cambisol, eutric	55,238.79	1.34
Fluvisol	Fluvisol	18,976.81	0.46
Gleysol	Gleysol	55,806.55	1.36
Calcocambisol	Cambisol, leptic, hyperskeletic	1,667,087.59	40.55
Koluvium	Regosol, anthropic, leptic	26,099.94	0.63
Litosol	Leptosol, lithic, hyperskeletic	82,426.74	2.00
Luvisol	Luvisol	259,330.28	6.31
Podzol	Podsol	792.18	0.02
Pseudogley	Planosol; albeluvisol	86,276.67	2.10
Ranker	Leptosol, lithic, hyperskeletic	2943.58	0.07
Rendzina	Leptosol, rendzic, hyperskeletic, calcaric	604,098.08	14.69
Terra rossa	Cambisol, chromic	453,375.18	11.03
Total		4,111,551	100

WRB

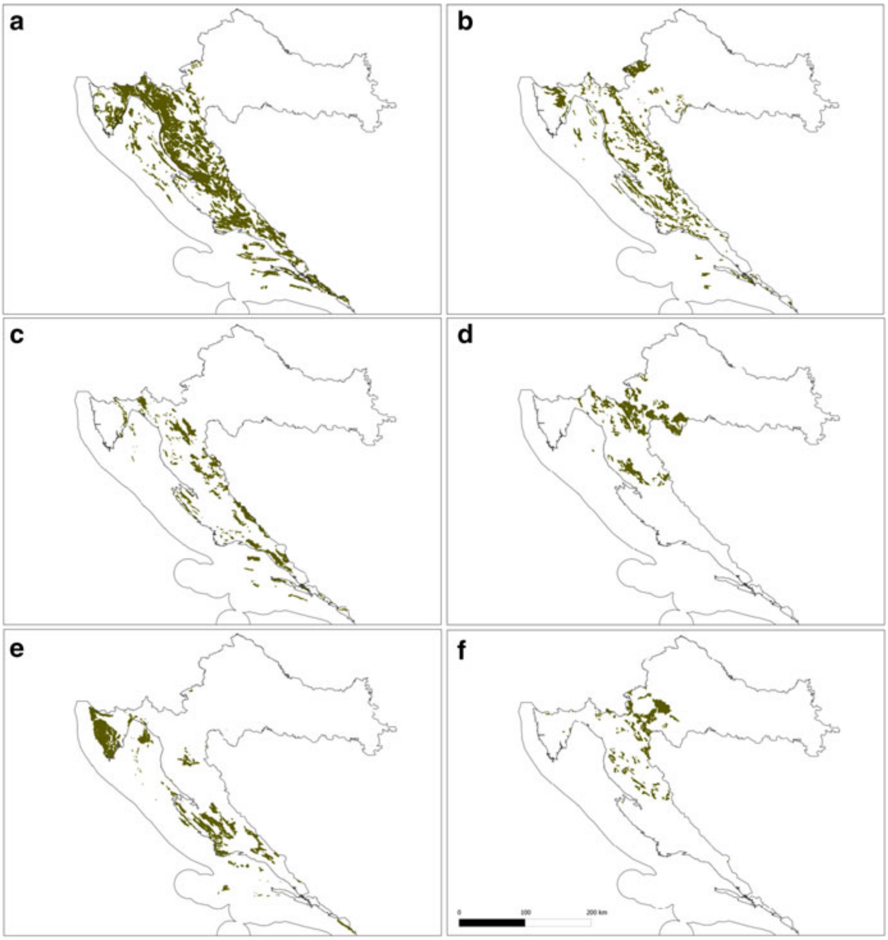

Fig. 9.4 Maps showing distribution of dominant soil type, from *top left row*: calcocambisol (**a**); rendzina (**b**); calcomelanosol (**c**); dystric cambisol (**d**); terra rossa (**e**); luvisol (**f**)

the area and presents the dominant soil type in the Dinarides. Calcocambisols are relatively shallow soils that form on accumulated non-calcareous residuum of limestone, constituting not more than 1 % in this rock.

In the continental part of the Dinarides, there are areas with parent material formed of flint and silica (sandstone, slate, acid igneous rock) with a low amount of basic cations. In this condition, on 9.09 % of area, dystric cambisol (cambisol, leptic, dystric) is formed. The dominant soil-forming process in this soil type is brunification (weathering of primary minerals, synthesis of clay, and accumulation of iron oxides). The main property of dystric cambisol is its acidity, but also the relatively higher soil depth.

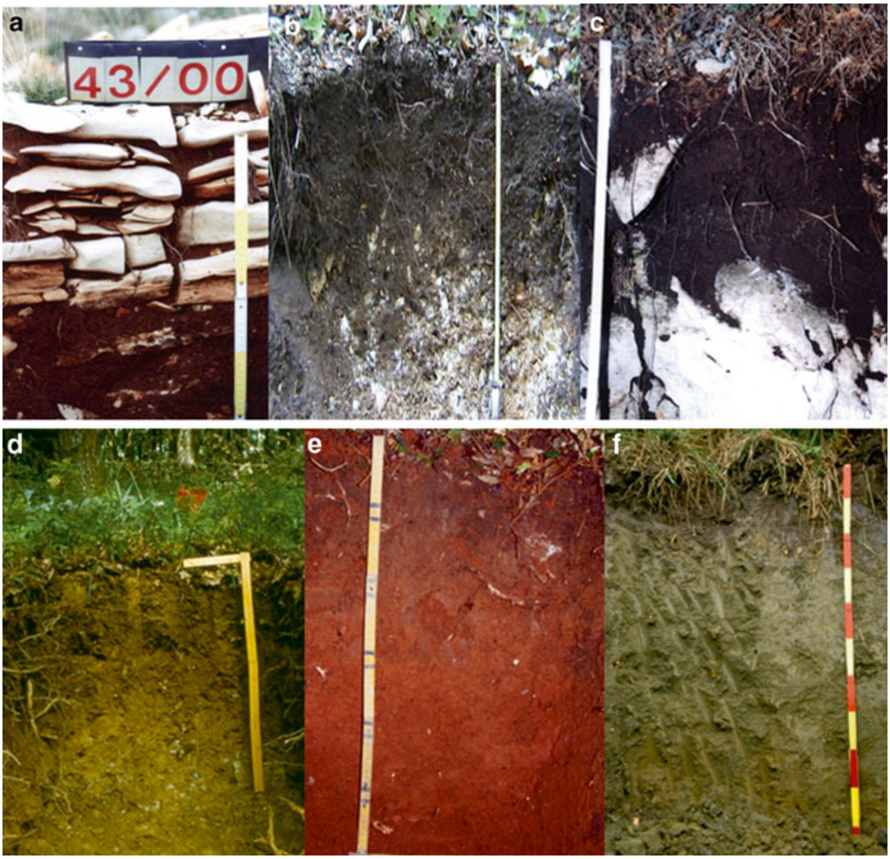

Fig. 9.5 Profiles of dominant soil types, from *top left row*: calcocambisol (**a**); rendzina (**b**); calcomelanosol (**c**); dystric cambisol (**d**); terra rossa (**e**); luvisol (**f**)

Further evolution from cambisols presents luvisol type (luvisol), which exists on deeper loamy substrate with formation with descending water movement. For this soil type, leaching of clay from upper soil horizons and secondary accumulation in lower horizons is common (clay migration). Luvisols prevail in the continental Dinaric part, with equal distribution of precipitation and related soil processes throughout the year. In the littoral zone with Mediterranean climate, terra rossa (cambisol, chromic) with characteristic intensive red color from dehydration and crystallization of iron oxides presents the most developed soil type, which covers 11.03 % of the area.

9.5 Forest Vegetation of Dinarides

As elsewhere in the world, in the Croatian Dinaric mountain massif, among a series of different abiotic factors climate exercises the strongest effect on site conditions, fauna, and flora (vegetation cover), as well as on human life and activities. Different regional vegetational-climatological studies led to different bioclimatic classifications of terrestrial vegetation that were commonly used beginning in 1947 (Holdridge 1947). According to the European Environmental Agency (2007), the forest vegetation of Europe is classified into 14 types, of which 11 can be found in Croatia. The high level of forest type diversity in Croatia, mainly in the Dinaric region, has its origin in biogeographic position across three main regions: continental, alpine, and Mediterranean (Pilaš et al. 2014).

Most of the Croatian climatozonal forest communities are distinguished by rich autochthones and well-preserved floristic composition, extensive area, and related ecological and phytocoenological differences in horizontal and vertical directions. In the Dinaric region, two fundamental vegetation regions are distinguished: Mediterranean and continental (Bertović 1975), and 10 of 11 forest bioclimates are described (Medvedović and Medak 2007).

The forest vegetation of the Dinaric mountains (Table 9.2) stretches vertically through five vegetation belts (Mediterranean littoral and montane, continental colline, montane, and subalpine) and horizontally is connected to specific Illyrian provinces. Generally, the northeastern expositions of the Dinaric Mountains and continental climate influence formed covered (green) karst in the continental vegetation belt where five bioclimates (A–E) are present. Bioclimates A and B represent areas of subalpine vegetation. The climatozonal community of mugho pine (*Hyperico grisebachii–Pinetum muhgi*) forms the upper boundary of forest vegetation (above 1400 m) in the Croatian Dinaric Mountains (bioclimate A) (Fig. 9.6). A large area of the mountain range above 1200 m is covered by subalpine beech forest (bioclimate B), with characteristic saber-like trunks in higher positions (Fig. 9.7a, b). Some spruce and fir phytocoenoses (*Calamagrostio–Abietetum*, *Lonicero caeruleae–Piceetum*, *Hyperico grisebachii–Piceetum*, *Laserpitio krapfii–Piceetum*) in the subalpine belt (1100–1500 m) are also included in this bioclimate.

The central forest community of the Croatian Dinaric area is Dinaric beech–fir forest (*Omphalodo–Fagetum*), which covers more than 150,000 ha (bioclimate C). It is characterized by numerous Illyrian species such as *Omphalodes verna*, *Calamintha grandiflora*, and *Cardamine eneaphyllos*. Many other azonal communities, such as *Helleboro nigri–Fagetum*, *Aremonio–Piceetum*, *Helleboro nigri–Piceetum*, and *Blechno–Abietetum*, belong to bioclimate C. Bioclimate D is represented by beech forest with deadnettle (*Lamio orvale–Fagetum*), with Illyrian species also abundant (*Lamium orvala*, *Daphne laureola*, *Scopolia carniolica*, *Euphorbia carniolica*, *Epimedium alpinum*). The beech forest grows at altitudes between 400 and 800 m on different exposures and terrains, where also grow some azonal communities such as *Luzulo–Fagetum sylvaticae*, *Helleboro–Pinetum* (relict pine forest), *Tilio platyphylli–Taxetum* (relict yew forest), and *Blechno–Fagetum*.

Table 9.2 Combinations of soil and vegetation types in bioclimates and ecosystems in Dinarides

Bioclimate	Ecosystem	Phytocenoses	Soil type
A	A1	*Lonicero-Pinetum mugi*/Ht. 1938/Borh. 1963	Calcomelanosol
B	B1	*Homogino alpinae-Fagetum sylvaticae*/ Ht. 1938/Borh. 1963	Calcicambisol
	B2	*Listero-Piceetum abietis*/Ht. 1938/Fuk. 1969	Calcicambisol
C	C1	*Abieti-Fagetum dinaricum* Treg. 1957	Calcicambisol shallow and medium deep
	C2	*Abieti-Fagetum dinaricum* Treg. 1957	Calcicambisol deep
	C3	*Abieti-Fagetum dinaricum* Treg. 1957	Calcomelanosol, organomineral
	C5	Jelova šuma s rebračom (*Blechno-Abietetum* Ht. 1950)	Brunipodsol
	C6	*Aremonio-Piceetum abietetis* Ht. 1950	Brunipodsol
D	D1	*Lamio orvale-Fagetum sylvaticae* Ht. 1938	Calcicambisol shallow and medium deep
	D2	*Lamio orvale-Fagetum sylvaticae* Ht. 1938	Rendzina on unbounded sediments
	D3	*Lamio orvale-Fagetum sylvaticae* Ht. 1938	Rendzina on dolomite
	D4	*Lamio orvale-Fagetum sylvaticae* Ht. 1938	Pseudogley on hillside
	D5	*Lamio orvale-Fagetum sylvaticae* Ht. 1938	Luvisol
	D6	*Lamio orvale-Fagetum sylvaticae* Ht. 1938	Dystric cambisol
	D7	*Carici pilosae-Fagetum sylvaticae* Pelcer 1975	Pseudogley on hillside
	D8	*Helleboro-Pinetum* Ht. 1958	Rendzina on dolomite
E	E1	*Luzulo-Quercetum petraeae*/Hill. 1932/ Pass. 1953	Dystric cambisol, shallow and medium deep
	E2	*Querco-Castaneetum sativae* Ht. 1938	Dystric cambisol
	E3	*Epimedio-Carpinetum betuli*/Ht. 1938/ Borh.1963	Rendzina on flysch and soft limestone
	E4	*Epimedio-Carpinetum betuli*/Ht. 1938/ Borh.1963	Eutric cambisol
	E5	*Epimedio-Carpinetum betuli*/Ht. 1938/ Borh.1963	Calcicambisol
	E6	*Epimedio-Carpinetum betuli*/Ht. 1938/ Borh.1963	Dystric cambisol
	E7	*Epimedio-Carpinetum betuli*/Ht. 1938/ Borh.1963	Distrično smeđe tlo na lesu
	E8	*Epimedio-Carpinetum betuli*/Ht. 1938/ Borh.1963	Pseudogley on hillside

(continued)

Table 9.2 (continued)

Bioclimate	Ecosystem	Phytocenoses	Soil type
	E9	*Epimedio-Carpinetum betuli*/Ht. 1938/ Borh.1963	Luvisol on unbounded sediments
	E10	*Festuco drymeiae-Carpinetum betuli* Vukelić/1990/1991	Pseudogley on hillside
	E11	*Querco-Ostryetum caroinifoliae* Ht. 1938	Rendzina
H	H1	*Seslerio-Fagetum sylvaticae*/Ht. 1950/M. Wraber 1960	Calcicambisol
	H2	*Ostryo-Fagetum aylvaticae* Wraber/1950/1958	Rendzina on dolomite
	H3	*Chamaebuxo-Pinetum* Ht. 1956	Rendzina on dolomite medium deep
	H4	*Cotoneastro-Pinetim nigrae* Ht. 1938	Rendzina-calcicambisol
	H5	*Junipero sibiricae-Pinetum dalmaticae* Domac/1962/1965	Calcicambisol
J	J1	*Ostryo-Quercetum pubescentis*/Ht./ Trinajstić 1977	Calcicambisol, shallow and medium deep
	J2	*Ostryo-Quercetum pubescentis*/Ht./ Trinajstić 1977	Terra rossa
	J3	*Ostryo-Quercetum pubescentis*/Ht./ Trinajstić 1977	Rendzina (on flysch and dolomite)
	J4	*Ostryo-Quercetum virgilianae* Trinajstić 1987	Calcicambisol
	J5	*Ostryo-Quercetum virgilianae* Trinajstić 1987	Calcomelanosol, organomineral
	J6	*Orno-Quercetum virgilianae* Trinajstić 1954	Rendzina on platy and marly limestone
	J7	*Erico manipuliflorae-Pinetum dalmaticae* Trinajstić 1977	Rendzina on dolomite
	J8	Ostryo-*Abietetum*/Fukarek/Trinajstić 1983	Rendzina on dolomite
	J9	*Molinio-Quercetum pubescentis* Šugar 1981	Rendzina on flysch, brunified
K	K1	*Querco-Carpinetum orientalis* H-ić 1939	Calcicambisol, shallow and medium deep
	K2	*Querco-Carpinetum orientalis* H-ić 1939	Terra rossa
	K3	*Querco-Carpinetum orientalis* H-ić 1939	Rendzina (on flysch and dolomite)
	K4	*Carpino orientalis-Quercetum virgilianae* Trinajstić 1987	Calcicambisol, medium deep
L	L1	*Querco ilicis-Pinetum halepensis* Loisel 1971	Calcicambisol
	L2	*Querco ilicis-Pinetum halepensis* Loisel 1971	Terra rossa

(continued)

Table 9.2 (continued)

Bioclimate	Ecosystem	Phytocenoses	Soil type
	L3	*Erico-Pinetum halepensis* Krause i dr. 1963	Rendzina on dolomite
	L4	*Pistacio-Juniperetum phoeniceae* Trinajstić 1987	Calcomelanosol, brunified
	L5	*Orno-Quercetum ilicis* H-ić/1956/1958	Calcicambisol shallow
	L6	*Quercetum ilicis-virgilianae* Trinajstić 1983	Calcicambisol, medium deep
	L7	*Myrto-Quercetum ilicis*/H-ić/Trinajstić 1985	Calcicambisol shallow
	L8	*Ostryo-Quercetum ilicis* Trinajstić/1965/1974	Calcicambisol shallow
	L9	*Querco ilicis-Pinetum dalmaticae* Trinajstić 1986	Rendzina on dolomite

Fig. 9.6 Climatozonal community of mugho pine (*Hyperico grisebachii–Pinetum muhgi*) (bioclimate A)

Fig. 9.7 (**a**) Subalpine beech forest (bioclimate B), with characteristic saber-like trunks in higher positions. (**b**) Mountainous spruce forest on Velebit Mountain

Fig. 9.8 Maritime beech forest (*Seslerio–Fagetum sylvaticae*) (bioclimate H)

Oak–hornbeam forests of the Illyrian province (*Epimedio–Carpinetum betuli*) grow in the colline belt (bioclimate E), less in the Dinaric than in the Pannonian space. Important Illyrian species such as *Crocus vernus*, *Erythronium dens-canis*, *Primula vulgaris*, *Lonicera caprifolium*, *Epimedium alpinum*, and *Knautia drymeia* are part of this rich floristic community.

The Mediterranean phytogeographic region of the Dinaric mountains is characterized by southwestern exposures, Mediterranean climate, and, therefore, often thermophilic and xerophilic life conditions. On the sea-exposed area of the Dinaric mountains there are three bioclimates in the littoral and montane vegetation belt.

Maritime beech forest (*Seslerio–Fagetum sylvaticae*) builds its vegetation zone in the montane belt (mostly above 800 m) of littoral slopes of the Dinaric range (bioclimate H). It is a community of high karst, from Istria to Biokovo, the most beautifully developed on Učka (Fig. 9.8; Fig. 9.9). Azonal forest communities of black pine and Dalmatian black pine (*Cotoneastro–Pinetum nigrae*, *Junipero sibiricae–Pinetum dalmaticae*) also belong to bioclimate H. The forests and shrubs of pubescent oak and hop hornbeam (*Aristolochio luteae–Quercetum pubescentis*) cover large areas in the Mediterranean region (bioclimate J), with zonal stands in northern Istria and the littoral slopes of Velebit. In this bioclimate also belong communities such as *Molinio–Quercetum pubescentis* in Istria, *Ostryo–Abietetum* on Biokovo, and *Erico manipuliflorae–Pinetum dalmaticae* on the islands of Brač, Hvar, and Pelješac.

Fig. 9.9 *Aquilegia kitaibelliana*, Dinaric endemic species

Bioclimate K is represented by the most important climatozonal forest community in the sub-Mediterranean region, the forest of pubescent oak and oriental hornbeam (*Querco–Carpinetum orientalis*). It extends from Istria to Montenegro, on the sea slopes of Učka, Ćićarija, Velebit, Biokovo, and Dinara, mostly developed in its degraded stages.

To quantify the influence of climate on vegetation zonation and formation of bioclimates, additional spatial analysis was performed in this study. The methodology consists of overlaying existing bioclimatic envelopes in Fig. 9.10 (Pilaš et al. 2014) with digital annual temperature and precipitation maps (Gajić-Čapka et al. 2003). Analysis was performed using SAGA GIS geo-processing tools. The results of aggregation of average annual temperatures and precipitation are presented in Fig. 9.11a, b. The obtained results clearly confirm a relationship between altitudinal vegetation zonation and decrease of average temperature. Average temperatures from the lowest type of sessile oak forests of hilly terrain (bioclimate E) to the highest subalpine dwarf pine forests (bioclimate A) range from 9.95 °C to 4.43 °C. There is also a very evident precipitation gradient from 1110.6 mm at the lowest point (bioclimate E) up to 2261.8 mm at the highest elevation (bioclimate A). In Mediterranean associations, there is also evidence of increasing temperature and decreasing precipitation in the north(western) to south(eastern) gradient along the littoral zone (bioclimates H, J, K, L).

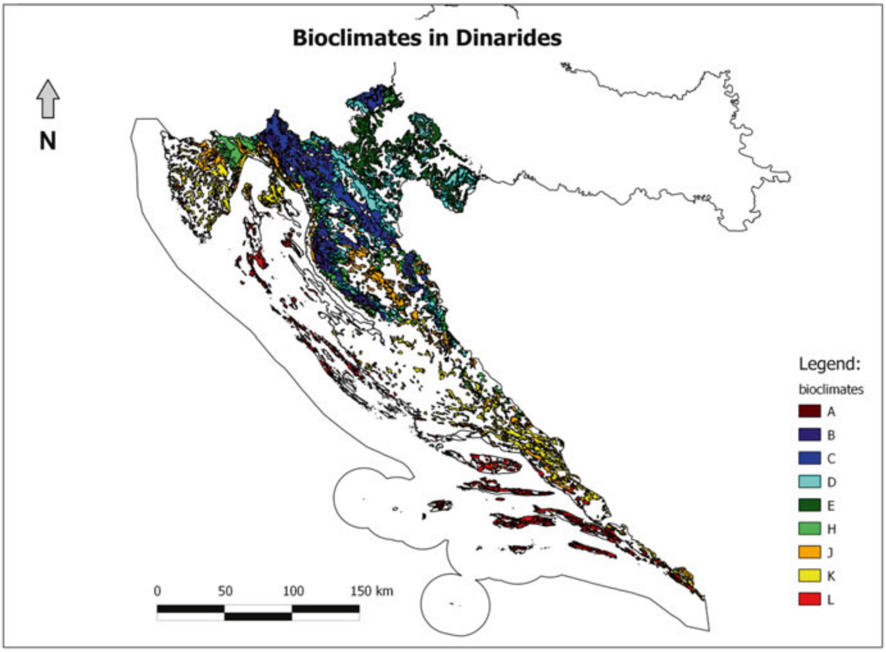

Fig. 9.10 Map showing the distribution of bioclimates in Dinaric area

9.6 Climate Modeling and Future Climate Changes in Croatia

Because processes in the climate system are nonlinear, it is not possible to extrapolate observed trends of climate parameters to determine their evolution in the future. Instead, components of the climate system and their interactions are usually simulated by global climate models (GCMs), which consist of models of the atmosphere, oceans, soil, vegetation, and ice and include carbon and other greenhouse gas (GHG) cycles. Simulations are first performed for the past periods when a GCM follows the observed values of the GHG concentrations, and then a model is integrated for the future period(s) under a prescribed scenario(s) of GHG emissions.

As the horizontal resolution is relatively coarse (generally 100–200 km), representation of topography in GCMs does not correspond to the actual relief on Earth, particularly in steep mountainous areas. This discrepancy mostly affects the results of simulated surface climate parameters, such as air temperature and precipitation, which are strongly influenced by local topographic variations. To obtain reasonably detailed structures of possible future changes at regional and local levels, these climate parameters should be analyzed at a higher horizontal resolution. One method to increase horizontal resolution is dynamical downscaling where the global model results are used as the initial and boundary conditions for a regional climate model

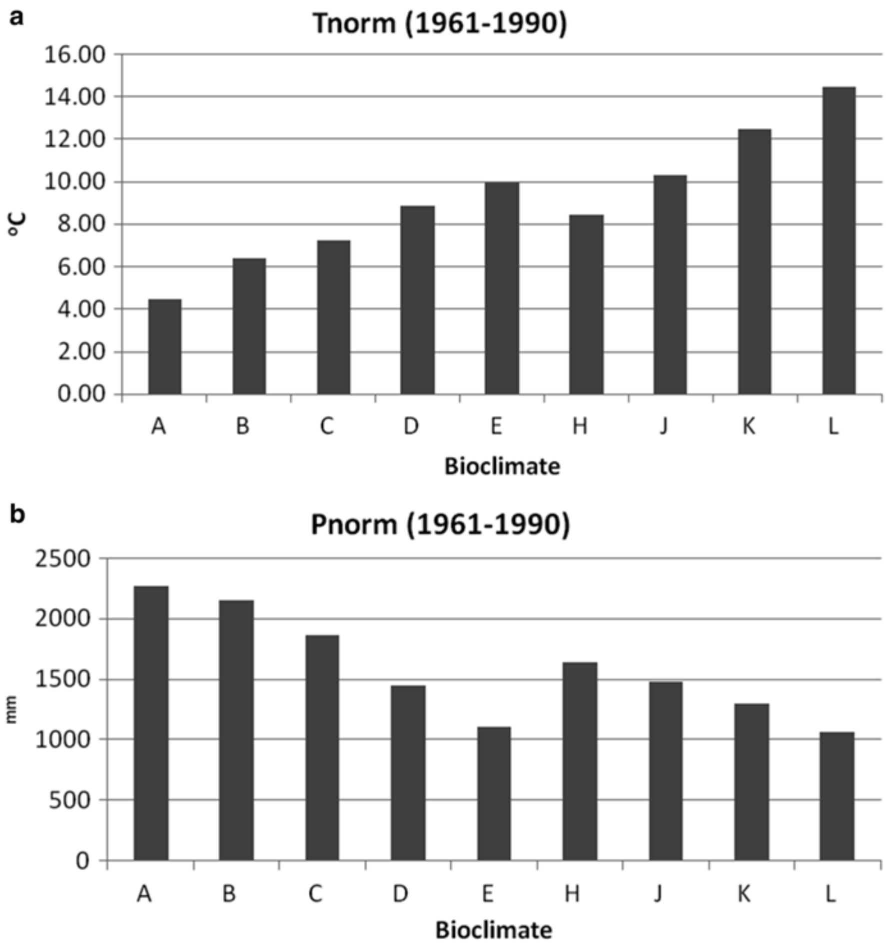

Fig. 9.11 (**a**) Relationship between bioclimates and average temperatures. (**b**) Relationship between bioclimates and annual precipitation, based on 1961–1990 averages

(RCM). Regional climate models are integrated over a smaller domain, but with higher spatial resolution, mainly between 10 km and 50 km. Topographic characteristics at a RCM higher horizontal resolution correspond better to the actual relief than those from a global climate model. Because of the various uncertainties in future climate projections, climate simulations should be performed in ensemble mode where a RCM is forced with different realizations of the same GCM, with various GCMs, or multiple RCMs are forced with different GCMs under several GHG emission scenarios.

At the Meteorological and Hydrological Service of Croatia, future climate changes over southern Europe, including Croatia, were investigated in several studies using both GCM and RCM results. An assessment of future climate changes over the southern Europe and Mediterranean region from a global climate model under the Intergovernmental Panel on Climate Change (IPCC) A2 emission scenario (Nakićenović et al. 2000) for the mid-twenty-first century (2041–2070) is presented by Branković et al. (2010). The near-future (2011–2040) climate changes in Croatia, based on a single RCM forced with three different realizations of the same GCM under the A2 scenario, are described by Branković et al. (2012). From the same set of simulations, changes in extreme precipitation indices over the Croatian Adriatic region were analyzed by Patarčić et al. (under review in Climate Research). An ensemble of five RCMs was used to assess changes of surface air temperature and precipitation at the Croatian Adriatic throughout the twenty-first century under the IPCC A1B scenario by Branković et al. (2013). Based on the results from these studies, a statistically significant warming in Croatia is already projected in the near-future climate, whereas a reduction in precipitation becomes evident from the mid-twenty-first century in southern Croatia.

As an example of the analysis of the projected climate change over Croatia, we present the results of the simulated 2-month air temperature and total precipitation for the reference period 1961–1990 and the future climate for the period 2041–2070 in the 15 RCMs from the ENSEMBLES project (van der Linden and Mitchell 2009; Christensen et al. 2010), which were forced by different GCMs under the IPCC A1B scenario. For more details regarding the methodology and results for different periods in the twenty-first century, see MZOIP (2014).

For the period 2041–2070, representing the middle of the twenty-first century, the projected winter warming over continental Croatia is between 2.5 °C and 3 °C with respect to the simulated 1961–1990 period. The increase of the mean 2-month air temperature projected over the coastal areas is between 2 °C and 2.5 °C (Fig. 9.12a). In the summer, the warming over central and southern Dalmatia is from 3 °C to 3.5 °C, and for the remaining parts of Croatia (including mountainous regions) a temperature increase from 2.5 °C to 3 °C is projected (Fig. 9.12c). In the spring and autumn, the projected warming is spatially homogeneous with the temperature increase from 2 °C to 2.5 °C (Fig. 9.12b, d).

For the period 2041–2070, a projected increase in the winter total precipitation, between 5 % and 15 % relative to the reference period 1961–1990, is found in the ENSEMBLES RCM simulations under the IPCC A1B scenario (Fig. 9.13a). A decrease in total precipitation between −15 % and −25 % is projected for the summer season over almost the entire country, except in the northernmost and the westernmost parts of Croatia, where a decrease in total precipitation may occur, from −15 % to 5 % (Fig. 9.13c). A projected decrease in the total precipitation between −15 % and −5 % in the spring season is found in the ENSEMBLES RCM simulations over the entire coastal area and its hinterland (Fig. 9.13b). During the autumn, an increase in precipitation from 5 % to 15 % is projected over the central and eastern northern lowlands (Fig. 9.13d). Most of the projected precipitation changes are present in at least two thirds of the models.

At the spatial resolution of the regional climate models included in the ENSEMLBES project (which equals approximately 25 km), projected climate change in both 2-month air temperature and precipitation is generally homogeneous over the continental parts of Croatia. Spatial variability of the expected temperature

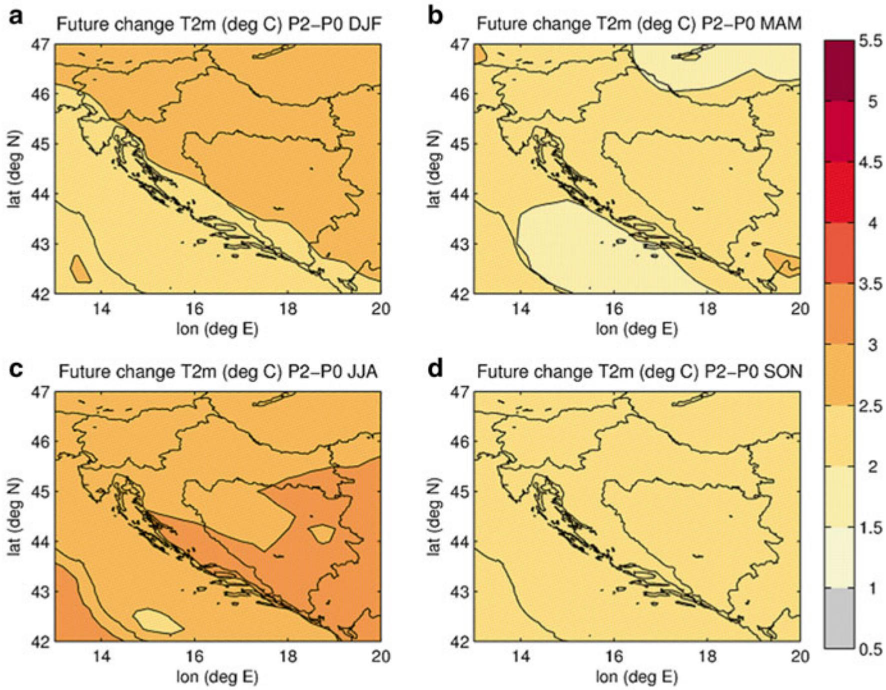

Fig. 9.12 Ensemble-mean difference (in °C) of the simulated 2-month mean temperature between the periods P2 (2041–2070) and P0 (1961–1990) in winter (DJF) (**a**), spring (MAM) (**b**), summer (JJA) (**c**), and autumn (SON) (**d**)

climate change should be revisited in future work using climate change projections from the currently running EURO-CORDEX project (e.g., Jacob et al. 2014) with RCM simulations using a finer horizontal resolution, such as 12.5 km.

9.7 Conclusions

In this study we described formation of the forest ecosystems in the broader region of Dinarides, with emphasis on soils and vegetation. Variability of climatic conditions and unified bedrock consisting of Mesozoic marine sediments, limestone breccias, marly limestones, and marlstones present the dominant soil- and ecosystem-forming factors. The air temperature gradient is higher on the coastal side (0.7 °C/100 m) than on the mainland (0.5 °C/100 m). The average annual temperature ranges from 3.5 °C at the highest station on the Velebit Mountain (Zavižan; h = 1594 m) to 8.4 °C at the Lika plateau (e.g., Gospić; h = 564 m).

Steep orography and a strong north Mediterranean cyclogenetic effect cause abundant precipitation: the largest annual amounts, from 3000 mm to more than

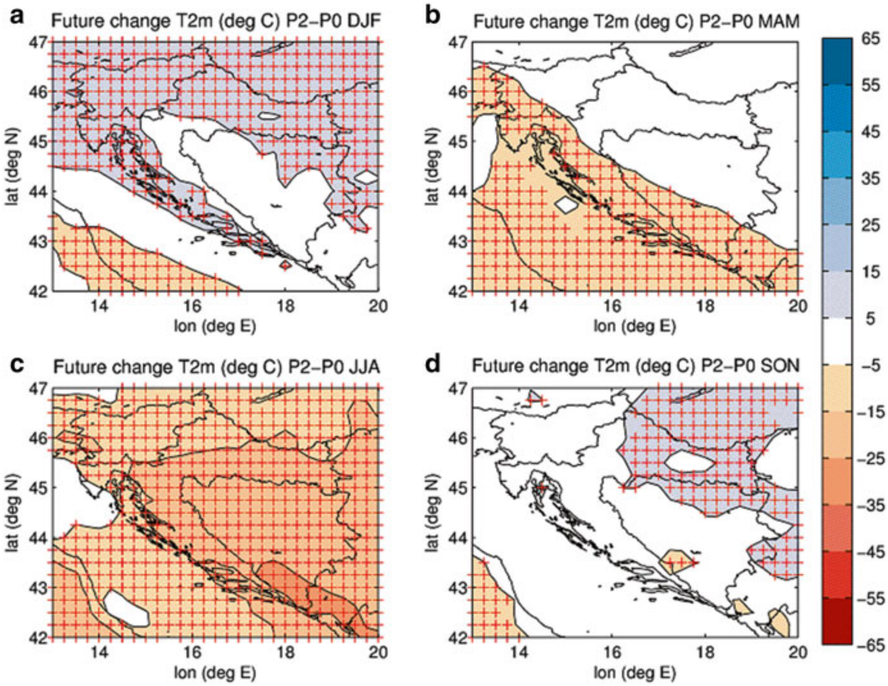

Fig. 9.13 Ensemble-mean relative difference (in %) of the simulated total precipitation in winter (DJF) (**a**), spring (MAM) (**b**), summer (JJA) (**c**), and autumn (SON) (**d**). The "+" sign denotes grid points where the sign of change in at least two thirds of the models agrees with the sign of change of the ensemble mean difference and when the relative difference of ensemble means is outside the interval ±5 %

3500 mm, fall over the peaks on the Velebit Mountain and in Gorski kotar. The precipitation vertical gradients are in the range between 57 mm/100 m and 151 mm/100 m, depending on the mountain. The mountain slopes that are oriented toward the sea receive more precipitation than the leeward slopes.

The Dinaric mountains in Croatia strongly affect the climate of the Adriatic region, making a distinct boundary between the maritime and the continental climate. Therefore, existing soil types are formed under condition of three types of climate: mountainous, continental, and Mediterranean. The most abundant soil types present are calcicambisols, calcomelanosols, and rendzinas, which are relatively shallow soils developed on hard limestone and dolomite. In the continental part of the Dinarides, there are areas with parent material formed of flint and silica (sandstone, slate, acid igneous rock) and in this condition dystric cambisols and luvisols are formed. In the littoral zone with Mediterranean climate, terra rossa with characteristic intensive red color is very common.

The forest vegetation of Dinaric mountains stretches vertically through five vegetation belts (Mediterranean littoral and montane, continental colline, montane, and subalpine), and horizontally is connected to specific Illyrian provinces. Northeastern exposures of the Dinaric Mountains and continental climate influence formed covered (green) karst in the continental vegetation belt where five bioclimates (A–E) are present. Bioclimates A and B represent areas of subalpine vegetation. The central forest community of the Croatian Dinaric area is dinaric beech–fir forest (*Omphalodo–Fagetum*), which covers more than 150,000 ha (bioclimate C). It is characterized by numerous Illyrian species such as *Omphalodes verna*, *Calamintha grandiflora*, and *Cardamine eneaphyllos*. Many other azonal communities such as *Helleboro nigri–Fagetum*, *Aremonio–Piceetum*, *Helleboro nigri–Piceetum*, and *Blechno–Abietetum* are present. Bioclimate D is represented by beech forest with deadnettle (*Lamio orvale–Fagetum*), also abundant with Illyrian species (*Lamium orvala*, *Daphne laureola*, *Scopolia carniolica*, *Euphorbia carniolica*, and *Epimedium alpinum*).

The Mediterranean phytogeographic region of the Dinaric Mountains consists of maritime beech forest (*Seslerio–Fagetum sylvaticae*) in the montane belt (mostly above 800 m) with azonal forest communities of black pine and Dalmatian black pine (*Cotoneastro–Pinetum nigrae*, *Junipero sibiricae–Pinetum dalmaticae*) (bioclimate H). In the sub-Mediterranean region, the forest of pubescent oak and oriental hornbeam (*Querco–Carpinetum orientalis*) is the most important climatozonal forest.

At the Meteorological and Hydrological Service of Croatia, future climate changes over southern Europe including Croatia were investigated in several studies using both GCM and RCM results. Based on the results from these studies, a statistically significant warming in Croatia is projected already in the near-future climate, whereas a reduction in precipitation becomes evident from the mid-twenty-first century in southern Croatia.

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Chapter 10
Assessment of Greek Forests Protection and Management

Alexandra D. Solomou, George Karetsos, Elpiniki Skoufogianni, Konstantinos Martinos, Athanasios Sfougaris, and Konstantinia Tsagari

Abstract Forests perform multiple and intertwined social, economic, and environmental functions. Greek forests are complex biotic communities, characterized by trees, and encompassing much of the life on Earth. Efficient forest management strategies should be formed to consider the future forest dynamics to achieve important management objectives such as biodiversity conservation preserving ecological functions and countering climate change. Greek forests have long been threatened by a variety of destructive agents. The greatest problem for Greek forests is the lack of management. In Greece, during past years, serious natural disasters have occurred, associated with fires and floods that are inextricably linked to its geographic location, geology, geomorphology, vegetation, and the prevailing climatic conditions. Hence, restoration of forest ecosystems is of great importance and a main environmental issue in Greece. Efforts of restoration are based on earlier empirical techniques, which were later improved, and supported by scientific research. The selection of a suitable method and its implementation demands deeper knowledge of natural ecosystem functions and of the physiology of diverse organisms. Moreover, a versatile, and interscientific approach is required, coordinated with the direction of the goals and objectives of the restoration, individual actions, utilization of research results, usage and improvement of technologies, as well as the creation, improvement, and development of infrastructure.

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10.1 Introduction: Forest Ecosystems in Greece

The Greek flora is characterized by high plant diversity and endemism. The diversity of Greek flora is a result of interplay between various factors such as the geographic position of Greece, its geomorphology, the presence of flora of past geologic eras, and the coexistence and interaction of biotic and nonbiotic factors. The main tree species found in Greece that form the basis of forest ecosystems can be classified into four basic spatial groups, depending on their phytogeographic origin: Meso European, south-southeast European, Mediterranean species, and endemic species of the Balkan Peninsula. The four main forest vegetation zones, concluded from the findings of various researchers throughout the years, are the Eu–Mediterranean vegetation zone, the Para–Mediterranean vegetation zone, the beech–fir vegetation zone, and the boreal conifer vegetation zone. The boundaries of these zones are often intertwined in a vague manner whereas plant communities often appear in the form of a mosaic.

10.1.1 The General Context

Greece occupies the southern end of the Balkan Peninsula in the eastern Mediterranean (Fig. 10.1). It is mostly a mountainous country, and almost 25 % of the territory is covered with forests, making it the fourth largest country in Europe with respect to forest resources (Fig. 10.2). The majority of the forests in Greece are natural and not artificial. To be more specific, Greece covers 12,890,000 ha, and the forest land area in Greece was most recently measured as 3,903,000 ha, according to the FAO (2010). Also, Greek forests are 4.6 % of the forest area of Mediterranean countries (FAO 2010), and Greece produced 1,272,916 m^3 of forest products in its last report in 2007 (FAO 2010). About 56 % of the country's communities are located in mountainous or semi-mountainous areas, according to the National Population Census (National Statistical Service of Greece 1995). Almost 80 % of these communities have forests in their territory and 32 % of the country's population lives in these areas. Hence, forest resources have an important place in the economy of the mountainous and semi-mountainous areas of the country.

Greece is characterized by a Mediterranean climate, with precipitation concentrated in the cool period, from October to March, and almost no precipitation in the hottest months, July and August. The amount of rainfall ranges from 780 to 1280 mm per year in the western part of Greece. This amount is approximately halved in the eastern part, where rainfall ranges from 380 to 640 mm per year.

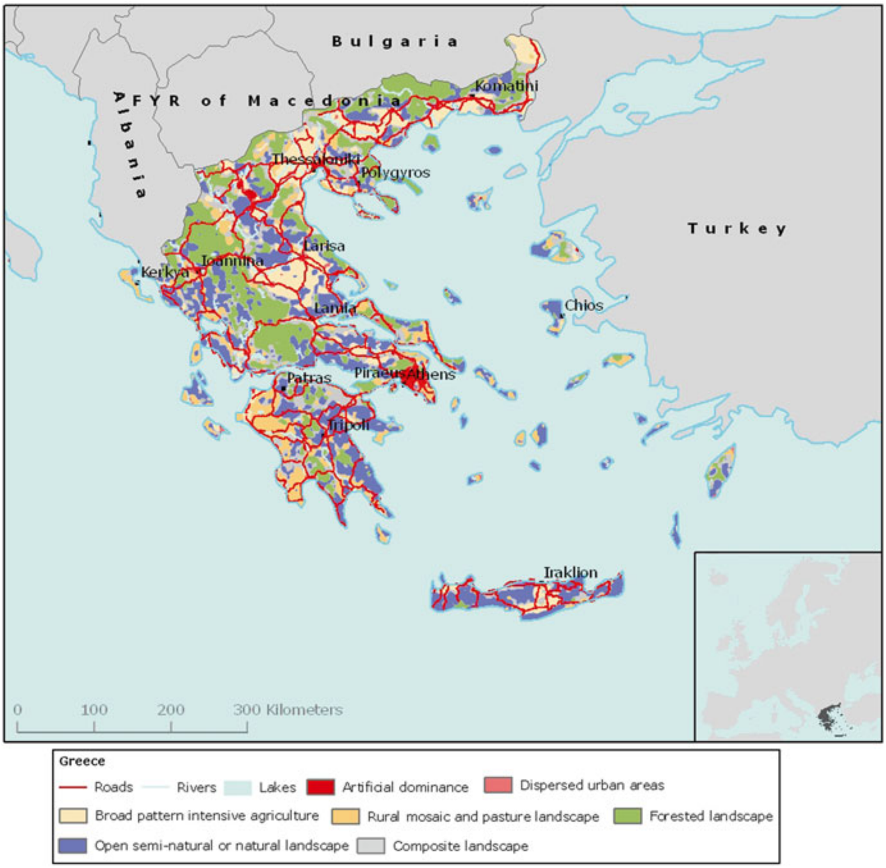

Fig. 10.1 Map of Greece (EEA 2007)

Rain erosivity is higher in the western and southwestern parts of the mainland, in the eastern Aegean islands, and in most of the island of Crete. Precipitation of lower erosivity occurs in the northwestern regions, and precipitation of medium erosivity mostly occurs in the central and eastern parts of the mainland (Kosmas et al. 2006).

10.1.2 Greek Diversity

Greek vascular flora is characterized by high plant diversity, with 5752 species and 1893 subspiecies representing 6600 taxa. According to present knowledge, the endemic vascular flora consists of 1462 taxa (22.2 % of the total number of Greek taxa) (Dimopoulos et al. 2013). The diversity of Greek flora is the result of interplay between various factors, and according to many researchers (Turrill 1929; Polunin 1980; Strid and Papanikolaou 1985; Iatrou 1996; Strid and Tan 1997;

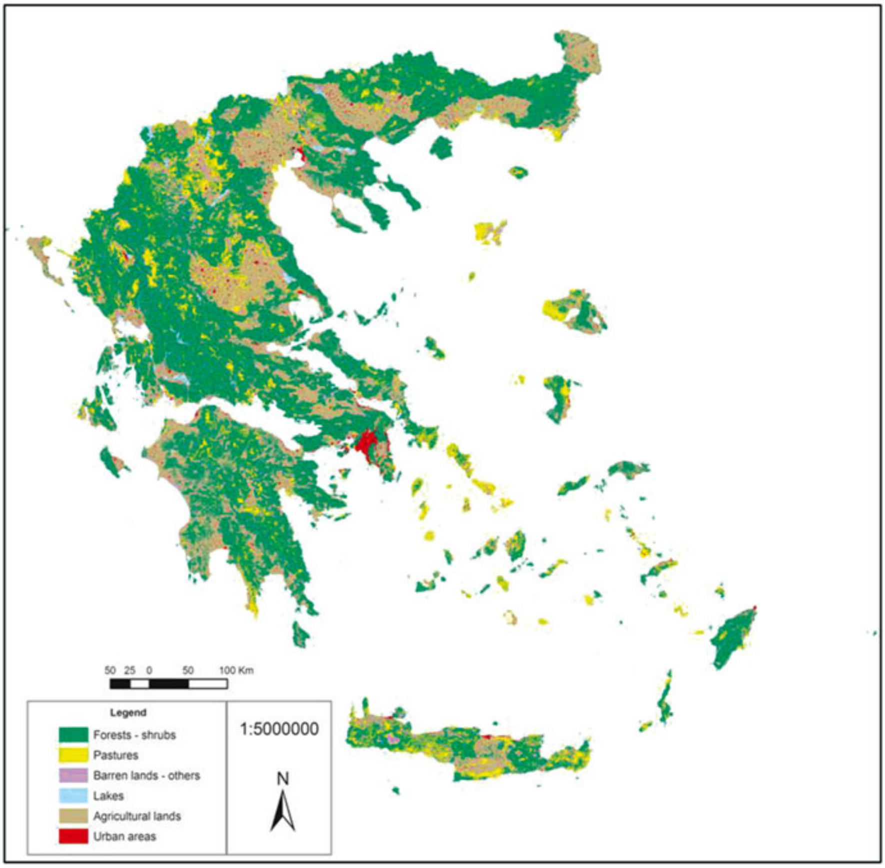

Fig 10.2 Map of vegetation and land use of Greece (Ministry of Reconstruction of Production, Environment and Energies, General Directorate of Development and Protection of Forest and Rural Environment, Directorate of Forest Infrastructions, Section of Forest Mapping and Inventory)

Thompson et al. 2005; Georghiou and Delipetrou 2010), the most important factors are those stated here:

(a) The geographic position of Greece, which stands between fundamental floras. The Mediterranean, the meso-European, the tropical/subtropical and other floras, have, in various degrees, enriched the diversity of the Greek flora.
(b) The geomorphology of Greece. The presence of peninsulas, mountains, and islands reflect the area's geologic history, which had an important impact on plant populations. The origin and distribution of the country's flora and endemics have been connected to palaeogeographic patterns (Turrill 1929; Rechinger 1965; Dimopoulos et al. 2013).
(c) The presence of flora of past geologic eras and Greece's function as an important European species refuge during the Ice Ages. The flora has been influenced by east-to-west migration during the Miocene and by a north-to-south migration in consecutive waves (Iatrou 1986).

The coexistence and interaction of biotic and nonbiotic factors, such as plant and climate diversity, combined with long-term human presence (Portoghesi 2006; Arianoutsou et al. 2011), resulted in a mosaic composed of natural, seminatural, and man-made plant communities. The great diversity that characterizes Greece (Médail and Quézel 1997; Trigas et al. 2007; Schindler et al. 2008) is shown by plant communities varying from subtropical such as Crete's palm tree forests (Vai, Preveli, and elsewhere), to north European-type spruce forests as well as sphagnum bogs in Rhodope and Voras mountain that bring more northern climates to mind (Mavrommatis 1980; Gerasimidis et al. 2009).

The main tree species found in Greece that form the basis of forest ecosystems can be classified into four basic spatial groups, depending on their phytogeographic origin (Debazac and Mavromatis 1971):

(a) Meso-European species

This group includes species that mainly span central and northern Europe as well as northern Asia. Their distribution extends toward the south and reaches northern or central Greece, in the mountains, where they form ecosystems of meso-European character, as accompanied by shrubby and herbaceous species of similar geographic spread. Among these species are the valuable and timber-yielding tree species of Greece such as *Fagus sylvatica*, *Picea abies*, *Betula pendula*, *Pinus sylvestris*, *Carpinus betulus*, *Quercus petraea*, *Acer pseudoplatanus*, and *Acer platanoides*.

- South-southeast European species and Black Sea species

A significant number of thermophilous deciduous trees and shrubs that dominate the ecosystems of semi-mountainous zones and low elevations of the continental areas have their center of spread in southern Europe and the Black Sea (Portoghesi 2006; Korakis 2012). Thermophilous deciduous forests are widely met in Greece (Bergmeier and Dimopoulos 2008). Among these species we encounter *Quercus pubescens*, *Q. frainetto*, *Q. cerris*, *Ostrya carpinifolia*, *Carpinus orientalis*, *Fraxinus ornus*, *Tilia tomentosa*, *Acer tataricum*, and *Acer hyrcanum.*

- Mediterranean species

The Mediterranean flora of Greece posesses a holarctic character (Strid and Tan 1997). Under Raven (1973), species with tropical affinities are exceptions, such as olive, fig, and carob. Mediterranean flora derived from the evolution of both temperate and tropical originated agents. These species are spread more or less around the Mediterranean basin and are dependent on its bioclimate. They are found in abundance in Greece, especially in low altitudes, characterizing coastal and island vegetation (Korakis 2012). The most important representatives of this group are *Olea europaea*, *Ceratonia siliqua*, *Quercus ilex*, *Pistacia lentiscus*, *Myrtus communis*, *Phillyrea latifolia*, *Pinus halepensis*, *Pinus halepensis* subsp., *Brutia Pinus pinea*, *Juniperus phoenicea*, and *Laurus nobilis*.

- Endemic tree species of the Balkan Peninsula

A small number of tree species of the Greek flora is characterized by a limited distribution located within the Balkan Peninsula. These species are important additions to the biodiversity of the Greek flora, as many are remnants of older geologic eras (Korakis 2012). These species are mainly spread in the mountainous vegetation zone. The most important species are *Abies cephalonica*, *Aesculus hippocastanum*, *Pinus leucodermis*, *Pinus peuce*, *Quercus trojana*, *Quercus trojana* subsp. *euboica*, *Acer heldreichii*, and *Zelcova abelicea.*

(b) The classification of forest vegetation

Academic papers related to the total forest vegetation and floristic diversity of Greek forests have not yet been published. However, numerous individual studies containing detailed information on the structure and composition of forest plant communities have been carried out (Korakis 2012). For a general overview of forest vegetation of Greece, see classical classification followed in zones proposed by Dafis (1973) and an adaptation of the classification of Glavač et al. (1972), and Horvat et al. (1974) concerning the vegetation of southeast Europe. Moreover, the consideration of ecological divisions of forest vegetation is suggested for habitats of the main forest species (Debazac and Mavromatis 1971). In Greece there are four vegetation zones (Nakos 1984). The four main forest vegetation zones resulting from this classification are distinctive in a floristic, ecological, physiognomic, and historical manner as follows:

- The maquis zone (or the zone of evergreen broadleaf) is found at an altitude of 0–1300 m. The main vegetation consists of Aleppo pine *(Pinus halepensis*), Brutia pine (*Pinus brutia*), and evergreen broad-leaved species (*Quercus coccifera*, *Arbutus* sp., etc); it occupies 47.5 % of the country area.
- The zone of deciduous oaks is found at an altitude of 200–300 m and also between 1000 and 1300 m. The species include *Quercus frainetto*, *Quercus ithaburensis*, *Quercus cerris*, *Quercus pubescens*, and *Quercus robur*. It occupies 39.2 % of the country area.
- The fir (*Abies*) zone with the subzones o*f Fagus* sp., *Pinus sylvestris*, and *Pinus nigra* ranges between 700 and 1800 m in altitude. It is the most important forest zone, covering 11.8 % of the country area.
- The pseudoalpine zone is found at an altitude of more than 1600 m and occupies 1.5 % of the country area. In this zone one can find the species *Juniperus nana*, *Juniperus foeditissima*, *Festuca* sp., *Astragalus* sp., and *Sesleria* sp., among others.

The boundaries of these zones are often intertwined in an indistinct manner; the plant communities often appear in the form of a mosaic (Schindler et al. 2008), and their mapping is possible only after removal of details (Dafis 1973; Strid and Tan 1997).

10.2 Forests in Mountain Regions of Greece

Southern European mountains are considered as areas of remarkably high plant diversity, and the mountains of the Mediterranean basin exhibit a high rate of speciation. Mountains, without doubt, constitute the backbone of the entire Mediterranean region. Greece is a country of the Mediterranean with a contrasting geographic terrain, and more than 60 % of the country consists of mountainous or semi-mountainous regions. Many of Greece's historic and cultural landscapes are found in mountainous areas. The mountain flora of Greece consists of approximately 1600 species, of which 405 are endemic. Differences in climate, substrate, and long-term human activity have resulted in dramatic contrasts between mountains in different parts of the country, ranging from the desert-like uplands of the White Mountains in Crete to wet and forested mountains on the borders to the north. *Fagus*, *Abies*, *Pinus*, *Juglans*, *Juniperus*, and many other genera of tree species form the diverse forest fauna of the country, covering and surrounding its mountain regions at various altitudes.

10.2.1 Morphology and Diversity

Southern European mountains are considered as areas of remarkably high plant diversity (Väre et al. 2003). The mountains of the Mediterranean basin especially exhibit a high rate of speciation (Martín-Bravo et al. 2010) and are rich in endemic species (Gómez-Campo 1985; Sainz and Moreno Saiz 2002; Nagy et al. 2003). Mountains, without doubt, constitute the backbone of the entire Mediterranean region, as they cover approximately 1.7 million km^2 (Vogiatzakis 2012). Greece is a country of the Mediterranean with a contrasting geographic terrain, and more than 60 % of the country consists of mountainous or semi-mountainous regions (Chalikias and Kolovos 2013; Regato and Salman 2008). Many of Greece's historic and cultural landscapes are found in mountainous areas, with altitude above 700 m, intense relief, and slopes between 16 % and 20 % that cover 43 % of Greece (Stergiadou et al. 2009). Greece is considered as one of the most biologically diverse countries of the European continent (Kokkoris et al 2014) as the Greek flora is highly diverse in relationship to its size (Georghiou and Delipetrou 2010).

10.2.2 Species and Formations of Forests in Mountainous Regions of Greece

An attempt to identify species was made according to the flora Europaea (Tutin et al. 1964–1980) and mountain flora of Greece (Strid 1986; Strid and Kit-Tan 1991), concluding with 1520 taxa that are included in its two volumes. Differences in climate, substrate, and long-term human activity (Geeson et al. 2002; Pausas et al. 2004; Portoghesi 2006; Marzano et al. 2012; Le Houerou 1987; Trabaud and Lepart 1980) have resulted in dramatic contrasts between mountains in different parts of the country, ranging from the desert-like uplands of the White Mountains in Crete to wet and forested mountains on the borders to the north.

As regards mountain flora, Greece is divided into eight regions (Fig. 10.3). Total numbers of mountain taxa in the regions are Peloponnisos, 540; Sterea Ellas, 751; Crete, 217; S. Pindhos, 609; N. Pindhos, 780; E. Central, 278; N. Central, 868; and North-East, 665 (Strid 1995).

Specifically, *Fagus* forests are widespread in the mountains of northern and central Greece (Portoghesi 2006) [Rodopi, mountain chains of Voras-Olimbos (Olympus), Pilio, Varnous-Vourinos, and Pindos], generally in altitudes between 800 and 1800 m, often in pure stands or sometimes mixed with other broad-leaved deciduous trees (Strid 1995) or forming a distinct vegetation zone together with species of *Abies* (Zoller et al. 1977; Raus 1980; Bergmeier 1990; Reif and Loblich-Ille 1999; Bergmeier and Dimopoulos 2001). Moreover, small areas of *Fagus* forests belonging to the *Doronico orientalis–Fagion moesiacae* alliance with *Silene multicaulis*, *Lathyrus alpestris*, *Orthilia secunda, Festuca drymeja*, and *Doronicum orientale* occur and are known as Moesian mountainous beech forests (Portoghesi 2006) that prefer to grow at altitudes of 900–1800 m. *Pinus nigra* and *Abies* species often grow in mixed stands (Bergmeier 2002) on drier slopes throughout the mainland. *Picea abies* forests occur in almost virgin stands, for example, in Rodhopi near the Bulgarian border (Papageorgiou et al. 2012). Coniferous forest formations become progressively more prominent at the expense of broad-leaved deciduous forest south along the mountains of Greece. On Peloponnisos, practically all mountainous forests are dominated by *Pinus nigra* and *Abies cephalonica* (Sfenthourakis et al. 1998), reflecting the remnants of mountainous forest that still exist in Crete (especially in the White Mountains) and consist of species such as *Cupressus sempervirens* and *Pinus brutia* (Portoghesi 2006). Deciduous forests are practically lacking in the mountains of Crete (Brofas et al. 2006; Spanos et al. 2010). *Aesculus ippocastanus* and *Juglans regia* mixed woods are natively found in eastern Greece in damp mountain ravines and valleys between 350 and 1350 m (Polunin and Walters 1985).

A number of Anatolian taxa is found in the northeast and sometimes also in the north and central regions of Greece; these are woodland species often associated with noncalcareous substrates. In the south, a small group of Anatolian mountain taxa is found in Crete. Moreover, numerous Anatolian taxa bypass Crete and reappear in the mountains of Peloponnisos and Sterea Ellas. These species tend to prefer arid, rocky habitats and are usually found on limestone. Some of them are considered rare elements in the European flora, for example, *Juniperus drupacea* (Papageorgiou et al. 2012).

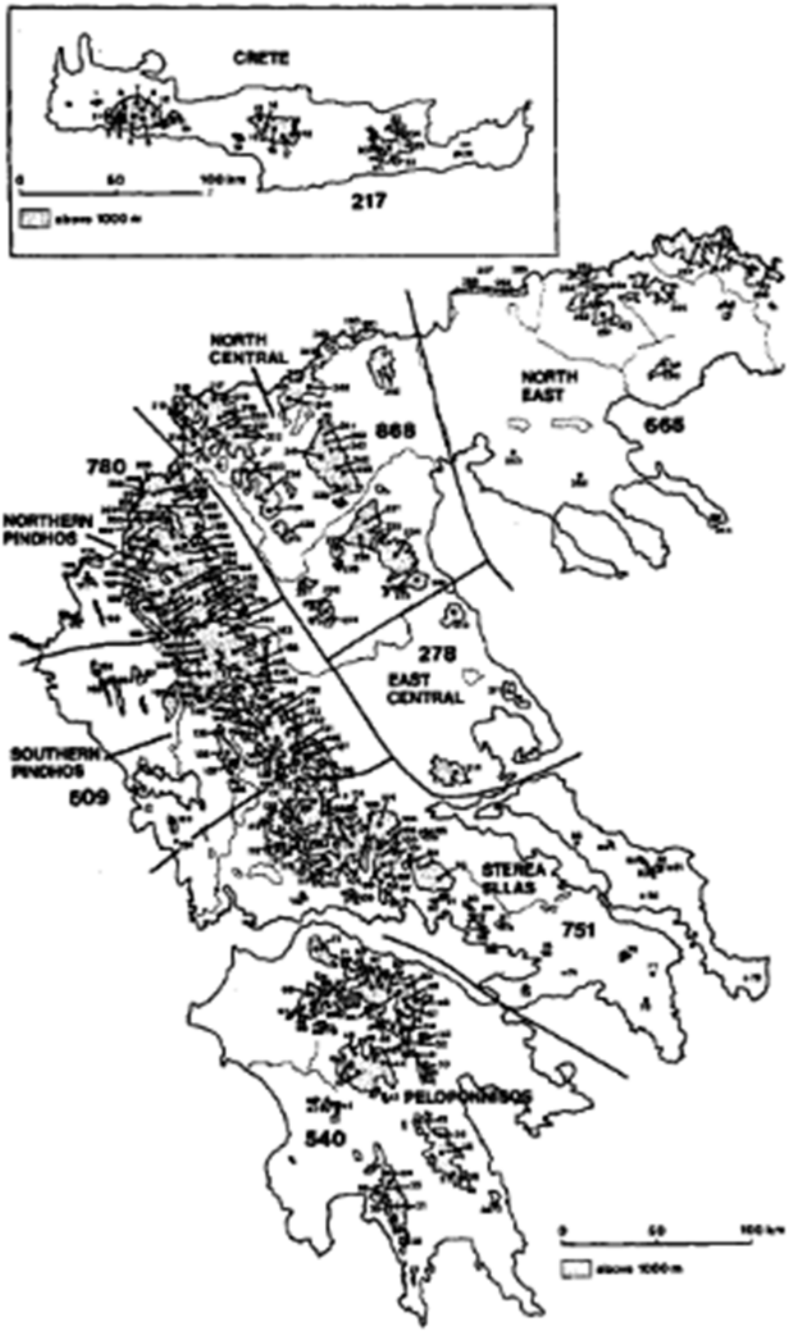

Fig. 10.3 The absolute numbers of mountain taxa indicated for each region of Greece (Strid 1995)

10.3 Direct and Indirect Benefits of Forests

Forests perform multiple and intertwined social, economic, and environmental functions. The contribution of forests is multiple and sustainable, and therefore they constitute a valuable natural resource. The benefits and values of forests can be divided into those of direct and indirect use. Greek forests offer the full spectrum of productive, protective, recreational, and environmental functions. Direct benefits include timber (sawn wood, fiberboard, particle board, pulpwood, fuelwood) and non-timber products (bark, resin, honey, small berries, aromatic leaves, mushrooms, medicinal herbs, game, forage material), employment (an emphasized benefit in the context of the economic crisis), and recreational (eco-tourism, forest tourism), and cultural values, among others. Indirect benefits include their hydrologic function and watershed control (flood protection), soil stabilization (protection from erosion), atmosphere cleansing (climate interaction and carbon sequestration), and biodiversity sustenance, serving as shelters of flora and fauna.

In recent years, many important changes have been observed in the different functions of forests (Tampakis 2011) regarding issues of biodiversity in plants and animals, environmental protection, watershed control, crop protection from harmful weather effects, development of aesthetic landscape values, recreation, and tourism development (Papastavrou et al. 1999; Bull and Nothway 2007). The benefits and values of forests can be divided into those of direct and indirect use (Christopoulou 2001). Greek forests offer the full spectrum of productive, protective, recreational, and environmental functions (Galatsidas 2001).

10.3.1 Direct Benefits

- Timber products and non-timber products

The wood industry offers sawn wood, fiberboard, particle board, pulpwood, and fuelwood as well as wood chips and bark for bioenergy. In 2010, 3,595,000 ha of forest land was considered as production oriented in Greece (FAO 2010). Aboveground biomass of forests accounted for 132 billion metric tons in 2010; the respective number for belowground biomass was 37 billion metric tons (FAO 2010). Wood removed for energy production in Greece during 2007 included 795,000 m^3 of underbark wood and 914,000 m^3 of overbark wood (FAO 2010). The industrial roundwood removals (the wood removed for production of goods and services other than energy production) reached 948,000 m^3 in underbark and 1,090,000 m^3 in overbark wood, respectively, in 2007 (FAO 2010). Non-timber products include bark, resin, honey, small berries, aromatic leaves, mushrooms, medicinal herbs, game, and forage materials.

- Employment

Employment, particularly for population living near the forests, and the exploitation of forest resources can be added to the long list of forest benefits. This is an emphasized benefit in the context of the economic crisis that has been experienced by Greece since 2010. The contribution of timber production to the national economy is small, although the sector of silviculture employed about 35,000 people in 1999 (Christodoulou et al. 1999). Official data show a steady decline in the number of forest workers in Greece; however, the exact figure of the forestry workforce in the country cannot be estimated because of the unknown number of inactive members of the forest cooperatives (Sakkas 1980; Tsioras 2004).

- Recreation, tourism, and cultural values

Forests have always had, and still do have, an important role in the daily life of the Mediterranean peoples, providing a 'sense of place.' In the past, forests and trees attributed long-standing cultural values that have defined the Mediterranean landscapes. Forest tourism is being developed, which can be combined with walking tourism and eco-tourism, and it is a constantly growing subcategory of tourism. Moreover, recreational activities raise the value of neighboring properties (Pearce 2001) and encourage tourism.

Recreation has always been a significant activity in the Mediterranean. Its estimated value varies widely across countries, from 5 million euro/ha to 167/ha (Croitoru 2007). Forest recreation is a function that gained importance in past decades, when the lack of leisure time is growing and the people's need to escape from the urban environment has been emphasized. The Greek Forest Service, contributing to this need, has established recreation places for a variety of activities (Galatsidas 2001), particularly at peri-urban forests, and it has also organized ten special areas for controlled hunting as well as 20 breeding centers for game animals (Kasioumis 1994).

10.3.2 Indirect Benefits

- Atmospheric benefits

Special attention should be paid to the vital contribution of forests to the oxygen cycle, to carbon dioxide absorption, and to air cleansing. Environment purification functions are crucial to peoples' health (Xie et al. 2010). Forests along with the oceans constitute the main mechanisms that regulate the balance and the equilibrium of the carbon dioxide cycle. Forests act as the storage or drainage system for huge quantities of pollutants and interact with climate, acting as sinks of CO_2 (Chrysopolitou et al. 2013). For example, forest leaves hold a large amount of industrial dust (Kailidis 1991). Forests can also reduce greenhouse gas (GHG) concentrations by sequestering atmospheric carbon in biomass and soil, and the carbon can remain stored in any wood products made from the harvested trees

(Malmsheimer et al. 2008). Carbon found in aboveground biomass in 2010 in Greece's forest was 62 million metric tons; the respective number for belowground biomass was 17 million metric tons (FAO 2010).

- Watershed protection: hydrologic function

The hydrologic relevance of forests in the Mediterranean has been emphasized by many authors in the past few decades (Bosch and Hewlett 1982; Sahin and Hall 1996; Andréassian 2004; Cosandey et al. 2005; Gallart and Llorens 2004; Guojing et al. 2005). Forests serve as natural barriers to storms and floods (Croitoru 2007), and they have considerable water retention capacity that reduces landslides during periods of heavy rain, preventing flooding while protecting settlements and infrastructures. Wooded areas are the main collector and water movement mediator regarding underground water layers (Camp and Dangherty 1997; Nels et al. 2001). Forests regulate quality as well as quantity of water, being the base for an integrated management of hydrologic resources (Dudley and Stolton 2003). The role of forests in water conservation is particularly important (Croitoru 2007), whereas enrichment of underground aquifers and contribution to the quality of water from a chemical/microbiological scope lies among the indirect benefits of the forest's environmental value (Christopoulou 2001).

- Soil protection and stabilization

Dense forest cover ensures the presence of a prevailing subsurface flow, thus reducing soil erosion (Serrano-Muela et al. 2008). In particular, soil protection from erosion and prevention of torrential phenomena has been a high-priority task for decades for the Forest Service, and a great number of dams and other soil stabilization works have been undertaken in watersheds with acute erosion problems. As erosion is linked with the existence of surface water, measures taken to prevent erosion contribute positively to the hydrologic cycle as well, increasing the protective role of forests on water quantity and quality. The irregular topography of our country renders the largest part of its land vulnerable to erosion (Tampakis 2011). This sensitivity is intensified by the dry climate of Greece, the shallow soil, and the irregularity of rainfall (Yasoglou 1995). The "protective" forests institution may be considered as one of the most important provisions delivered by the first Forest Law (N. 4173/1929). These forests were mainly created in disrupted areas near large urban settlements. These periurban forests protect settlements against soil erosion, landslides, and flooding (Christopoulou et al. 2007; Galatsidas 2001).

- Biodiversity

The contribution of forests to biodiversity cannot be ignored. Forests serve not only as a shelter for flora and fauna, but also as a valuable natural gene pool (Christopoulou 2001). The Greek flora constitutes almost 6,000 plant species (Strid and Tan 1997), many of which are endemic. The fauna is also rich and hosts species that are very scarce in middle-west Europe (e.g., brown bear and wolf). Forests are the main reserves for the majority of flora and fauna. For the protection of this biological diversity, various types of protected areas have been established. In 2010, 164,000 ha were characterized for their biodiversity function in Greece (FAO 2010).

Last but not least, the value of scientific data deriving from forest biodiversity is of great importance for a number of sciences (Christopoulou 2001).

10.4 Sustainable Forest Management

Interest in the sustainability of agricultural systems can be traced to environmental concerns that began to appear in the 1950s–1960s. Today, sustainable forest management (SFM) is the management of forests in a viable manner to achieve environmental, social, and economic benefits for present and future generations. The methods and structure of sustainable forest management are a group of ever-evolving parameters that should closely follow current scientific and ecological data, economic reevaluations, and emerging social issues. The issue of forests has been a priority on international policy and political agendas for the past years. The European Union is also concerned with SFM and has many administrative organs working on this matter of importance. However, the degree of underestimation of sustainable management is particularly high in southern and eastern Mediterranean countries. On a national level, it is futile to consider sustainable forest management without clarifying fundamental issues that seem to be in an vague state such as the legal framework. On the event horizon of the changing political scenery in Greece at the dawn of 2015, possibly new outtakes and perspectives on sustainable forest management remain to be seen.

10.4.1 A Definition

Interest in the sustainability of agricultural systems can be traced to environmental concerns that began to appear in the 1950s–1960s (Pretty 2008). Similar ideas, however, are found in the oldest surviving writings from China, Greece, and Rome (Cato 1979; Hesiod 1988; Conway and Pretty 1991; Li Wenhua 2001; Pretty 2002, 2005). Today, sustainable forest management (SFM) is the management of forests in a viable manner to achieve environmental, social, and economical benefits for present and future generations (Brand 1997). Sustainable forest management is based on methods that do not risk future benefits of the environmental services of the ecosystem (Putz 1994). It is needless to say that different sustainable forest management strategies are needed in different forest types in different regions of the world.

10.4.2 The Global View

The issue of forests has been a priority on international policy and political agendas for the past years. Among many international organizations, the UNFF (United Nations Forum on Forests) was established by ECOSOC Resolution/2000/35 as part of a new international arrangement on forests. The Instrument was adopted by the UN General Assembly (Resolution 62/98) on 17 December 2007 (UNFF 2000). The UNFF sets objectives promoting protection and sustainable management of forests on a global level.

10.4.3 The European View

FOREST EUROPE (The Ministerial Conference on the Protection of Forests in Europe) is the pan-European political process aiming at sustainable management of the continent's forests. The conference works on shared strategies for 46 member countries and the European Union on how to protect and sustainably manage forests (Forest Europe 2011). Since 1990, the collaboration of the ministers responsible for forests in Europe has had a great impact, nationally and internationally, on economic, environmental, and social levels. Signatory countries participate in the Intergovernmental Negotiating Committee (INC). The ministers responsible for forests gather in a Ministerial Conference to discuss and promote sustainable forest management. The organization is involved with other global and regional initiatives and committees concerned with social and political issues regarding forests. FOREST EUROPE works closely with the UNFF. Greece is one of the signatory countries of FOREST EUROPE and is in cooperation with the organization via the nation's Ministry of Environment, Energy and Climate Change.

FOREST EUROPE, through the Oslo Ministerial Decision: European Forests 2020, came up with a new vision and new objectives for the future of the continent's forests (FOREST EUROPE 2014). Some of the main tasks regarding SFM that FOREST EUROPE is currently undertaking are these:

(a) Develop and update policies and tools for sustainable forest management.
(b) Monitor commitments on forests and sustainable forest management in all European countries.
(c) Promote education, research and the use of scientific knowledge.
(d) Facilitate the sharing of experiences across countries on all aspects of sustainable forest management.
(e) Raise awareness and understanding of the contributions by FOREST EUROPE to sustainable forest management.

10.4.4 Greek Management

The degree of underestimation of sustainable management is particularly high in southern and eastern Mediterranean countries (Croitoru 2007). Almost 80 % of Greece's forests belong to the government (FAO 2010). The Greek forest legislation is covered by the Forest Code (Sfenthourakis et al. 1998) as a part of the general law system of Greece and is defined as a very complicated sector. Many legislative frameworks and relative provisions about the protection and management of the natural environment have been published throughout the years. Over the years, the legitimate definitions of forest had become ineffective and obsolete as a result of the existence of too many laws that often cause overlapping and confusion. Moreover, in the context of the recent economic crisis, environmental management agencies have been merged and the results have been disappointing (Apostolopoulou et al. 2012).

10.4.5 Regional Issues

Greece, as part of the Mediterranean Basin, which is a biodiversity hotspot (Myers et al. 2000; Malcolm et al. 2006; Trigas et al. 2007; Médail and Diadema 2009; Dimopoulos et al 2013), is projected to be among the countries most vulnerable to climate change. Furthermore, there was evidence of climate change during the last half of the twentieth century, with winter and summer showing evidence of warming in large parts of the region combined with a statistically significant decrease in precipitation (Giannakopoulos et al. 2005). As a result of climate change, new assemblages of species in space and time and major shifts in the geographic distribution of forest vegetation are expected to occur (Kirschbaum 2000; Hansen et al. 2001). A common phenomenon is dieback and decline events caused by insect and pathogen outbreaks and diseases, something that has already been observed (FAO 2006). The changes just mentioned have many direct indirect effects on the state of the Greek forests. Chrysopolitou carried out research on four pilot forest sites in Greece in 2013 and mentioned an array of problems, with diverse possible causes, that briefly reflect a part of the current situation in Greece:

(a) An extensive necrosis of Scots pine has been observed at Mount Pieria during the past 30 years caused by the combined action of the primary pathogenic fungus *Peridermium pini* and bark beetles. It is assumed that changes in climatic parameters over the years have considerably aided in this. Today, the state of health in the Scots pine forest in this area is alarming.
(b) Inappropriate management applied in the region by the local Forest Service at Aspropotamos–Kalambaka might have led to the weakening of the local broad-leaved forest.
(c) An outbreak of the bark beetle *Peridermium spinidens*, an extremely dangerous bark-eating insect, caused the dieback of Greek fir in the National Park of Parnitha and Mount Taygetos. The dominance of this bark beetle is, again, highly influenced by climatic changes.

Another issue regards the increased danger for fire events. The Eastern Mediterranean, including Greece, during summertime is characterized by specific meteorological and climate conditions that favor the phenomenon (Poupkou et al. 2014). During the summer of 2000, more than 1000 km^2 of forests and grasslands were burnt in Greece (Keramitsoglou et al. 2004). The foregoing data offer us a clear view of another major issue to be confronted, forest fires. Last but not least, erosion remains one of the main problems of the mountain forests of Greece.

10.4.6 The Future Approach

Sustainable forest management is gaining more and more attention nowadays and the subject is of dominant interest in many Mediterranean countries, such as Greece (Zagas et al. 2011). The Mediterranean region is fairly wide, with many degraded ecosystems (Brofas et al. 2006). There is a need for immediate response and for optimal management of forest services to counter possible dangers and threats to Greece's forests (Michopoulos 2013). Efficient forest management strategies should be formed to consider future forest dynamics to achieve important management objectives such as biodiversity conservation (Lindenmayer et al. 2007; Wijewardana 2008; Oikonomakis and Ganatsas 2012), preserving ecological functions (Scarascia-Mugnozza et al. 2000), and countering climate change (Scheffer et al. 2001; Ostrom 2009). It is of paramount importance to begin developing adaptation strategies as soon as possible (Bäurle 2001), for adaptation is not something to be applied only in the future: immediate actions are needed view of future conditions (Spittlehouse and Stewart 2003). On a national level, it is futile to consider sustainable forest management without clarifying fundamental issues such as the legal framework. It is indispensable for the government to clarify this publicly to exercise forest policy (Athanasiadis and Andreopoulou 2013). On the event horizon of the changing political scenery in Greece at the dawn of 2015, possibly new outtakes and perspectives on sustainable forest management remain to be seen.

10.5 Threats and Risks of the Greek Forests

Greek forests face important threats and risks that threaten the balance of the ecosystem. The greatest problem for Greek forests is the lack of management. In Greece, during past years, serious natural disasters have occurred associated with fires and floods that are inextricably linked to its geographic location, geology, geomorphology, vegetation, and the prevailing climatic conditions. At the same time, traditional occupations of the rural population contributing to protection (resin production, slope crops, extensive grazing) were limited, abandoned, or changed. As a result, the accumulation of biomass in the ecosystems of the Mediterranean was greatly increased and they became more vulnerable to fires. In conclusion, the combination and interplay of all points mentioned increase the issue's complexity when it comes to management. Given the economic crisis, the decline of services, and the inefficiency and complexity of its legal framework, Greece is one of the most vulnerable countries in southern Europe.

The greatest problem for Greek forests is the lack of management, caused by the staff reduction of the Forest Service to about half during the past 30 years (Albanis et al. 2000). During the same period, the economic activity of the country turned to tourism development, especially in the islands and coastal areas. In Greece there is no national development plan or national land register, with the result that the tourist and residential infrastructure is pushing the boundaries of free woodland. The legal framework was lenient and construction was authorized. Most of the staff of the Forest Service turned to protecting public property, because most of the country's forest land is state owned (70 % state-owned and 30 % private). The effective management of forests was confined to the north part of the country. The rural population declined dramatically as did their traditional occupations. Forestry was limited to the more financially important forests of the north, although the prices of manufactured wood products were not competitive compared to those of imported products.

The result of all this was the explosive rise of fires, with a mean burned area of 53,000 ha per year (Tsagari et al. 2011). As a duty, the suppression of fires was undertaken by the fire department while suppressive management activities decreased to a minimum. The cost of fire suppression quadrupled, and the results were dramatic (Xanthopoulos 2012).

Wildfires are intertwined with the Mediterranean climate, and only in recent decades we have accepted their ecological role. The problem is intensified when fire frequency increases and ecosystems do not have time to recover. If we also accept the effects of climate change toward warmer and drier environments, then the phenomenon of desertification is also intensified. In addition to the loss of soil and water, which are the two key elements to deficiency in the Mediterranean area, vegetation will be limited to the north and to higher altitudes. Biodiversity will decrease and the land will become barren. A rich literature has been developed around this issue, through which scientists are sounding the alarm (Radoglou and Korakaki 2012). The results are not yet clearly visible, but we recognize the intensity of extreme events (unequal distribution of rainfall, floods, rising fires) and the ambiguity in the succession of the seasons.

In conclusion, the combination and interplay of all points mentioned here increase the issue's complexity when it comes to management. Given the economic crisis, the decline of services, and the inefficiency and complexity of the legal framework, Greece is one of the most vulnerable countries in southern Europe.

10.6 Restoration of Greek Forest Ecosystems

Restoration of Mediterranean-type forest ecosystems is of great importance and a main environmental issue in Greece and other countries of the Mediterranean basin as well. During the past years, natural disaster phenomena of exceptional proportions occur more frequently. Contemporary man is confirmed to be responsible for many of the natural disasters, despite his accumulated knowledge and experience, as well as the development of technology. Issues about restoration and reformation of affected areas constantly emerge after the manifestation of such phenomena. Efforts of restoration are based on earlier empirical techniques, which are later improved and supported by scientific research. The selection of a suitable method and its implementation demands deeper knowledge of natural ecosystem functions and of the physiology of diverse organisms. Moreover, a versatile, interscientific approach is required that will be coordinated with the direction of the goals and objectives of the restoration, individual actions, utilization of research results, and usage and improvement of technologies, as well as the creation, improvement, and development of infrastructure.

In Greece, during the past years, serious natural disasters have occurred, associated with fires and floods that are inextricably linked to its geographic location, geology, geomorphology, vegetation, and the prevailing climatic conditions. In addition to natural causes, a dominant role in shaping the character of the landscape, as well as the character of the wider Mediterranean landscape, has been played by mankind, whose influence was so intense that today we talk about an anthropogenically formed Mediterranean environment (Le Houerou 1981; Naveh and Kutiel 1990; Bottema et al. 1990; Karetsos et al. 2012).

Stripping various areas of their natural vegetation renders them susceptible to further degradation, whose final stages depend mainly on human actions. The restoration of the affected areas, and burned land, intends to invert the degradation of the ecosystems, enhance their natural function, and restore them to their situation before the disruption. Given that the Mediterranean ecosystems have been degraded for centuries, it is hard to find a reference point for restoring the area to the situation before its disorder (Tomaselli 1977, 1981). In general, it is accepted that the natural processes of restoration are able to reverse degradation but rather in the long term (Karetsos et al. 2012).

Forest fires are large-scale natural phenomena that man has not been able to control until now. The problem in our country is occasionally acute with extreme disasters (e.g., 2000, 2007, 2009) (Tsagari et al. 2011). The negative consequences that always follow large-scale forest fires are already known: microclimate change, restriction of flora and fauna or even their displacement, reduction of the seed bank, soil erosion, strong outflow followed by floods, and landscape degradation of an aesthetic nature combined with concurrent trends regarding the change in land usage (Arianoutsou and Papanastasis 2004; Papanastasis et al. 2004; Tsagari et al. 2011). Design of an integrated Project of Action and Restoration adapted to the needs and the particular conditions of every fire-stricken area is initially required for the restoration. Moreover, a schedule has to be followed according to which all the actions will be accomplished. Specialized scientists recommend the following measures:

- Declaration of burned land as reforested according to the Article 117 of the Constitution

The Forest Inspectionsof the areas must take immediate action to declare these areas as reforested, by emphasizing and prioritizing protected areas. Aerial photography of burned-over land is an essential tool for many areas before their characterization (Karetsos et al. 2012).

- Anti-erosive and flood-prevention projects

The purpose of implementing such projects is to control soil erosion and floods caused by surface outflow and brought material, particularly in areas with steep slopes. This category includes the construction of log and branch bundles, steps, drainage canals, etc., after taking into account the specific conditions of each area. Another category of such projects is the construction of small dams made of logs from burned trees in the streambeds, which reduce water velocity and protect the bed from erosion. The construction of concrete dams to hold brought material and to control flooding outflow is the solution for large streams whose drainage basin is mountainous and that cross agricultural or residential areas (Karetsos et al. 2012).

- Tasks and reforestation projects

Design of soil studies and reforestation studies is a necessary prerequisite. The recommended components for materializing an effective reforestation are the following: (a) selection of planting material, (b) selection of reforestation season, (c) ways of reforestation (seeding or saplings), and (d) planting order when many species are involved. These components must be adapted to the specific conditions and requirements of each region and at regions where natural regeneration is not feasible (Karetsos et al. 2012).

- Protection and guarding of burnt areas

Burned areas require protection and guarding. A necessary measure is the issue of forest prohibitive provisions regarding grazing, hunting, and even entrance of vehicles in such areas, as well as strict guarding by qualified services. This measure presupposes increasing the number of guards and patrols. Construction of observation platforms will also help with monitoring (Karetsos et al. 2012).

- Protection of fauna

Organizing teams of specialized scientists to watch and record the population of animals is a necessary measure for protecting their remaining numbers in burnt areas, because conditions in such areas restrict animal feeding and result in their death because of the lack of food and water; construction projects will help the survival and growth of animal populations (Karetsos et al. 2012).

- Natural Regeneration

Natural ecosystems are a result of natural evolution rather than human intervention. Long-term observations in natural forest ecosystems have shown that nature follows a marvelous restoration process of vegetation, a phenomenon of natural or ecological succession. The first species that resprout are aquatic ones such as plane trees, silver berries, and black locust. Evergreen broad-leafed plants follow: hollies, arbutuses, and lentisks. Even after a period of prolonged drought, by 1.5 months after the fire, fresh, small, tender sprouts spring out from the burnt trunks and the burnt soil close to the roots of oak trees, together with cyclamens and anemones, followed by thorny bushwoods, brooms, asphodels, thyme, and annual and perennial turfs. In a 1-year time, they cover the soil, offering perfect protection from the erosive effects of rain. Afterward, the first few pine trees spring up among them.

The next year the soil is more protected, shaded and cooler, and the pine trees will spring continually for a period of 5–6 years after the fire. Moreover, the thorny shrubs mainly protect the germinant pine trees from being grazed. In the fifth year, when germinant pine trees grow taller than bushwoods, even if their top is being grazed by sheep and goats, they will not be uprooted because they have already developed a strong root system. Gradually, the ecosystem is restored through an ecologically noble selection and mixture of species, the so-called biodiversity, which is different for each ecotope. Most importantly, in these "under erection" natural ecosystems, bee swarms and many other species of wild endemic fauna and avifauna begin to find food and shelter. By following ancient magical recipes, microcosmos and megacosmos establish the right for life at the burnt land. Cosmogony is spread silently, inch by inch, and a miracle takes place (Karetsos et al. 2012)

Moreover, there are some other necessary measures at the level of restoration:

- Constant monitoring of land use and ecological evolution of burnt areas by utilizing contemporary technologies of remote sensing.
- Activation of the "outdoor body," as proposed in the chapter on "forest management and prevention," aiming at protecting burned and reforested areas from adverse land use changes.
- Activity regulation of burnt wooded areas and provision of economic impulses and counterbalancing measures for those directly affected by the restoration processes, such as financial support to stock farmers so they do not range their livestock in regenerating areas.

Infrastructure and know-how development for successful and scientifically correct restoration: (a) intensification of applied research for the development of plant reproductive material suitable for all forest types; (b) strategic planning for the formation of reproductive material, which will comply with the foregoing research, as well as the respective development and aid of public forest plant nurseries for the propagation of plants locally adapted to crucial areas; (c) constant scientific monitoring of areas under restoration; (d) institutional and administrative protection of agents who undertake the restoration plan and safeguarding of burnt areas, from external intervention and supervision of the implementation of studies and the respective planning.

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Chapter 11
Mapping Forest Fragmentation Based on Morphological Image Analysis of Mountain Regions in Bulgaria and Slovakia

Rumiana Vatseva, Monika Kopecka, and Jozef Novacek

Abstract Forest landscapes are at high risk of fragmentation as a result of changes in land cover and land use, which affect habitat loss and degradation. Therefore, it is essential in the forest management and biodiversity policy context to monitor and assess forest fragmentation using reliable data from remote sensing and GIS. This chapter focuses on the assessment and mapping forest fragmentation in two mountain regions in Bulgaria (part of the Eastern Rhodopes Mountain) and in Slovakia (the Tatra Mountains). The aim is to point out the correlation between the observed land cover changes during the 22-year period from 1990 to 2012 and forest fragmentation, which affects loss of biodiversity. The landscape fragmentation tool (LFT v2.0) was used to map the forest fragmentation and to analyze the forest pattern. The results indicate more significant forest fragmentation in the Tatra Mountains and decrease of the compact forest areas (i.e., core forest) in both mountain regions. The main causes for forest fragmentation were natural disasters and human activities. Generated maps identify areas in which to focus management efforts aimed at minimizing forest fragmentation.

Keywords Forest fragmentation • Morphological image analysis • Land cover • Land use • Eastern Rhodopes Mountain in Bulgaria • Tatra Mountains in Slovakia

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11.1 Introduction

Forest ecosystems play a crucial role in stabilizing the climate, providing vital economic benefits and promoting human well-being, and supporting biodiversity conservation. As a result of land cover and land use changes over time, forest landscapes are at high risk of fragmentation. The direct drivers of forest fragmentation are natural phenomena, or human activities, or the interaction of both natural causes and human impacts. Fragmentation increases habitat loss and degradation, which contribute to the decline of biodiversity and have profound influence on the ecological processes of the environment (Green et al. 2006; Gardner et al. 2007; Collinge 2009; Kozak 2010). Therefore, forest fragmentation is essential in the context of sustainable forest management and biodiversity policy (Girvetz et al. 2008; Kozak et al. 2013).

Forest landscapes are very sensitive to fragmentation. For instance, Farina (2010) found that a forest can be reduced by fragmentation to small portions of isolated trees and revert to an early successional stage. As the landscape structure is considered to be correlated with ecological processes, quantification of landscape fragmentation at certain spatial and temporal scales can be used to assess the potential ecological effects (Forman 1995; Turner 2005; Giulio et al. 2009; Riitters et al. 2009; Ostapowicz 2013).

Forest fragmentation is generally understood as process of breaking up originally compact forest areas into smaller units (fragments). Several approaches are already available for forest pattern analysis at both the landscape and the pixel level. The application of morphological image processing (Soille 2003) to identify structural patterns at pixel level on binary land cover maps is illustrated in several series of ecological research and assessment (Vogt et al. 2007a, b; Riitters et al. 2007; Ostapowicz et al. 2008; Soille and Vogt 2009).

Extending knowledge about fragmentation processes in forest landscapes is only possible with the use of reliable data, new tools for data analysis, and advanced geospatial technologies and methods, such as remote sensing (RS) and geographic information systems (GIS). In particular, the integration of RS and GIS is fundamental for studying forest fragmentation and provides the basis for analysis and monitoring systems.

This study focuses on the assessment and mapping forest fragmentation in two mountain regions: part of the Eastern Rhodopes Mountain in Bulgaria and the Tatra Mountains in Slovakia. The intent is to point out the correlation between the observed land cover changes during the 22-year period from 1990 to 2012 and forest fragmentation, which affects the biodiversity and habitat loss. The landscape fragmentation tool (LFT v2.0) (CLEAR 2015) is used to map and to quantify forest fragmentation to provide reliable and comparable data.

11.2 Materials and Methods

11.2.1 Study Areas

Two study areas were investigated in mountain regions in Bulgaria and Slovakia where significant and compact land cover changes in forest complexes were registered during the period 1990–2012 (Fig. 11.1). In addition, parts of these regions have conservation importance for biodiversity because of their value for habitats and for rare and threatened plant and animal species, including birds. Furthermore, these forest habitats are threatened by natural disasters, which could cause their destruction and fragmentation on a large scale.

The study area in Bulgaria is situated in the southeastern part of the country. It covers part of the lowest branches of the Eastern Rhodopes Mountain (41°19′05″–41°50′34″N and 25°33′19″–26°12′02″E) immediately adjacent to the state border with Greece. The relief is predominantly hilly and low mountainous, about 35–870 m above sea level (a.s.l.); at certain places in the region there are low cliffs. The study area includes parts of the Arda watershed (the largest river in the Rhodopes Mountain) and the Byala Reka watershed. The regional vegetation is quite diverse and heavily influenced by the Mediterranean climate. Old mixed forests of beech/*Fagus sylvatica* L. subsp. *moesiaca* and oak/*Quercus dalechampii*, *Q. virgiliana*, *Q. frainetto*, *and Q. pubescens*, occasionally interspersed with *Carpinus orientalis*, are widely distributed. The total studied area in Bulgaria is 1,336.80 km^2.

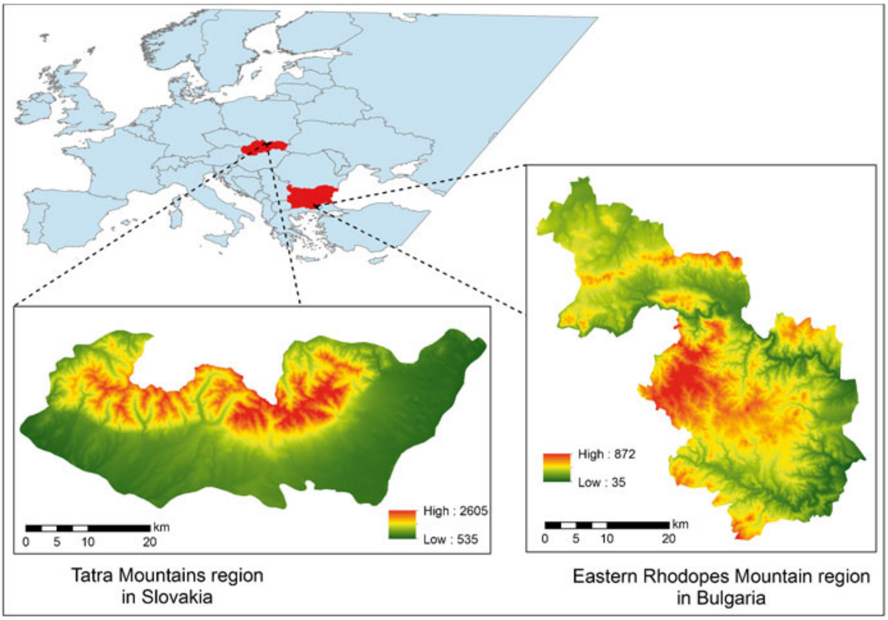

Fig. 11.1 Study areas in mountain regions in Bulgaria and Slovakia

The study area in Slovakia covers the whole Slovak part of Tatra Mountains (High, Belianske, and West Tatras) and a part of the basin Podtatranska Kotlina (49°01′15″–49°17′20″N and 19°31′02″–20°30′57″E). The Slovak–Polish border runs north of the study area. In the west the borders of the territory coincide with the mountain range of Skorusinske Vrchy and in the east with the Spisska Magura Mountains. Part of the study area is situated in the basin Podtatranska kotlina. The submontane zone covers the lowest part of the region up to 800–900 m a.s.l. The original mixed forests, which once covered this part of the study area, survive only in inaccessible and mostly wet-logged localities, and an agricultural landscape prevails. The montane zone, located at altitudes from 800–900 m a.s.l. to 1500–1550 m a.s.l., includes thick woods with the dominance of *Picea abies*. Broad-leaved forests dominated with birch and alder trees prevail on the wet soils in the foothills of the Tatras. The subalpine zone extends from 1500 to 1800 m. a.s.l., and the vegetation consists of continuous growth of *Pinus mugo* and dwarfed trees. The tallest peaks of the Tatras are above 2600 m a.s.l. The total studied area in Slovakia is 1359.76 km^2.

11.2.2 Data

The input data for forest fragmentation mapping and assessment were land cover maps (CORINE Land Cover, CLC) derived from remote sensing, which ensures comparability of data over large geographic regions and long time periods. The CLC nomenclature comprises 44 land cover classes at scale of 1:100,000 with a minimum mapping unit of 25 ha, the minimum width of a linear element = 100 m, and a minimum mapping unit of changed area = 5 ha (EEA 1995; Perdigao and Annoni 1997; Bossard et al. 2000; EEA 2007).

The CLC vector data were derived from satellite images for four time horizons, 1990, 2000, 2006 and 2012, covering a 22-year period. Binary (two categories) land cover maps were obtained by reclassifying land cover vector data from different years using ArcGIS 10.3. The reclassified vector data were transformed into binary raster maps with cells of 25 m (0.0625 ha per pixel), taking into account the pixel size (25 m) of satellite images. The produced land cover grid maps (forest mask) contain values of 1 for pixels representing the fragmenting land cover, that is, non-forest, and values of 2 for pixels representing the fragmented land cover, that is, forest (Fig. 11.2).

In this study, the non-forest land cover categories include a variety of landscape elements, such as urban areas, arable land, seminatural areas, wetlands, and water. The forest includes CLC classes 311, 312, and 313, corresponding to broad-leaved forest, coniferous forest, and mixed forest, respectively. These classes were combined to generate the binary forest map.

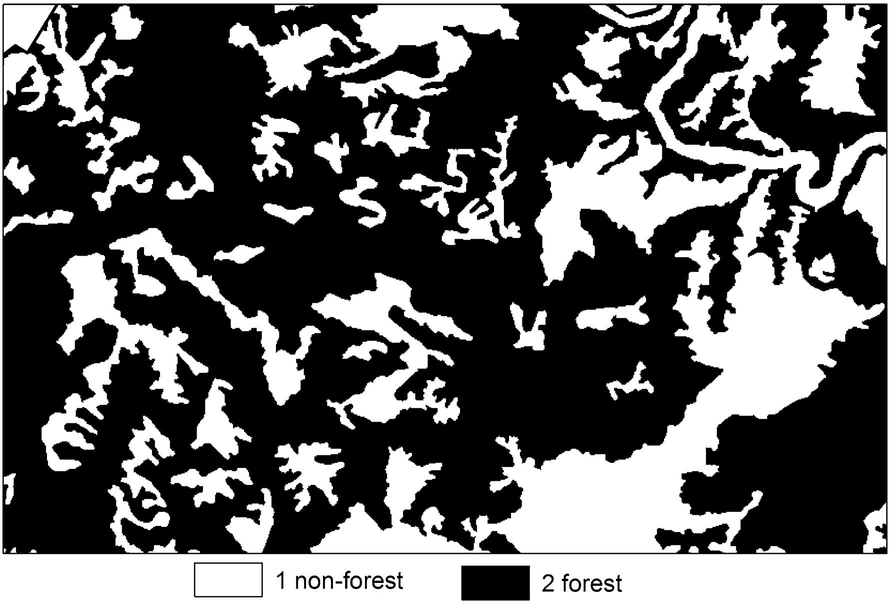

Fig. 11.2 Binary forest map derived from the CORINE land cover data

11.2.3 Morphological Image Analysis

For forest fragmentation analysis, the Landscape Fragmentation Tool (LFT v2.0) (CLEAR 2015) was used to quantify internal and external fragmentation categories for a forest and identifying forest changes over time. The concept for the model is based on the research of Vogt et al. (2007a), who developed an improved method for classifying forest fragmentation based on morphological image processing (Soille 2003). The LFT v2.0 classifies forest patterns on a pixel level and performs an efficient spatial analysis because it is a python script that runs out of ArcToolbox in ArcGIS 10.3 with Spatial Analyst.

The LFT v2.0 classifies a forest pattern into four main categories: patch, edge, perforated, and core. The core category is further divided into three subcategories based on the area: small, medium, and large. According to Vogt et al. (2007a, b), the "core forest pixels are the inner part of a forested region, beyond a certain distance to forest boundary. Patch forest pixels are forest regions that are too small to contain core forest. Perforated forest pixels are the transition zone between core forest and a non-forest patch. Edge forest pixels are the transition zone between core forest and core non-forest."

The main fragmentation categories are defined based on an edge width parameter. Therefore, many studies examine the forest fragmentation and "edge effects" (Vogt et al. 2007b; Riitters et al. 2009; Soille and Vogt 2009; Saura et al. 2011; Estreguil et al. 2012). The edge width indicates the distance over which the fragmenting land cover (i.e., non-forest) has a degrading effect on the fragmented land cover (i.e., forest). The studies have found that an edge width must be greater than the size of the land cover pixel. Thus, it can be set to any multiple integer of the pixel resolution of imagery. According to the species or issue being studied, the width of "edge effects" varies and can range from 25 m to several hundred meters. An edge width of 100 m is most often used for general purpose analyses.

In this study, a value of 125 m was used for the edge width parameter in the LFT v2.0. Such an edge is considered optimal for the wide range of species in the investigated mountain regions, as well as taking into account the pixel size (25 m) of satellite images and land cover data. Forest patterns were mapped at the pixel level. Therefore, it could be possible to aggregate results according to different units (ecological or administrative) for further assessments.

11.3 Results and Discussion

Forest fragmentation maps that identify patch, edge, perforated, and core forest were generated using the LFT v2.0 (Figs. 11.3 and 11.4). The maps illustrate good correlation between forest features detected by analysis of land cover (CLC) data and spatial patterns observed in satellite images. The classification results for forest fragmentation show that the impact of landscape changes to forest habitats and quality is much greater than forest removal alone, because edge effects also have a significant impact.

In the Eastern Rhodopes Mountain in Bulgaria, forest fragmentation maps (Fig. 11.3) demonstrate a relatively stable areal extent during the first period, 1990 to 2000. Table 11.1 provides statistics identifying the change for each forest pattern class over the investigated 22-year period from 1990 to 2012. As shown in Table 11.1, a small increase of compact forest areas (core forest) was observed as a result of the natural forest development for the first period, 1990–2000. At the same time a decrease of disrupted forest areas (edge forest) was registered.

During the second period, 2000–2006, in terms of the forest fragmentation categories, large-core forest (>200 ha) was decreased at a significant rate, mainly in the southeastern (around Ivailovgrad) and the central (close to Madzarovo) parts of the region. Continued decrease of the large core forest (>200 ha) was identified during the last period, 2006–2012. It is important to note that the edge forest and perforated forest were relatively stable with minimal decrease during the last two periods from 2000 to 2012.

The main causes of forest landscape changes were some natural and man-made disturbances such as fires and human activities related to forestry. The mountain region of Eastern Rhodopes in Bulgaria is considered as one of the territories with high risk of forest fires. In a large wildfire that occurred in August 2001 near the national border with Greece, more than 1450 ha broadleaf and coniferous forests were burned and transformed into transitional woodland/shrub. The last large fire incident occurred in May 2011, when mainly coniferous forest was burned; that fire

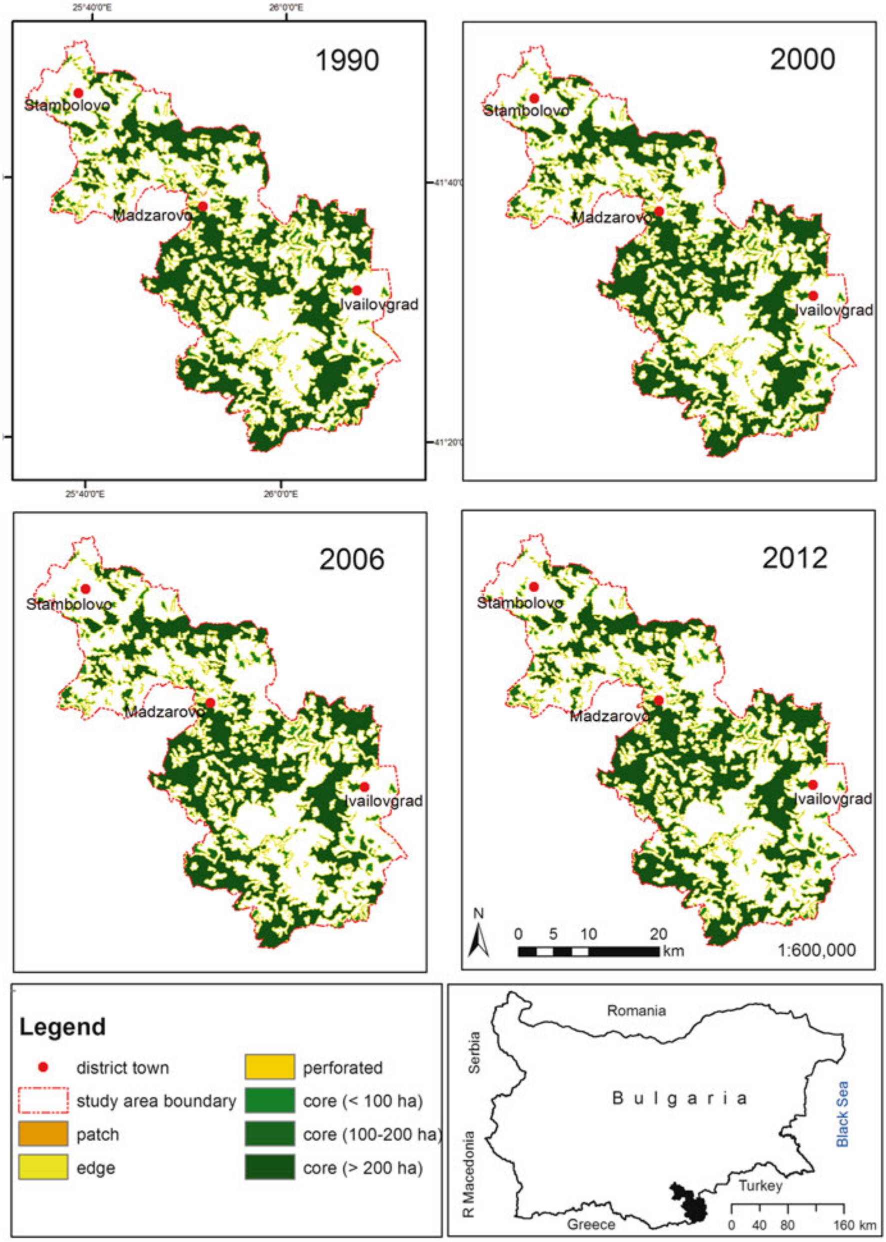

Fig. 11.3 Maps of forest fragmentation in the Eastern Rhodopes Mountain in Bulgaria for the period 1990–2012

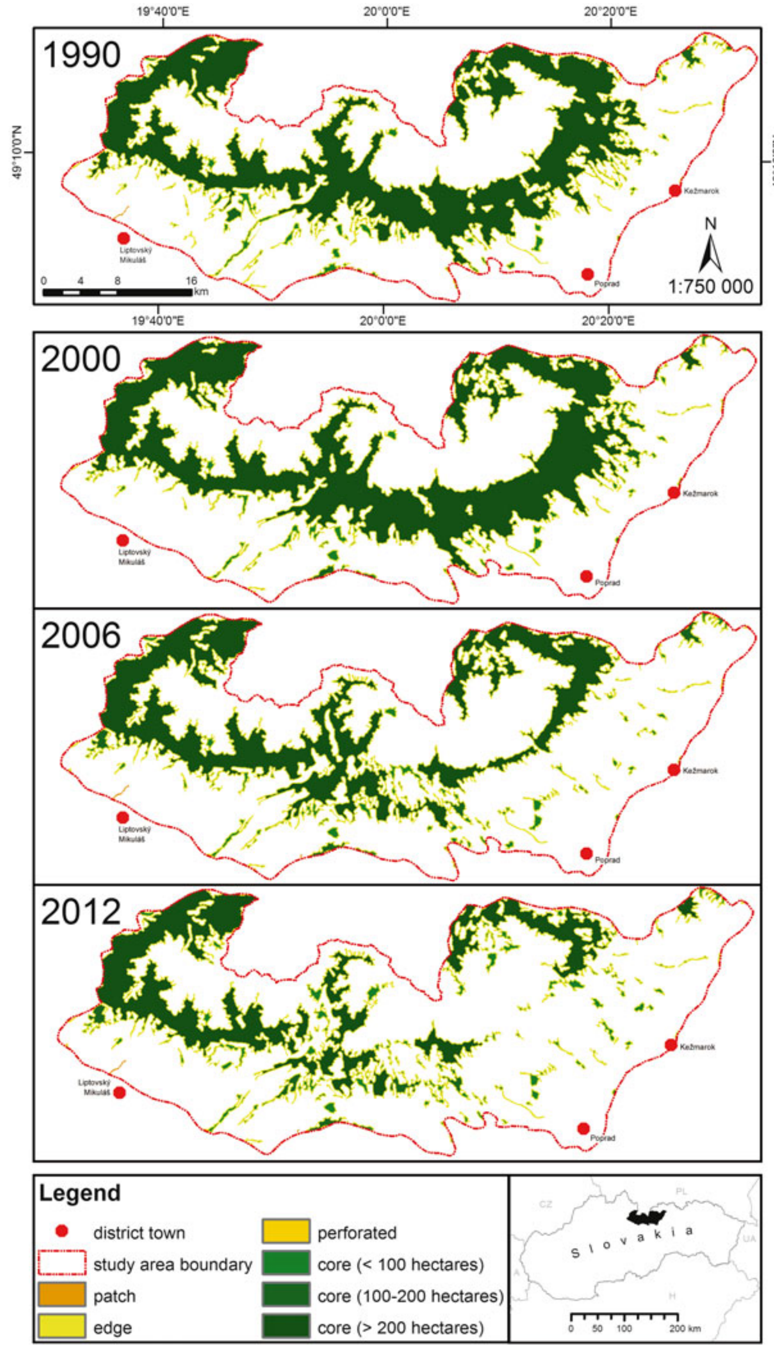

Fig. 11.4 Maps of forest fragmentation in the Tatra Mountains in Slovakia for the period 1990–2012

Table 11.1 Forest fragmentation in the Eastern Rhodopes Mountain in Bulgaria for 1990–2012

	1990		2000		2006		2012	
Pattern class	Area (ha)	Area (% of total area)	Area (ha)	Area (% of total area)	Area (ha)	Area (% of total area)	Area (ha)	Area (% of total area)
Patch	70.31	0.05	73.94	0.06	73.63	0.06	73.63	0.06
Edge	23,208.25	17.36	22,698.38	16.98	22,353.00	16.72	22,368.13	16.73
Perforated	302.75	0.23	299.38	0.22	284.81	0.21	284.81	0.21
Core (<100 ha)	2,879.25	2.15	2,667.25	2.00	2,975.19	2.23	2,975.19	2.23
Core (100–200 ha)	1,223.19	0.92	1,356.94	1.02	1,395.50	1.04	1,395.50	1.04
Core (>200 ha)	41,701.19	31.19	42,161.19	31.54	39,912.25	29.86	39,874.13	29.83
Total core forest	45,803.63	34.26	46,185.38	34.55	44,282.94	33.13	44,244.81	33.10
Total area	133,680.49	100.00	133,680.5	100	133,680.49	100.00	133,680.5	100.00

was started intentionally. According to statistics, most forest fires in Bulgaria were probably directly or indirectly influenced by humans. The post-fire change of land cover in the Eastern Rhodopes Mountain shows temporary forest fragmentation processes, which are convertible if site-specific forest restoration activities can be implemented, such as natural forest regeneration or restoration after plantation with fast-growing wood species.

In the Tatra Mountains in Slovakia, the overall studied period from 1990 to 2012 shows significant forest landscape change (Fig. 11.4). During this period, the CLC class of coniferous forest decreased from 35.75 % to 25.05 % of the total extent of the study area (Table 11.2). However, during the first period, 1990–2000, the inverse change appeared as the extent of coniferous forest increased up to 36.23 %. Such changes were observed especially on the contact of forests with agricultural land where meadows and pastures were successively transformed into forests.

In the periods 2000–2006 and 2006–2012, natural disasters substantially modified the landscape scenery in the Tatra Mountains. The main reason of these changes

Table 11.2 CORINE land cover (CLC) class in the Tatra Mountains in Slovakia for 1990–2012

CLC class	1990	2000	2006	2012	Change 1990–2012
112	4,161.12	3,799.38	4,104.38	4,136.85	–24.27
121	561.46	600.42	770.12	781.62	220.16
122	0.00	0.00	26.23	351.05	351.05
124	154.37	153.34	153.34	153.34	–1.03
131	146.92	125.59	125.59	164.53	17.61
133	0.00	0.00	360.49	350.68	35.68
142	1,450.15	1,007.26	1,074.12	1,116.77	–333.38
211	28,426.10	27,802.16	27,002.23	26,979.43	–1,446.67
222	8.34	7.25	0.00	0.00	–8.34
231	14,136.80	12,849.42	11,801.14	11,746.21	–2,390.59
242	387.49	1,804.07	1,968.46	1,934.54	1,547.05
243	4,426.25	3,442.53	3,980.50	4,007.92	–418.33
311	343.55	346.32	360.43	360.43	16.88
312	48,668.80	49,265.92	38,617.55	34,068.66	–14,600.14
313	2,064.86	2,000.24	2,030.01	2,070.43	5.57
321	8,711.64	8,143.19	7,909.29	7,909.29	–802.35
322	8,770.70	9,111.91	9,431.79	9,498.5	727.8
324	3,092.28	5,152.26	15,969.47	20,369.89	17,277.61
332	6,293.28	6,095.76	6,141.00	6,141.00	–152.28
333	4,094.64	4,070.06	4,066.20	4,066.20	–28.44
412	50.80	56.06	56.06	56.06	5.26
511	0.00	141.59	0.00	0.00	0.00
512	25.89	0.71	27.04	27.04	1.15
Total	135,975.44	135,975.44	135,975.44	135,975.44	

was the calamity whirlwind of November 2004, which has substantially changed the vegetation cover in the whole area of the Tatra Mountains. The calamity windfall destroyed about 12,000 ha of forest at altitudes between 700 and 1350 m a.s.l. in the Tatra region. The storm not only affected the very susceptible spruce monocultures, but also damaged mixed forests to some extent, including close-to-nature stands believed to have higher resistance against wind damage (Crofts et al. 2005; Faltan et al. 2011). In 2005, large wildfires aggravated environmental problems of the territory affected by the windfall and increased the dramatic forest fragmentation in Tatra National Park. Decrease of the area of the CLC forest classes (311, 312, 313) on land cover maps from 2000 to 2006 was connected with an increased number of transitional woodland/shrubs polygons. This land cover type is represented by the young wood species that are planted after clear-cuts or after calamities of any origin, in forest nurseries, and at stages of natural development of the forest (Feranec and Otahel 2001). Extensive windthrows in spruce forests almost inevitably give rise to subsequent outbreaks of the European spruce bark beetle [*Ips typographus* (L.)]. The populations first develop in the fallen timber, and then the beetles attack living trees along adjacent stand borders and elsewhere in the forest nearby. Despite large clear-cuts in areas destroyed by windthrow, in other unmanaged spruce forests situated in strictly protected zones where removal of fallen trees was forbidden, massive bark beetle outbreaks occurred and more than 2 million trees have been destroyed (Nikolov et al. 2014). Large areas of damaged forests are the main reason for the increase of CLC class 324, from 11.74 % in 2006 to 14.98 % in 2012.

Table 11.3 demonstrates significant decrease of the compact forest areas (core) between the years 2000 and 2012. On the other hand, an increased percentage of forest edges was observed. Nikolov et al. (2014) confirmed the influence of forest edges on bark beetle outbreak and spreading in Tatra National Park. In all studied sections a remarkable decrease in damaged areas was recorded with increasing distance from windthrow areas. Most infestations were recorded within 100 m of uncleared windthrow sites, and more than 50 % of total damage was observed within 300 m of windthrow stands in each section, compared with about 10 % in the most distant zones (700–1000 m).

The changes of forest into transitional woodland indicate a temporary fragmentation with possible forest regeneration. However, forest destruction in the National Park facilitated the development of travel and tourism (new hotels, ski parks, etc.), resulting in permanent forest fragmentation.

One of the most important issues related to biodiversity and forest landscape quality is fragmentation of the surrounding landscapes. Transforming large habitat patches into smaller, more isolated fragments of habitat is most evident especially in urbanized or otherwise intensively used regions, where fragmentation is the product of the linkage of built-up areas via linear infrastructure. From this point of view, construction of the highway in the southern part of the study area (class 122) was the most significant change after 2000. This type of fragmentation results in collisions of wild animals with vehicles, prevents access to resources, facilitates the spread of invasive species, reduces habitat area and quality, and subdivides and

Table 11.3 Forest fragmentation in the Tatra Mountains in Slovakia for 1990–2012

	1990		2000		2006		2012	
Pattern class	Area (ha)	Area (% of total area)	Area (ha)	Area (% of total area)	Area (ha)	Area (% of total area)	Area (ha)	Area (% of total area)
Patch	86.08	6.33	36.72	0.03	60.84	0.04	59.24	0.04
Edge	12,527.96	9.21	11,308.24	8.32	12,631.24	9.29	13,345.32	9.81
Perforated	161.84	0.12	103.48	0.08	130.96	0.1	120.44	0.09
Core (<100 ha)	1,202.52	0.88	1,099.4	0.81	1,295.96	0.95	1,967.24	1.45
Core (100–200 ha)	307.84	0.23	411.16	0.3	615.04	0.45	770.16	0.57
Core (>200 ha)	36,794.28	27.06	38,655.12	28.43	26,270.32	19.32	20,236.56	14.88
Total core forest	38,304.64	28.17	401,65.68	29.54	28,181.32	20.72	22,973.96	16.90
Total area	135,975.8	100.00	135,975.8	100	135,975.84	100.00	135,975.8	100.00

isolates animal populations into smaller and more vulnerable fractions. Noise and pollution from traffic also threaten human and environmental well-being and further impair the scenic and recreational qualities of the landscape (EEA 2011).

11.4 Conclusion

The studied mountain regions in Slovakia (the Tatra Mountains) and Bulgaria (part of the Eastern Rhodopes Mountain) have clearly lost compact forest areas (i.e., core forest) during the 22-year period of this analysis. The main causes for forest fragmentation were natural disasters such as catastrophic whirlwind and fires, as well as human activities related to forestry and tourism.

The extent of the negative impacts of habitat fragmentation on animal and plant populations is difficult to quantify because the full extent of the ecological effects of landscape alterations will only become evident decades afterward. According to the EEA (2011) document, many countries in Europe are now emphasizing the need to preserve biodiversity and to ensure connectivity between the remaining natural areas for the movement of animals, including migration and dispersal, for access to different types of habitats and other resources, for recolonization of empty habitats, and for genetic exchange between populations.

Forest fragmentation is mapped and assessed using the landscape fragmentation tool that integrates spatial analysis in the GIS environment and remotely sensed land cover data. Therefore, the obtained data are reliable and consistent, and can help us to understand much better the impact of management decisions on the forest ecosystem. The generated maps identify areas in which to focus management efforts aimed at minimizing forest fragmentation. For a better understanding of post-disaster forest fragmentation dynamics, land cover data can be further analyzed to explore potential correlations between climatic and stand-specific factors (e.g., tree composition) and topographic parameters (slope, aspect, and elevation).

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Chapter 12
Evaluation of the Avalanche Danger in Northwest Rila Mountain

Krasimir Stoyanov

Abstract This chapter considers the conditions determining avalanche formation and action in Northwest Rila. It provides an analysis of the current morphosculptural impact of avalanches on the alpine and subalpine mountain zones. The most hazardous avalanche terrains are also specified.

Keywords Avalanches • Avalanche danger • Tourism • Northwest Rila mountain

12.1 Introduction

The formation of avalanches is a risky geomorphological process and a common event on the steep slopes of high mountains. An avalanche is a snow slide on slopes with a certain declination. The place from where the avalanche breaks off is called the beginning and the line of its breaking is an edge of breaking off. The distance from there until the place where it stops is the route of the avalanche, and the snow that is piled up is called the avalanche cone.

Northwest Rila Mountain, with its Alpine type of relief and the formation of a thick and durable snow cover, is a region with high intensity of avalanche formation.

The Alpine part of Northwest Rila Mountain is frequently visited by skiers and snowboarders. The accelerated development of these sports is connected with the expanding of locations for their practicing. Nowadays skiing is mainly practiced around the Mountain Base "*Malyovitsa*" and the hostel "Rila Lakes." In the future, with further tourist infrastructure projects, the number of visitors in the high part of the mountain will increase many fold. The region is also one of the important tourist destinations. Here are located various sites of the "Hundred National Tourists Sites," the most popular and most visited mountain lakes in our country: the Seven Rila Lakes, the highest waterfall in Rila Mountain, the Skakavitsa Waterfall, and here also pass some of the main tourist paths to the Rila Monastery. The territory of

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Northwest Rila falls within the boundaries of the National Park "Rila" and the Natural Park "Rila Monastery." In this region can successfully be developed eco-tourism, as well as natural scientific, cultural, and religious visits (Zhechev and Stoilov 2003).

Northwest Rila Mountain also is the main center of alpinism in the country. The region has a built-up tourist infrastructure and is visited during almost all seasons. This frequency also means more avalanche incidents. A significant number of the avalanches are caused by the tourists themselves.

12.2 Avalanche and Avalanche Danger

There are different classifications of the avalanches, which are grouped according to different signs (Fig. 12.1). The avalanches slide along the slope, flowing or moving in the air. They have different speeds: avalanches of dry snow move faster than those formed by wet snow (Fig. 12.1).

The avalanche formation in Northwest Rila Mountain creates specific ground surface forms. The avalanches cause the largest contemporary denudation gravitation changes in the high part of the mountain. They break off, shake down, and transport with high speed different pieces of rock in the alpine and subalpine zones. Under certain conditions, they also destroy the forest plants.

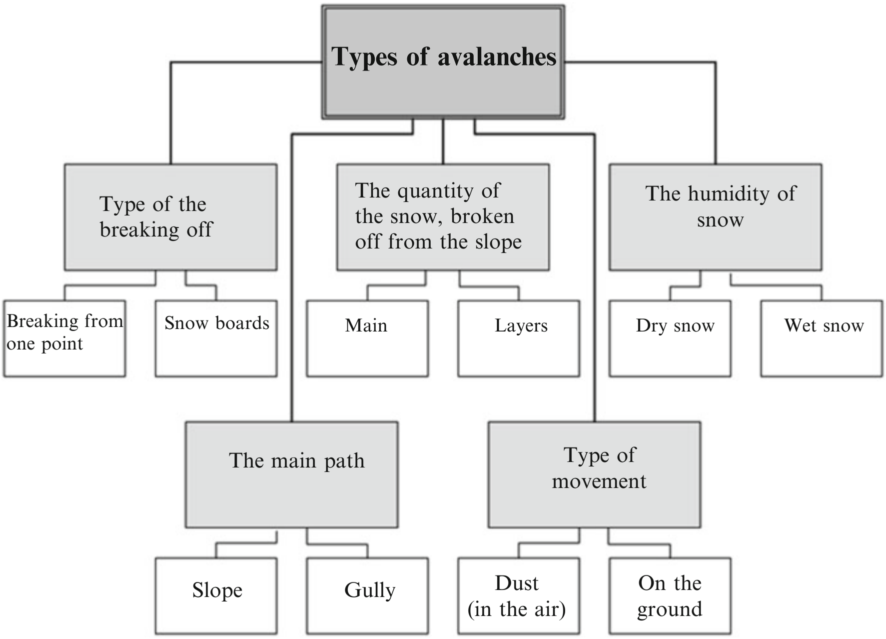

Fig. 12.1 Classification of avalanches

The main ground surface forms that are formed by avalanche activity are the avalanche gullies, the avalanche rails, and cones. The first two types in their genesis are nival corrosion and gravitation forms, because they are formed along the strongly declined slopes of the cirques and the glacial trough valleys. Almost all avalanche gullies end in their mouths with avalanche sediments under the form of an avalanche cone (Fig. 12.2) (Peev 1968; Peev and Dimitrov 1971).

In the Northwest Rila Mountain can be seen one of the most specific avalanche gullies in the whole mountain. Such can be seen at the cirque of the Seven Lakes, Urdinia Circus, under the southern edge of the Koupen Ridge to the valley of the Rilska River and the Meadow of Cyril, the location The Evil Streams, the alpine part of the valley of the Rivers Malyovitsa, Dupnishka Bistritsa, and Skakavitsa, the northern slopes of the Kalinian part, the Otovishki circus, etc. (Figs. 12.2 and 12.3).

For the formation of avalanches, certain climatic and geomorphological conditions must be present. Almost all slopes in the alpine part of Northwest Rila Mountain under relevant conditions can be avalanche dangerous. On some of them, the skiers often do ski jumping and snowboarding, which can be very dangerous.

The largest and most dangerous avalanches are formed along the slopes with declination between 25° and 45° (Mardirosyan 2007). The specifics of snow coverage are very important: its thickness, structure, and the peculiarities of its distribution. The leeward slopes have thicker snow coverage.

Fig. 12.2 An avalanche cone on the left valley slope of the River Skakavitsa

Fig. 12.3 The northern steep and rectilinear slope of the Otovishki ridge is avalanche dangerous and holds much snow until late spring

The mountain hostels located in the alpine zone of Northwest Rila are "Ivan Vazov," "The Seven Lakes," "The Rila Lakes," "Skakavitsa," and "Malyovitsa" (Fig. 12.4). In winter, under certain conditions, their approaches are avalanche dangerous.

In the region of the hostel "Ivan Vazov" (2300 m above sea level) was observed a snow coverage with a thickness of 3–4 m, when the posts of the winter marking were also covered up. The approaches to it in winter have a moderate avalanche risk.

For the past few years, the region around the hostel "The Seven Rila Lakes" became extremely popular with admirers of the free-ride driving in Bulgaria. In the region the eastern slope of the Dry Hill is avalanche dangerous, turned to the cirque of the Seven Lakes and especially its northern part. The gullies opposite the hostel "Rila Lakes" are very steep, and after January big peaks are also in the central gullies, making them quite dangerous after snowfalls and winds. Many of the self-confident skiers underestimate this danger and they ski along the gullies under any kind of conditions.

Another avalanche-dangerous part of the mountain is the valley of the Malyovitsa River. Along all routes to the Shelter "BAK," The Rila Monastery, and "Ivan Vazov"

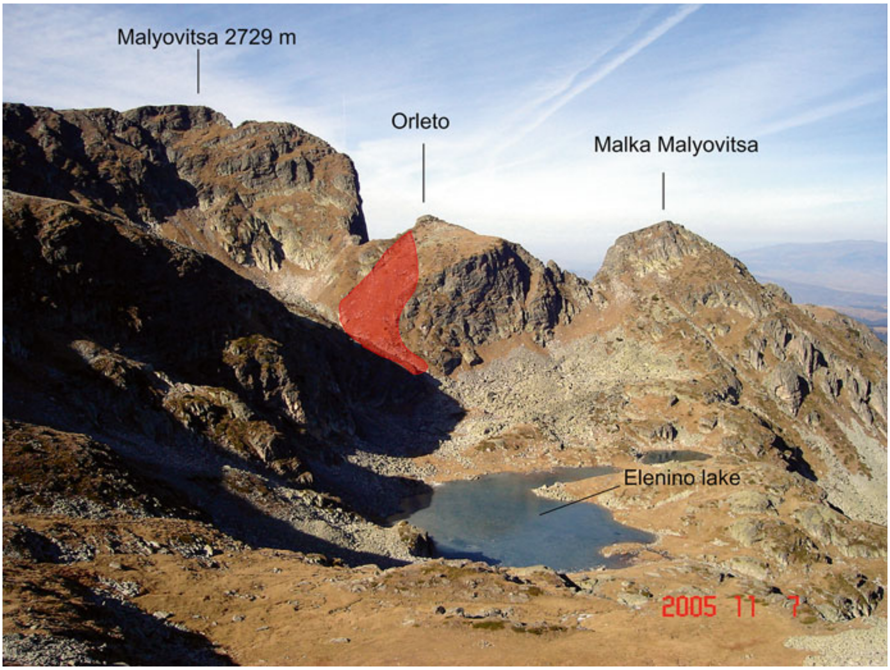

Fig. 12.4 Path of the avalanche along the southwest slope of the Orleto Hill in December 1965

there is a high level of avalanche danger. The gullies of the Kalbura Hill over the first terrace are very unstable immediately after snowfalls (Panayotov 2004). Along the right slope of the valley, between the peaks The Black Rock and The Camel, an avalanche 1 km long and 300 m wide broke off in the winter of 2006. Six Slovak tourists were affected, but they managed to get away only with some small grazes and trauma. According to the mountain rescuers from the region, such a large avalanche had not been seen in recent years at Malyovitsa.

The southwest slope of the Orleto Hill has the most tragic reputation. In December 1965 an avalanche dropped down this slope, and although it traveled only 50–60 m, it took the lives of 11 people. (Fig. 12.4). Also dangerous is the southern slope of the Malka Malyovitsa Hill. The last case was a woman who was buried by an avalanche while she was moving a little ways past the marked path for Malyovitsa Hill on the second terrace (Panayotov 2004).

The region of the hostel "Skakavitsa" is also avalanche dangerous. Especially dangerous are the gullies over the chalet on the eastern slope of the Kabul Hill. Small avalanches also fall along the path to the chalet "Rila Lakes" when there is a lot of snow, right above the forest belt. Also avalanche dangerous is the valley of Skakavitsa River above the chalet where the avalanches form specific avalanche gullies. They are clearly reflected in the relief with the formed swells and rocky pilings as well as by destruction of the foliage (Fig. 12.2).

From the chalet "Ivan Vazov" to the village of Bistritsa there are also a few dangerous places where there are pilings caused by avalanches. The first one is along the slope of the hill Skalitsa (2666 m) and the Birds' Peak. The second is along the Otovishko Bilo, whose northern slope is avalanche dangerous and where large peaks are formed (Fig. 12.3). Other extremely dangerous slopes on northwest Rila are the slope before the lake, The Eye, and the big gully left of the waterfall Skakavitsa (Fig. 12.5).

12.3 Conclusions

The formation of avalanches is a risky geomorphological process that requires specific climatic and geomorphological conditions. The formation of avalanches in Northwest Rila occurs with great intensity. The destructive activity of the avalanches is caused by the detonation caused by the snow mass and the preceding air wave. The avalanches cause not only direct demolition but also the formation of avalanche gullies, at the base of which rock aggregations are piled up.

Avalanches can be formed also in a thin forest, and on their path they also affect the forest belt by lowering the upper boundary of the forest.

The number of the victims of an avalanche does not depend on its size. An example for this is the small avalanche that dropped down from Orleto Hill and took the lives of 11 people.

The region has a well-developed infrastructure and is visited all year round; this also presupposes more avalanche incidents. A significant part of the avalanches are caused by the tourists themselves.

Plant cover affords significant snow-holding advantages. By such relevant activities, the formation of avalanches can be significantly decreased.

Avalanches occur most frequently along the steep glacial slopes through valleys of the Rivers Malyovitsa, Urdina, Skakavitza, Prav Iskar, Dupniska Bistritza, and Drushliavitza, as well as along the walls of all the cirques in the region. Under certain conditions, there is no completely safe road despite the winter markings.

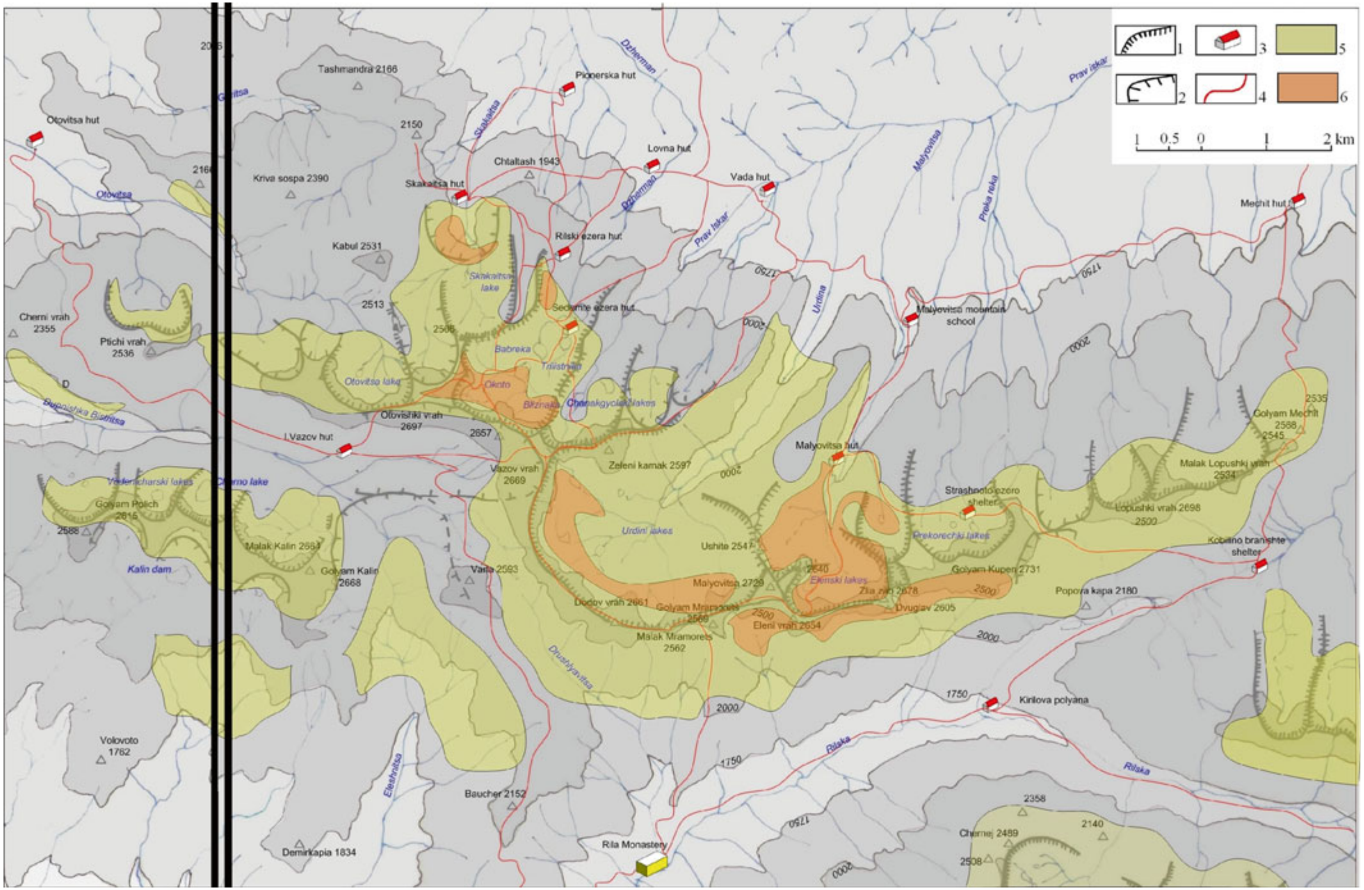

Fig. 12.5 Tourist infrastructure and avalanche danger in Northwest Rila Mountain. (1) Outline of the relief and well-formed cirques; (2) embryonic, shallow cirques with steep slopes; (3) tourist hostels and shelters; (4) more important marked paths. (5) A region with high avalanche danger. Avalanches fall at certain conditions intermittently. (6) A region with high avalanche danger. Avalanches fall a few times during the season along the well-known routes

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Chapter 13
Management of Snow Avalanche Risk in the Ski Areas of the Southern Carpathians–Romanian Carpathians

Mircea Voiculescu and Florentina Popescu

Abstract Snow avalanches represent an undeniable reality in the Southern Carpathians, both as a geomorphological process and as a type of natural hazard with the highest number of fatalities and injuries, and also substantial impact upon forests, highways, and people. This study focuses on the Făgăraş massif and on the Bucegi Mountains, representative mountain units in the eastern part of the Southern Carpathians with altitudes surpassing 2500 m, large quantities of snowfall, between 6 and 8 months/year of soil with snow cover, or even 10–11 months/year at high elevations, and a high occurrence of snow avalanches. The importance of management of snow avalanche risk resides in the fact that these mountains have important winter tourism activities. Today, the main management measures on snow avalanche risk are preventive temporary or permanent measures, passive and active defense points of intervention, temporary closure of ski pistes, and the issuance of danger level.

Keywords Management • Snow avalanche risk • Ski areas • Făgăraş massif • Bucegi Mountains • Southern Carpathians

13.1 Introduction

Management of snow avalanche risk represents a stringent aspect in several countries with a large proportion of mountain-covered areas that are endowed with characteristic and associated winter tourist activities in Europe, Canada, and the USA. Snow avalanche risk has an important impact on human life (Fuchs and Bründl 2005; Höller 2009) and, implicitly, on human activities such as skiing (Höller 2007, 2009; Stethem et al. 2003) or other recreational activities (Höller 2009; Keiler et al. 2006). Winter tourism is a very important economic activity (Rixen

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et al. 2003). Alpine skiing as an attribute of winter tourism, and at the same time a sport activity, has generated an entire industry within mountain areas (Agrawala 2007; Bürki et al. 2005; Hudson 2002; Lew et al. 2008). Winter sports entail a series of investments insofar as blueprinting, infrastructure, and connected activities are concerned, and they are destined for a tourist segment that is willing to invest time, money, and physical effort.

This item becomes important through its affiliation to the global concern regarding the relationship to tourist practices, especially skiing and natural risk within mountain areas, in the present case (Casale and Margottini 2004; Herwijnen and Jamieson 2007; Quinn and Phillips 2000; Schweizer and Camponovo 2001; Schweizer and Lütschg 2001; Schweizer and Jamieson 2001).

Snow avalanches are one of the most important natural risks and hazards that, acting on the mountain environment in ski areas, each year cause several fatalities (Höller 2007; Jamieson and Stethem 2002; Keiler 2004; Keiler et al. 2005; Voiculescu 2009, 2014) and serious damage to human settlements and infrastructures (Fuchs et al. 2004; Fuchs and Bründl 2005; Fuchs et al. 2005; Jamieson and Stethem 2002; de Scally 1994; Stethem et al. 2003; Voiculescu 2009).

The purpose of this study is to (i) analyze the terrain factors and climatic variables that determine the development of ski activities, and (ii) present the state of the management of snow avalanche risk in two of the most representative mountain areas of the Southern Carpathians, the Bâlea glacial ski area of Făgăraş massif and the Sinaia ski area in the Bucegi Mountains. These areasare known for their natural potential with regard to winter tourism activities, especially ski activity, but also for the high incidence of snow avalanches, some of which are even triggered by skiers.

13.2 General Facts of the Studied Area

The Făgăraş massif is situated in central Romania at the intersection of the 45°30′ parallel with the 24°30′ meridian, within the Făgăraş group from the Southern Carpathians (Fig. 13.1a.).

These mountains are also known as the Transylvanian Alps because of their high altitude, which surpasses 2400–2500 m (Moldoveanu, 2544 m a.s.l.; Negoiu, 2535 m a.s.l.), their massiveness, their sharp glacial crests, their inherited glacial landforms (cirques and glacial valleys), and also because of their present periglacial processes of high spatial dynamics. The Făgăraş massif occupies more than 1500 m^2 and the alpine level, which represents the basis for skiing activities, occupies around 438.5 km^2, from 148.8 km^2 on the northern slope and 684.7 km^2 on the southern slope (Voiculescu 2002). In the Făgăraş massif, skiing takes place traditionally in the Bâlea glacial ski area that includes the cirque and also the glacial valley (Fig. 13.1b.).

Until the 1989 Romanian Revolution, only alpine skiing was practiced here, but afterward and especially in recent years skiing activities have been extended to snowboarding, telemark skiing, ski-touring, heli-skiing, etc. On the other hand,

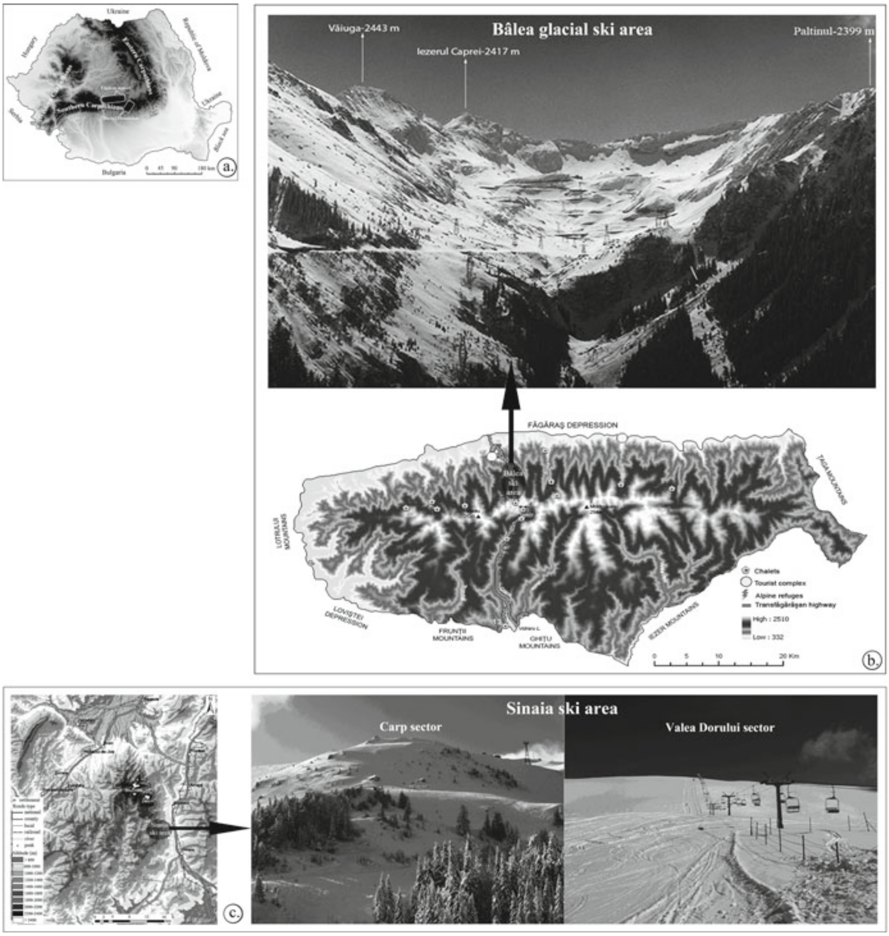

Fig. 13.1 Geographic location of Făgăraş massif and Bucegi Mountains

free-ride and free-style skiing have emerged here as in other mountain areas of the world (Hudson 2004; Pickering et al. 2003). All these forms therefore complete the range of tourist activities available in the Făgăraş Massif and pertain to the alternative forms of tourism according to Beedie and Hudson (2003), to Buckley (2006), and to Pomfret (2006). It is the only area that apart from a good accommodation infrastructure has also ski pistes that are unattended, unequipped, are not delineated by pennons, and lack warning signs. As for cable transportation, this ski area has only one cable car.

The Bucegi Mountains are located in the eastern part of the Southern Carpathians, within the mountain group that bears their name (see Fig. 13.1a.). The Bucegi Mountains are bordered by cliffs on three sides (on the east toward the Prahova valley, on the west toward the Rucăr-Bran-Dragoslavele Corridor, and on the northern side toward the Braşov Basin), and by the Ialomiţa's Subcarpathians on the southern side. They have the form of an amphitheatre with its opening toward the south,where the Ialomiţa valley lies. The highest altitudes are concentrated in the northern part. The foremost important orographic knot is situated in the northern part of the Bucegi Mountains and is represented by the Vf. Omu at 2505 m a.s.l. The mountain mass appears as if suspended: the altimetry differences oscillate between 1200 m, above the Prahova River (a favorable element for the implementation of ski pistes, because of the relief's high potential), and 500 m against the Rucăr–Bran corridor and the Subcarpathians, pointing out their genetic connection rendered by the detailed morphology, by the biopedoclimatic levels, and also by the local diversity thrusts by exposition, declivity, and even by shelter conditions. The most important ski area in these mountains is to be found in their southern part, above the tourist resort of Sinaia that covers about 116 ha (Bogdan 2008): it entails two sectors, the Carp sector on the eastern part and the Valea Dorului sector on the western part of the Sinaia ski area (Fig. 13.1c.).

13.3 Terrain Factors and Climatic Variables Analysis as Favorable for Ski Activities

The natural ski potential is favored first and foremost by the parameters of two components of the mountain environment (Jamieson and Johnson 1998; McClung and Schweizer 1999; Schweizer and Jamieson 2001): terrain factors and climatic variables.

13.3.1 Terrain Factors

Terrain factorsare represented by elevation, slope, and aspect. Altitude is essential for skiing activities, and for the latitude of temperate climate in which our country is located, it must be at least 1000 m (Besancenot 1990) to maintain a favorable snow layer for at least 3 months/year.

Slope represents another factor of great importance for skiing activities. This is the element that separates the categories of this activity's practitioners into two large categories: skiers and beginners. The first category was defined as *users of skis, snowboards or other gravity-propelled recreational devices whose design and function allow users a significant degree of control over speed and direction on snow* (Penniman 1999, p. 36), and for beginning skiers or beginners as *those individuals who are using one or another of these devices for the first time or who possess marginal abilities to turn or stop on slopes with incline greater than 20%* (Penniman 1999, p. 36).

Performing a more analytical classification in accordance with the degree of slope declivity, the following categories have been established: beginners or novices who make use of slope gradients with a declivity not higher than 11.5°, intermediates who use the slope gradients between 18° and 19°, advanced skiers, who use the slope gradients of 19°, and experts who use slope gradients that surpass 19° or even 39° (Borgersen 1977; Gaylor and Rombold 1964, quoted by Penniman 1999). For economic exploitation we need to consider the slopes between 10° and 45°. Any ski area needs to include all the categories of slope gradients. It is well known that most of the skiers would rather ski on slopes less than 30° and that beginners will usually not use those greater than 10°.

Using the applications of ArcGIS and respecting their working methods (Török 2001–2002), we have created the digital elevation model (DEM) (Fig. 13.2) that we used in generating the thematic maps (elevation, slope, and aspect) for the Bâlea glacial ski area and for the Sinaia ski area.

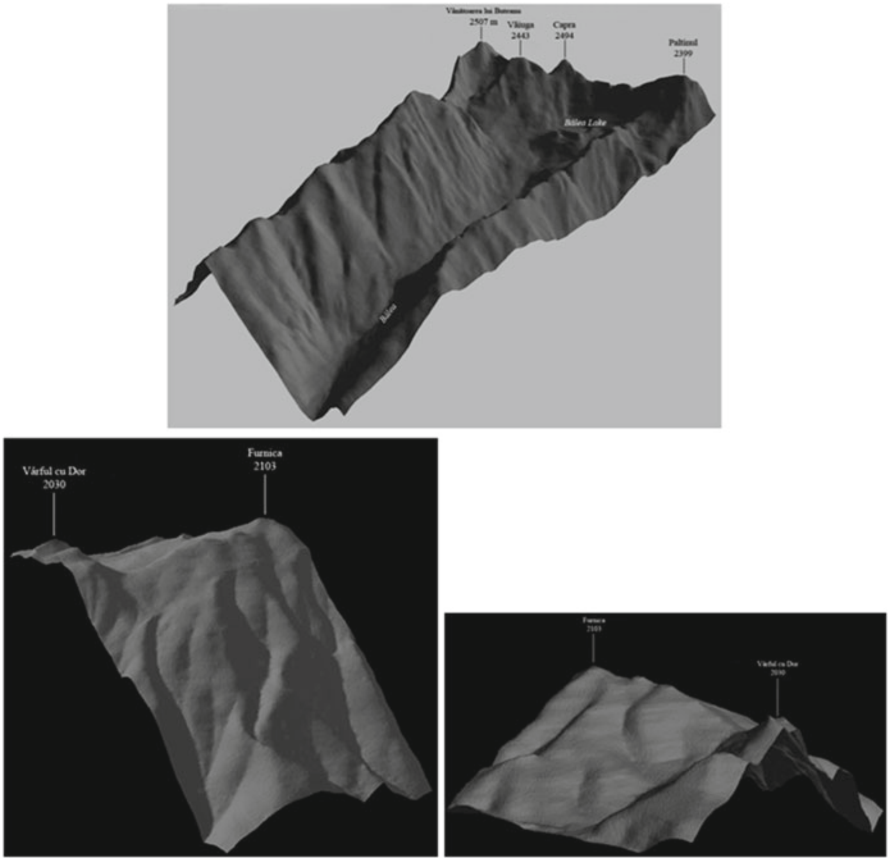

Fig. 13.2 Digital model of terrain of Bâlea ski area (*top*), of Carp ski sector of Sinaia ski area (*bottom left*), and of Valea Dorului ski sector of Sinaia ski area (*bottom right*)

The altitude of the ski pistes is a crucial element for practicing specific activities. The Bâlea glacial ski area is situated at high altitudes where skiing is practiced on the glacial cirque walls, just under the cliffs, within the cirque, but also along the glacial valley, on the eastern slope especially. Voiculescu et al. (2011) identified 29 main snow avalanche tracks: 5 on the western slope of the glacial valley, 21 on the eastern slope of the glacial valley, and 3 on the glacial cirque. The vast majority of snow avalanche accidents were recorded on the glacial cirque and on the eastern slope, where are the main ski pistes. The elevation map of the Bâlea glacial ski area highlights this mathematic element (Fig. 13.3). The Bâlea glacial ski area is endowed with pistes that are not groomed, or even named for that matter, which have high slopes, and can only be used by expert or advanced skiers. The slope map points out the high degree of declivity for the studied area (see Fig. 13.3). The values between 1° and 15° represent 6.9% (3.4 km^2), the values between 15° and 25° represent 18.1% (9 km^2), the values between 25° and 35° represent 11.1% (5.5 km^2), the values between 25° and 35° represent 33.2% (16.4 km^2), the values between 35° and 45° represent 31.8% (15.8 km^2), and the values above 45° represent 9.5% (4.7 km^2) of the total of the Bâlea glacial ski area.

Another important topographic factor is the aspect of the slopes, especially because it is the one factor that influences the radiation of the sun and also the presence of the wind. The radiation of the sun controls snow surface temperature more than air temperature (Tremper 2001), affecting snow instability and determining the snow avalanche type (McClung and Schaerer 2006). If the snow avalanche is produced in spring, the temperature increase enhances the stability of the snowpack on shady slopes and its instability on sunny slopes (Ancey 2001, p. 3). For this purpose, we made the aspect map. For the Bâlea glacial ski area the aspect map shows that western slopes cover 27.1% (1.8 km^2) of the area, the northeastern slopes 20.3% (1.3 km^2), and the eastern slopes 19.5% (1.3 km^2) (see Fig. 13.3). Within this topographic context, the ski pistes in the Bâlea glacial ski area are designed especially for the advanced and expert skiers who practice free-ride or free-style skiing. Unfortunately, under thesecircumstances, the snow avalanche risk is imminent, and therefore human victims, fatalities, and injuries/burials are recorded.

The Sinaia ski area has gradually enlarged its surface, the number of ski pistes and their length, from 85.1 ha and 12 ski pistes with a length of 15.1 km in 2001 (Ţigu 2001), to 16 ski pistes measuring 23 km (Bogdan 2008) and even to 24 ski pistes with a total length of 22.3 km (according to Institutul Naţional de Cercetare–Dezvoltare în turism 2009; Voiculescu et al. 2012). The average declivity of this ski area ranges between 13.3° and 32.5°, which agrees with the skier's preference (of less than 30°), but neglects or overworks the beginners. Within the Sinaia ski area there are 13 main ski pistes of which 23% are intended for expert skiers, 61.7% for medium-ability skiers, and 15.3% for beginner skiers (Table 13.1).

The mathematic parameters of the terrain underline the high potential of the Sinaia ski area for tourist activities. Therefore, the altitude of the ski pistes is relatively high, around 2000 m for both sectors of the ski area, Carp and Valea Dorului (Fig. 13.4). The slopes map emphasizes the predominance of high values, explaining the classification of ski pistes predominantly for expert and advanced skiers (see Fig. 13.4).

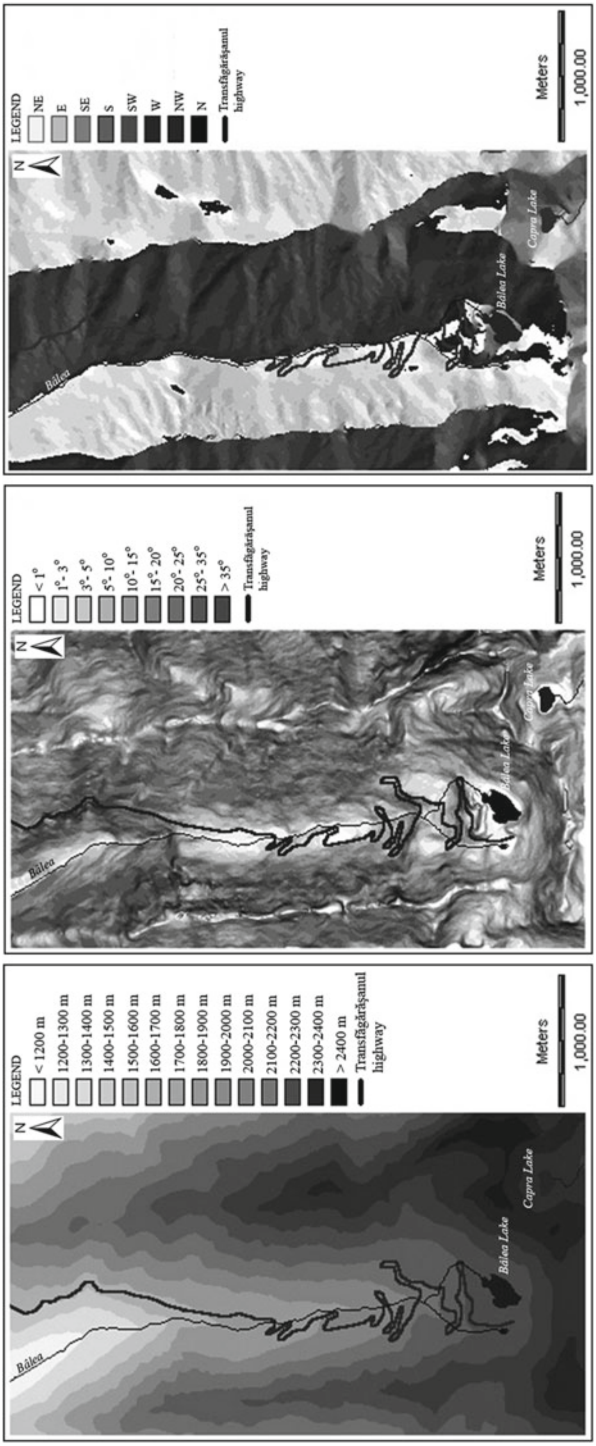

Fig. 13.3 Bâlea ski area: elevation map (*left*), declivity map (*center*), and aspect map (*right*)

Table 13.1 The main patterns of the Sinaia ski area

Ski piste	Patterns of the ski pistes								Homologation date	Facilities	
	Difficulty level	Length (m)	Departure elevation (m)	Arrival elevation (m)	Mean slope (°)	Vertical drop (m)	Mean width (m)	Surface (km^2)		Type of cable car	Artificial snow
Valea Dorului sub telescaun 2	M	804	2,049	1,818	28.7	231	40	0.032	02.07.2008	Chairlift	No
Valea Soarelui	M	1,191	2,035	1,820	18.1	215	40	0.048	02.07.2008	Chairlift	No
Valea Dorului variantă	M	896	2,033	1,834	22.2	199	40	0.036	02.07.2008	Chairlift	No
Valea Dorului sub telescaun 1	M	776	2,040	1,822	28.1	218	40	0.031	02.07.2008	Chairlift	No
Carp	D	1,382	2,056	1,607	32.5	449	50	0.069	02.07.2008	Chairlift	No
Papagal	M	847	1,870	1,649	26.1	221	40	0.034	02.07.2008	Chairlift	No
Drumul de vară	M	2,971	2,044	1,650	13.3	394	30	0.089	02.07.2008	Chairlift	No
Scândurari	M	505	1,969	1820	29.5	148	30	0.025	02.07.2008	Ski-lift	No
Începători	B	173				20			Not homologated		
Legătura	D	173				91			Not homologated		
Târle	D	534				221			Not homologated		
Furnica	B	270				77			Not homologated		
Noua Turistică (Cota 1400)	M	2,154				402			Not homologated		
	23 % for advanced skiers		12,676					0.374			
	61.5 % for medium skiers										
	15.3 % for beginner skiers										

According to National Institute of Research-Development in Tourism, 2009, and Voiculescu et al. 2012 with additions

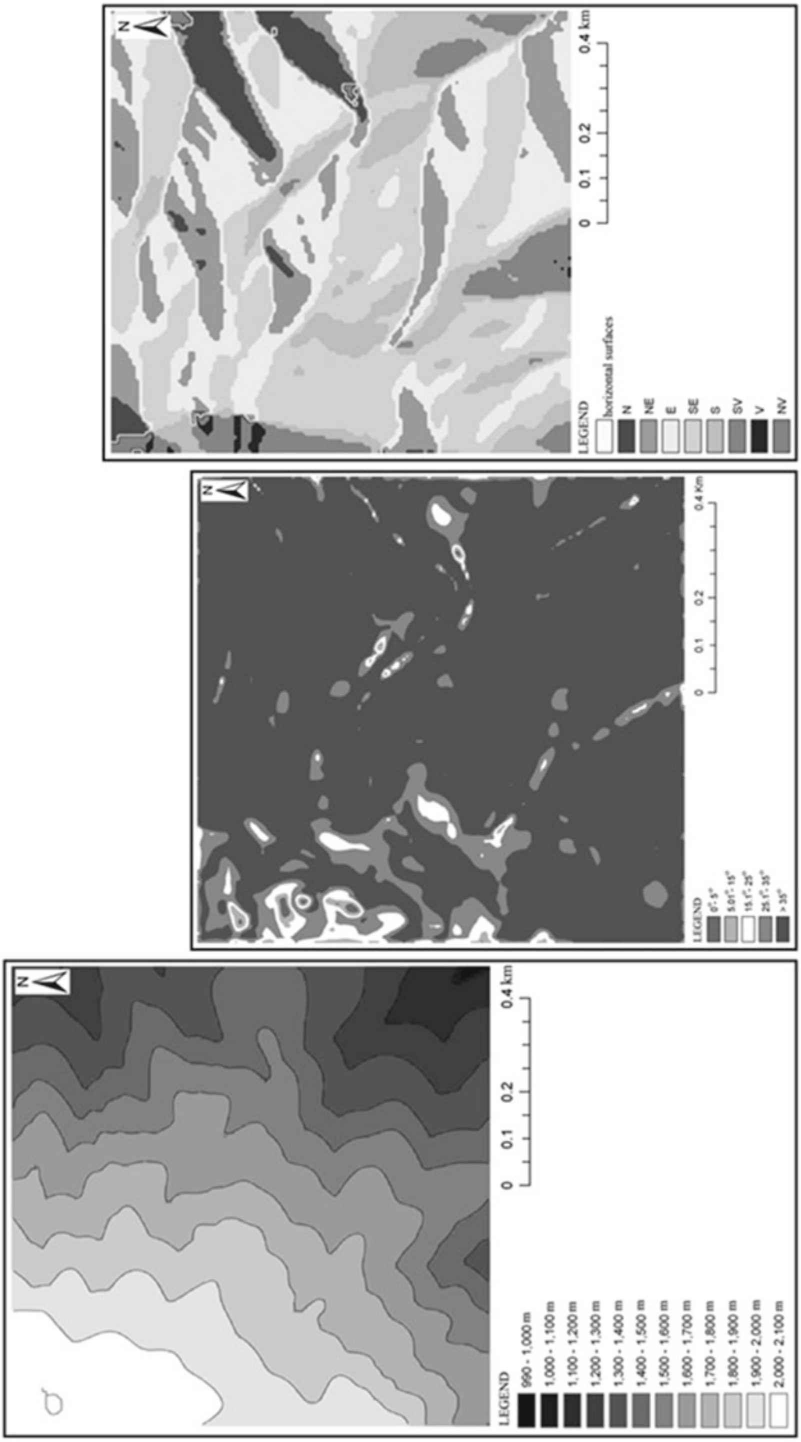

Fig. 13.4 Sinaia ski area: hypsometric map (*left*), declivity map (*center*), and aspect map (*right*)

The aspect map shows two different situations: within theCarp sector eastern slopes are predominant, whereas in the Valea Dorului sector the western orientation is predominant, both profiting from good radiation. In detail, especially for the Carp sector, we note the eastern, southeastern, and northeastern aspects, the latter favoring the persistence of snow until late spring. Small surfaces have south and southwestern aspects; these are the beneficiaries of the best insulation, but having in view the high slopes, which range between 25° and 35° and the lack of woodland vegetation, we need to consider their inclination toward generating avalanches (see Fig. 13.4).

13.3.2 Climatic Variables

The climate through its variables becomes an important tourist resource (Besancenot 1990) and is analyzed considering the snow depth with regard to the ski activities, being safe to say we have a snow-reliable area if *in seven of ten winters there is snow covering of at least 30 cm on at least 100 days between 1 December and 15 April* (Becken and Hay 2007, p. 38).

Romania is located within the temperate-continental climate zone, which is characterized by large quantitiesof snowfall and snow avalanches when near maritime and transitional zones (Birkeland and Mock 2001; Hägeli and McClung 2004; McClung and Schaerer 2006; Mock 1996; Mock and Birkeland 2000). As a consequence of its geographic position, many types of climatic influences can be identified on the mentioned ski areas. The northern slope of the Făgăraş massif, where the skiarea of Bâlea can be found, is under the humid oceanic influence. The Sinaia ski area is under continental influences. Therefore, the regional climate also determines the solar radiation, temperature, snowfall quantity, and type of snow (McClung and Schaerer 2006; Zingg 1966). Characteristics of the climate of the Făgăraş massif are registered at the weather stations of Bâlea Lake (2070 m a.s.l.) and Cozia (1577 m a.s.l.) and at the weather stations of the Bucegi Mountains at Vf. Omu (2505 m a.s.l.), Sinaia (1500 m a.s.l.), and at Predeal (1030 m a.s.l.). The main climatic characteristics of the Făgăraş massif and of the Bucegi Mountains are presented in Table 13.2.

Snow is a very important resource for winter tourism, especially for ski activity (Breiling and Charamza 1999). Snowfall, snow cover, and snow duration have a major role in environmental and socioeconomic practices in mountain regions (Beniston 1997, 2003; Beniston et al. 2003) and also in the Romanian Carpathians (Micu 2009). On the other hand, snow can generate natural hazards (i.e., snow avalanches) (Beniston et al. 2003; Elsasser and Messerli 2001).

The variation in time and space of snow depth is caused by climatic influences, snowfall frequency, the elevation of the 0 °C isotherm, slope aspect, and topographic features. The best Pearson correlation was given by elevation and number of days with snowfall and snow depth and elevation (Fig. 13.5a, b.). The number of days with snow cover is another important factor for ski activity. In our study area the

Table 13.2 The main climatic characteristics of the Făgăraş massif and the Bucegi Mountains

Weather station altitude (m a.s.l.)	Geographic coordinates		Time period	Climatic influence	Air temperature (0 °C)		Total rainfalls (mm)		Snow depth (cm)
	Latitude	Longitude			Annual	Winter season	Annual	Winter season	
Vf. Omu (2505)	45°27′	25°27′	1961–2011	Eastern	−2.5	−9.7	995.7	184.8	62.6
Bâlea Lake (2070)	45°36′	24°37′	1979–2011	Western	0.2	−7.3	1213.7	225.7	66.1
Cozia (1577)	45°18′	24°20′	1980–1994	Southern	3	−5.2	844.2	157	39.5
Sinaia (1500)	45°23′	25°30′	1961–2011	Eastern	3.7	−4.5	1057.4	191.8	47.6
Predeal (1090)	45°30′	25°33′	1961–2011	Eastern	4.9	−1.3	942.5	54.9	30.9

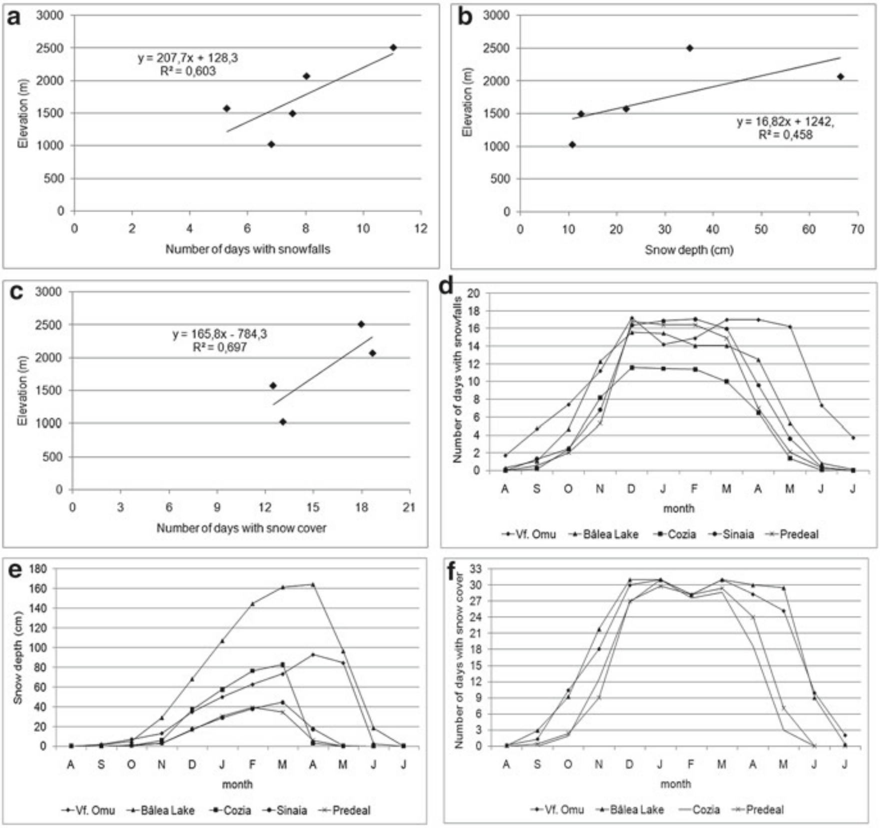

Fig. 13.5 Monthly variation of snowfalls (**a**), of snow depth (**b**), and of number of days with snow cover (**c**); correlation between altitude and number of days with snowfalls (**d**), between altitude and snow depth (**e**), and between altitude and snow cover (**f**)

best Pearson correlation was given by elevation and number of days with snow cover (Fig. 13.5c.).

The snow parameter is subjected to altitude variations but also to local conditions. Therefore, for the Bâlea glacial ski area the highest values are registered within the December–March interval, the total number within the October–May interval, summing up 150 days. For the Sinaia ski area, the highest values regarding the days with snow cover is reached in the November–March interval at the highest altitudes and November–April in the middle and lower part of the area. The total number of days with snow cover is 224 at the highest altitudes, about 66 in the middle, and only 45–46 days in its lower part. Therefore we can ascertain that in the case of the Bâlea glacial ski area and also in the case of the higher part of the Sinaia ski area there is a minimum of 100 days of snow coverage, as is stated in the dedicated literature (Besancenot 1990; Becken and Hay 2007). For skiing activity to take place in good conditions, it is necessary that the snow depth be at least 30 cm

(Agrawala 2007; Besancenot 1990; Becken and Hay 2007; Freitas 2005; Hall and Higham 2005). In accordance with the snow depth we have determined the type of the seasonal variation of snowfall or the type of nivometric regime (Besancenot 1990) (Fig. 13.5d.). Thus, for the Bâlea glacial ski area the characteristic nivometric regime is bimodal, characterized by a secondary maximum of the snow depth in February and the main maximum in April, with a relative winter minimum between the two. This type of regime is characteristic for high altitudes. For the Sinaia ski area we noticed a difference from the monomodal regime, with a single maximum in full winter toward the type of balanced regime, displaying similar quantities of snowfall in the months of December, January, and February. Toward the highest altitudes the type of nivometric regime is bimodal as well. Snow depth increases with altitude (Fig. 13.5e.). The highest values are recorded between February and April or even May. Snow cover is very important for ski activity and is directly related to snow depth. This parameter is determined by altitude and occurs between 6 and 8 months/year. At high altitudes 8–10 months/year are recorded with snow cover and at highest altitudes even 11 or 12 months/year (Fig. 13.5f). The necessary 30 cm of snow is provided in all cases (Agrawala 2007; Besancenot 1990; Becken and Hay 2007; Freitas 2005; Hall and Higham 2005).

Schweizer et al. (2003) described five factors that contribute to avalanche danger: terrain, precipitation (or new surplus snow), wind, temperature (including radiation effects), and snowpack stratigraphy. The snow depth is very important in producing snow avalanches (McClung and Schaerer 2006). According to Salm (1982, quoted by Schweizer et al. 2003), the new snow depth causes snowpack instability. In this context and according to Schweizer et al. (2003), we considered different snow depth thresholds that produce snow avalanches as less than 30 cm, 30 to 50 cm, 50 to 80 cm, 80 to 120 cm, and greater than 120 cm) (Fig. 13.6).

13.4 Management of Snow Avalanche Risk

The history of management of snow avalanche risk in Romanian mountains registered two important moments (Voiculescu 2009).

The first momentwas when the Mountain Rescuer Public Services (MRPS) was formed according to Ministerial Decision 140/1968. This service is administrated by district councils. The MRPS have the role to prevent survey, coordinate, and organize mountain rescues in the event of snow avalanches and other damaging events. For the Făgăraş massif, the MRPS has two units on the northern slope, namely, Sibiu and Victoria, and another two units on the southern slope, namely, Făgăraş Sud and Curtea de Argeş. For the Bâlea glacial ski area, the unit is located in the Bâlea glacial cirque, above 2000 m a.s.l. For the Bucegi Mountains, the MRPS has one unit, namely, the Sinaia MRPS, located at 2000 m a.s.l.

The second moment was in 2003 when the Programme of Nivometeorology was set within the National Administration of Meteorology (PN-NAM) in partnership with Météo France, Centre d'Études de la Neige-Grenoble. The main purpose of the

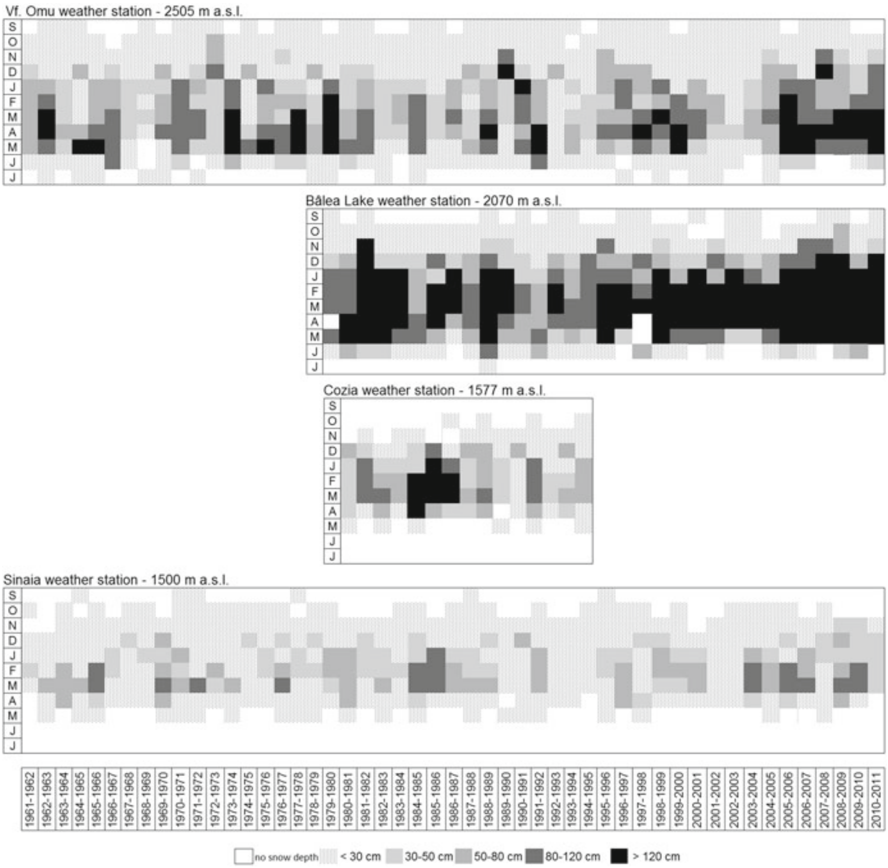

Fig. 13.6 Snow depth thresholds for determining snow avalanche risk, according to Schweizer et al. (2003) classification, between 1961 and 2011 for Vf. Omu and Sinaia weather stations, between 1979 and 2011 for Bâlea Lake weather station, and between 1980 and 1994 for Cozia weather station

program is to study snow and its future evolution as well as snow avalanche-triggering conditions. All nivometeorological data are analyzed by means of two systems developed by Centre d'Études de la Neige-Grenoble known as GELINIV and CROCUS-MEPRA PC (Voiculescu 2009). For the Bâlea glacial ski area, PN-NAM has Bâlea Work Nivology Laboratory (Bâlea WNL), located at 2070 m a.s.l. in the Bâlea glacial cirque on the northern slope of the Făgăraş massif. For the Bucegi Mountains, PN-NAM has two work nivology laboratories, at Vf. Omu weather station (2505 m a.s.l.) and at Sinaia weather station (1500 m a.s.l.).

Experience from past years suggested that values at risk and spatial planning should be increasingly considered within the framework of natural hazard risk reduction (Fuchs et al. 2005; Keiler et al. 2006; Zischg et al. 2005). To meet this goal, integral risk management strategies seem to be a valuable instrument to reduce the susceptibility of buildings and infrastructure to natural hazards and to develop strategies for a strengthened resistance (Fuchs et al. 2005), above all by means of local protection measures.

Many snow avalanches are triggered by backcountry skiers, off-piste skiers, and climbers, as is mentioned in several reports (Grímsdóttir and McClung 2006; Tremper 2001; Schweizer and Camponovo 2001; Schweizer and Lütschg 2001). The Făgăraş massif is characterized by high snow avalanche activity, especially in the Bâlea glacial ski area. A considerable ratio of fatalities and burials/injuries is represented by backcountry skiers, off-piste skiers, and climbers (100% in Făgăraş massif and 95% in Bâlea glacial area) (Voiculescu 2014), similar to that recorded in Europe (Tschirky et al. 2001; Zweifel et al. 2012). In the database statistics of Sibiu MRPS a large number of snow avalanche accidents was recorded. The Făgăraş massif holds the record in terms of the number of cases, with 76 fatalities and 50 burials/injuries (62 fatalities and 50 burials/injuries on the northern slope and 14 fatalities on the southern slope). In the Bâlea glacial ski area, 40 fatalities and 42 burials/injuries were recorded for the months November–June for the years 1940 (1968)–2011 (Voiculescu 2009, 2014) (Fig. 13.7). Here it should be noted that the 1977 snow avalanche killed 23 skiers (with the eldest person being 53 years and the youngest being 15 years) and injured 2 people. In the history of the Romanian Carpathians, this snow avalanche is known as the most tragic snow avalanche event.

Within the Sinaia ski area the frequency of snow avalanches does not have the intensity of those in the Făgăraş massif. Unfortunately, the Sinaia MRPS and Sinaia PN-NAM database statistics remain incomplete, perennial, and difficult to use. Therefore we used other sources of information (Table 13.3). Nevertheless, because of the large number of skiers in the past years and also the terrain and climatic factors that are favorable for skiing, here also some accidents have occurred that have determined the local authorities to take some precautionary measures.

Risk management of tourism practices is based on two strategies (Fig. 13.8): duration of protection–preventive temporary or permanent measures (snow pack support structures, drainage system to reduce roughness surface of avalanche moving, closing of highway) and passive and active defense points of intervention (snow sheds, wall support, deflecting dike, splitter to protect electricity poles) (Höller 2007, 2009; Jamieson and Stethem 2002). The Transfăgărăşan highway was built between 1970 and 1974. It is 90 km long and connects the northern and southern slopes stretching through two major Romanian regions, Transylvania and Muntenia. The passage from one slope to another is made through a 900-m-long tunnel under Paltinul Peak (2399 m) between 2025 and 2042 m. The Transfăgărășan highway is affected by snow avalanches both in its alpine level and in its forest level. For the safety of both vehicles and tourists, the Transfăgărășan highway is temporarily closed between October 1 and July 1, as determined by the Roads National Authority. To protect the Transfăgărășan highway and to highlight the risk management in sectors that are the most vulnerable to snow avalanche, some measures have been applied.

Unfortunately, the implementation of standardized pennons according to the French system, especially within the Bâlea glacial ski area (where the ski pistes are

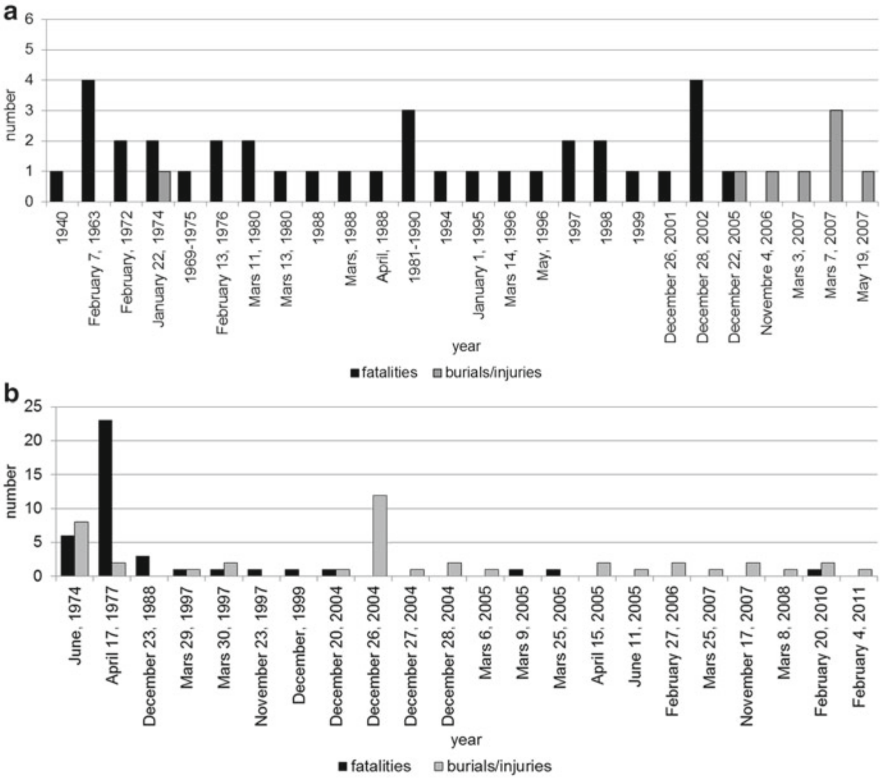

Fig. 13.7 Number of fatalities and injuries/burials in the Făgăraş massif (**a**) and the Bâlea glacial area (**b**) between 1940 and 2011

Table 13.3 Recorded main snow avalanches that have caused fatalities and burials/injuries on the Sinaia ski area

Year of snow avalanche event	Fatalities and/or burials/injuries	Source
February 1981	Two fatalities	Commemorative plaque and croix
February 11, 2005	One person buried	PN-NAM, 2004–2005
January and February 2006	Eight burials/injuries and roads blocked	PN-NAM, 2005–2006
February 21, 2009	One fatality	PN-NAM, 2008–2009
February 10, 2010	Four burials/injuries	http://avalanse.blogspot.ro/2010/03/bucegi-sinaia-carp-februarie2010.html

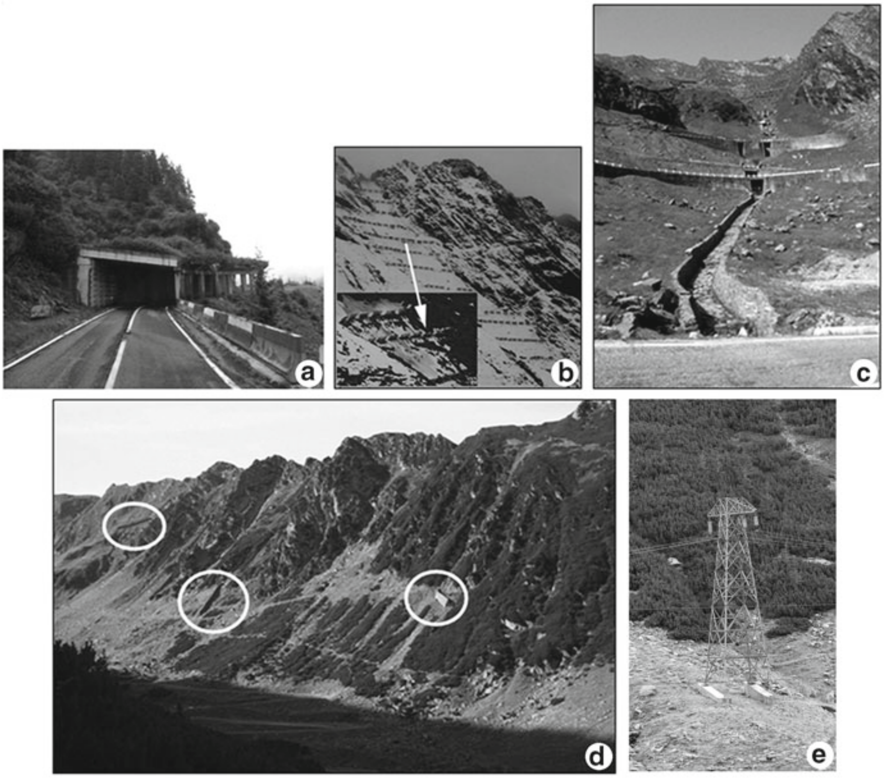

Fig. 13.8 Traditional forms of snow avalanche management: snow sheds (**a**), snowpack support structures (**b**), systems drainage (**c**), deflecting dikes (**d**), and splitter to protect electricity poles (**e**). (From Voiculescu 2004, 2008)

unequipped) and warning panels, according to European or North American systems, are still not current. In this context it is necessary to place (according to the North American and European systems) display panels that read, for example, "No Stopping" or "Avalanche Area" along the roads or in the ski areas where the snow avalanche hazard is imminent.

In the Sinaia ski area from the Bucegi Mountains, attention was drawn quite recently to management of snow avalanche risk by several accidents that took place here. This response mainly consists of delineating the ski pistes by signs and marking the degree of difficulty on the already-mentioned signs, but also of the implementation of snow pack structures where the occurrence of snow avalanche is imminent, which are the most common and the most efficient form of avalanche preventions. Also, warning signs such as those seen in other mountain areas have been implemented (Weir 2002), which read "Danger of avalanches" or "Trail closed during winter" (Fig. 13.9). Finally, another measure is the temporary closure of ski pistes.

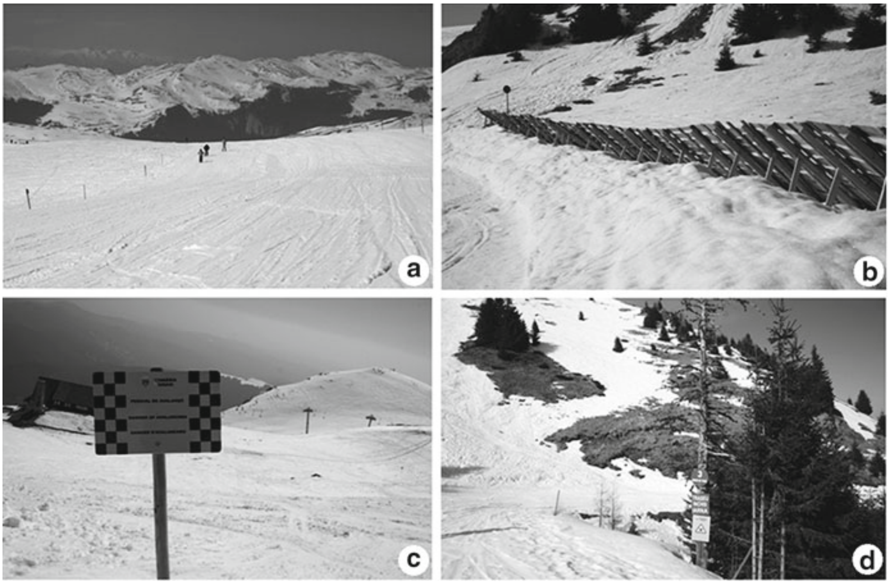

Fig. 13.9 Delineated pistes and snowpack support (**a**, **b**) and display panels (**c**, **d**). (From Popescu 2009)

Since the 2004–2005 winter season, according to European Scale, PN-issued avalanche danger levels (Administraţia Naţională de Meteorologie 2004-2005; 2005–2006; 2006–2007; 2007–2008, 2008–2009, 2009–2010, and 2010–2011) (Fig. 13.10). This is another form of management of snow avalanche risk. Above 2000 m a.s.l., the highest rate was recorded in March, sometimes in April, or even in May, when the snow depth is the greatest. In the Făgăraş massif in all analyzed winter seasons the moderate, considerable, and high danger levels have the highest frequency. In some winter seasons a very high danger level was recorded. In the Bucegi Mountains the moderate and considerable danger levels have the highest frequency, sometimes high and very high danger levels.

It is an important fact that Romania has joined other European Union countries in both monitoring and snow avalanche hazard prevention; thus after the European snow avalanche risk scale was launched in 1993–1994, Romania adopted it because of the need for unique snow avalanche prevention criteria. In this respect, there are permanent broadcasts regarding snow avalanche risks during periods with large quantities of snowfall (PN-NAM, 2004–2005, 2005–2006, 2006–2007, 2007–2008).

A large part of the Romanian Carpathians, such as Eastern Carpathians and Southern Carpathians (except the Western Carpathians), are areas exposed to snow avalanches. They are recorded in the European Spatial Planning Observation Network (ESPON). On the other hand, research institutes grant a heightened attention to the phenomenon. Therefore, the Geographic Institute of the Romanian Academy is developing a general map (using ESRI GIS ArcView) of geomorphological risks,

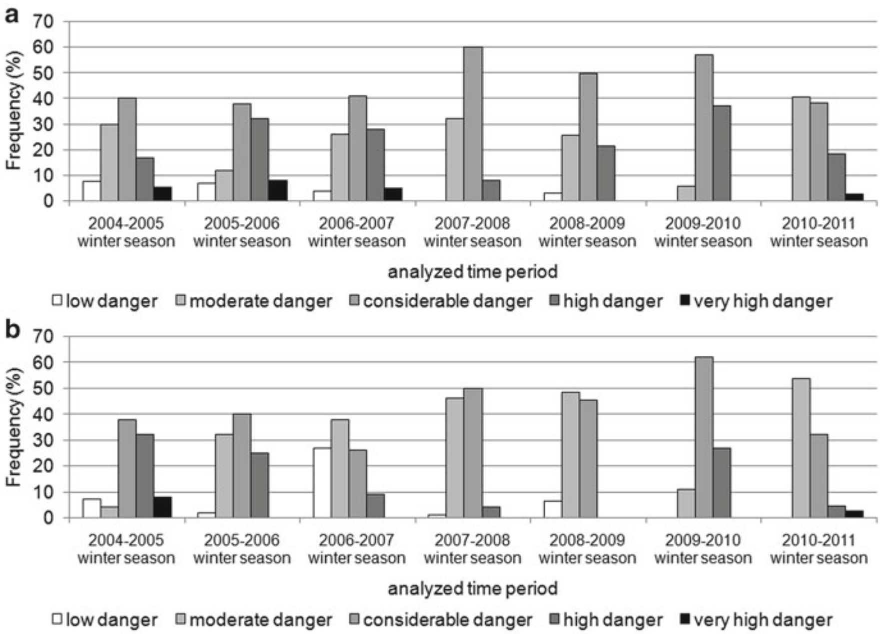

Fig. 13.10 Frequency of danger level in Bâlea glacial ski area (**a**) and Sinaia ski area (**b**)

including snow avalanche hazards. In this respect it need be mentioned that hazard mapping snow avalanches, which includes the zoning criteria, *does not prevent avalanches; they only reduce the probability of damage* (Höller 2007, p. 96), and therefore are of high necessity within mountain areas with winter sports potential.

13.5 Conclusions

Unfortunately, the management of snow avalanche risk does not yet represent a major concern. The increasing incidence of snow avalanches affects not only skiers (backcountry skiers and off-piste skiers), but also the entire economy of the ski areas. The authorities responsible for the management of the ski areas need to invest in the following:

- Surveillance of the phenomena;
- Sending warnings through special services that would transmit nivometeorological bulletins;
- Drawing up vigilance maps on groups or mountain massifs;
- Emitting codes;

- Risk reduction, the consolidation and extension of snow avalanche protection structures such as deflecting dikes, snow pack support structures, snow sheds, and the introduction of explosive controls, as well as artificial release of snow in ski areas and along roads;
- Integrating and using the European avalanche risk scale, especially as Romania is part of the European Spatial Planning Observation Network (ESPON) database insofar as mountain hazards are concerned;
- Implementing standardized pennons (as in the French system) especially within ski domains (which would display trail number, type, or off-trail domain) and to implement warningpanels (European or North American system);
- Placing display panels that read, for example, "No Stopping" or "Avalanche Area" along the roads or in the ski areas (Weir 2002) where snow avalanche hazard is imminent;
- Implementing more nivometeorology laboratories of the PN-NAM within mountains with snow avalanche risk to collect meteorological data useful for GELINIV and CROCUS-MEPRA PC programs. Using these programs, snow avalanche risk maps will be produced as well as warnings for skiers and tourists.

Also, a more serious preoccupation regarding the construction of preventive measures (may be temporary or permanent and of intervention points active or passive) needs to be undertaken.

On the other hand, the management of crisis situations (present emergencies and future misfortunes) need to be prepared and also the blueprints of the territory need to be revised by elaboration of snow avalanche zoning maps and other thematic maps of exposure to natural risk phenomena.

And last but not least, Romania needs to achieve international standards through the provision of good education regarding the understanding and management of natural hazards or risk phenomena.

Acknowledgments The authors express their appreciation to the members of the Bâlea and Sinaia 1500 nivometeorology laboratories for having made available documentation of the nivometeorological reports for the winter seasons from 2003–2004 to 2010–2011 and also to the Sibiu and Sinaia Mountain Rescuer Public Services for the all information on snow avalanche accidents.

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Chapter 14
Landscape Structure and Ecosystem Services of Etropole Municipality

Stoyan Nedkov

Abstract This chapter represents an approach to investigate the landscape structure at municipality level and the possibilities of using it for evaluation of ecosystem services. Landscape differentiation of the area was investigated using a GIS-based model. The most important ecosystem services of the Etropole municipality are provided by the forest landscapes. Only 27 % of their total value belongs to the provisioning service, which is the most used at present. The importance of their regulation services, especially regulation of flood risk, will increase in the future because of climate change. The valuation of ecosystem services is considered as an important and useful activity for the achievement of sustainable development. It gives an opportunity to involve some resources and services that are usually ignored in the process of regional planning. Further progress of the valuation and assessment methods will improve their preciseness and reliability.

Keywords Landscape structure • Ecosystem services • Valuation

14.1 Introduction

The small municipalities in Bulgaria located in mountain areas have low economic potential. Their labor force and productive capital are limited, so in most cases they rely mainly on the natural resources. Their economic valuation is usually concentrated on the possibility of extracting raw materials or in some cases on tourist potential. Many useful ecosystem functions such as storage and retention of water, regulation of atmospheric chemical compounds, and regulation of disturbance regimes are ignored. One of the reasons is that the profits they provide are not direct and need long-term planning. On the other hand, the conventional methods of economic valuation are not applicable to them. The concept of ecosystem services

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gives the opportunity to solve this problem. It is based on the assumption that "the services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the earth's life-support system, they contribute to human welfare and therefore represent part of the total economic value of the planet" (Costanza et al. 1997). This concept is fully compatible with the idea of sustainable development because it gives the possibility to involve important resources and services for future generations such as genetic material and habitat function in the processes of economic valuation and regional planning.

The ecosystem services are defined as "the conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfill human life…" (Daily 1997), "ecological processes that benefit people directly (e.g., food) or indirectly (e.g., pollination)" (Luck et al. 2003), "benefits that people derive from ecosystems" (Millennium Ecosystem Assessment 2005). Ecosystem services consist of flows of materials, energy, and information from natural capital stocks that combine with manufactured and human capital services to provide human welfare (Costanza et al. 1997). The term ecosystem services lumps together economic benefits that can be classified as (1) goods: products obtained from ecosystems, such as resource harvest, water, or timber; and (2) services: certain ecological regulatory functions, such as water purification, climate regulation, or erosion control. Thus, in the current literature the word "goods" is usually left out of the term but the meaning remains the same. According to the Millennium Ecosystem Assessment (2005), the ecosystem services are grouped into four broad categories: *supporting services; provisioning services; regulation services; cultural services*. The ecosystem functions providing these services can be classified into four primary categories (de Groot et al. 2000): (1) *regulation functions:* related to the capacity of natural ecosystems to regulate essential ecological processes and life support systems through biogeochemical cycles and other biospheric processes; (2) *habitat functions:* natural ecosystems provide refuge and reproduction habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes; (3) *production functions:* photosynthesis and nutrient uptake by autotrophs convert energy, carbon dioxide, water, and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create an even larger variety of living biomass; (4) *information functions:* because most of human evolution took place within the context of undomesticated habitat, natural ecosystems provide an essential 'reference function' and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation, and aesthetic experience. The valuation of ecosystem services is an important task "inseparable from the choices and decisions we have to make about ecological systems" (Costanza et al. 1997).

The landscape is considered as "a heterogeneous territory consisting of cluster of interacting ecosystems that are repeated in space" (Forman and Godron 1986). The ecosystems could have different spatial extent, and the mapping of all ecosystems for a particular area (i.e., a municipality) is an almost unattainable task. On the other hand the valuation of the ecosystem services requires appropriate spatial data for the investigated area, so it is better to carry out this activity at a landscape level. Remote sensing data and the GIS database can be useful tools for its realization. This chapter is an approach to investigate the landscape structure at municipality level and the possibilities of using it for the valuation of ecosystem services.

14.2 Study Area

The municipality of Etropole is situated in the north part of Bulgaria with an area of 371.7 km^2 (Fig. 14.1). It occupies the northern slopes of the easternmost part of the West Stara Planina Mountain (called Etropolska Mountain) and the average elevation is 914 m. The climate is typical temperate-continental characterized by a relatively warm summer and cold winter. The temperatures gradually decrease from north to south with the increase of elevation from 9.5 °C to 2 °C. The annual precipitation varies from 750 to 800 mm in the north part to 1100 mm for the highest parts of the mountain. Because of the mountainous character of the region, extreme precipitation is intensive and most often concentrated in single parts of the catchment areas. Malki Iskar River, with its tributaries Ravna, Suha, Jablanitsa, and Strara reka, drains the area. There are nine protected areas within the municipality, four natural landmarks, and five protected sites.

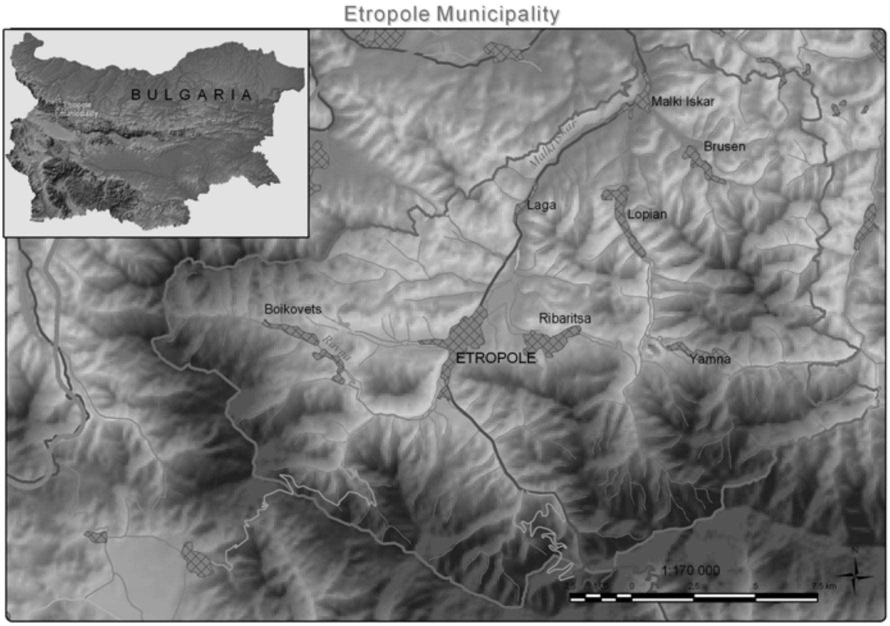

Fig. 14.1 Study area: Etropole municipality

The municipality contains one town, Etropole (11,840 inhabitants), and nine villages. The largest of these are Lopian (516 inhabitants) and Malki Iskar (351 inhavitsssstnst). The population of the municipality is characterized by an unfavorable age structure and negative growth rate. The share of the industrial enterprises in the economic sector in 2003 is 73 %, and they ensure 57.3 % of the workplaces in the municipality. The agriculture is dominated by stock breeding. According to the municipality data, the wood output within its boundaries has been drastically increased in the course of the past 7 or 8 years, from 12,000 m^3 to 35,000 m^3 annually. The plan for municipal progress until 2013 envisaged development of tourism on the basis of the nine protected territories and the remarkable cultural heritage.

14.3 Materials and Methods

The mountain landscapes are characterized by a higher level of heterogeneity resulting from the great variety of geographic conditions. The change of landscape units in the mountains takes place within few kilometers whereas in the plains the corresponding change can be detected only after hundreds and thousands of kilometers. This difference necessitates the implementation of a specific approach that takes into account the third dimension of the landscape, the elevation. To investigate the landscape heterogeneity, methods by which spatial patterning can be described and quantified are necessary. Thus, we developed an approach using regression dependencies and GIS tools for spatial analyses to model the spatial pattern and produce landscape maps for the mountain areas. It is based on a regression model of interpolation using correlation dependencies between hydroclimatic indices and altitude (Gikov and Nedkov 2005). The GIS map layers of the climatic indices are analyzed and verified using satellite images and forest cadastre data to create a map layer of the potential landscapes in the area. CORINE Land Cover data are used as a basis to create map layers for contemporary landscapes. They are transformed and generalized to fit the working map scale and then intersected with the previously created map layers. The landscape map was created using a two-level classification scheme to represent the hierarchical structure. The first level (landscape types) represents the landscape differentiation caused by the influence of main flows of energy and matter, calculated by hydroclimatic indices. Land use data were used at the second level for delineation of the contemporary landscapes. CORINE land cover classes have been generalized to 11 land use types, which represent the contemporary landscapes of the area.

There are various methods used to estimate both the market and non-market components of the value of ecosystem services (Costanza et al. 1997). The valuation needs a synthesized approach based on a variety of methods used in different scientific disciplines, noting the limitations and assumptions underlying each. The value of ecosystem services is divided into three main types: ecological, sociocultural, and economic (de Groot et al. 2002). The latter can be divided into (1) direct market valuation; (2) indirect market valuation; (3) contingent valuation; and (4) group valuation. The first one is easily applicable for most provisioning services such as raw materials, food, or fresh water because of their wide use in the economy. The indirect methods use different techniques to reveal the Willingness To Pay or Willingness To Accept Compensation for the availability or loss of these services. It includes Avoided costs (services allow society to avoid costs that would have been incurred in the absence of those services), Replacement costs (services could be replaced with human-made systems), etc. Contingent valuation uses a social survey questionnaire to express willingness to pay for a particular service. Group valuation is a method derived from social and political theory based on the principles of deliberative democracy.

The valuation of ecosystem services in Etropole municipality was made using some of the values given in different investigations of the world ecosystems (de Groot 1994; Costanza et al. 1997; Millennium Ecosystem Assessment 2005) and regional studies (MakKinnon and Yan 2001; Weber 2005; EFTEC 2005; Barclay et al. 2004). The work of Zevurdakis et al. (2007) makes an attempt to valuate the ecosystem services of the Rhodope Mountain area in Bulgaria. They also recalculated all values in Bulgarian currency, BGN. Their results are a useful source for the situation in Bulgarian mountainareas, but they used CORINE land cover as an initial spatial data for the evaluation. The values from all these sources have been verified for the study area and corrected where necessary. For example, Zevurdakis et al. (2007) valuated the provisioning functions from the forest ecosystems at 282 BGN/ha/year but in the landscape typology there is a possibility to classify them in more detail. There are beech forests, oak–hornbeam forests, and artificial coniferous forest, which have some differences in their services. The beech forests in the higher part of the area have higher disturbance regulation services, which was detected using GIS-based hydrologic models (Nikolova et al. 2008; Nedkov 2008). The valuation of the mixed classes such as forest-arable land areas has been calculated using the values of the original land use types reduced according to their share in the particular area. The value of the transitional woodland–shrub class was calculated by reduction of the forest values with the services that this class is not able to support (for example, timber production) or have less potential (regulation of disturbance regime). For the review of ecosystem services, this paper follows the Millennium Ecosystem Assessment typology, grouping the ecosystem services into four main categories (see foregoing). As the supporting services are considered to be necessary for the production of all other services, they were not included in the valuation at this stage of the investigation.

14.4 Results

The area of Etropole municipality belongs entirely to mountain landscapes. According to the classification scheme made by Velchev et al. (1992), modified for mountain areas by Gikov and Nedkov (2009), there are two landscape types and 11 contemporary modifications (Fig. 14.2). The south part of the municipality is

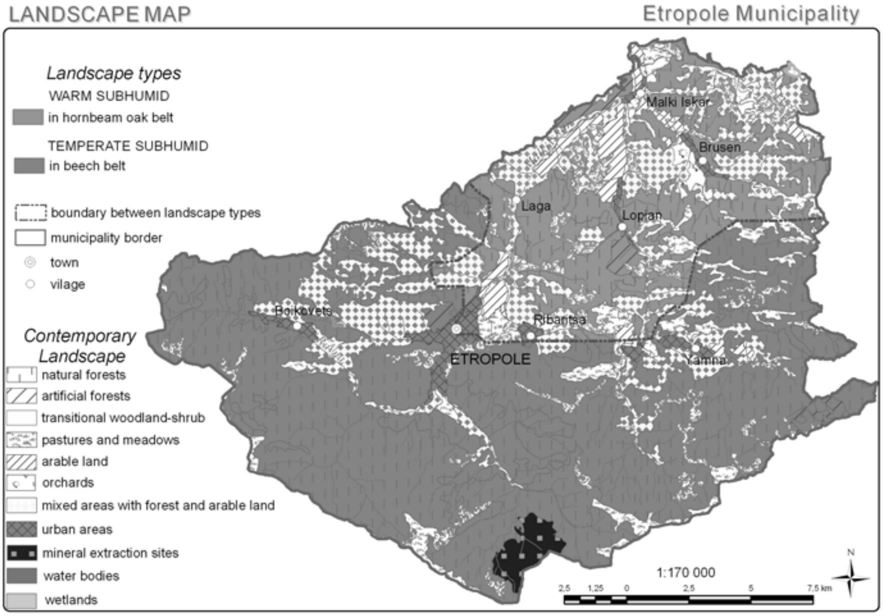

Fig. 14.2 Landscape map of Etropole Municipality

occupied by *temperate subhumid landscapes in the beech forests belt*, which cover 25,180 ha (69 % of the area of the municipality), located in the mountain belt above 450 m. The natural beech forests are very well preserved, occupying 75% of the area. There are no extended arable lands within this type. They are represented by relatively small patches surrounded by forests or grassland, which is why the second largest land use type is *mixed areas with forest and arable land* (12 %). The pastures and meadows occupy about 5 % of the area. They are represented mainly by secondary vegetation types in place of former forests, used predominantly for livestock grazing. Transitional woodland–scrub landscapes (5 % of the area) are located in areas used for timber extraction in the past, which are now at different stages of the reforestation process. The north, lower part of the municipality is occupied by *warm subhumid landscapes in the belt of hornbeam–oak forests*, which cover 11,542 ha (31 % of the area of the municipality). The share of natural forests here is less than in the previous type (41 %) but they still occupy the largest area. The arable lands are larger but still most of them are included in the mixed land use class (27 % of the area) and only 3,068 ha (8 %) is identified as extensive cultivated fields. The share of the *artificial forests* (3 %) here is larger than in the previous type, as well as the *transitional woodland–shrub* and *pasture* landscapes, which is the result of the higher level of anthropogenic influence in this part of the municipality (Table14.1).

Valuation based on the described approach shows that the potential value of the ecosystem services provided by the landscapes of Etropole municipality to the society is 35.3 million BGN/year. Provisioning services constitute 27 % of this, whereas

Table 14.1 Value of the ecosystem services in Etropole Municipality (the area of mineral extraction sites is not included)

Landscapes	Area (ha)	Value of the ecosystem service (in BGN/ha/year)			Value for the whole landscape (in thousand BGN/year)			Sum (in thousand BGN/year)
		Provision	Regulation	Cultivation	Provision	Regulation	Cultivation	
Temperate subhumid								
Natural forests	18,869.1	288	581	382	5,434	10,963	7,208	23,605
Artificial forests	215	80	481	250	17	103	54	174
Transitional woodland-shrub	1,377.7	60	335	–	83	462	0	544
Pastures and meadows	1,164.6	107	26	200	125	30	233	388
Mixed areas with forest and arable land	2,954.2	365	235	–	1,078	694	0	1,773
Arable land	77.5	421	69	0	33	5	0	38
Water bodies	12	156	550	0	2	7	0	8
Urban areas	510.3	0	662	0	0	338	0	338
Wetlands	0	143	588	100	0	0	0	0
Sum	25,180.4	–	–		6,772	12,602	7,495	26,868
Warm sumhumid								
Natural forests	4,734	210	471	382	994	2230	1808	5,032
Artificial forests	298.7	40	431	250	12	129	75	215
Transitional woodland-shrub	955.4	30	285	–	29	272	0	301
Pastures and meadows	921.3	107	26	200	99	24	184	307

(continued)

Table 14.1 (continued)

Landscapes	Area (ha)	Value of the ecosystem service (in BGN/ha/year)			Value for the whole landscape (in thousand BGN/year)			Sum (in thousand BGN/year)
		Provision	Regulation	Cultivation	Provision	Regulation	Cultivation	
Mixed areas with forest and arable land	3,068.8	325	235		997	721	0	1,719
Arable land	925.4	421	69	0	390	64	0	453
Orchards	269.8	421	69	0	114	19	0	132
Water bodies	16	156	550	0	2	9	0	11
Urban areas	317.9	0	662	0	0	210	0	210
Wetlands	35	143	972	100	5	34	4	43
Sum	11,542.3	–	–	–	2,641	3,712	2,071	8,424
Whole municipality	36,723.7	–	–	–	9,413	16,314	9,565	35,292

the share of regulation services is almost half the value (46 %). Forest landscapes by far provide the biggest contribution (28.6 million BGN/year), accounting for 81 % of the total value. The extraction of raw materials (mainly timber) has 3303 BGN/year, which is only 11 % of their total value. The excessive timber production menaces some of the regulation services, which could have a negative effect in the future. The forest ecosystems in the temperate subhumid landscape type have higher regulation value because of their function in flood risk reduction (Nikolova et al. 2008). This value is calculated to be 4.7 million BGN/year, which is almost half the total value of the regulation services. The provisioning services in warm subhumid landscapes have lower value because the hornbeam–oak forests there have lower timber quality and the forest fragmentation is higher. On the other hand, the non-tree forest resources there are greater, which reduces the difference. The artificial forest landscapes have lower values, because they are mainly coniferous with lower timber quality, lower regulation capacity, and lack of non-forest resources. The anthropogenic landscapes have relatively high value compared with their area, which is the result of their high cultural value and the assessment method, which takes into account the replacement costs for the building of equipment producing this service. As the cost of the land for building in the urban areas is high, the value also increases (Zevurdakis et al. 2007).

14.5 Conclusion

The most important ecosystem services of the Etropole municipality are provided by the forest landscapes. Only 27 % of their total value belongs to the provisioning service, which is the most used at present. The importance of their regulation services, especially the regulation of flood risk, will increase in the future because of climate change (Nikolova et al. 2008). This change necessitates prevention activities directed to the preservation of the regulation function of the forest ecosystems in the critical areas of the basin. Such measures would have positive effects also on the genetic and regulation services and the total economic value as well (Nedkov 2008). The use of the landscape approach gives opportunity for more precise valuation than using pure land cover data (i.e., CORINE). The quality of the spatial data is a very important factor for the preciseness of the valuation. CORINE land cover is a good source for broad- and middle-scale research but for small municipalities, investigated in finer scale, it is necessary to involve satellite images with high resolution. ASTER Terra images provide satisfactory quality (15-m resolution) at reasonable cost for that purpose.

The valuation of ecosystem services of the municipality is an important and useful activity for the achievement of sustainable development. It gives the opportunity to involve some resources and services that are usually ignored in the process of regional planning. Although, this valuation is “certainly difficult and fraught of uncertainties” (Costanza et al. 1997) and is criticized by many authors, its contribution for sustainable development can be very useful. Further progress of the valuation and assessment methods will improve preciseness and reliability.

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Part III
Social, Economic and Regional Problems of Mountain Regions

Chapter 15
Demographic Potential and Problems of the Settlements Network in the Mountains of Bulgaria

Chavdar Mladenov

Abstract Mountainous areas cover approximately 47.8 % of Bulgarian territory. Those areas are comparatively densely populated; the settlement network is well developed, and some 1.938 million people (25.4 % of the total population) live there (2007). However, there have been strong trends of population decline for reasons of natural decrease, aging, and emigration. The average birth rates are lower than the national average, although the death rate levels and the natural increase are similar to the national averages. In many mountainous areas, emigration exceeds admissible proportions and results in inexcusable decrease of population numbers as well as deterioration of the age structure. Most of the mountainous settlements are small. However, all larger and medium-sized urban settlements, as well as some of the small towns, have comparatively well-developed socioeconomic potential, enough arable lands and conditions for tourism and recreational activities, and usable housing.

Keywords Mountain regions • Depopulation • Aging • Regressive reproduction • Migration • Demographic crisis

The issues connected to the utilization of the resources of our mountains are influenced to a great extent by the demographic and settlement potential and their dynamics. In the current analysis, the area taken into consideration is delimited by the physical-geographic boundaries of the Bulgarian mountains, which cover approximately 47.8 % of the total area of the country. That area is considerably larger than the area outlined in the Directive for selecting criteria for defining unfavorable regions and their span (published in the *State Gazette*, issue 20/26, Feb. 2006). The adopted criteria in that Directive are highly exaggerated and do not respond to the specific conditions for mountainous region delimitation that exist in

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the country. For example, the climate component has not been taken in consideration, which has led to the exclusion of vast areas (Fig. 15.1).

Historically, for political, economic, religious, and demographic reasons, the Bulgarian mountains have been comparatively densely populated and the settlement network has been well developed. In 2007 the mountains were home to approximately 1.938 million inhabitants, or 25.4 % of the total population of the country. With its natural increase, the population numbers in the mountains increased until 1975, although its relative share was decreasing with emigration. In the years that followed, the trends were equalized: both number and relative share started to decrease (Fig. 15.2).

The density of the population living in mountainous regions in the past was 10 percentage points lower than the national average, but presently it is twofold lower than the national average, and in 2007 it was 36.7 inhabitants/km^2, which is threefold lower than the population density in non-mountainous regions. The major part of the population in Bulgaria is concentrated in the hypsometric belts up to 500 m above sea level. Basically, that is a result of the concentration of urban population there (approximately three fourths of that population inhabit those belts). The concentration of population in those hypsometric belts is the result of the comparatively low altitude of our mountains, together with the accepted boundaries of the latter. Altitude by itself has little significance for the distribution of population throughout different hypsometric belts: its effect is revealed mostly by the industry conditions (especially agriculture) and the popular customs of the population (Fig. 15.3).

The dynamics of the number and distribution of the population across the different mountains is shown in Table 15.1. In 2007, 875,300 people lived in Stara Planina, which was 45.2 % of the total mountainous population of Bulgaria, 579,200 people (29.9 %) inhabited the Rodopi mountains, 194,100 people (10 %) lived in Rila and Pirin, 175,600 people (9.2 %) in Sredna Gora, and 113,900 people (5.7 %) inhabited the rest of the mountains.

In many mountainous regions, the trend of population number decrease and its concentration in urban areas is still strong. Decrease in population number is a trend spread out in all mountains as a consequence of natural decrease, aging, and emigration. The significant reduction of the number of population in the Rodopi Mountains is the result of emigration of ethnic Turks in 1989 and the years that followed. Depopulation in some mountains has taken on staggering proportions, which requires urgent and decisive actions by the state authorities. Within the mountain regions themselves, the scale of depopulation is even larger.

From a quantitative point of view, in most mountainous areas, the population numbers (and density) are appropriate in terms of rational utilization and enrichment of the natural and socioeconomic potential of those regions. Only in the Eastern and Western Rodopi Mountains and in Eastern Stara Planina does the number of population exceed the current demand: the municipalities of Satovcha, Garmen, Borino, Ruen, Kirkovo, etc. From a qualitative point of view (especially when labor force is concerned), the population in mountainous regions is far behind that of the non-mountainous areas, especially for rural areas that lost a significant

Fig. 15.1 The mountainous areas of Bulgaria

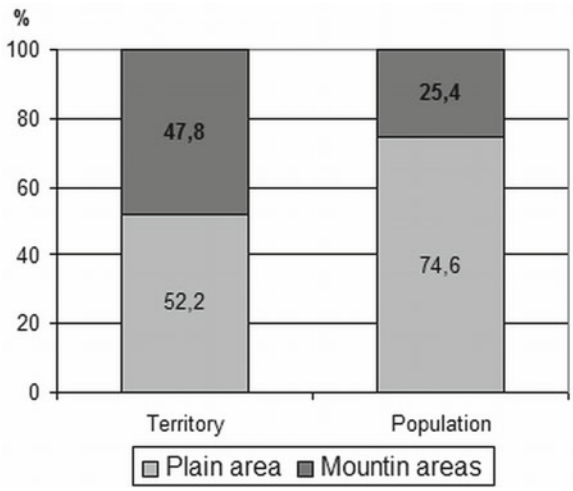

Fig. 15.2 Ratio between mountain and plain areas and population in Bulgaria

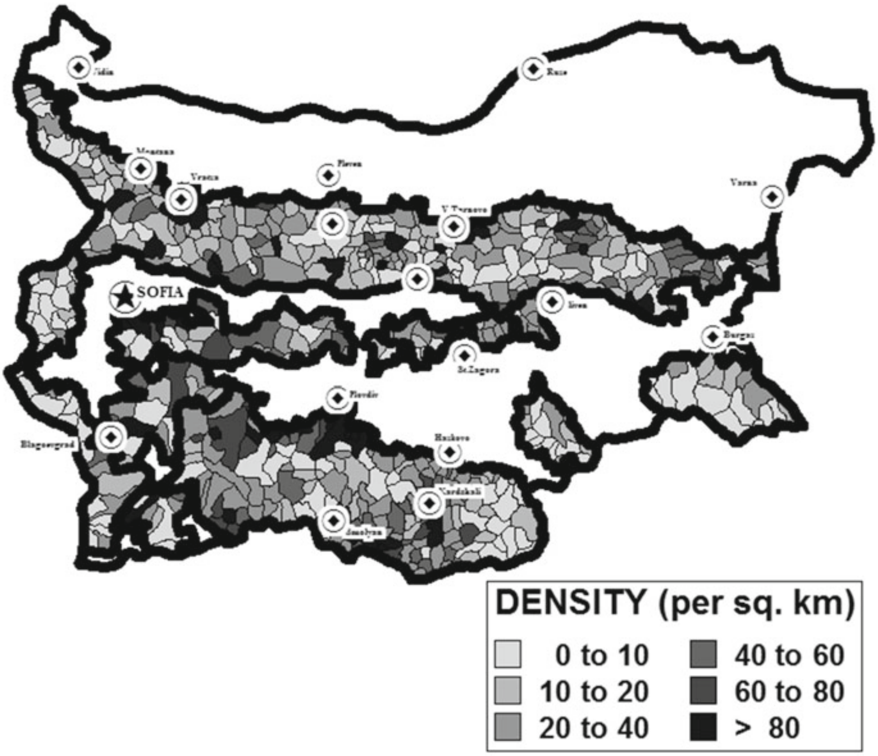

Fig. 15.3 Density of population: 2007

part of their population in the years after 1975: the central Stara Planina region, Western Border areas, and the Strandzha-Sakar region.

The trends in reproduction of the mountainous population and the population of the country as a whole are generally the same. However, within the various mountainous regions, population reproduction differs significantly from the general trends and has specific features. As opposed to the past, average birth rates of the mountainous population are now lower than the national average, although the death rates and the natural increase (decrease) are similar to the national average. Compared to earlier periods, when the natural increase was much higher, a process of natural decrease has begun since 1993. The spatial differences in birth and death rates tend to become more and more insignificant. Higher than the national average birth rates are estimated in the Rodopi Mountains, Rila, Pirin, and Strandzha (in the latter, this is only because of the high relative share of urban population). The lowest birth rates are recorded in Sakar (5.9‰) and the Western Border mountains (6.3‰). In the same time, in those two regions the death rates were the highest: 23.9 % in Sakar mountain and 21.9 % in the Western Border Mountains, whereas in the Rodopi Mountains the death rates are the lowest, mostly because of the younger age structure of the population there. Just the opposite, in Sakar and the Western Border Mountains, because of the considerable aging of the population, the levels of natural decrease are the highest, higher than 15 % (in other words, a natural increase of −15 %), as opposed to that in the Rodopi Mountains, where the natural increase of the population reaches 2.1 %. Demographic aging, therefore, is a key to the significant decrease of birth rates and increase of death rates (Figs. 15.4, 15.5, and 15.6).

The mountainous population in Bulgaria as a whole is distinguished by its relatively high migration mobility. In the past the migration flows were directed from rural mountainous areas to local urban centers and in a lesser extent to other parts of the country, but nowadays migration is directed to the largest cities and tourist centers in the country on the one hand and to foreign countries on the other. In many mountainous areas emigration exceeds a reasonable scale and leads to huge population losses and age structure deterioration. From an economic and social point of view, modern-day migration is a necessary process which however has a demolishing effect on demographic structures, reproduction, and population numbers. Negative consequences for settlements, and the network of settlements as a whole, are inevitable. As a matter of fact, according to the 2001 census, all uninhabited settlements in the country are located in mountainous regions, as well as the 40 villages erased from The List of Settlements in the Republic of Bulgaria.

In recent years, decrease of the population numbers in mountainous settlements caused by emigration is about 1.7 % (or migration growth of −1.7 %). To a great extent, this is a result of the combined effect of exhaustion of migration outflows on the one hand, and the thriving of tourism and relative economic stabilization of some mountainous towns on the other (in Strandzha region, for example, migration growth of the population is 12‰). The highest population decrease rates from migration are measured in Sakar Mountain, 6.6 % (or increase of –6.6 %), which lacks any significant natural and economic potential for development. The comparatively higher emigration decrease of the population in the Stara planina

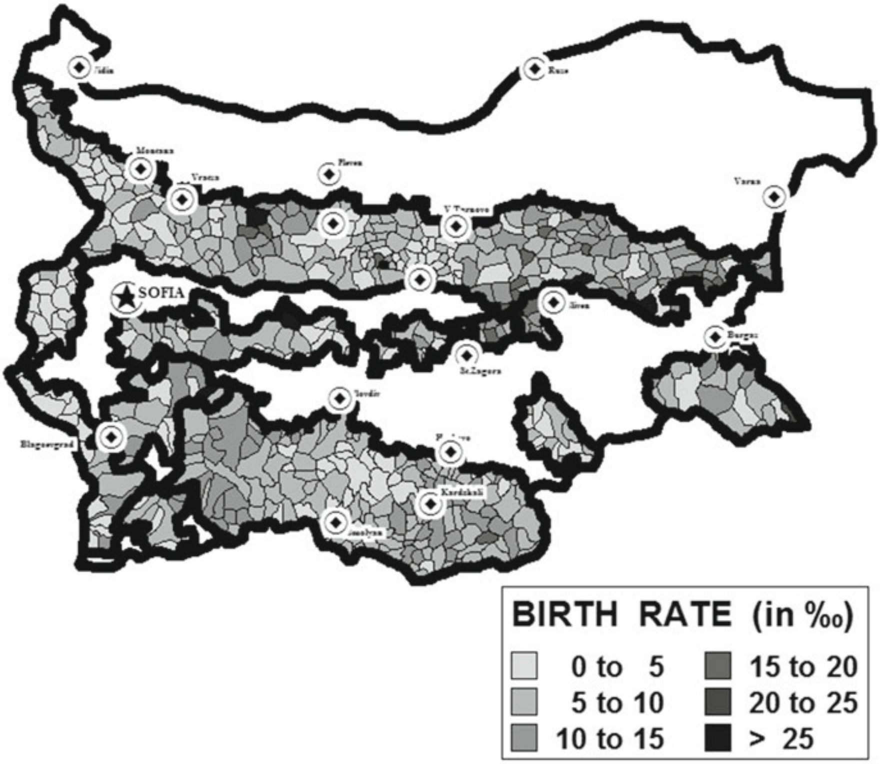

Fig. 15.4 Birth rate: 2002–2007

region is caused by the existing population outflow from small towns, which is also triggered by the scarcity of economic potential in those settlements. Growth of immigration rates is detected in those mountains, in which a rural population dominates: Sredna Gora Mountain and the Western Border Mountains. Immigration flows in those areas consist mostly of retired, former local residents (Figs. 15.7, 15.8, and 15.9).

Age structure has a key role in the demographic development of the population. During past periods, age structure shaped the general and the regional features of both reproduction and migration processes. In contrast to past periods, nowadays the age composition of the population in mountainous regions is worse compared to the national average, because of the negative changes in the age structure of the population of the Rodopi Mountains, Eastern Stara planina and, to some extent, in Rila and Pirin. There is a trend of constant aging of the population that is visible not only at the top but also at the bottom of the sex–age pyramid. The increase of average life expectancy affects to a great extent the aging at the top of the pyramid, whereas the lowering birth rates result in aging at the bottom of the sex–age pyramid. In both cases, emigration has a major role in the aging process.

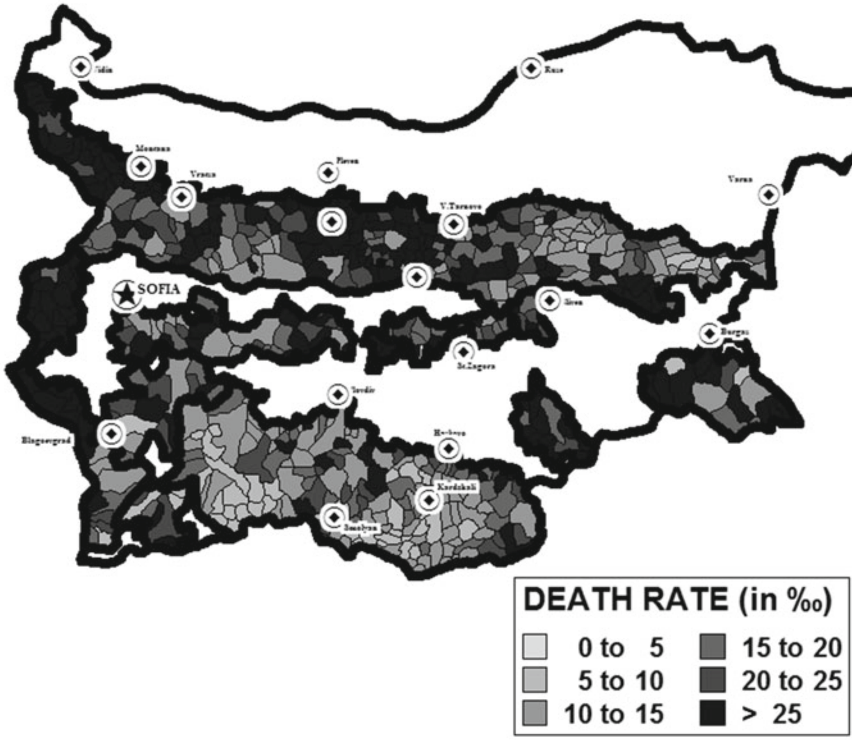

Fig. 15.5 Death rate: 2002–2007

According to the age structure of their population, Bulgarian mountains can be divided into two main groups: a group of mountains with an extremely old age structure of the population and a group of mountains with moderately old age structure, and there is no group of mountains with a population of young age structure. The first group is composed of the Western and Central Stara planina, the Kraishte region, Sredna Gora, Strandzha, and Sakar. The population aged 0–14 years in those mountains is less than 15 % of the total, but the share of population over 60 years of age is more than 25 %. The extreme ageing of the population in those areas is a result of both the intensive emigration of young residents in the past and the extremely low current birth rates (Fig. 15.10).

The second group consists mostly of towns in the Rodopi Mountains, Eastern Stara planina, and partially the Rila and Pirin mountains, the result of the maintained higher birth rates in the past, combined with lower migration mobility. However, with the decreasing birth rates and increasing migration mobility in recent years, the age structure of the population in those areas has worsened, although only to a moderate level. The share of population aged 0–15 years in these regions varies from 15 % to 17 %, whereas the share of population over 60 years does not exceed 20 % of the total. Nevertheless, within the mountainous regions as a whole, age

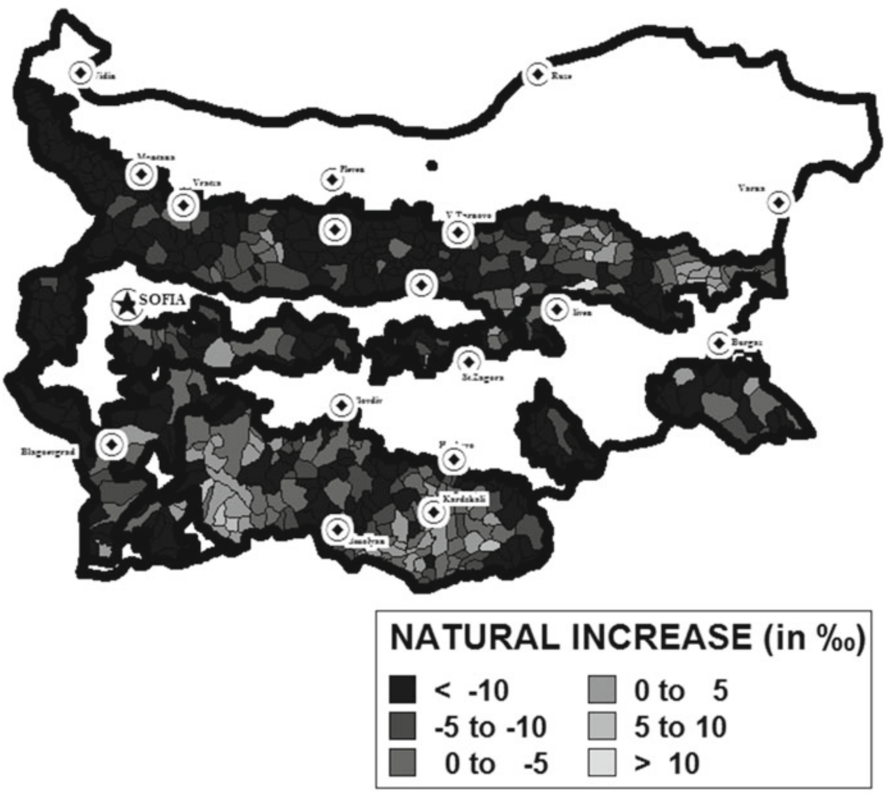

Fig. 15.6 Natural increase: 2002–2007

structures differ notably. In the forthcoming decades, significant negative changes are expected to occur in the age structure of mountainous population. The share of elderly residents will continue to grow (by ~2 %), whereas that of the younger population will decrease (by 2.5 %). Aging of the population will be defined mostly by the population in Stara planina, the Rodopi Mountains, Rila, and Pirin.

At the current stage of demographic development, from an economic and social point of view, the age composition of the mountainous population can be generally described as favorable. To reduce the negative consequences of the aging process, a purposeful socioeconomic policy aimed at preventing population loss in the areas with a moderately aged population is required. Those mountains and parts of mountains in which the population age structure is extremely old would improve their situation only by attracting younger settlers from other regions. Improvement of the age structure by the natural reproduction process is possible; however, that is not quite optimal, for there is a great danger of unwanted quantitative changes in the population numbers that would eventually lead to depopulation of vast rural areas.

The natural conditions and resources of our mountains favor the development of the network of settlements. More than half of the mountainous settlements (51 %),

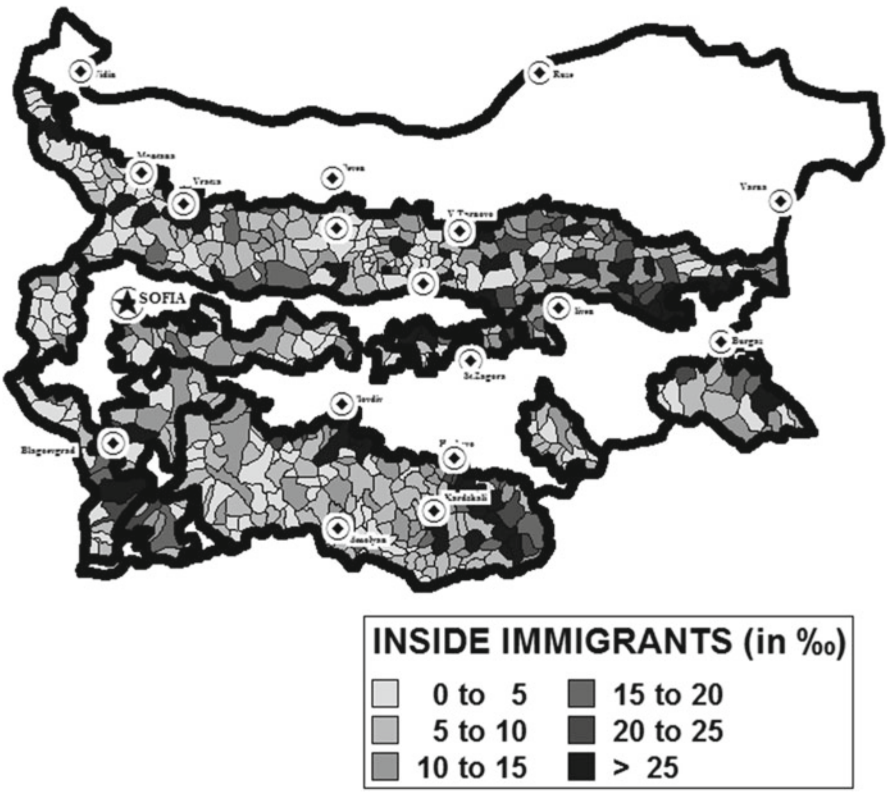

Fig. 15.7 Inside immigrants: 2002–2007

including the largest ones, are situated at an altitude up to 500 m, and 91 % of the settlements are located up to 1000 m above sea level. Therefore, the altitude in general does not represent an obstacle for their overall development. Most rural settlements are small, and many of them are of the scattered settlements type. Typical small settlements municipalities are those of Troyan, Gabrovo, Tryavna, Kilifarevo, and Elena, in the northern slopes of the Central Stara planina range, Shiroka Laka, Madan, Rudozem, Smilyan, Chernoochene, and Ivaylovgrad in the Rodopi Mountains, and Tran, Treklyano, Dragovishtitsa, Parvomay, etc. in other parts of the country. All the larger and medium-sized towns, as well as a significant part of the small towns, have a comparatively well-developed socioeconomic potential. The majority of the villages are provided with enough arable land, conditions for tourism development, and habitable houses. Along with those, however, there are many small villages with transport-unfavorable location, poor arable land, difficulty of access, poor or lack of infrastructure, highly deteriorated age structure, and poor or no reproduction capability of the inhabitants. From the economic, social, and esthetic aspects, the existence of such settlements becomes more and more unjustified, and those villages gradually drop out of the settlements network. The majority

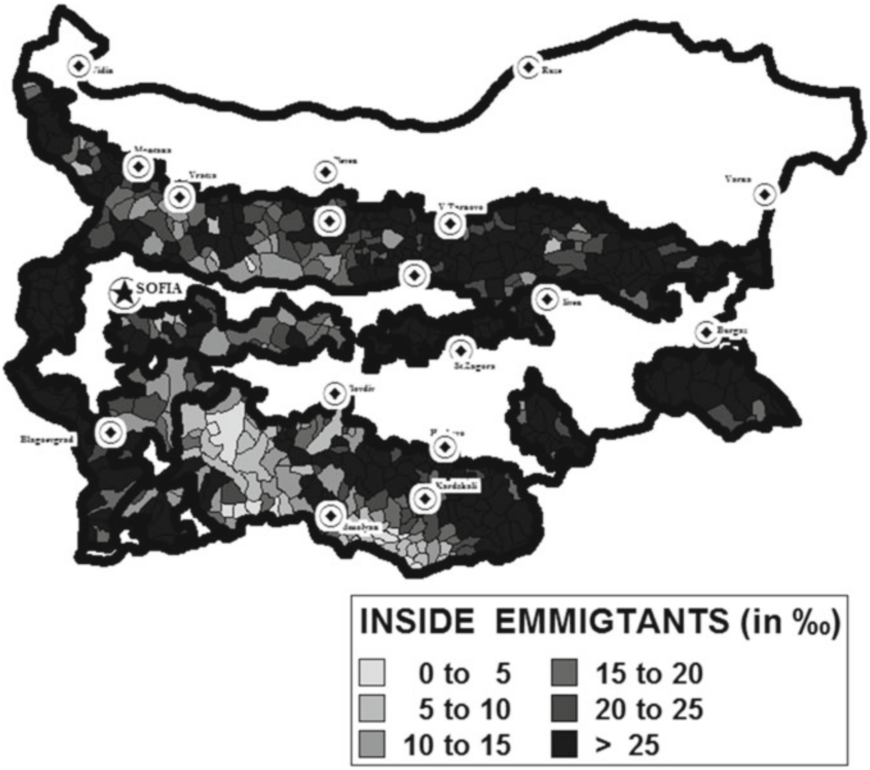

Fig. 15.8 Inside emigrants: 2002–2007

of the mountainous settlements are located in limited terrain, which arrests their growth, and requires multi-story buildings in the larger towns and villages as well as laying a transit transport infrastructure outside the settlement limits.

The transport accessibility of most mountainous settlements is good. It is limited in some municipalities of the Central Stara planina region, such as Tryavna, Kilifarevo, and Elena. In those municipalities only 42 % of the settlements are accessible by asphalt roads, 20 % of the settlements can be reached only by gravel-covered roads, and bus services cover a mere 36 % of all settlements. Rural settlements lacking convenient transport accessibility are, as a rule, scarcely populated, and the majority of those will eventually drop out of the settlements network. Numerous villages in the Western Border Mountains, Sakar, Strandzha, and the Rodopi Mountains also have transport-unfavorable locations. More than 40 % of the Rodopi Mountains settlements still have no convenient road accessibility (those are settlements located predominantly in Madan, Banite, Nedelino, Smolyan, Kardzhali, Chernoochene, Momchilgrad, Krumovgrad, Ivaylovgrad, etc.). Improvement of the road network and transport services is crucial for intensifying the development of mountainous settlements.

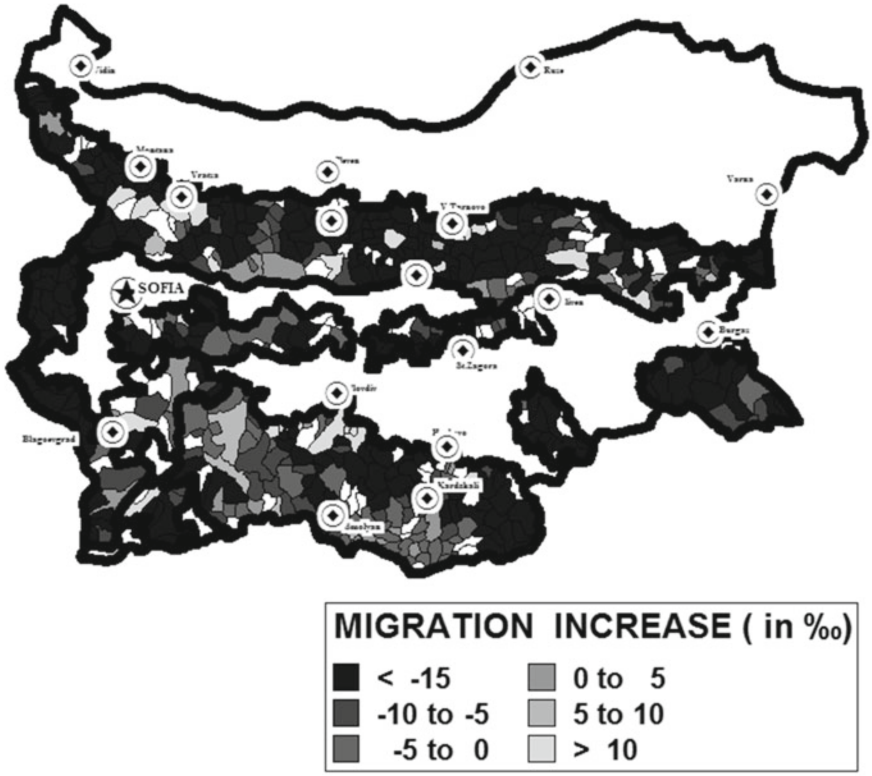

Fig. 15.9 Migration increase: 2002–2007

The established demographic situation in Bulgarian mountains predetermines the reproduction capabilities of their population for both the quantitative and the qualitative parameters of human resources. The existing climatic, water, forest, and grass resources, in equal to other conditions, would help with sustaining the existing network of settlements and even for the establishment of new ones (such as new tourist centers, for example).

However, because of the lack of affirmed concept and a long-term development program, implementation of demographic and migration policies aimed at improvement of the demographic structures of the population and its spatial distribution is impossible. Special attention has to be paid to the stimulation of so-called central villages, through activation of their administrative function, economy, and service sector. In villages with rich and fertile arable land, the predominant growing of well-paid agricultural plants should be sought, so that farming becomes the main income source for the majority of the population. Mountain pastures and their rational use in cattle breeding represent an additional reserve for economic activation of rural settlements. Sustaining of scattered and small-sized villages in mountain areas is inappropriate and unjustified.

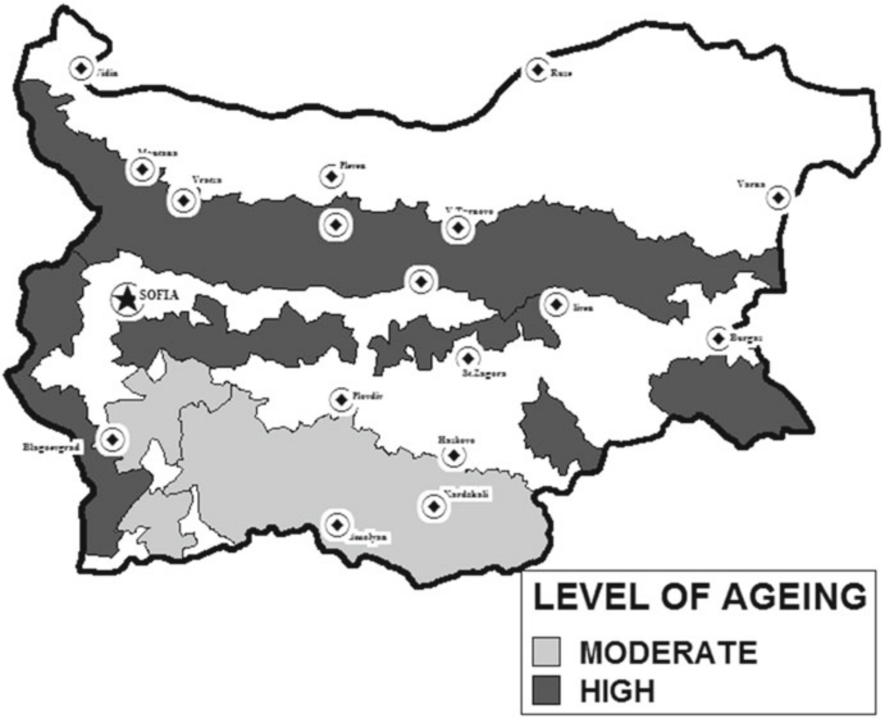

Fig. 15.10 Level of population aging: 2001

Considering the importance of permanent residency, the comparatively well-developed network of settlements in our mountains, together with the settlements' place in the process of optimal nature resources utilization and further nature productivity growth, the national authorities need to aim their activities at improvement of the demographic situation and the network of settlements in mountainous areas. To achieve these goals, the following actions are needed:

1. Development of a complete, scientifically based, demographic strategy for spatial development of mountainous population, in accordance with the goals of regional development of the country.
2. Estimation of the optimal number of population capacity of each hypsometric belt, to avoid further depopulation of the mountains, especially in the high mountain areas, by providing conditions for rational exploitation of natural resources and the protection of the reproduction potential of nature.
3. Detailed geodemographic research and prognostication of the reproduction abilities of the population, together with pointing out the actions necessary for normalization of the age structure and reaching zero natural decrease or even natural increase of the population, in all mountains and their inner regions.
4. Development of a migration policy concept aimed at the mountainous population, in accordance with the general migration policy of the country, and in

accordance with the specific natural, demographic, socioeconomic, and environmental conditions in each mountain and inner mountainous region.

5. Complex evaluation, typology, and classification of mountainous settlements, together with a developed concept for settlement network improvement, appropriate to the changes that have occurred and to the further requirements for spatial organization development and the various needs of the population.
6. Creation of a concept for demographic development and support of small towns and central villages with favorable economic-geographic location, to achieve rational utilization of the residential, public, and industrial infrastructure.
7. Development of legislation base and a plan for granting certain mountain villages the status of towns (for example, Tsareva lLvada, Ruen, Garmen, Satovcha).

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Chapter 16
Demographic Limits to Sustainable Development of Mountain Regions in Serbia

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Abstract Intense industrialization of Serbia during the period of socialist Yugoslavia induced voluminous internal migration, mainly from villages to the fast-growing industrial centers, which resulted in a disturbed sex composition of the current population in the prime reproductive ages (20–39 years) at the settlement level of the country. As a result, both agrarian zones of young men surplus and urban "oases" of young women surplus jointly reinforce the processes of demographic aging and poverty in Serbia, despite the goals of policy makers presented through crucial national strategies regarding sustainable development of the country. The rural zones with a deficit of young women, which are predominantly border and mountain regions, are the first to experience the negative effects of the prevailing demographic trend in the future. Some of the findings in this chapter point to the typical positive feedback loop "population–poverty" as the intrinsic mechanism of persistent "highlands to lowlands" migration. Finally, the probabilistic population projection of mountain regions in Serbia indicates decreasing and aging of its population as an inevitable and dominant demographic process in the next few decades. These tendencies could be substantial obstacles to efforts in achieving sustainable development of Serbia's mountain regions.

Keywords Demographic limits • Sex ratio • Population aging • Serbia • Mountains

16.1 Introduction

Mountain regions in Serbia are located in the southern part of the country, specifically in the east and the west border region. Demographic indicators were polarized in this manner for decades. Indeed, most of the population lives in the northern part, predominantly represented by plains (the lowest part of Pannonia, the region of Belgrade City, and river valleys of central parts of the country), whereas the mountain regions are almost deserted, gathering the oldest population in the country.

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This problem is the main result of the continuous "highlands to lowlands" migration within the country borders that started soon after World War II. Demographic implications of the phenomenon are substantial for future sustainable development of mountain regions. The dominant demographic process during the next decades will be population aging throughout the whole of Europe. This process, which has already begun, has especially affected Serbia because of its half-century-long period of below-replacement fertility and traditional emigration history. However, the demographic polarization between urban and rural that existed for such a long period has become less and less pronounced as population aging has had the fastest pace in urban areas for the past two decades, the effect of permanent, irreversible migration of the population of the highest reproductive potential from villages toward towns after World War II. Nowadays, the largest part of those generations has entered into the group of old-age population, leaving behind considerably smaller generations of descendants than their own.

Given the essential striving of the process in regard to homogenization of the level of demographic aging across the territory of the whole country (Nikitović 2006), typical demographic indicators of aging process, such as aging index and median age of population, cannot express essential differences between plain regions (mainly urban)[1] and mountain regions (mainly rural). From the aspect of the topic of this chapter, substantial information on the future demographic and economic development of the mountain region lies in the sex ratio of the population aged 20 to 39 years. In other words, putting most of the nationally planned pronatalist policies into effect will not be possible if there are no prospects for a significant number of people to find a partner of the opposite sex because of the consequences of continuous migration from the mountain regions to the lowlands.

For decades, more young females than males have migrated from villages to towns. In the beginning of the process, the highest intensity migrations were from mountains to nearby towns, and afterward, when demographic capacities of hinterland subsided, the largest flows were from small and middle-sized towns to the largest centers in the country. According to the recent censuses of population, the number of men is slightly higher than the number of women in the group aged 20 to 39 years (1.006 in 2002 and 1.034 in 2011)[2] at the level of the country, which is determined by sex ratio at birth and age patterns of mortality and international migration. However, continuous internal "highlands to lowlands" migration during the past five decades has produced a disrupted sex composition of the group at the settlement level of the country. Generally, regions having more men than women aged 20 to 39 years are poor, agrarian, mountainous, and mainly border, whereas areas populated by more women than men of the same age group are predominantly urban and lowland. The cause of this selectivity of migration by sex is founded in the traditional family organization whereby males were taught to be "tied to the land" while females were encouraged to leave their paternal houses. During the

[1] About 83 % of the urban population in Serbia lives in plains regions according to the 2011 Census.

[2] The 2011 Census registered the increase in the share of males for the first time after two decades of the opposite tendency.

strong and fast industrialization of socialist Yugoslavia, mountain regions were generally neglected, which transformed them into backward areas characterized by low agriculture production and a lower economic position in relationship to the rest of the country (Kupiszewski et al. 2012). Simultaneously, fast-growing towns (because of immigration) during the period had the advantages of industrialization and modernization, thus presenting today the only oases of development in the country.

The idea of this chapter is to point out the correlation between the disturbed sex ratio of the most vital population and economic development across the regions in Serbia. In other words, the surplus of young men in mountain regions and the surplus of young women in the lowlands could be a fine-tuned indicator of the economic level of the area showing simultaneously in which ways national strategies concerning demographic processes in the future sustainable development should be implemented. In that sense, sustainable development of mountain regions is of specific interest for the country because the combination of their poor economic situation and the lack of females of reproductive age will reinforce both demographic desertification of the area and the trend of population concentration in the several largest centers of the country.

16.2 The Analysis

The analysis is based on both the 2002 and 2011 Census of Population, and the 2007 Living Standards Measurement Study in Serbia funded by the World Bank. The Census results provided a possibility for the analysis at the settlement level that was used as a starting point. Settlements were not classified into lowlands or highlands according to their absolute elevation but rather to their position in relationship to the frontier between the plains and the mountains. The frontier was drawn according to the administrative districts of the Republic. This kind of distinction provided classification that gives more weight to the geographic surroundings of a settlement than to its own absolute elevation. The main advantage of the approach is that it is closer to reality. For example, it does not put a settlement automatically into the highlands category if it is located on an isolated hill inside a plain because it is a part of the surrounding net of settlements.

The 2007 Living Standards Measurement Study (LSMS) resulted from the questionnaires prepared by the instructions of the World Bank experts as help in formulating the Government Poverty Reduction Strategy. The sample encompassed 17,375 persons who reside in Serbia. Territorial representativeness of the sample was adjusted to six macro-regions of the country (SORS 2003b). For the analysis in this paper, the main demographic characteristics of the questioned population were used along with two summary indicators of living standard: the limit of poverty and quantiles of consumption.

Two of the six macro-regions, the East and the Southeast plus half of the West region, represent the Mountain area as it is defined here. According to the 2011 Census the area was populated by 1.40 million people (1.57 in 2002), which

Table 16.1 Dependency ratios of two geographic areas by urban–rural distinction

		65/0–19			65/20–64		
	Area	Urban	Rural	Total	Urban	Rural	Total
The 2002 Census	Plains	0.67	0.88	0.76	0.23	0.33	0.27
	Mountains	0.43	0.98	0.70	0.18	0.40	0.28
The 2007 LSMS	Plains	0.76	0.95	0.84	0.23	0.33	0.27
	Mountains	0.53	1.43	0.91	0.20	0.49	0.33
The 2011 Census	Plains	0.82	0.98	0.88	0.25	0.31	0.27
	Mountains	0.62	1.17	0.86	0.22	0.40	0.30

Source: Statistical Office of the Republic of Serbia (2003a, 2012) and World Bank (2007)

represented 19.5 % (20.9 % in 2002) of the country population. Slightly more people lived in urban than in rural settlements, 52.9 % versus 47.1 %, while in the lowlands area this relationship is much more pronounced, 61.0 % versus 39.0 %. Table 16.1 shows homogenization of the population aging across the country according to the usual summary indicators: age dependency ratios. Results from both census counts of population (2002 and 2011) and the 2007 LSMS are presented.

As was noted earlier, there is no substantial difference between highlands and lowlands according to the dependency ratios for total population regardless of the source. However, it can be noted that the older population (aged 65 and older) have somewhat greater presence in the mountains than in the plains if rural settlements are considered.[3] On the other hand, urban populations are older in the plains than in the mountains. The difference between these two areas in the level of dependency ratios for urban population (aging index particularly) indicates the direction that dominates migration streams in the country during the past five decades. Because the majority of the settlements' population is represented by migrants who settled down during the 1960s–1980s period, these places are now facing strong population aging as large immigrant cohorts enter into old age.

Although the direction of internal migration in Serbia is still generally from the mountains to the plains, the most attractive targets for migrants are the largest cities in the country nowadays. Because industrialization has almost exhausted the population stock of rural areas, particularly in the mountains, small and middle-sized towns became new sources of population influx for a few large urban hubs in Serbia. Consequently, this directed a more detailed analysis of the sex ratio at the most dynamic part of the migrating population, those aged 20 to 39 years, which also represents the population of the highest reproductive potential. Table 16.2 shows the ratio for this population segment depending on its geographic location and type of settlement.

Both geographic areas are characterized by male surplus of the group if rural population is considered although a surplus of females is a common feature for urban centers of the plains irrespective of the source and time point. Furthermore, between 2002 and 2011, an increase of male surplus in the group aged 20 to 39

[3] The difference is more pronounced by the 2007 LSMS, which can be accounted to a certain extent for the variation of the sample.

Table 16.2 Sex ratio of the population aged 20–39 years according to its geographic location

		Males/females		
	Area	Urban	Rural	Total
The 2002 Census	Plains	0.955	1.072	0.999
	Mountains	0.959	1.130	1.036
The 2007 LSMS	Plains	0.911	1.116	0.981
	Mountains	1.039	1.136	1.079
The 2011 Census	Plains	0.979	1.120	1.027
	Mountains	1.016	1.141	1.067

Source: Statistical Office of the Republic of Serbia (2003a, 2012) and World Bank (2007)

Table 16.3 Sex ratio (males/females) of the population aged 20–39 years according to six macro-regions

		LSMS	Census	
Regions		2007	2002	2011
City of Belgrade	Total	0.857	0.948	0.963
	Urban	0.821	0.931	0.941
	Rural	1.062	1.029	1.074
Vojvodina	Total	1.009	1.024	1.057
	Urban	0.986	0.990	1.009
	Rural	1.043	1.074	1.141
Sumadija	Total	1.096	0.998	1.055
	Urban	1.054	0.940	0.995
	Rural	1.153	1.067	1.121
West Serbia	Total	1.156	1.031	1.069
	Urban	1.124	0.931	1.009
	Rural	1.181	1.108	1.142
East Serbia	Total	0.948	1.031	1.083
	Urban	0.844	0.976	1.039
	Rural	1.082	1.096	1.140
Southeast Serbia	Total	1.064	1.044	1.053
	Urban	0.932	0.968	1.002
	Rural	1.269	1.134	1.130

Source: Statistical Office of the Republic of Serbia (2003a, 2012) and World Bank (2007)

years was registered in rural zones, particularly in those of the plains. According to the 2011 Census, more males than females of the group were observed even for the urban population of the mountains, although the surplus was lower than the average of the country. Thus, Table 16.2 clearly confirms the accumulation of young women in the urban centers of the Plains.

The sex ratio of those aged 20 to 39 at the macro-regional level gives a more precise look at the spatial distribution of the indicator in the two basic geographic areas (Table 16.3). The region of the city of Belgrade has the biggest surplus of females aged 20 to 39 years in the country. Compared to the other five regions, it is obvious that the capital represents the most attractive destination of internal migration flows. It can be noted that the male surplus of the group was observed in 2011 even in the urban centers of East Serbia, which has been recognized as the strongest emigration area of the country, characterized by the labor emigration flows (consisting mainly of males) to the West European countries since the late 1960s (ISS 2013). Rural areas of all regions in the country suffer from lack of females of reproductive age. However, the demographic masculinization of the population in the prime reproductive ages was much stronger in urban than in rural areas of dominantly mountain and border regions (West, East, Southeast) between 2002 and 2011, which is the opposite of what was registered in the Northern regions (City of Belgrade and Vojvodina) that comprise the densely populated area of the two largest cities in the country.

If we take a closer look (municipality level) at the spatial differentiation of the sex ratio of those aged 20 to 39, the distinction between the plains and the mountains in regard to this indicator is clearly pronounced (Fig. 16.1). The comparison between the 2002 and 2011 census counts points to a tendency toward young females congregating in regional centers not located in the mountains. According to the 2002 Census, almost all the "islands" of young female surplus belong to the plains. Only four of these are located in mountain regions, which could be easily explained. Two of these "islands" represent industrial centers based on mining whereas the other two are predominantly populated by Muslims whose male

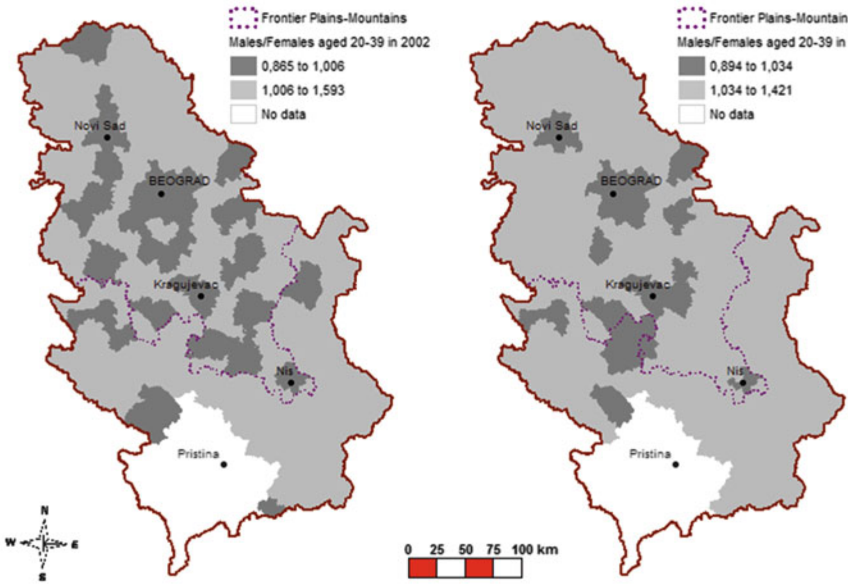

Fig. 16.1 "Islands" of young women surplus against zone of young men surplus: 2002 (*left*) and 2011 (*right*)

population participates considerably in the country's emigration stock in Western Europe. Thus, it is quite obvious that regional centers of the mountains already lacked a female population of reproductive age according to the 2002 Census. The frontier between the plains and the mountains, as drawn in this chapter, almost sharply splits the country into two parts: Northern, with islands of young female surplus, and Southern, an almost compact zone that lacks females of reproductive age. Such a frontier could be a huge obstacle not only in achieving aims planned by the government pronatalist strategy but also the long-term limit to sustainable development of the mountain regions in Serbia. It is proved by the results of the 2011 Census, which shows that the process of masculinization of urban population aged 20 to 39 years had spread to the plains as well. As can be noted in Fig. 16.1, the number of "islands" of young female surplus reduced to only the several largest urban hubs in the country between 2002 and 2011, which implies that the female surplus in the prime reproductive ages fades away in the regional centers of the country that experienced a population boom during the socialist period of intense industrialization.

Apart from war conflicts, economic factors are dominant stimuli to migrations. Given the nature of the industrialization process in Serbia during the last half of the twentieth century, it was expected that mountain regions would be the less developed part of the country today. That situation shaped the general direction of internal migration in Serbia, from the highlands to the lowlands. As a result, the plains acquired more working-age population having a higher living standard compared to the mountains. But this process has no tendency to allow the areas to exchange their positions. It is more likely that distinction between them will be more pronounced in the future. The question is – why? The analysis of indicators of disturbed sex composition at lower spatial levels pointed to profound economic and social factors (analyzed through poverty indicators) as a driving force of internal migration in a typical positive feedback loop, "population–poverty." The mechanism of this feedback loop acts as follows: people will migrate from poor regions to the wealthier ones leaving behind a population structure worse than it was, but improving the demographic composition of wealthier areas. In other words, the fewer young people stay in the Mountains the poorer the mountain regions will be. And the opposite: the more young people who come to the urban centers, the better living standard in the Plains.

> "In system terms these structures are called "success to successful" feedback loops. They tend to be endemic in any society that does not consciously implement counterbalancing structures to level the playing field." (Meadows et al. 2004: 44).

One of the advantages of using a questionnaire about the living standards of Serbian citizens instead of the common GDP (gross domestic product) refers to the fact that size or wealth of the economy is not such an important predictor as it is the extent to which economic improvement actually touches the lives of all families, and especially the lives of women. In this chapter, quantiles of consumption were used as a basic indicator of the living standard of people. The spatial distribution of the sex ratio of those aged 20 to 39 years (as shown in Fig. 16.1) already indicated potential positive correlation between a female surplus of the age group and higher consumption level across the small territorial units. The Pearson product moment correlation coefficient between these two variables across the 2007 LSMS sample is 0.72, which confirms the hypothesis about the sex ratio of the most vital age group as a fine-tuned indicator of the living standard of an area. This relatively strong correlation points, above all, to a socially very established way of personal dealing with the inherited problems of highly uneven development across the regions in Serbia, which can be generalized by intrinsic opposition between the Plains and the Mountains. Consequently, the aims presented in government strategies on pronatalism, poverty reduction, and population aging (MLESP 2006; MLSP 2008) imply counterbalancing of strong regional differences. If this prerequisite is absent, the well-established migration flow from high (poor) to low (higher standard) lands will further deteriorate the sex structure of the most vital population group across all the regions of the country.

16.3 The Future

The foregoing analysis recognized some of the not so obvious demographic limits to sustainable development of mountain regions, pointing to the already significant amount of "frozen" reproductive potential that is of no effective use because of its spatial dispersion. Resulting opposition between backward agrarian zones of surplus young men and urban "islands" of surplus young women will reinforce processes of demographic aging and poverty throughout the country, despite the goals of policy makers. This point could be easily illustrated by the projection of future population change in Serbia.

The populationprojection specially prepared for the purposes of this chapter presents some possible ways to exceed the current demographic limits to sustainable development of Serbia and its mountain regions in particular. General hypotheses on future demographic developments coincide with assumptions used in the recent study on impact of demographic and migration flows on Serbia until 2041 issued by IOM (Kupiszewski et al. 2012). Yet, the projection horizon presented in this chapter was extended to 2051 to allow for consideration of the long-term implications of current demographic trends. Also, the projection exercise was developed in the probabilistic framework[4] resulting in forecast intervals with attached probability around the most probable future. Precisely, the projection does not assume any dramatic improvement of fertility, similarly to the hypotheses for low-fertility countries in the recent probabilistic projections by UN (Alkema et al. 2013; UN 2013), but takes into account both polar cases: implementation of officially proclaimed pronatalist aims and decreases of total fertility rate to the lowest level recorded in Europe. A slow increase of life expectancy at birth for both sexes was

[4] The projection code was written in R as the modification of the code developed by Hunsinger (2011).

generally assumed; target values are close to current levels recorded in the countries with the longest lifespan.

Migration as a component of population change has generally the lowest predictability (Matysiak and Nowok 2006), especially in countries such as Serbia (Nikitović 2010). On the other hand, its importance could be immense in traditional low-fertility countries where the fertility impact on improving age structure is limited (Nikitović and Lukić 2010). This projection took into account both possible futures of international migration in Serbia: (a) accession to the EU around 2021, which could result in migration transition on the long run, turning current net emigration to net immigration, and (b) intensifying emigration character of migration in response to an unfavorable political and economic situation (Kupiszewski et al. 2012). It was assumed that the direction and intensity of internal migration is perfectly correlated to the predicted character of international migration.

The probabilistic forecast shows that both geographic areas of Serbia will face significant population aging and reduction of population with no chance to reverse the process during the projection horizon. In that context, population projection for the mountains shows that the current demographic situation could be improved to some extent if positive trends in fertility and migration occur in the next period. In addition, the mountain regions will be probably somewhat younger than the lowlands because of the accumulation of the migrant population in the plains during the past several decades. That stock will enter the old-aged group during the projection horizon (Table 16.4).

The median, or the most probable, forecast shows a decrease of total population in the mountains by almost one third in 2051 if compared to the 2011 Census. But if the aims of the government pronatalist strategy fail and emigration intensifies, the population size of the area could be reduced by as much as 40 % percent according to the lower limit of the 80 % forecast interval. However, the most concerning message relates to the optimistic end of the interval, saying that not even the positive winds, implying immigration into the area in synergy with fertility improvement,

Table 16.4 Population projection results for 2051: median and 80 % forecast limits

				Age groups (percent)		
	Total	OADR	AI	0–19 years	65+ years	85+ years
MOUNTAINS	*(1,400,384)*	*(0.271)*	*(0.861)*	*(21.06)*	*(18.13)*	*(1.11)*
Upper limit	1,039,973	0.501	2.216	21.84	29.91	4.02
Median	**945,563**	**0.447**	**1.504**	**17.84**	**26.82**	**3.53**
Lower limit	849,812	0.405	1.128	13.40	24.33	3.15
PLAINS	*(5,786,478)*	*(0.251)*	*(0.880)*	*(19.57)*	*(17.22)*	*(1.14)*
Upper limit	4,367,807	0.554	2.406	21.67	31.96	3.98
Median	**3,973,129**	**0.493**	**1.628**	**17.63**	**28.71**	**3.50**
Lower limit	3,572,617	0.447	1.218	13.19	26.07	3.12

Source: Author's calculation

OADR old age dependency ratio (65+/20–64), *AI* aging index (65+/0–19)

Values in *parentheses* are 2011 Census

could stop the decrease of population size of the mountains in the long run. Furthermore, the projection indicates that the current population of the area will be reduced by one fourth with 90% probability for such an outcome. Thus, assumed improvements seemed to be of limited capacity, given the actual age structure of the population and the growing spatial dispersion of the most vital age group.

The forecast dependency ratios show that population aging will most probably be stronger in the plains than in the mountains, which is expected given the accumulated stock of working-age population from current and earlier periods. However, this is not so encouraging for the future of the mountains because its demographic indicators are not very favorable compared to the plains. Also, these general figures hide the spatial isolation among places in the mountain region, which could easily place real future values of demographic indicators closer to the unfavorable forecasting limit rather than to the most probable forecast (median) or desirable forecasting bound. At the same time, the population settled in the plains could achieve at least the most probable forecast (median) values using benefits of its high spatial concentration given the same migration conditions across the country. In other words, even if Serbia experiences a large population influx in the next decades, it would be much easier to achieve desired demographic development with a population at the most vital ages that is not spatially dispersed and differentiated according to sex.

Recognized demographic limits to sustainable development of the mountains will certainly deteriorate in the forthcoming period if the causes of spatial barriers between two sexes in the most vital ages remain. Thus, reducing the strong regional differences between the plains and the mountains, above all, represents the basic prerequisite for the future sustainable development of the mountain regions in Serbia.

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Chapter 17
Changes in the Ethnic and Demographic Profile of the Population in Eastern Stara Planina Region

Nadezhda Ilieva and Boris Kazakov

Abstract This chapter focuses on the ethnic groups of the population in the Eastern Stara Planina region, the changes in their spatial distribution and population numbers during the period between 1965 and 2001. This region is one of the regions in Bulgaria with a significant concentration of ethnic Turks and a Roma population, which greatly affects the demographic, social, and economic profile of the region. The region is also important from the NATURA 2000 point of view because vast areas in Eastern Stara Planina Mountain are protected areas according to (in most cases) both NATURA 2000 directives. The specific features of the ethnic and cultural development of ethnic groups influence their reproduction and migration behavior in various ways. The dynamics and spatial distribution of the ethnic Bulgarians are also described. The main factors for the changes in population numbers are outlined. The chosen period is set between the three most representative, in terms of ethnicity, censuses in Bulgaria, that is, 1965, 1992, and 2001, which define important subperiods of changes in the ethnic structure of the population in Bulgaria in past decades.

Keywords Ethnicity • Ethnic groups • Ethnic composition of the population • Demographic profile

17.1 General Notes

The 1965 census has been chosen as the beginning of the period to be discussed because that was the last census in which ethnicity was impartially observed. During the 1975 census, such data were gathered, but were immediately classified, whereas

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during the 1985 census ethnicity was not observed at all. The 1992 census revealed the changes that had happened right after the so-called revival process (a process in which the Muslims in Bulgaria were forced to adopt Christian names instead of their Turkic-Arabic names), and the 2001 census showed the beginning of the demographic crisis and all the changes that occurred yearly during the years of the transitional period in Bulgaria (Table17.1, Figs. 17.1 and 17.2).

The differences in the reproduction process of the three ethnic groups are quite distinctive throughout the entire period. The decline in Roma birth rate in recent years is the result of socioeconomic and cultural changes, such as the increase of educational level and decrease in infant mortality. Despite those factors, the decline of Roma birth rates is slow; at the end of the discussed period it is nearly four times higher than the Bulgarian birth rate, and two times higher than that of Turks. As a result of healthcare improvement, the Roma mortality rate has declined, which process has neutralized to some extent the decline in birth rate, and thus the natural increase remained unchanged. Just the opposite, Bulgarian death rates began to increase during the mid-1970s as a result of aging. The Turks, and especially the Roma, have a much better overall demographic situation than that of the Bulgarians, because of the different start in demographic transition of the three groups as a result of their cultural differences. Another factor is the lower "rural-to-urban" migration rate of the Turks and Roma in the past. In the 1960s and the 1970s, the natural increase of the Turks and Roma was approximately four times higher than that of the Bulgarians. In recent years, however, the demographic behavior of Turks began to resemble more and more that of Bulgarians, while that of Roma remains quite conservative. The economic stabilization that began after the 1996–1997 crisis period, together with a tolerant policy toward minority groups, limited migration to Turkey, etc., and resulted in reduction of the Turkish birth rate growth in recent years. Despite that, an insignificant growth of the natural increase is observed in only a few of the municipalities of the Eastern Stara planina region.

Table 17.1 Natural reproduction of the three major ethnic groups in Bulgaria for the period 1946–2000 (per thousand, ‰)

	Crude birth rate			Crude death rate			Natural increase		
Ethnic group	1965	1975	2000	1965	1975	2000	1965	1975	2000
Bulgarian	13.6	15.6	6.9	8.3	9.8	15	5.3	5.8	–8.1
Turkish	29.3	29.6	13	7.2	8.1	10.5	22.1	21.5	2.7
Roma	24.2	33.3	26.7	5.2	8.2	7.5	19	25.1	19.4

Source: The calculations for 1946, 1956, 1965, and 1975 are based on Central State Archive data, and those for 2000 are by Tomova (2005)

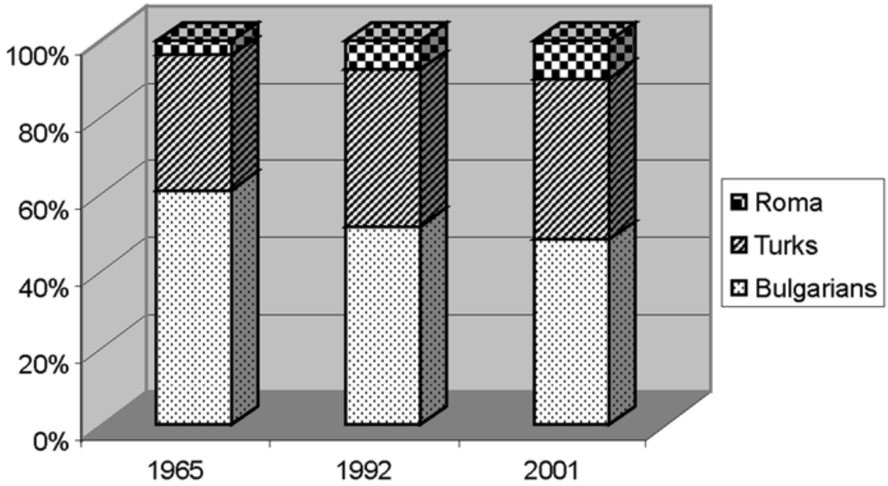

Fig. 17.1 Changes in ethnic structure of the population in Eastern Stara Planina region

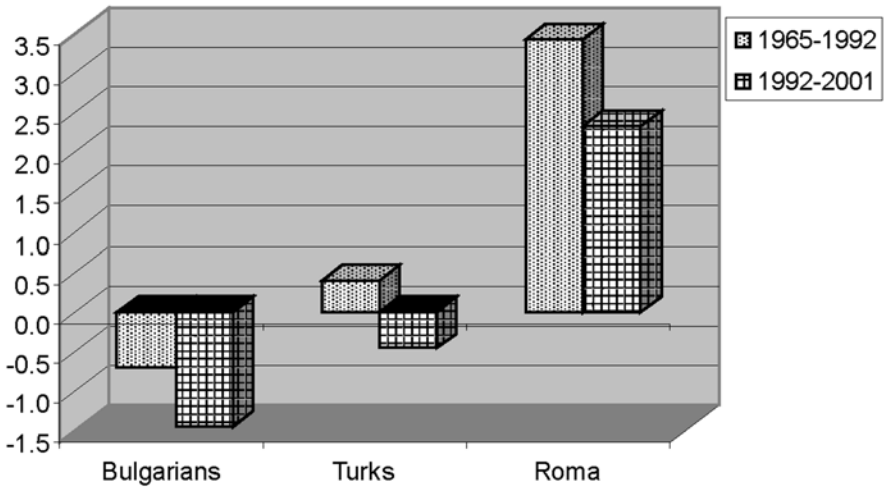

Fig. 17.2 Average annual increase of the population numbers of the main ethnic groups in Eastern Stara Planina region (1965–2001)

17.2 The Turkish Ethnic Group

The Turkish ethnic group is the second largest after the Bulgarian group in the observed region and in the country as a whole (according to the official data). During the period between 1965 and 1992, in contrast to other parts of the country with a Turkish population, the number of Turks grew in the Eastern Stara planina region. This change is a result of a smaller-scale emigration to Turkey in the period 1969–1978 and in the late 1980s, compared to that in other parts of the country, such as the Eastern Rodopi and the North-Eastern region. Thus, the Turkish population in Eastern Stara planina had an average annual increase of 0.4 % per year during the period 1965–1992, and from 76,000 in the beginning of that period, reached 84,000 by 1992. The growth in number led to a growth of the relative share of Turks by 5 %, which by 1992 reached 40.5 % of the total population in the region. Exceptions to that dynamics were the municipalities of Kotel, Smyadovo, Omurtag, and Varbitsa, where a nonsignificant decline of the number of Turks was observed (−0.5 % average annual decrease). During that period of time, the Turkish population grew, in both rural and urban settlements of the region.

The ethnocultural specifics of the Turkish population, together with the mountainous features of the region, the lack of a significant urban (industrial) center and urbanization level, determine the lower migration rate of Turks, compared to that of Bulgarians. In contrast to Turks, ethnic Bulgarians emigrated out of the region much more intensively, and thus the rate of decrease in their population numbers was three times greater than that of Turks. All these reasons led to growing shares of Turks in all municipalities in the region, with more than 5 % in Ruen and Byala municipalities, and with more than 10 % in the municipalities of Sungurlare, Dolni Chiflik, Dalgopol, and Pomorie, between 1965 and 1992. This trend, although not so strong, continued in the next decade.

The Eastern Stara planina region was not quite affected by Turkish emigration in the second subperiod (1992–2001) and again, differing from other parts of the country, the decrease in the number of Turks was not significant. In the beginning of the twenty-first century the ethnic Turks in the region numbered 80,830. In the different municipalities, the rates of population number change were different, between −2 % in Varbitsa municipality and +3.6 % in Dolni Chiflik municipality. The Turks decreased in number in those municipalities where they were the largest ethnic group – Ruen, Omurtag, and Varbitsa – while in the rest of the region their numbers increased. However, because of the decrease in the number of Bulgarians, the share of Turks kept rising, as well as their spreading across the region. A specific feature of Turkish distribution in Bulgaria is their traditional concentration in rural settlements: rural settlements were home for nearly 90 % of Turks in the region by 2001.

In the beginning as well as in the end of the period under discussion, more than half of the Turks in the region lived in just two municipalities, Ruen and Omurtag. Throughout the whole period, the concentration of Turks decreased as their distribution eastward became more and more uniform across the area of the region. By the end of the observed period their number grew significantly in the municipalities of Pomorie, Nesebar, Dalgopol, Dolni Chiflick, and Sungurlare, which in some cases led to dramatic change of the ethnic structure of their population.

A typical feature of the municipalities populated predominantly by ethnic Turks (Ruen, Omurtag, and Varbitsa) is the existence of many entirely Turkish villages, which constitute two thirds of all settlements in those municipalities. In the majority of those settlements, the population numbers remain almost unchanged compared to the beginning of the discussed period. That group of villages is the strongest in its

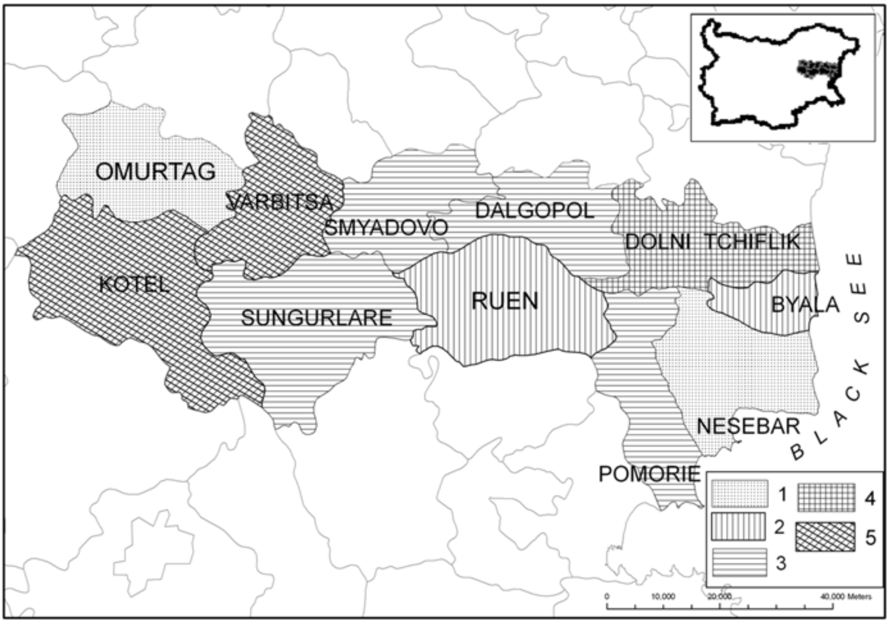

Fig. 17.3 Changes in the relative share of the Turkish ethnic group in Eastern Stara Planina region between 1965 and 2001 (in percentage points). I. *Increase*: (1) 0–5, (2) 5–10, (3) 10–15, (4) more than 15; II. *Decrease*: (5) 0–15

range and is broadened by including other villages in which Bulgarians used to live but eventually left or passed away. Along with the group of entirely Turkish villages, there is another quite significant group of mixed settlements in which the population is predominantly Turkish. Differing from the previous group, however, in this second group the number of Turks declined throughout the period being discussed, but in the same time the number of that type of villages actually grew.

In the municipalities, where the majority of the population is Bulgarian, villages with entirely Turkish population are rare, although such villages do exist. However, in the predominantly Bulgarian municipalities, the main part of the Turkish population inhabits mixed, bi-ethnic (Bulgarian-Turkish or Turkish-Bulgarian) settlements. In most of those, the number and share of Turks grew through the observed period, which eventually led to some settlements transforming from Bulgarian-Turkish into Turkish-Bulgarian (Fig. 17.3).

17.3 The Bulgarian and the Roma Ethnic Groups

In the beginning of the period, the number of ethnic Bulgarians inhabiting the Eastern Stara planina region was 131,000 people, which was around 60 % of the population. The last census, that of 2001, showed that their number had been

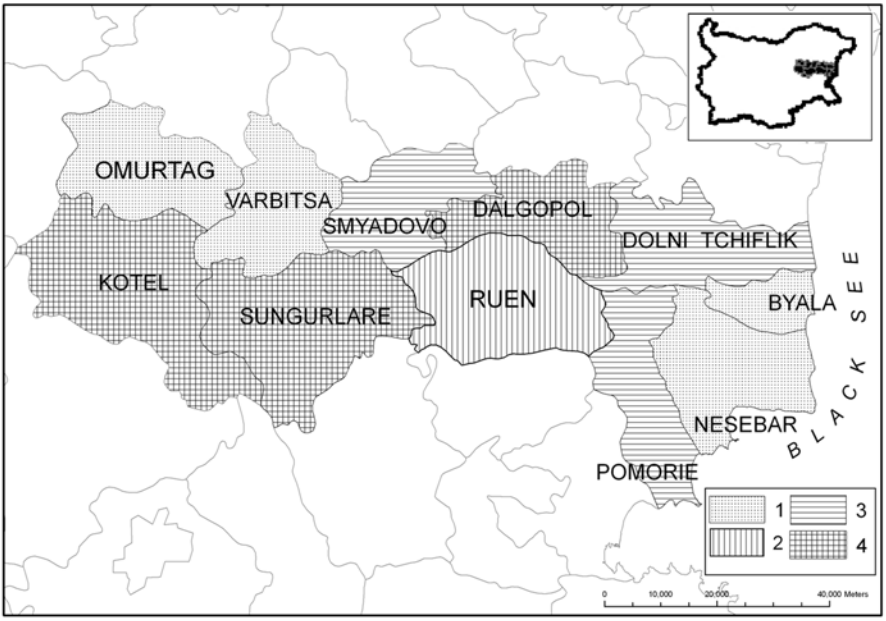

Fig. 17.4 Decrease in relative share of the Bulgarian ethnic group in Eastern Stara Planina region between 1965 and 2001 (in percentage points): (1) 0–10, (2) 10–15, (3) 15–20, (4) more than 20

reduced by 38,000 and had fallen to approximately 93,000 people, which was only 70 % of the number registered in 1965. The share of Bulgarians, therefore, was reduced from 60 % to 47 % of the total population of the region. Nevertheless, Bulgarians remained the largest ethnic group in that traditionally mixed region of the country. However, although in the beginning of the observed period ethnic Bulgarians were double the number of the second largest group, that of Turks, by 2001 that difference had evaporated to a mere 6 %, or 12,000 people. The fact that Bulgarians remained the largest ethnic group, despite the significant reduction of their number, results to a great extent from the several emigration waves of Turks to Turkey (although, as mentioned earlier, on a smaller scale compared to other regions) (Figs. 17.4 and 17.5).

The largest absolute population loss was observed in Sungurlare and Kotel municipalities, where the number of Bulgarians was reduced by 50 % of their number in 1965; in Ruen municipality, the relative loss was the highest (60 %).

In the beginning of the period the Bulgarian population was predominantly concentrated in the municipalities of Pomorie, Sungurlare, Kotel, and Dolni Chiflik, where more than half of all Bulgarians in the region lived. By 2001, however, the majority of Bulgarians lived in only three municipalities, Pomorie, Nesebar, and Dolni Chiflik. Moreover, a significant part of the population was concentrated in the towns of the region, especially Pomorie and Nesebar. The urban concentration of the ethnic Bulgarians is quite distinctive, keeping in mind that the urban Bulgarian

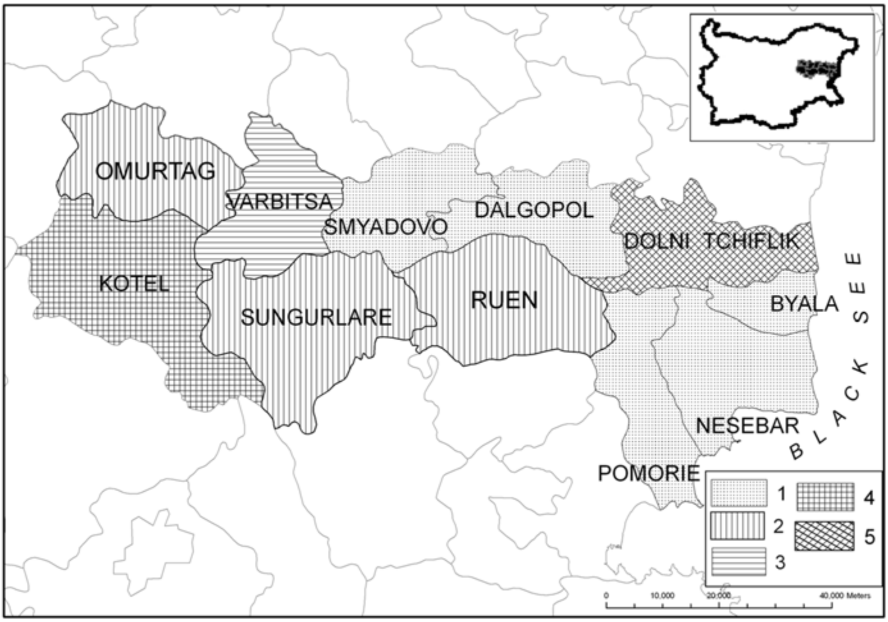

Fig. 17.5 Changes in relative share of the Roma ethnic group in Eastern Stara Planina region between 1965 and 2001 (in percentage points). I. *Increase*: (1) 0–5, (2) 5–10, (3) 10–15, (4) more than 15; II. *Decrease*: (5) 0–15

population in the region essentially has not changed during the discussed period, but in the beginning it constituted only a third of the total Bulgarian population, whereas in 2001 more than half of Bulgarians lived in urban settlements. Despite the fact that urban settlements in the region traditionally have a predominantly Bulgarian ethnic population composition, one of the municipal centers is an important exception. The town of Varbitsa is ethnically mixed, which is not unusual. However, it was the only town in the country (by 2001) where the share of the Roma population exceeded that of Turks and Bulgarians, being the smallest of the three ethnic groups (Ninov 1999). On the other hand, the towns along the Black Sea coast—Nesebar, Sveti Vlas, Obzor, and Byala—remained almost entirely Bulgarian; more than 90 % of the population is Bulgarian. The towns of Nesebar and Sveti Vlas grew significantly during the observed period, and those are the two settlements with the highest relative increase of Bulgarian population as well (by 100–140 %). However, the relative share of Bulgarians, as in all other towns in the region, decreased. Nevertheless, all towns in the region, with the exception of the earlier mentioned town of Varbitsa, are predominantly Bulgarian by the ethnic structure of the population. The lowest share of Bulgarians reside in the towns Kotel and Dolni Chiflik, where Bulgarians comprise only 60 % of the population; the rest are mostly Roma (town of Kotel) or Turks (Dolni Chiflik). The latter is an interesting case of altering its ethnic profile from Bulgarian-Roma in the beginning of the period to Bulgarian-Turkish at the end of the period. Such profound changes, however, should be looked at quite suspiciously, for the Roma residents have a notorious tendency to self-proclaim themselves as Bulgarians or Turks, usually depending on the ethno-confessional environment in which they are. Thus, some Bulgarian-Roma settlements sometimes "turn into" Bulgarian-Turkish, without the actual occurrence of such a transition. Estimating the exact number of Roma population, therefore, is almost impossible on a regional and national level (as well as on an international level).

Settlements predominantly or entirely Bulgarian by ethnic composition have a dispersed distribution across the observed region. Only in its eastern part do those settlements clearly dominate (municipalities of Nesebar and Byala). It is only in the almost entirely Turkish municipality of Ruen where Bulgarian villages practically do not exist.

In contrast to towns, none of which has a 100 % Bulgarian population, such villages traditionally exist in the region. In 1965, 71 settlements were entirely Bulgarian, or with a share of Bulgarians greater than 90 % of the population. Their number fell to 56 by 2001, or by 20 %. That group of settlements includes towns, very small villages as well as some of the largest ones: the resort villages of Aheloy (the largest village on the Bulgarian Black Sea coast), Ravda, and Sveti Vlas (which was granted a town status in 2006).

Besides that group of Bulgarian settlements, another group is traditionally typical for the region, that of the bi-ethnic settlements, in which Bulgarians live together with Turks or Roma. The majority of those settlements are Bulgarian-Turkish or Turkish-Bulgarian. Their number, however, declined through the observed period, in favor of tri-ethnic settlements, some of which have a significant share of Roma population. Again, the distribution of those settlements is fairly consistent across the region.

In the beginning of the period in observation, the majority of settlements where Bulgarians live together with the Roma population were settlements in Dolni Chiflik municipality, including the municipal center, whereas by 2001 such settlements had spread throughout the whole region. Another significant change in the settlements network is that if in the beginning there were no settlements in which the Roma had the largest share, by the end of the period such settlements, although not too many, already existed. One of those settlements, the village of Gradets, Kotel municipality, had changed from almost entirely Bulgarian to almost entirely Roma.

The total number of Roma population in the observed area grew from 8,000 to 19,000 during this period. As mentioned earlier, that number could be twice as great. Nevertheless, the growth of the Roma population number is significant, as well as their spreading across the region. In the beginning of the period the Roma lived predominantly in Dolni Chiflik and Omurtag municipalities, whereas by 2001 they were concentrated mostly in Kotel municipality (one third of all Roma in the region) and Omurtag and Varbitsa municipalities. The largest Roma population groups are found in the towns of Kotel and Varbitsa, as well as in the village of Gradets, Kotel municipality.

In contrast to the mixed Bulgarian-Roma or Roma-Bulgarian settlements, which are typical for the area, settlements in which Roma live together with Turks are rare, despite the fact that their number grew from one to seven during the period between

1965 and 2001. A representative of that group of settlements is one of the municipal centers in the region, the village of Ruen. By 2001 there were no settlements in the region (and the country) inhabited by Roma population only.

17.4 Classification and Grouping

One of the final stages of a geographic study is the group arrangement (classification) of similar geographic objects (in this case, settlements). Settlements have been assigned to various groups according to their ethnic structure. Each group consists of settlements with a similar structure. Because the share of the three main ethnic groups can vary considerably, the formation of a certain group, its range, and its name are up to the researcher, and therefore this is a subjective process, as applies especially for the groups consisting of settlements with mixed population. To avoid an excessive variety of groups, compromise with accuracy was necessary. For example, "mono-ethnic" were considered to be settlements with 90 % of the total or more of the population belonging to one ethnic group. Thus, settlements with 100 % mono-ethnic population and practically bi-ethnic settlements, in which the minority group is sometimes almost 10 % of the total population, find themselves in one and the same group. The "true" mono-ethnic settlements are less common than the bi-ethnic settlements in that group. On the other hand, in the group of settlements with mixed (tri-ethnic) population, sometimes the dominating group exceeds by far the other two groups, and yet it is less than 90 % of the total population and, therefore, could not be considered to be in the mono-ethnic group (Figs. 17.6 and 17.7).

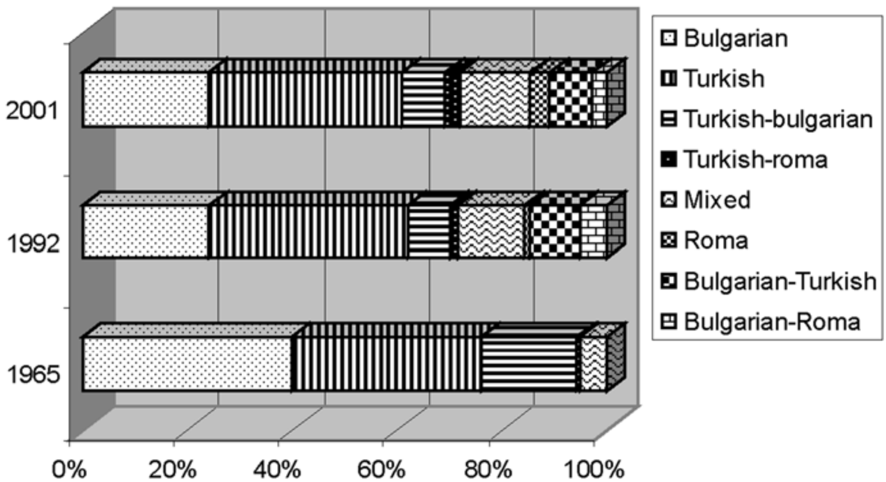

Fig. 17.6 Share of settlements of various types of ethnic structure in Eastern Stara Planina region (1965, 1992 and 2001)

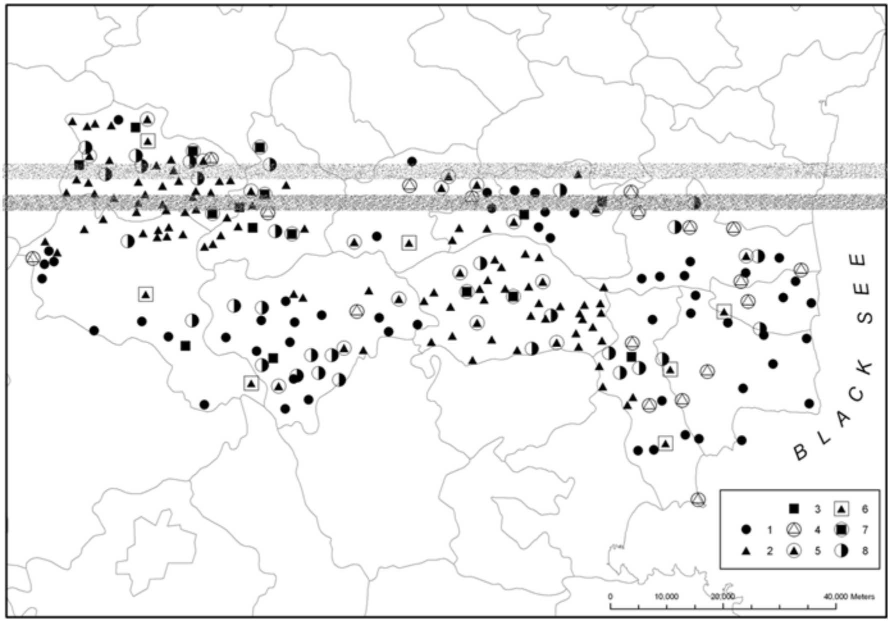

Fig. 17.7 Classification of settlements in Eastern Stara Planina region according to their ethnic structure (as of 2001): (*1*) Bulgarian, (*2*) Turkish, (*3*) Roma, (*4*) Bulgarian-Turkish, (*5*) Turkish-Bulgarian, (*6*) Turkish-Roma, (*7*) Bulgarian-Roma, (*8*) mixed

The group of settlements with the highest share of Roma population consists of settlements in which the Roma ethnic group is the largest, and the percentage share itself was not taken into consideration. For example, in some settlements of that group, the Roma population is about 40 % of the total, whereas in others that share is more than 80 %. The main criterion in defining that group, of course, was that it is the Roma population that is dominant.

The bi-ethnic groups, such as Bulgarian-Turkish, Turkish-Bulgarian, the Bulgarian-Roma, and the Turkish-Roma are sometimes tri-ethnic, but the presence of a third ethnic group is insignificant; more than 90 % of the population belongs to the dominant two ethnic groups.

In some cases, settlements have been conditionally put in the group of settlements with a mixed ethnic structure, only because of the higher share of population with undeclared ethnicity (2001), whereas in the classification based on 1965 census data, a certain number of settlements formed a "no data" group.

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Chapter 18
Small Urban Centers in the Alps and Their Development Issues

David Bole, Janez Nared, and Matija Zorn

Abstract Mountainous areas are by default physically unsuitable for larger urban agglomerations, yet are nevertheless urbanized to a substantial extent. This chapter describes the development of such urbanized areas, the small urban centers (towns) in the Alps.

Inner Alpine areas are increasingly "threatened" by expanding suburbanization processes from pre-alpine mega-agglomerations (Milan, Turin, Munich, Vienna, Zurich, etc.), which have a damaging impact on the Alpine settlement structure. This chapter focuses on smaller and peripheral towns in the Alps that provide a backbone of social, economic, and cultural activities. Thanks to the physical structure of the Alps, the landscape is dominated by smaller settlements, which have important central functions for large mountainous areas. These small urban centers therefore are important as generators of Alpine economic and social capital.

The Alps thus reflect duality: on the one hand, some well-connected valley regions experience rapid development, which is often associated with the suburbanization of pre-alpine metropolitan areas, and on the other hand there are areas that are no longer attractive to people and capital and are thus subject to depopulation. As is the case elsewhere in Europe, the urbanization of the Alps keeps changing, especially in response to the impact of economic structural changes.

Keywords Small urban centers • Development • Mountainous areas • The Alps

18.1 Introduction

The Alps represent an important economic area because a significant part belongs to some of the most developed European regions; this is especially true for the Western and Central Alps. The Alpine urban system in particular forms the core of

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the successful socioeconomic development of this entire mountain area. A specific feature of the Alpine urban system is the small and medium-size towns that predominate in it (Perlik 2007), whereas pre-alpine areas are characterized by large metropolitan areas that are also important on an international scale (e.g., Munich, Milan, Vienna, Zürich, Turin).

The special features of Alpine space are reflected in a wide range of spatial characteristics. With more than 60 inhabitants per square kilometer, the Alps are a rather sparsely populated area, but the regional differences are considerable (Fig. 18.1). If the area of permanent settlement (mostly the Alpine valleys) is taken as the base for population density, it is comparable with the most densely populated regions in the world (The Alps 2007).

The Alps are not merely rural areas, but have always had and still have an important urban function. Their natural functions (such as biodiversity and water, energy, and biomass supply) are often emphasized. Among social functions, their tourism and recreational function is most often highlighted (Nordregio 2004), whereas other functions (e.g., economic, cultural, social, technological) are often overlooked and only concentrated in non-mountainous (flatland) areas (Bole and Nared 2009).

The Alps thus reflect duality: on the one hand, some well-connected valley regions experience rapid development, which is often associated with the suburbanization of pre-alpine metropolitan areas, and on the other hand there are areas that are no longer attractive to people and capital and are thus subject to depopulation (Bätzing 2002). As is the case elsewhere in Europe, the urbanization

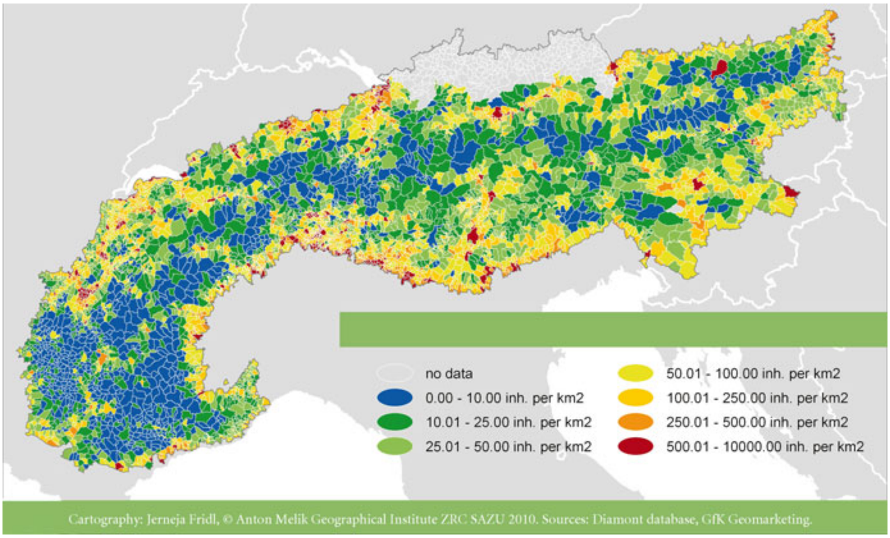

Fig. 18.1 Population density in the Alps (Bole and Nared 2010)

of the Alps keeps changing, especially as the result of the impact of economic structural changes. Globalization and the shift to a flexible form of production lead to a more pronounced internationalization of settlements, including medium-sized and small towns. In connection with the Alps, Perlik (2007) primarily mentions the growth and expansion of recreational functions from large towns toward the countryside, which is gradually acquiring urban functions and an increased urban image. On the other hand, older town centers with rich historical and cultural potential often stagnate if they are located outside the development circle that usually forms around major metropolitan areas.

Small towns thus have an important place in the Alps. Previous studies on the urbanization of the Alps (Perlik et al. 2001) have shown that urbanization processes in the Alps do not differ considerably from those in non-alpine Europe. However, what raises concern are the data on employment in the growing economic sectors, which lag behind those in pre-alpine areas. Perlik et al. (2001) emphasize that this calls for a policy of strengthening small and medium-sized alpine towns, which may be the only ones capable of preserving the values, lifestyle, and management practices typical of the Alps. Failing this, there is a serious danger that true Alpine identity will be impoverished if pre-alpine agglomerations continue to spread deeper into Alpine space.

The mountain character of the Alps is reflected in a number of development challenges that are specific to the area but could also be relevant to other mountain areas (Bole and Nared 2009, 2010). This chapter elucidates the urban structure of the Alps. It presents some socioeconomic characteristics of the alpine urban system and outlines the future development tendencies of small Alpine towns on the basis of a questionnaire that accounted for around 10 % of Alpine municipalities.

18.2 Basic Features of Small Urban Centers in the Alps

The concept of a "small town" is very flexible and depends much on the purpose of a study (Bole and Nared 2009). The criteria for determining small alpine urban centers in this paper are summarized in Table 18.1.

The implementation of this definition demonstrates that 440 small Alpine towns or small-town municipalities can be excluded (Table 18.2, Fig. 18.2); they account for only 8 % of all municipalities, but have almost 20 % of all the population and cover 15 % of the total territory. The most small towns are found in Austria (130), followed by Italy (110), Switzerland (102), France (83), Slovenia (13), and Liechtenstein (2).

Table 18.1 Criteria for determining small alpine urban centers in this chapter

	Centrality	Elevation	Minimum population	Maximum population
	50 jobs/100 working population	Up to 600 m	5,000	20,000
or	50 jobs/100 working population	600–1000 m	2,500	20,000
or	50 jobs/100 working population	Above 1000 m	1,000	20,000

Table 18.2 Basic settlement features in the Alps

Type of municipality	Number and percentage (%) of municipalities	Population and percentage (%)	Area (km^2)	Density of settlement	Area suitable for settlement (km^2)	Density of settlement in areas suitable for settlement
Large towns	54 (1 %)	2,363,822 (19 %)	3,976	595	1,490	1,586
Small towns	440 (8 %)	2,904,667 (24 %)	27,385	106	4,850	599
Rural, suburban	5,108 (91 %)	6,945,890 (57 %)	148,536	47	21,897	317
Total	5,602	12,214,379	179,897	88	28,237	433

18.2.1 Population Growth

Small Alpine towns had a positive growth index from 1990 to 2000 (Fig. 18.3), but lower than the rural/suburban municipalities, which is also connected with the growth of pre-alpine metropolitan agglomerations and the peri-urbanization of Alpine space. The highest growth is typical of small towns in Switzerland (+7 %), and the lowest of those in Slovenia (+2.4 %), which is probably connected with the specific demographic tendencies of individual Alpine countries. In general, the Alps are characterized by above-average population growth when compared to other EU members (Heinrich 2008), but also by more pronounced regional differences resulting from abandonment of peripheral areas and the growth of pre-alpine and Alpine urban agglomerations (Bätzing 2002; Bole and Nared 2009).

18.2.2 Aging of the Population

The age index, which shows the ratio between the older (over 64 years) and younger (under 14 years) population, reveals a fairly negative situation in small Alpine towns. The index value is 92, which means that the older population predominates over the younger, whereas the index in large towns is 123, and in other

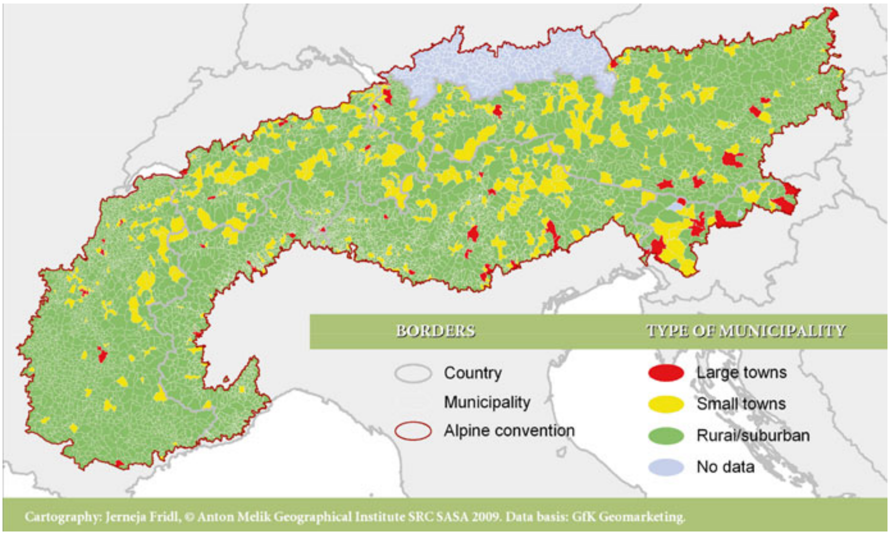

Fig. 18.2 Type of municipality (Bole and Nared 2009)

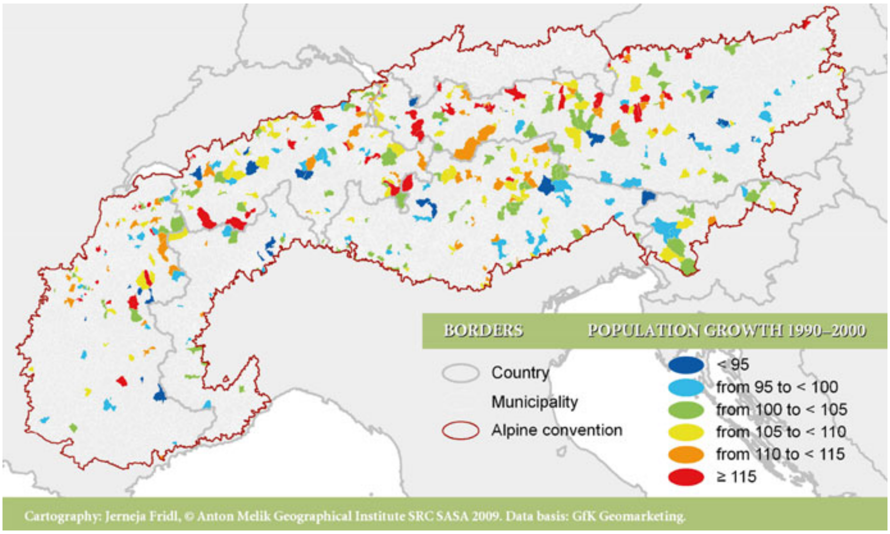

Fig. 18.3 Population growth index in small Alpine towns between 1990 and 2000 (Bole and Nared 2009)

municipalities also above 100. The age index raises special concern in French small towns (77), whereas it is the most favorable in Italian small towns. This index shows a considerably dramatic image of this problem in the Alps, which is primarily the result of young people moving away and starting families in the nearby Alpine agglomerations, which provide better employment opportunities (Bender 2008; Bole and Nared 2009).

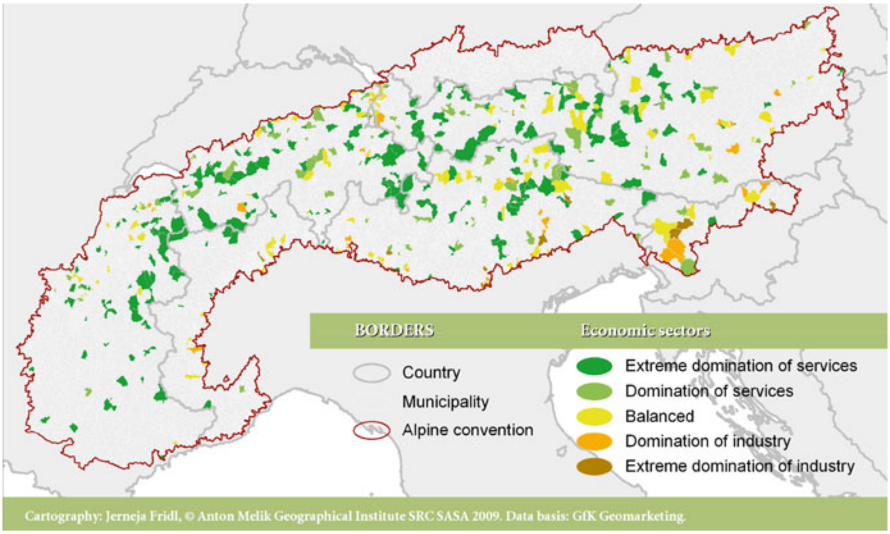

Fig. 18.4 Predominating sector structure of small Alpine towns (Bole and Nared 2009)

18.2.3 Working Population

Despite the fact that small towns have the oldest population, information on the level of work activity shows exactly the opposite. The total share of working population is 67.9 %, which is considerably more than in large towns and rural/suburban municipalities. The level of work activity is also a good indicator of the fact that in small Alpine towns various important economic activities take place, which obviously provide for above-average employment of the local population. Differences in the work activity of women are also evident: it is the greatest in Switzerland and Liechtenstein, and the lowest in Italy, where only 56 % of women 15 to 64 years old are employed (Bole and Nared 2009).

18.2.4 Jobs

The sector structure (Fig. 18.4) of jobs is as expected: services strongly predominate in large towns, which is the result of a higher level of centrality and greater diversity of services provided to the nearby population. In small Alpine towns, the share of services is significantly smaller (i.e., slightly above 60 %), whereas the share of industry is less than 40 %, and the share of agriculture is merely 2 %. These data partially contradict the predominating concepts of the Alps as an area exclusively oriented toward tourism and services (Bole and Nared 2009).

Great differences also occur between individual regions. In Slovenia, small towns are characterized by above-average industrialization, but significantly poorer

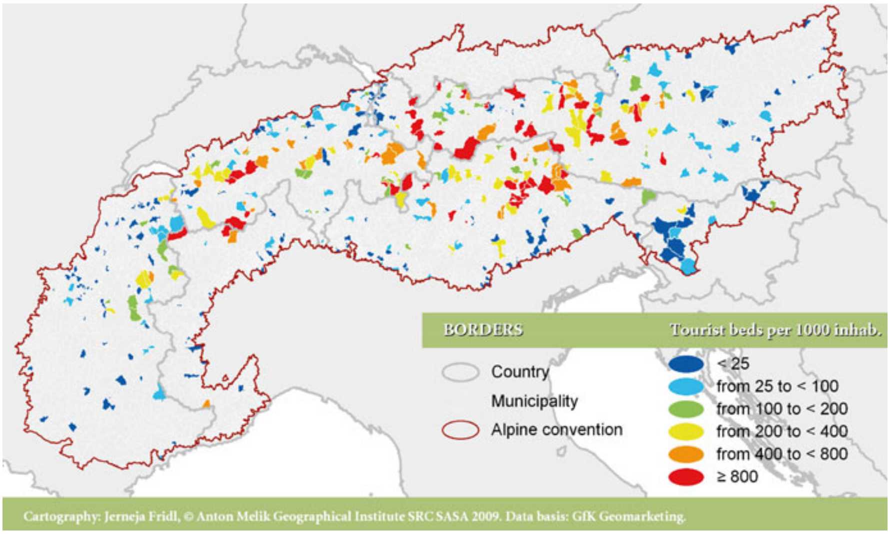

Fig. 18.5 Density of tourist beds per 1,000 inhabitants in small Alpine towns (Bole and Nared 2009)

availability of services, which is the result of intense industrialization in the communist era. On the other hand, Swiss small towns are markedly service oriented because the share of services exceeds 67 %. This figure is partly the result of the pronounced tourism orientation of certain small towns at higher elevations (e.g., Davos, St. Moritz, or in France Chamonix, and Albertville), which are also important for their supply function because they serve as a supply center for extensive and poorly settled areas (Bole and Nared 2009).

Data on job density are also interesting because it turns out that, despite their size, small towns are very important in terms of employment. In small towns, job density equals 74 per 100 working population and is only slightly lower than in larger towns (78 jobs per 100 working population). In France, the job density in small towns is even significantly higher than in large towns. This result only confirms the assumptions that in the Alpine area small towns perform an important function because they serve as employment centers, which is a precondition for the development of other functions (e.g., cultural and social) and for bearers of regional identity (Bole and Nared 2009).

18.2.5 Tourism

The tourism function is frequently mentioned in connection with the development of the Alps (both their rural and urban parts). A comparison of the data on the number of tourist beds per 1,000 inhabitants (Fig. 18.5) shows that small Alpine towns are the center of the tourism function in the Alps. Small Alpine towns have a total of

Table 18.3 Road distance (in kilometres, km) to the nearest regional center with the percentage (%) of towns in each group

		0–24 km	25–49 km	50–74 km	75–99 km	100 km and more
Austria	Small towns	28.2	15.4	26.9	18.9	10.6
Switzerland	Small towns	46.4	30.5	17.9	4.6	0.6
France	Small towns	46.5	23.5	17.6	10.6	1.7
Italy	Small towns	6.6	17.8	27.8	26.5	21.3
Liechtenstein	Small towns	100	0	0	0	0
Slovenia	Small towns	4.4	34.7	24.1	32.6	4.2
The Alps	Larger towns	56.8	13.9	13.1	8.1	8.1
The Alps	Small towns	28.7	21.5	23.3	17.1	9.4
The Alps	Other	21.9	24.1	22.6	17	14.4

141 beds per 1,000 inhabitants, whereas larger towns only have 30, and the remaining municipalities (i.e., rural/suburban) have 90. The differences are so obvious that it can be claimed with great certainty that small towns are also centers of tourism activities in the Alps. Many well-known winter and year-round resorts fall within our definition of a small town (e.g., Bormio, Chamonix, Bled, St. Moritz, Predazzo, Davos). By far the most tourist beds can be found in Austria, Italy, and Switzerland, whereas tourism appears to be less developed in France and Slovenia (Bole and Nared 2009).

Despite the importance of the tourism function, nearly 40 % of all the employees work in industry, which shatters the stereotypical notions of small Alpine towns being exclusively centers of tourism, administration, and other services (Bole and Nared 2009).

18.2.6 Transport Accessibility and Mobility

The Alps are regarded as difficult to access, especially because of their great differences in relief. Transport accessibility can also be defined as the road distance to the nearest regional center. Table 18.3 shows that the inhabitants of small Alpine towns have slightly poorer accessibility to the nearby regional centers than larger towns, which is completely understandable. However, there are great differences between individual countries because, for example, road accessibility in Italy is considerably poorer than in Switzerland; this is partly the result of the methodology used for defining regional centers, and partly the result of the condition of road and settlement infrastructure (Bole and Nared 2009).

Employee mobility is also as expected. Small towns serve as obvious employment centers because the daily commuter balance shows that the number of incoming commuters exceeds the number of outgoing commuters by 234,000, confirming the thesis that small towns are important employment centers in the Alps. Moreover, the data show that the total number of those commuting to small Alpine towns is higher than the number of those commuting to large towns (i.e., 830,000 to small towns and 629,000 to large towns). However, regional differences occur here as well: French small towns are especially attractive to daily commuters, whereas Slovenian small towns attract them the least.

18.3 Survey on Contemporary Development Issues

To gain first-hand information on development issues in small Alpine towns, a questionnaire on development issues was sent out in 2009. The questionnaire contained several sets of questions (on demography, the economy, the environment, infrastructure, etc.) and was sent to nearly all the Alpine municipalities. It was targeted at administrators in the municipalities, who we believe are best acquainted with the conditions in their municipalities; to this end, it was addressed to mayors, town councillors, space planners, and so on (Bole and Nared 2009, 2010).

A total of 340 questionnaires were completed, which was less than 10 % of all Alpine municipalities; however, the sample was large enough to make conclusions about certain development forces in the Alpine municipalities. The distribution per country was somewhat uneven because an above-average number of questionnaires were returned from Italy (130) and Austria (90), but only 13 from France. The questionnaire contained 22 questions, but only the most interesting responses are presented here.

Following the typical settlement pattern, most of the municipalities perceive themselves as rural and only 10 % as urban. The latter have better infrastructure facilities (Fig. 18.6), although some of these, such as access to airports, are insufficient in both types. Respondents also gave negative answers with regard to access to broadband and public transport. However, respondents found the availability of energy and social (public) infrastructure very satisfactory. These views comply with the general views on the Alpine area, considered as an economically and socially developed area that is well known for its rich natural resources.

The answers to the question about the greatest threats to future development (Fig. 18.7) are not surprising either. The lack of jobs and investment on the one hand, and out-migration of young people and aging of the population on the other, are the most serious problems of the Alpine municipalities, which has also been shown in other studies (Bätzing 2002). It is interesting that some factors that are widely publicized by researchers, such as climate changes and the risk of natural disasters (Agrawala 2007; Alpine … 2013), are not indicated as a problem.

The suburbanization process of large pre-alpine agglomerations is perceived as a problem. Nearly two thirds of surveyed municipalities believe that the expansion of large towns in their vicinity represents a major or relatively significant problem. Borsdorf (2006) believes exactly the opposite, claiming that peri-urbanization tendencies in the Alps revive remote rural communities and bring new people and jobs.

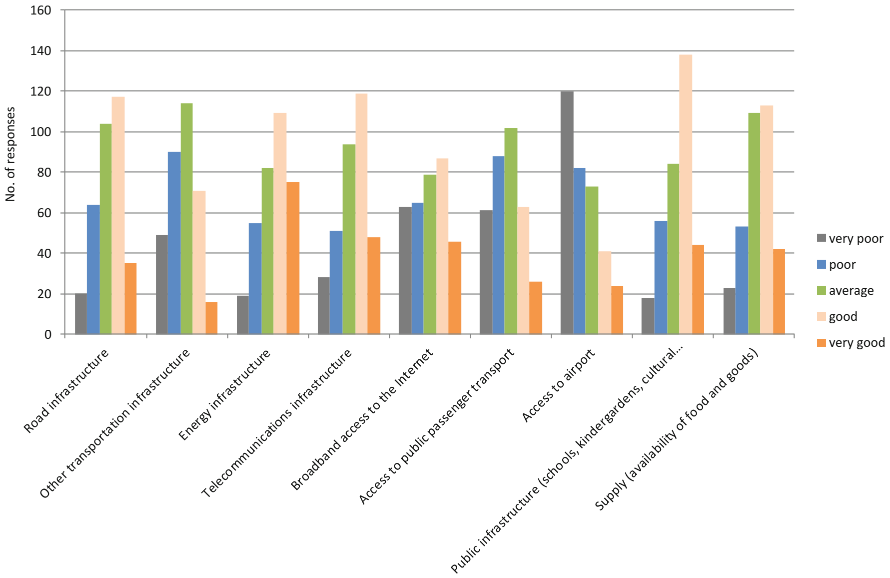

Fig. 18.6 Infrastructure availability in the municipalities according to the survey

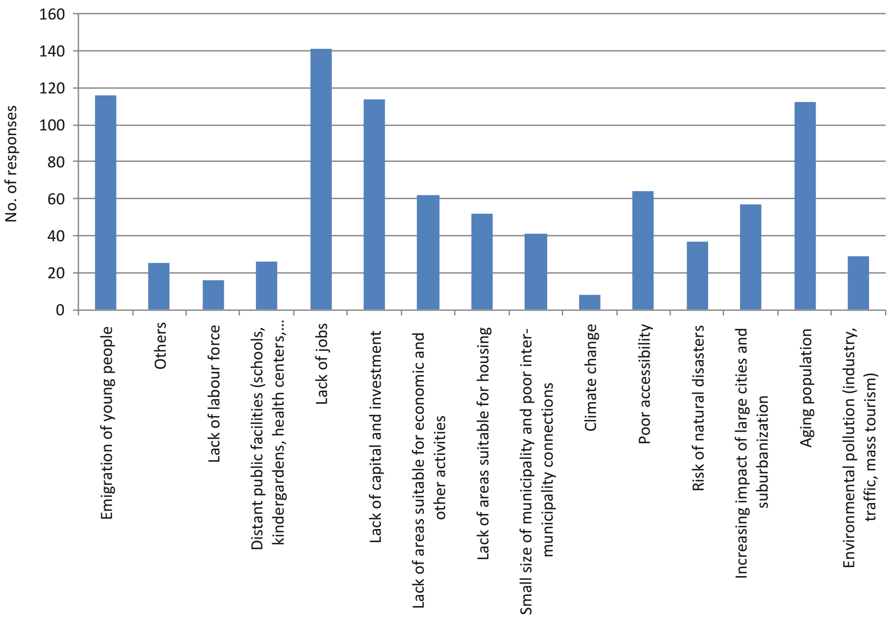

Fig. 18.7 Greatest threats to future development according to the survey

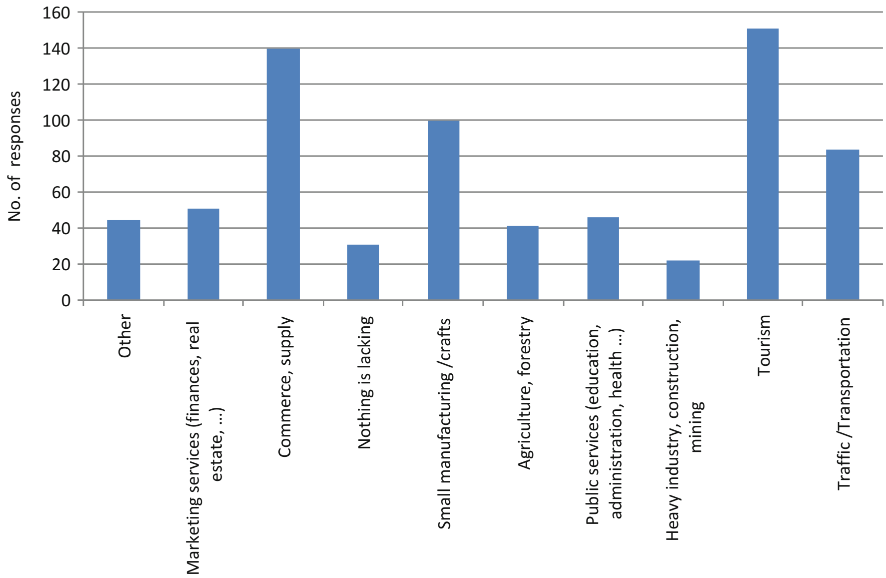

Fig. 18.8 Insufficiently developed economic functions in the municipality according to the survey

The aversion toward the growth of larger towns should thus be understood as a concern for preserving control over one's own territory and not as resistance to the advantages provided by such influences.

With regard to the economic questions, we were interested in which activities the respondents thought were the least developed (Fig. 18.8). It is interesting that tourism again predominated among the answers, as it is perceived as an activity that can ameliorate the problems already described. Commerce/supply, small manufacturing/crafts firms, and traffic/transportation appear to be insufficiently developed. However, these are all activities that are described as generally undesirable activities in Alpine space (except for sustainable forms of tourism) in a number of documents, such as the Alpine Convention. This result clearly shows a discrepancy between the aspirations of municipal representatives and various EU strategic documents that primarily emphasize innovation, creativity, and sustainable development.

Respondents were also asked to list the factors that will have an impact on their future development (Fig. 18.9). In contrast to the goals just described, Alpine municipalities especially would like a clean environment, natural heritage, and favorable location. A clean environment and natural heritage are factors that can generally attract tourists, but other factors, such as human potential and availability of capital, seem to be more important for other activities (e.g., crafts, transport, and supply).

One set of questions also focused on social development. The biggest problems listed by the representatives of municipalities included a lack of jobs, aging of the

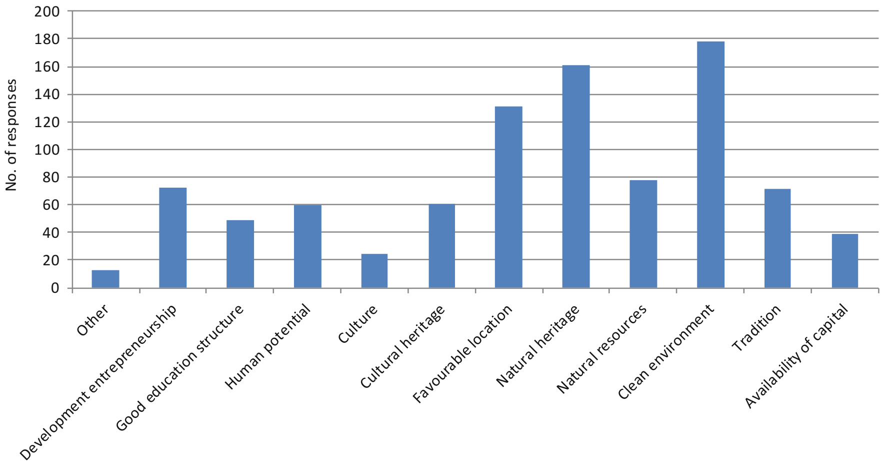

Fig. 18.9 Greatest advantages of municipalities with an impact on future development according to the survey

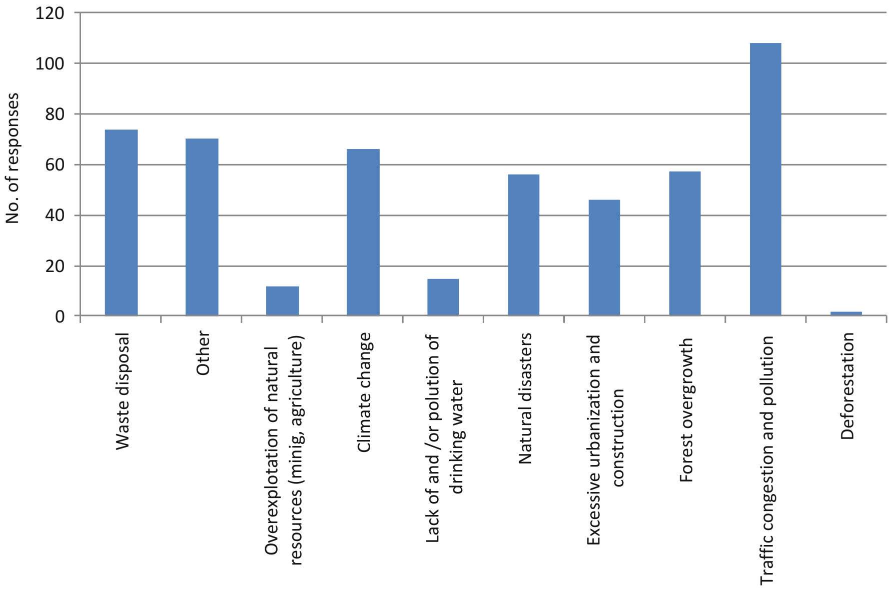

Fig. 18.10 Greatest future environmental problems in the Alps according to the survey

population, and poor population mobility consequent on inadequate transport infrastructure, findings that are in common with other studies (Tappeiner et al. 2008; Razpotnik et al. 2009). Among the environmental questions there was a question about the greatest environmental threats to the future development of municipalities (Fig. 18.10). Not surprisingly, the most frequent answers were traffic congestion and pollution. Perhaps what is surprising is the fact that climate change is perceived as a greater threat here than in other sets of questions.

18.4 Discussion

The issues discussed here have shown a certain image of the problems and opportunities perceived by those living in the Alps (Bole and Nared 2009, 2010). The inhabitants are greatly concerned about the aging of the population and the out-migration of young people from Alpine space. In general, the opinion about pre-alpine urban agglomerations is fairly negative because the majority of Alpine municipalities see these as a “threat” that causes out-migration of young people and their families. Aging of the population is generally a problem in all developed environments, but as are other mountain regions the Alps are particularly vulnerable because the greater part of the Alps consists of high-mountain regions, which are difficult to access and demographically more vulnerable.

In some way, the aging of the population and fear of the ever-greater impact of pre-alpine agglomerations are somewhat paradoxical because all the data (including those obtained from this survey) show that the Alps are still well equipped with infrastructure. According to the survey, public infrastructure (schools, public administration, healthcare, etc.) is the least problematic factor. Nevertheless, these amenities cannot prevent the young labor force from relocating to larger cities outside the Alps. This demographic “disease” probably also leads to a fear for the lack of investment and capital, which could also result in a decreased number of jobs and economic stagnation.

With regard to the question of which activities are insufficiently developed and could attract young people, new investment, and fresh capital, the respondents unanimously selected tourism. The fact is that the touristic function of the Alps is often emphasized and that, in the majority of regions affected by socioeconomic stagnation or decline, tourism appears to be an ideal secondary activity. Because of the natural conditions in the Alps and their central location and proximity to large European metropolises, the Alps undoubtedly have great potential for tourism. However, the question is whether tourism can replace more than one third of all jobs in industry and agriculture, which are regarded as unpromising sectors. The number of those that believe the future also lies in increasing organic farming is half the number of those who see the solution in tourism. The share of those who believe a better future lies in the development of high-tech innovative products is negligible, which may also be the result of the fact that, with regard to technologically intense activities, their “agglomeration” logic is emphasized. However, in theory this is more difficult to attain in the dispersed and less densely populated mountainous areas than in the densely populated pre-alpine urban agglomerations.

With regard to problems and opportunities mentioned by respondents, it is perhaps surprising that most do not miss greater control over economic, development, and social planning, even though this could prevent the out-migration of younger people and the lack of jobs to a great extent. The representatives of municipalities seek greater authority in spatial planning and planning on transport infrastructure, which, however, are not directly connected with the problems most strongly perceived to exist. Aspirations for greater influence in spatial planning and transport seem to be more of a result of acute issues affecting Alpine municipalities, such as the lack of construction land and poor transport accessibility, which have already been described in other studies (Alfare et al. 2008).

18.5 Conclusion

This chapter summarizes the findings of an analysis conducted in small Alpine towns. Their greatest problems arise from their location on the periphery, the lack of population concentration, the out-migration of population, and the subsequent shrinking of economic and social functions. Nonetheless, these small towns, which have not yet lost their true Alpine identity, carry great potential even on the global scale. They clearly see new opportunities, especially in the development of recreational and tourism functions, which are important in post-industrial society.

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Chapter 19
Impact of Macroeconomic Changes and Property Rights on Forest Degradation, Land Use, and Environmental Situation in Albania

Fatbardh Sallaku, Odeta Tota, Bujar Huqi, Etleva Jojic, Enkeleda Emiri, and Shkelqim Fortuzi

Abstract During the past 20 years, Albania has moved from being a predominately rural society to one in which the majority of the population lives in urban areas. This population movement fueled rapid urban development and at the same time led to absentee landownership in rural areas. Albania has among the lowest amount of agricultural land per capita (0.22 ha) in the region. Only 24 % of Albania consists of agricultural land; 36 % is forest, 16 % is meadows and pastures, and 24 % is unproductive land, such as urban land and inland waterways. Environmental changes are linked to land reform. Conversion of agricultural land to residential plots has increased in Albania as a consequence of land privatization and decentralization. The land reform in Albania was constructed at the national level. The decision of the Albanian government to redistribute the land on a per capita basis was framed by political and economic considerations. From a global perspective, the effects of forest degradation and forest cover loss on biodiversity may be significant, as Albania is located within the Mediterranean Basin, which is recognized as a global biodiversity hotspot in terms of endemic flora and fauna species. The loss of cropland and forest cover in Albania indicates that the transition and the associated macroeconomic recession led to dramatic changes in the landscape. The main objective of the proposed chapter is to identify the relationship between land reforms, land tenure, and macroeconomic changes on forest degradation and land use and environmental impact in Albania. This chapter provides a conceptual framework for understanding the relationship between land tenure, property rights, land reform, and environmental impact as well as forest quality in Albania during the post-socialist period. A systems approach is used to describe land use changes in Albania, addressing the complex and dynamic nature of the relationships among the subject matter areas.

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19.1 Historical Land Tenure in Albania

There are two outstanding characteristics of the development of land relationships since 1991 in Albania. The first is the creation of a nation of smallholders–owners of small farms held in freehold tenure brought about by Law 7501. Whatever the deficiencies of the content and implementation of this law, the fundamental socio-economic revolution brought about by this law should not be underestimated. The second characteristic, and one that is directly related to the first, is the exuberant urban development and rapid growth of land market that has taken place. Before World War II, the distribution of land in Albania was unequal. The most productive agricultural areas were owned by a few families. Under socialism, Albania was the only country in the CEE (Consortium for Energy Efficiency) that effectively nationalized all land, based on its 1976 Constitution (Agolli 2000; Civici 1994; de Waal 1996; Cungu and Swinnen 1999). After the demise of socialism, Albania implemented a comprehensive land redistribution program that established private property on virtually all cropland under use during the socialist period. Land redistribution was a politically feasible strategy; restitution to former owners would have resulted in less than 5 % of the population owning the most productive land. The Albanian land reform of 1991, the Land Law 7501, was intended to redistribute all collectivized land to former members of the cooperatives on an equal per capita basis. Other rural residents who were not members of the cooperatives were also awarded land but in smaller quantities (Law 7501, Art. 6). Land to be redistributed was stratified by variations in distance to the farmstead, soil fertility, and irrigation capacity. Village-level land distribution councils were formed to allocate plots, often in distant locations within the village territory, to each farm family proportional to their household size, including the elderly and small children. Although this urban development has not been universal throughout the country (there has been more in Tirana and the south of the country than in the north), it is a striking testimony to the effect of private ownership of land, the existence of a market for land, and access to the necessary financial resources to bring about urban development (Bloch 1998; Cungu and Swinnen 1999). These two interrelated characteristics, widespread private ownership of land, rapid development and its corollary, development of a land market, must be seen in the context of a major social change in the country: the rapid movement of population to urban areas and overseas to find work.

19.1.1 Privatization of Agricultural Land

The land privatization process began in 1991 with the approval of Law 7501 '*On Land.*' The law divided agricultural land among the inhabitants of the cooperatives and workers in the state-owned farms according to the quality and productivity of the soil and the number of people in the family registered in the civil registry in August 1991. Using a per capita basis, each family received equal amounts of arable and non-arable land, fruit trees, vineyards, and olive trees. the scarce amount of agricultural land in Albania (at average 0.22 ha per capita of population) and high proportion of rural population (64 %) were an argument in favor of the implementation of the land law. Another argument was the long time and great changes that had occurred in Albania during 1944–1990, which complicated the task of identifying old land boundaries, documentation of previous property ownership, etc. The most important aspect of this law, apart from its pivotal role in announcing the new legal regime of land tenure, management, and use, is that there has scarcely been any law enacted during the past 12 years to address the aforementioned topics. These aspects in turn would have provided the detailed legal regime foreshadowed by these provisions (Kelm 2000).

19.2 Main Land Tenure Issues

The agricultural structure comprises some large farms and millions of micro-farms, with an almost complete absence of intermediate-sized competitive, commercial farms. The larger farms, sometimes covering thousands of hectares, are operated by the state, commercial companies, private associations, or cooperatives. In contrast, farms of less than 1 ha account for 70 % or more of the total number of farms in Albania. Most farms are subsistence farms that produce little for the market, but for many rural residents these small farms are often an important source of income and food security. Assessing the effects of land privatization in Albania, it needs to be underlined that this process was associated with two negative phenomena. On one hand privatization has limited farm size, whereas on the other it has increased land fragmentation.

19.2.1 Land Fragmentation

Land fragmentation has been identified as one of the main obstacles to the development of the agricultural sector in Albania. Law 7501 was drafted to ensure a fair division of land among agricultural families. However, one of the ramifications of this policy is highly fragmented land plots. Families own several non-contiguous parcels spread over a wide territory, which makes farming at an economic scale next to impossible. As a result of this process of privatization, more than 90 % of agricultural land is now in private ownership (Kelm 2000). The complete break-up of the agricultural collectives in Albania led to fragmentation of land ownership. In 2005, 440,000 farm families operated on approximately 1.8 million parcels. An average farm household possessed 1.5 ha, spread over three to five parcels (Ministry of Agriculture and Food 2006; World Bank 2003, 2006). The inactive land market with few land sales and rentals hinders land consolidation.

19.3 Effects of Land Reforms on Land Use in Albania After 1991

Protection of natural resources and nature as a whole has been for decades an important argument for the whole civilized world, as proved by the large number of conventions/agreements signed by most of the countries including Albania. Albania faces many of the same environmental issues with which other countries in Eastern Europe are being confronted. Both air and water pollution are serious issues as a result of the lack of facilities and controls. Most of the environmental damage that occurred in rural areas during the socialist period has not been repaired. Large-scale cultivation destroyed field roads, watercourses, vegetation belts, and other landscape features suitable for individual farming. Environmental degradation has sometimes increased during the transition period, for example, through deforestation of valuable species, inappropriate tillage of soils, and failure to maintain a balance of nutrients in the topsoil. The degradation of natural resources in Albania is an important long-term constraint to sector development. The main problems include uncontrolled deforestation, large numbers of livestock and the consequent overgrazing of pasture land, particularly in mountain areas, soil erosion and degradation caused by production on marginal land, especially on steeply sloping land in hilly and mountain areas and before the collapse of the old regime, loss of scarce and productive arable land through rapid urbanization, depletion of marine fishing resources, degradation of water resources and watersheds, and increased vulnerability to flood damage.

19.3.1 Land Cover

Nationwide land use in Albania has changed little since the distribution of agricultural land to farmers' households in 1991. According to the MoAF (Ministry of Agriculture and Food 2006), the broad categories of arable land (24 %), forests (36 %), pastures and meadows (15 %), and other land (25 %) remained stable between 1991 and 2006. According to preliminary results of the Albanian National Forest Inventory (ANFI), the first nationwide analysis of remote sensing data for the years 1991 and 2006, broad land cover categories indeed changed relatively little. ANFI results for 2006 show cultivated area at 21 % and forest cover at 32 % (Fig. 19.1).[1]

However, a significant number of land cover modifications are observed as manifested in a change from forest to woodland of 2.8 % and from forest and woodland to bush, shrubs, and grassland of 1.4 %. This transition amounts to a significant degradation of forest cover of 4.2 % between 1991 and 2006 with a corresponding decrease in tree density. The spatial representation of selected major land cover modification shows a significant decrease and degradation of forest in the Northern mountainous areas and, to a lesser extent, in the Southeast (Fig. 19.2). Agricultural land area increased by 1.4 % according to ANFI data in this period, without pronounced hot spots of change across the country. Another major land cover change factor in this period is the expansion of urban areas on former agricultural land by almost 1 %, mostly around Tirana City.

19.3.2 Forest Degradation

Forests and pastures constitute a heritage with values not only for Albania but also for the whole region. This heritage should be protected and managed in such a way that will secure a higher growth development in the future by contributing to the decrease of poverty level without destroying the natural and biotical balance. In the past, including transition years as well, forests were evaluated for their economic importance, thus underestimating their multifunctional aspect. Their harvesting leads not only to profits but also to losses (when they are not harvested properly) such as those of capabilities for future development, which is a result of the degradation and desertification of forestry and the pastoral environment. Forests, pastures, agricultural land, and coastal areas are undergoing degradation as the result of poorly defined private responsibility and a lack of public oversight and enforcement (Figs. 19.3 and 19.4).

The emphasis on privatization of property has neglected the need to define the responsibilities of private owners, particularly concerning the protection of resources. Forest resources are composed of state, local, and private forests. Local forests are those under state ownership but allocated to villages for common use by the permanent residents who are entitled to take from the local forest a surface area from 0.4 to 1 ha per family. Private forests include all groups of trees and forests that are created or exist within the boundaries of private immoveable property. The current situation is characterized by rapid deforestation (or harvesting) of standing timber stocks and degradation in the productive potential of the forest and pastoral ecosystems. Forest resources have decreased significantly during the past 10 years

[1] As ANFI is a land-cover data set no land use assessments are involved. Therefore, it is not possible to calculate pastures and meadows. Major parts of the bush, shrub area as reported by the ANFI project are possibly used to graze livestock.

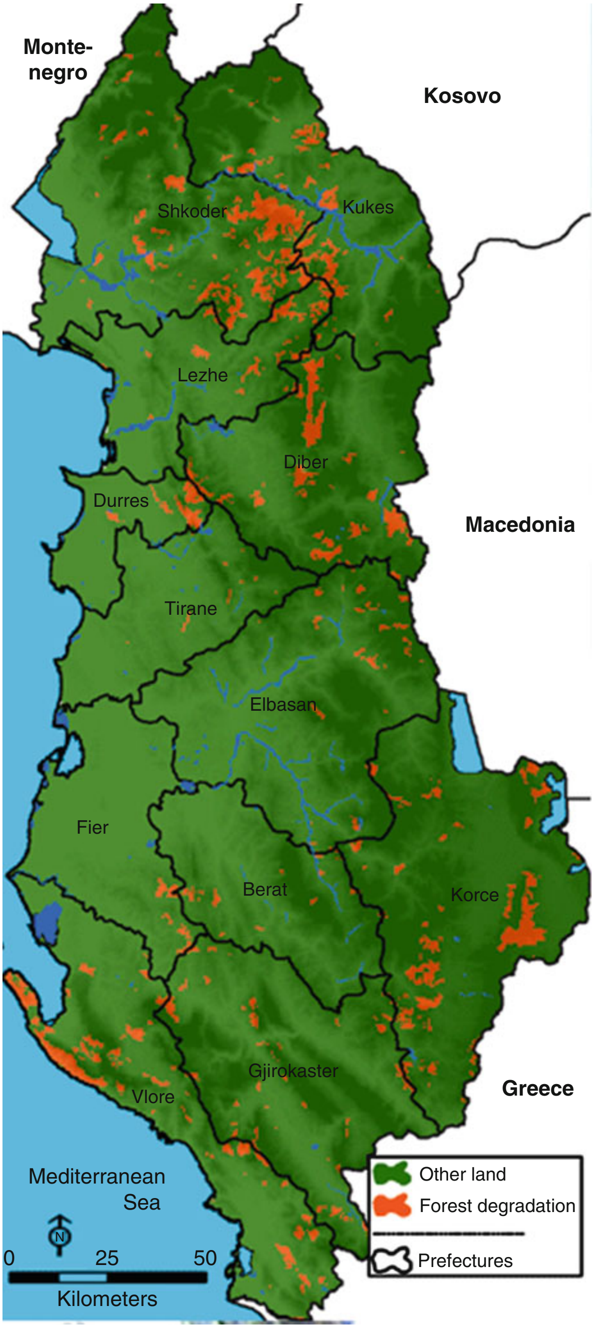

Fig. 19.1 Major land cover modification: 1991, 2001, 2006

Fig. 19.2 Major land cover modifications: 1991 to 2006

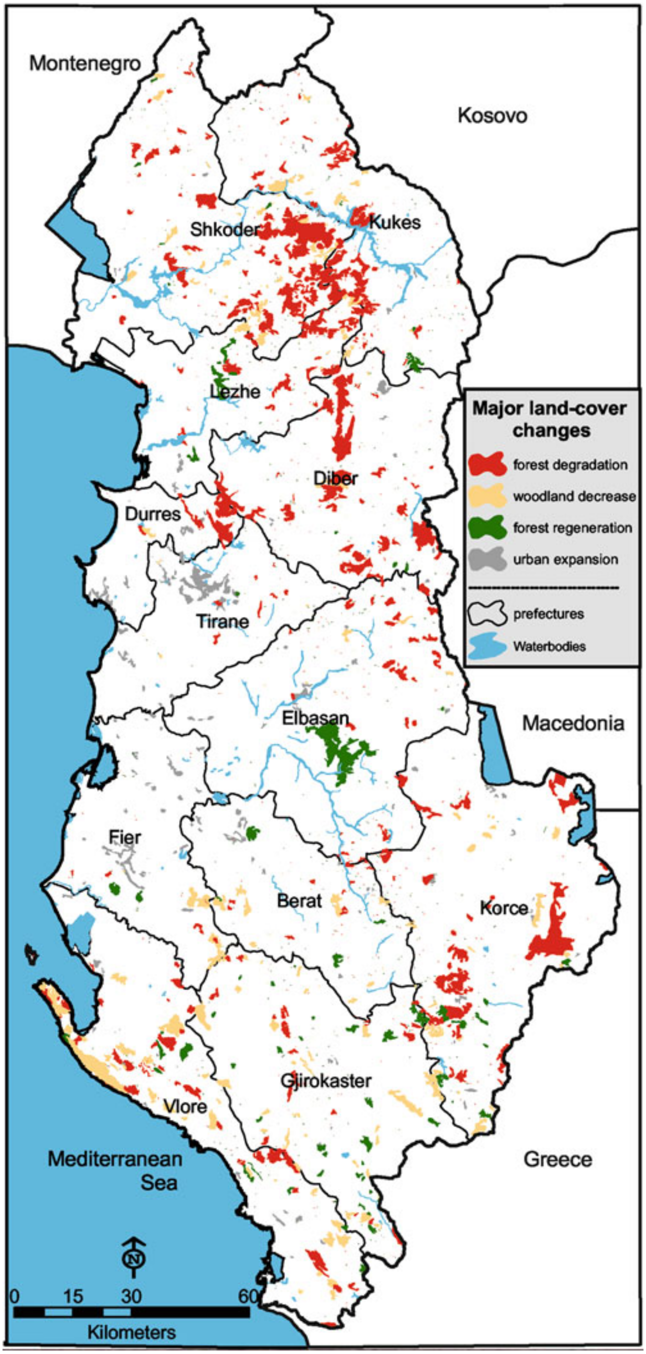

Fig. 19.3 Forest degradation during the period 1991–2006

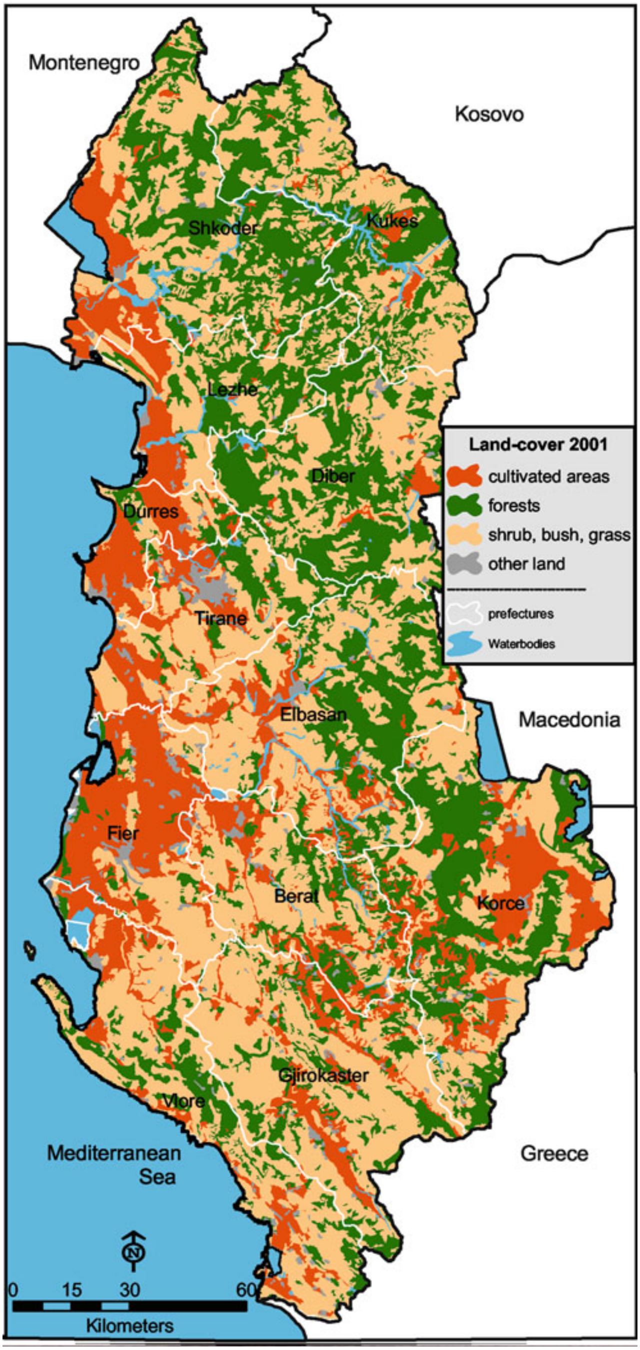

Fig. 19.4 Urban expansion

as a consequence of the country's transition to a market economy. In some areas, the total forest cover has decreased by an average of 15 % over a period of 5 years, with varying degrees of reduction in the different forest types (Ministry of Agriculture and Food 2002). During the period 1988–2006 total forest coverage remained stable with the ever-changing rural landscape in Albania. However, 6 % of the natural, old-growth forest of 1988 was cleared by 2006, and both old-growth and secondary forest regenerated on former bush and grassland, as well as on 94 km^2 of abandoned cropland. About 40 % of the landscape was forested in 1988; 202 km^2 or roughly 14 % of the land that was forest in 1988 was cleared by 2006. Substantial changes in forest integrity stem from the continuing reliance on forest biomass for heating and cooking. In addition, forests and other communal resources can suffer greatly when collective systems are replaced with market-based ones consequent to new collective action problems that arise in transitional periods. The loss of cropland and forest cover in Albania indicates that the transition and the associated macroeconomic recession led to dramatic changes in the landscape. Declining revenues from agriculture were accompanied by new livelihood strategies in a rapidly globalizing world. This change sparked demographic changes and pushed people into other sectors of the economy, leaving large tracts of cropland idle (De Soto et al. 2002; King 2005; World Bank 2003). The resulting land use changes are associated with interesting patterns such as the persistence of land fragmentation and the realignment of agricultural production as, over time, predominantly more remote and less productive areas fall out of cultivation. Forests have been threatened by the transition because a new delineation of rights to forest uses remains to be implemented. In addition, many households still rely on forest resources. This resource degradation, which includes uncontrolled woodcutting and overgrazing, is particularly intense in areas near villages and communities, exerting human pressure upon forest resources as the major cause of their deterioration. In parallel with degradation of forests and pastures, investments in forest management diminished considerably after the mid-1980s and were eventually discontinued in the 1990 because of dwindling resources allocated to the forest administration. Since the early years of the transition period, considerable quantities of wood have been illegally harvested. Forest health is a concern for local livelihoods that strongly depend on forest resources in the absence of other energy sources. The sustainable management of forest and pasture resources should be focused upon efficient management and utilization of resources to restore and maintain biodiversity, production, regenerative capacities, forestry vitality, and other diverse potentials both for the present time as well as for the future with the aim of fulfilling ecologically economic and social functions at the local, national, and global level without causing further damage to other ecosystems.

19.3.3 Pasture Degradation

Land use and land reform have also affected the development of the pasture sector in Albania. Approximately 60 % of pasture area is in the process of being transferred to the communes (Ministry of Agriculture and Food 2002). The strategy for the development of forestry and pasture sector is an action plan that aims at achieving an optimal contribution to this sector, to the general economic growth as well as to the sustainable development of the country. This process implies good management and utilization of pasture in a way that secures production, regenerative capacities, vitality, and pasture potential for the present and the future, ecological, economic, and social functions at the local and national level. At present, the main concerns in relationship to pasture management are degradation of pastures from overgrazing or other high pressures. So, it implies overgrazing of pastures beyond their regenerative capacity, without taking into account the technical criteria such as the increase of cattle to be grazing before the grazing season. Lack of investments and improvement operations in pastures have caused problems concerning the decrease of their holding capacities and their relevant qualities. During the last period, animal husbandry is having a vigorous development, which for the present condition of our country, and even for the future, is one of the most profitable branches of the national economy. This development, to keep this pace in conformity with people's needs for animal products, requires far more organized observations for the appropriate maintenance of livestock production. According to the cadastral data, natural pasture area is estimated to be 415,911 ha or 14 % of the whole territory, extended in 36 districts.

19.4 Conclusions

Although Albania is faced with many political, economic, and social problems, important steps have been taken. The commitment of Albanians to abandon five decades of state ownership and control and the steady progress made in completing substantive and procedural privatization laws are laudable. In this chapter we analyzed the impacts of heterogeneous land use incentives upon land cover, which allows us to examine land cover transitions following the large-scale policy shifts in the wake of transition along with the subsequent realignment of land use incentives caused by land reform. Agricultural abandonment in Albania is strongly mediated by both the biogeophysical environment and transportation infrastructure. District-level effects provide some evidence that abandonment is more likely in relatively remote areas, or when other economic opportunities, such as tourism, press themselves forward. Forest cover loss was highly sensitive to the time period. Forest clearing tended to shift from subsistence orientation in the first years after the collapse of socialism to more commercial extraction in later stages. The abandonment of large areas of cropland partly reflects the adjustment of the rural sector to the evolving market conditions and leads to a concentration of cultivation on more productive areas. In Albania, further abandonment of cropland may continue well into the future, given the fact that the younger generations will continue to secure their livelihood depending more and more on internal and international migration. This trend will become more worrisome with the elderly farmers declining faster and faster. Future abandonment in Albania may be aggravated by the projected reductions in crop productivity caused by high temperatures and drought in a region already vulnerable to climate variability. The impact of the successional vegetation on biodiversity, soil conditions, or carbon sequestration potential depends on the prevailing natural conditions and will therefore vary across regions. Rural landscapes will continue to evolve and change. Land reforms, particularly the establishment of private property rights, are based on the logic that efficiency gains in agricultural production will occur as a result. Nevertheless, impediments to a fully functioning land market remain. Issues such as restitution and compensation, illegal occupation of land, and other land disputes continue to cloud legal title. Rural conditions throughout the region in Albania have deteriorated during the transition period. There is growing inequality between rural and urban areas, with most of the poor now living in rural areas. These areas are characterized by declining populations, mainly represented by women and the elderly. Rural infrastructure has often deteriorated considerably, and many rural roads, irrigation systems, and erosion control measures are in poor condition. An effective incentive to production and conservation of land and water resources in Albania is the right to secure tenure to land and other natural resources. Security of tenure is a major concern of the land user in deciding whether to invest in measures to promote conservation or sustainable production on a long-term basis. Land rights must be robust, allowing the user effective control over the resource and the right to exclude others who might adversely affect its management. An important part of Albanian government policy should be to reduce disparities between urban and rural areas by improving the rural situation.

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Chapter 20
Sustainable Development in the Eastern Black Sea Mountains: Present State and Perspectives

Mehmet Somuncu

Abstract The Eastern Black Sea Region of Turkey, with a mountainous coastline of 39,203 km^2 (5.1 % of the country) and population of 3.2 million (2000 census), has the highest peaks (above 3900 m) in the central part of the region. Annual rainfall in the coastal areas ranges from 2000 to 2500 mm resulting in most dense forests in the region. Natural features in the Eastern Black Sea region make living conditions harsh; in addition, the area is difficult to access because of its distance from developed areas and an insufficient infrastructure. The mountain areas in this region suffer from lack of adequate basic services such as transportation, communication, education, and healthcare (Somuncu and İnci 2004). Mountains in the Eastern Black Sea Region are less developed areas. As a result of inadequate incomes and limited availability of basic services such as transportation, health services, and education, local people have been continuously migrating from mountains since the 1950s. Sustainable development is needed to reduce and stop emigrations from the region.

Keywords Sustainable development • Mountainous area development • Eastern Black Sea Region

20.1 Introduction

Mountains cover a significant portion of the land area of many countries in the world, and their resources are crucial in sustainable development. But the specific challenges of development in mountains are rarely reflected in national policies. Only a few countries have adopted coherent policies that address these challenges from a mountain perspective.

Mountains are a key to sustainable development, and their importance will increase in future. As the water towers of the world, mountains have a crucial func-

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tion in providing freshwater for a growing number of people, for industrial development, and for agriculture and irrigation in mountain and downstream areas. Food security, poverty alleviation, and, ultimately, political stability will thus be critically linked to mountain resources, and hence to the development taking place in mountain areas. Mountains will also continue to be important as hot spots of biodiversity. Increasing urbanization within mountains will put additional stress on scarce resources such as water. At the same time, mountains are characterized by specific development challenges. Typically, these include difficult access, economic and political marginality, outmigration, environmental sensitivity, diversity of livelihoods, and cultural diversity. These challenges need to be addressed by specific policies, laws, and institutional arrangements at the international, national, and local levels (Mountain Agenda 2002).

Turkey is situated in the Northern Hemisphere near the junction of the continents of Europe, Asia, and Africa, between 36° and 42° north latitude and 26° and 45° east longitude, so that it occupies a unique geographic and cultural position at the crossroads between Europe and Asia. Turkey is a vast country with an uneven topography. It consists of a land area of 814,578 km^2 and an average elevation of 1,132 m (Table 20.1). Mountain crests exceed 2,000 m in many places, particularly in the east, where Turkey's highest mountain, Mount Agri (Ararat), reaches 5,137 m close to the borders with Armenia, Nahçivan (Azerbaijan), and Iran. Steep slopes are common throughout the country, and flat or gently sloping land makes up barely one sixth of the total area.

In this study, the Eastern Black Sea Regional Development Plan (DOKAP) of Turkey is analyzed in terms of sustainable mountain development. The Plan is very important for Turkey and the global ecosystem because the mountainous area of the region is one of the least developed areas in the country. Also, the rich flora in the Eastern Black Sea Region is an important contribution to the world's biodiversity. The region is in the Caucasus Hot Spot.

20.2 The Eastern Black Sea Region

The Eastern Black Sea Region is in the northeastern corner of Turkey (Fig. 20.1). The region consists of seven provinces: Ordu, Giresun, Trabzon, Rize, and Artvin, facing the Black Sea, and Gumushane and Bayburt, situated away from the coast.

Table 20.1 Elevation groups in Turkey

Elevation groups (m)	Percent (%)
0–250	8.0
251–500	9.5
501–1000	27.0
1001–2000	45.5
2000+	10.0

Fig. 20.1 Location map

Total population and area of this region are, respectively, 3.2 million, accounting for 4.7 % of the national population, and 39,203 km^2, accounting for 5.1 % of the national area.

Within the Eastern Black Sea Region, high mountain ranges run parallel to the Black Sea coast in the north with undulating plateau on the southern foot of the mountains. High ridges trending east–west rise abruptly from the Black Sea coast, and the coastal plain has narrow openings at a few places. The mountain ranges are higher, narrower, and steeper toward the eastern area. Less than 75 km from the coast, the Eastern Black Sea Mountains rise to more than 3,700 m, with a maximum elevation of 3,932 m in the Kaçkar Mountain, among the steepest topography in the world (Fig. 20.1) (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000; Somuncu 1989).

Extensive glacier and water erosion have given these mountains their craggy, rugged look, and they are known for the complexity and power of the streams and rivers that rush down to the lower altitudes. In fact, this range is the third most important glacial region in Turkey, following the Mount Agri and Cilo-Sat Mountains. Today, there are five large glaciers in the Kaçkar Mountains National Park. Therefore, the region is characterized by harsh topography. Steep and high mountain ranges near the coastal area limit flat land, making both ordinary life and development activities difficult and costly, which may be one reason for emigration from the region.

The region is far from the major population centers in Turkey. Economic activity in the region is concentrated along the coast. There are physical limits to the growth of these areas because of the harsh topography. Concentration along the coast is associated with differences in income between these areas and the less developed inland and mountainous provinces, which has led to severe environmental degredation of the Black Sea coast (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

20.2.1 Settlement System

Major urban centers are located along the Black Sea coast, whereas there are a small number of centers in the inland, which are small compared to the centers along the seacoast. Rural or small-scale settlements are widely dispersed in the whole area of the region, and the residents are moving to urban areas (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

20.2.2 The Economy

In mountain areas, agriculture is the main economic activity in which crop production is accompanied by livestock husbandry. The western part of the coastal areas in the region, with relatively low elevation and precipitation, is planted predominantly with hazelnut, whereas the eastern part, having higher precipitation, is planted with tea. Inland dry areas are planted with field crops (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

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. The dry climate in inland areas, with an annual precipitation ranging from 400 to 600 mm, limits crops that can be cultivated under rainy conditions. Low temperature is another constraint limiting crop species in most inland areas with high elevation. Annual rainfall in Rize and parts of other coastal provinces amounts to more than 2500 mm with some 170 cloudy days annually. The large amount of rainfall leaches nutrients and makes soils acidic, which lowers crop productivity. Lack of sunshine also adversely affects crop performance. Monoculture of tea is attributed to this climate and soil condition. Livestock in the region is also very important for economic activity. In particular, cattle, dairy, and honey production are of national importance (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

As a result of the inadequacy of incomes and the limited availability of basic services such as transportation, health services, and education, many mountain residents have abandoned their mountain abodes since the 1950s. Sustainable development is needed to reduce and stop outmigration in the region.

20.3 The Eastern Black Sea Regional Development Plan (DOKAP) and Sustainable Mountain Development

In Turkey, regional development policies have been developed in the quest to eliminate regional disparities, to accelerate local and regional economic development, and to enable sustainable development (Kayasü 2006). Regional development projects have been designed, mainly for the less developed regions, and regional development policies have been developed as part of the National Development Plans, which have been also prepared by State Planning Organization (SPO). The Eastern Black Sea Regional Development Plan (DOKAP) is one of these (Fig. 20.2).

The regional development plan for this region is identified as the DOKAP, abbreviating its Turkish name. The Eastern Black Sea Regional Development Plan has been prepared for the Eastern Black Sea Region, one of the underdeveloped regions of Turkey and one from which a large number of people emigrate, according to the 1990, 2000 census. Currently, DOKAP is a regional development plan that covers seven northeastern provinces extending over the mountainous area in the Eastern Black Sea Region.

The Eastern Black Sea Development Plan was designed not only as a rural development plan but also as an economic initiative intended to have positive social and political consequences for urban areas. The project's main objectives were to improve living standards and income levels so as to eliminate regional development disparities, and to contribute to such national goals as social stability and economic growth by enhancing productivity and employment opportunities in the rural sector (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

Sustainable rural development is one of the major components of the Eastern Black Sea Regional Development Plan, which was prepared in 2000 by the State

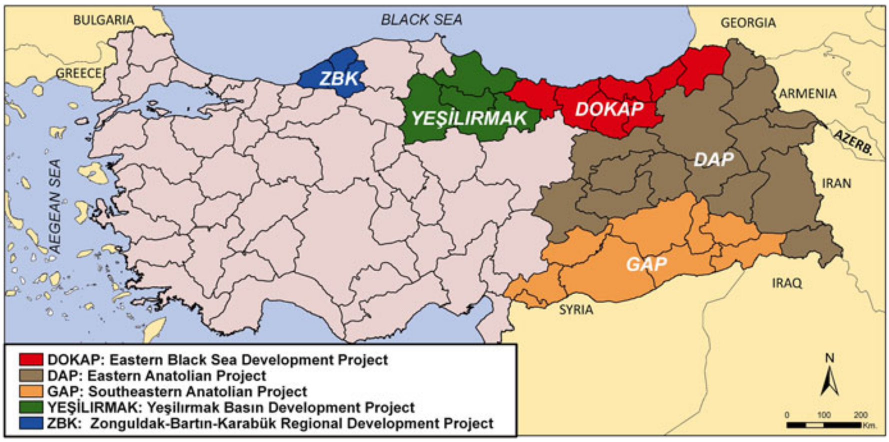

Fig. 20.2 Regional development projects in Turkey

Planning Organization and Japan International Cooperation Agency. The main objectives of the Eastern Black Sea Regional Development Plan are these:

- To develop an integrated regional development plan, providing short- and long-term development of the Eastern Black Sea Region to eliminate regional discrepancies between the DOKAP region and the other regions of Turkey.
- To define priority sectors and investment projects, and to cooperate with the relevant personnel during the course of this study for the purpose of developing their planning capabilities.

Under the scope of the preliminary studies, research has been conducted on the natural structure, social structure, urban impact areas, industry, and geographic information systems.

Within the framework of the first site study under DOKAP, the existing socioeconomic and topographic conditions of the region have been analyzed and a development strategy has been established. Furthermore, a draft integrated regional development plan has been prepared.

Under the scope of the second site study, project profiles for the selected priority projects/programs have been prepared and related studies have been initiated for the formulation of an action plan. The Final Report prepared within the framework of DOKAP studies consists of a Master Plan, Sectoral Reports, Institutional Development, Project Reports, and an Executive Summary. The DOKAP Master Plan includes 10 programs and 52 projects. The studies on the project have been completed and have been implemented since 2001 (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

20.3.1 Legislative Basis

The Government of the Republic of Turkey requested the Government of Japan for technical cooperation to prepare a multi-sectoral regional development master plan for the Eastern Black Sea region. In response to this request, the Government of Japan decided to implement this technical cooperation and entrusted the implementation to Japan International Cooperation Agency (JICA). The Scope of Work for this technical cooperation was contracted between the State Planning Organization (SPO) of the Turkish Government and JICA, and signed by respective representatives on December 17, 1998 (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

20.3.2 Design

The region covers seven provinces of Black Sea Region including Ordu, Giresun, Trabzon, Rize, Artvin, Gümüşhane, and Bayburt.

20.3.3 Objectives, Rationale, and General Description

Objectives for the DOKAP regional development are defined to address the most critical problems in economic, social, and environmental aspects, which are described next. They have the following aims:

- To strengthen the economic structure, responding to emerging opportunities, to diversify employment opportunities, raise income levels, and contribute to capital accumulation within the region.
- To promote regional integration or social cohesiveness through minimizing intraregional disparities and out-migration.
- To restore and sustain resource and environmental capacity as a basis for diversifying socioeconomic activities.

The basic strategy consists of the following four elements:

1. Upgrading of main infrastructure
2. Multi-purpose water resources development and management
3. Land tenure improvement
4. Strengthening local governments.

The DOKAP regional development to the year 2020 is supported by a set of development projects and programs and related institutional measures. A total of 52 projects and programs in different sectors were included in the DOKAP Master Plan. They were packaged into 10 broad programs:

(a) Spatial Structure Strengthening
(b) Local Alliance Urban Development and Management
(c) Comprehensive Water and Land Resources Management
(d) Industry and Trade Support
(e) Diversification of Rural Economy and Intensification
(f) Applied Research
(g) Strengthening of Local Administration
(h) Sustainable Human Development
(i) Enhancement of Living Environment
(j) Special Program to Establish DOKAP Identity

20.3.4 Financing

The investment requirements for achieving the projected socioeconomic development in the DOKAP region over 2000–2020 have been estimated. The total investment requirement is estimated as 46 billion US$ over 2000–2020, of which 18 billion US$ is for public investments.

20.3.5 Administration of the Plan

To facilitate the DOKAP Master Plan implementation through effective planning, coordination, and monitoring, it was proposed to establish a regional agency as a union of DOKAP local governments (Japan International Cooperation Agency and State Planning Organization the Republic of Turkey 2000).

20.4 The Project Achievements

20.4.1 Accessibility and Mountain Development

There is a common belief that underdeveloped regions with major accessibility problems have insufficient resources for development. However, social and economic development in these regions can be realized through proper planning and resource management (Somuncu and İnci 2004). The DOKAP Project, focusing on social and economic development through protection of biodiversity in northern Turkey, is a good example.

The DOKAP region is served by only one east–west artery road along the coast, and north–south lateral access capacity is limited. An important element of the basic strategy for the Eastern Black Sea regional development is to strengthen the main transport and communication infrastructure. In particular, for the transportation system, a multi-modal artery network was developed. The Eastern Black Sea Highway Project with 542 km was completed. The total cost of the project is estimated to be US$ 4.2 billion. The existing east–west artery along the coast was strengthened as a backbone axis, from which links to other areas of the DOKAP region and neighboring regions and countries could be extended. Some sections of the existing coastal highway were improved with lane expansion, minor realignment, and resurfacing. Also, the north–south lateral access capacity was expanded.

Village and *yayla (yayla: a temporary settlement in mountain pastures; plural: yaylas)* roads are an extremely important part of the rural infrastructure services in terms of both meeting the social needs of the people living in the rural areas and transporting agricultural products to the market in time. In the scope of the DOKAP project, asphalt roads and bridges have been constructed. Consequently, easier accessibility to mountainous areas is possible in the region and therefore rural tourism has developed. If a mountain community or region wishes to encourage flows of visitors, not only attractiveness but also relatively easy access is usually necessary. Improved accessibility by road, air, and/or rail may include either new technologies or improvement of existing routes; these may contribute to either intentional or unintentional tourism (Price et al. 1997).

20.4.2 Tourism and Mountain Development

Tourism has become a primary source of revenue for many mountain areas, providing a rare opportunity for mountain people to participate directly in the global economy. There are many opportunities for the development of tourism in mountain regions. Tourism offers a great variety of opportunities. Tourist activities include swimming, walking, visiting cities and national parks, skiing, snowboarding, birdwatching, diving, and a number of sports including bungee jumping, river rafting, paragliding, and mountaineering, to mention just a few. Many activities are specific to mountain areas, which provide a variety of natural and cultural settings. Mountains are highly diverse. Climatic zones are condensed over distances of a few kilometers. On a single mountain, one can experience a tropical climate at the base, a temperate zone at medium altitudes followed by alpine conditions higher up, and finally an arctic environment with snow and glaciers on the highest peaks (Mountain Agenda 1999).

The Eastern Black Sea Region mountainous areas have a strong potential for tourism because of their natural beatuies and cultural features. This area is Turkey's greenest region with outstanding natural beauty and has lush green mountains and valleys, glaciers, glacial lakes, and clear gushing mountain streams. With their mountain meadows adorned with colorful wildflowers, the highlands of the region are characterized by their spruce forests. The verdant appearance and lush green slopes of the region are the result not only of the abundant rainfall but also the humid and foggy weather. The humidity and the foggy weather give way to brilliant sunshine and oxygen-rich fresh mountain air as one ascends from the coastal areas high up to the mountains.

The region has four national parks, one biosphere reserve, one natural park, and four areas for preservation of nature in the mountainous areas. The area is also sprinkled with early Byzantine and Genoese monasteries and castles, rising impressively from the steep hillsides, and is renowned for their strong cultural traditions.

Tourism in mountainous areas has recently begun to diversify to fill different niches, including hiking, trekking, climbing, water sports, air sports, and birdwatching, and to meet the needs for local produce and handicrafts (Karadeniz and Somuncu 2003; Somuncu 2007).

Sustainable rural tourism is one of the major components of the Eastern Black Sea Regional Development Plan. Sixteen tourism centers were created in mountainous areas in the region by Turkish Government. Sustainable Rural Tourism Development Plans were prepared for these centers by the Ministry of Culture and Tourism. Transportation, electricity, communication, and accommodation facilities were developed in the centers. Today, the mountains of the Eastern Black Sea Region have become a well-known and popular tourist destination and are visited by a growing number of foreign and Turkish tourists. Tourism has contributed greatly to rural development in the region. The rise of tourism as a business has brought great benefits to the mountain areas in the region. Tourism has provided local people with additional income and employment, opened new career opportunities, and created markets for both high-quality traditional products and local products from mountain areas. Tourism is also opening new ideas and cultural exchange to the mountain region (Karadeniz and Somuncu 2003; Somuncu 1997, 2007).

20.4.3 The Kaçkar Mountains National Park: A Model for Sustainable Mountain Development

The Kaçkar Mountains National Park is situated in Rize Province in the Eastern Black Sea Region. The Park was created in 1994 and covers 51,500 ha. There are 11 villages and 44 *yaylas* in the National Park. Villagers mainly keep cattle, sheep, and goats, or live off the forest, and to a lesser degree they farm. Tea is the leading crop of the coastal strip, Rize being Turkey's one and only producer and processor of this leaf. In the mountains there is not enough land for extensive agriculture, so livestock breeding takes its place. Livestock farming as a household activity has significant place in the local economy. In early summer, rural families move to summer pasturage with their stock. Taking place in the alpine layer above 2000 m on average, summer pasturage has significant functions for purposes of both animal husbandry and of passing the summer in a cooler environment (Karadeniz and Somuncu 2003). Rural families live in wood cabins in *yaylas,* to return again to their villages with the approach of autumn.

The Kaçkar Mountains National Park has become one of the important points of attraction for tourism because of its natural features and cultural structure. Tourist activities in this area include climbing, trekking, camping, photography, viewing the flora, fauna, and natural beauty, meeting the local people who live in *yaylas* and learning about their lifestyle. From these activities, the local people earn from accommodations, transportation, souvenir sales, guidance services, etc., which further adds to the rural economy. The accommodation potential of the park is about 1000 beds. The characteristic feature of tourism here is its seasonality, having its peak during summer months. The average number of tourists per year is more than 100,000 (Somuncu 2007).

Economic and social effects of tourism in the Kaçkar Mountains National Park may be summarized here:

- The tourism of the National Park provides money inflow and increase in income not only for low-income villagers who live within the borders of the park but also for the towns and villages around the National Park.
- Because tourism is a service-based sector that requires more manpower, the development of tourism creates new job opportunities for local people.
- Another positive effect of tourism is related to the employment of women. Along with the development of tourism in the national park, local women have begun to work in touristic enterprises. Thus, the role of women, who were engaged primarily in housework and agricultural activities, has changed.

- Parallel to development of tourism, the host–guest relationship has begun to change in a positive direction.

20.5 Conclusion

The Eastern Black Sea Regional Development Plan has provided substantial contributions to the sustainable development of the Region and Turkey. The progress of the transportation system and accessibility to the mountainous areas have contributed significantly to mountain development in the region because accessibility to the mountainous areas has made growth of rural tourism possible. Rural tourism in the mountainous areas is continuing to grow. This plan has also more expected contributions in the future. The contributions of the plan are not only developments in the region but also protection of natural resources. The development of the Eastern Black Sea mountainous region is very important for Turkey and the global ecosystem. Development in the region will have a prominent role in Turkey's expanding relationships with the countries of Caucasus, Central Asia, and Black Sea Economic Cooperation countries by fostering foreign trade and social/cultural ties. Protection of biodiversity of the region also depends on sustainable development of the mountainous areas.

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Chapter 21
Regional Differences and Regional Planning of Economic Activities in Bosnia and Herzegovina

Rahman Nurković and Haris Jahić

Abstract In this chapter, regional differences as an indicator in regional development of Bosnia and Herzegovina have been studied. In this regard, economic development of new economic activities and contemporary activities, particularly development and structure of work function, are discussed. Unequal regional development in Bosnia and Herzegovina is a regularity of economic development, which is particularly expressed, at certain developmental stages, in polarization of population and income.

Keywords Regional development • Socioeconomic structure • Population • Number of employed people • Bosnia and Herzegovina

21.1 Introduction

Unequal regional development is a common regularity of economic development, which is particularly expressed, at some developmental stages, in polarization of economic activities, population, and income. At the same time certain parts of the country remain on the periphery, weakly or insufficiently included in general development. Thus, all countries are characterized by spatial–developmental disproportion, regardless of social arrangement and degree of development. As a rule, problems of regional development are more discussed when multiplicative effects of the lagging behind of the periphery start burdening more expressive development of the country as a whole. That development, therefore, has been increasingly monitored and directed by the plans of regional development in the past decades.

The methodology of exploring the differences at the level of regional development has evolved in accordance with understanding of that concept. At an earlier

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stage, when it had been mainly identified with spatially differentiated economic growth, regional development was expressed through social product or national product per capita, respectively, as a one-dimensional process.

By recognizing the understanding of regional development as natural-geographic and social-geographic processes of transformation of regional structures, new research approaches have developed, based on a larger number of indicators for measuring the development of spatial units. Among them, a distinguished place is held by systemic approach and multi-regional plans, on which current regional development in Bosnia and Herzegovina is substantially grounded.

As regional development is, first of all, manifested by unequal spatial distribution of population and activities, the function of work is particularly important as an indicator of differences in development of the spatial units of the same type. It is even more important because it is, at the same time, a basic factor of spatial plans and, especially, of their natural-geographic characteristics. Namely, by connecting the active population and natural resources in process of their economic evaluation, the oriented work is directly seen in dynamics, at the level of economic development of spatial plans. An objective of this paper was to determine regional differences in Bosnia and Herzegovina relative to the European Union.

21.2 Methodology of Research

Regional differences and regional planning of economic activities in Bosnia and Herzegovina have been analyzed in this chapter. Within that, development of economic activities as an indicator of the differences in modern regional development of Bosnia and Herzegovina is more closely discussed. Data on population numbers, share of investments, share of active population, and share of employment, the level reached in socioeconomic transition, structure of work, and the share of employed people in activities of the primary, secondary, and tertiary sector, respectively, were used as indicators of polarized development. Regional development of Bosnia and Herzegovina was examined at two levels of spatial analysis. The first level is existing regional structure, and the second is an envisaged regional structure compared to the European Union. Suitability of regional structure as spatial plans for exploring the regional development was determined, first of all, by the fact that the regions are spatial units of medium rank of managing territorial hierarchy and their inclusion mainly corresponds to notion of nodal-functional regions. Hence, they are proportionally stable analytical units for statistical research and, at the same time, spatially planned units of regional coordination. It should be noted that polarization and regional development are discussed in this chapter from the natural-geographic and social-geographic aspects, which means that its objective is not quantification of differences in social–economic development, but connection of relevant developments of spatial plans (Černe 2005, p. 24).

21.3 Socioeconomic Transformation and Regional Development of Bosnia and Herzegovina Since the Mid-Twentieth Century

The most dynamic economic development of Bosnia and Herzegovina was ongoing under the influence of industrialization after World War II. Industrialization of the country was followed by transformation of the overall economy and population, as well as by significant urbanization growth. It is the period in which Bosnia and Herzegovina experienced a significant economic growth and huge structural changes, in which it has grown from a predominantly agricultural country into a medium-developed industrial country, with a significant sector of export services. Generally, dynamic economic development by the middle of the second half of the twentieth century did not reflect so much on growth of the physical volume of the function of work, as it reflected on the change of socioeconomic structure of the population. This point is proved by the absolute and relative lagging in increase of active population number against the total population of Bosnia and Herzegovina in the period from 1991 to 2008. At the same time, it was evident that as an indicator of variable development of function of work, relatively the highest activity was recorded at the beginning of that period, whereas the highest number of active population was recorded at the beginning of the1990s.

By the end of the war, the volume of the economy of Bosnia and Herzegovina was reduced to around 35 % of annual production. After the Dayton Agreement had been signed, the focus of activities of governments at all levels was on reconstruction of economy and society, by extensive international financial and technical assistance (US$ 5.1 billion). Consumption of the government and donor funds was directed to reconstruction of infrastructure and housing projects, and to establishment and strengthening of key bodies and institutions of governments of the state and entities, so that they might bear responsibility for implementation of basic economic, political, and social reforms. In the period from 1996 to 2000, high rates of economic growth were achieved, which in some countries exceeded 20 %. However, the socioeconomic structure, which is dominated by industry and mining and the undeveloped primary sector, meant that such rates were not sustainable over the long term. Since 2000, the transition process of Bosnia and Herzegovina has been accelerated, mostly by monetary stabilization (low inflation, stable currency, and low external public debt), price liberalization, and the reform of the financial system. In Bosnia and Herzegovina economic development in 2007 in real conditions was 6.2 %, which is the highest growth in gross domestic product (GDP) in the past 5 years, and its average growth rate in this period was 5.2 %, in Bulgaria 5.6 %, in Serbia 5.5 %, in Romania 5.2 %, in Albania 5.0 %, in Croatia 4.6 %, in Macedonia 4.0 %, and in Montenegro 4.0 % (Table 21.1, Fig. 21.1).

Despite an absolute and relatively slow growth of the numbers of employed people, more complex economic development has generated a strong socioeconomic

Table 21.1 Regional comparison of gross domestic product (GDP) growth rate in 2007

Country	Growth rate of real GDP (%)	PPP/per capita GDP (USD)
Bosnia and Herzegovina	6.2	7,168
Bulgaria	5.6	8,026
Serbia	5.5	5,348
Rumania	5.2	8,413
Albania	5.0	4,929
Croatia	4.6	12,336
Macedonia	4.0	6,767
Montenegro	4.0	–

Source: World Economic Outlook 2006/MMF
PPP purchasing power parity

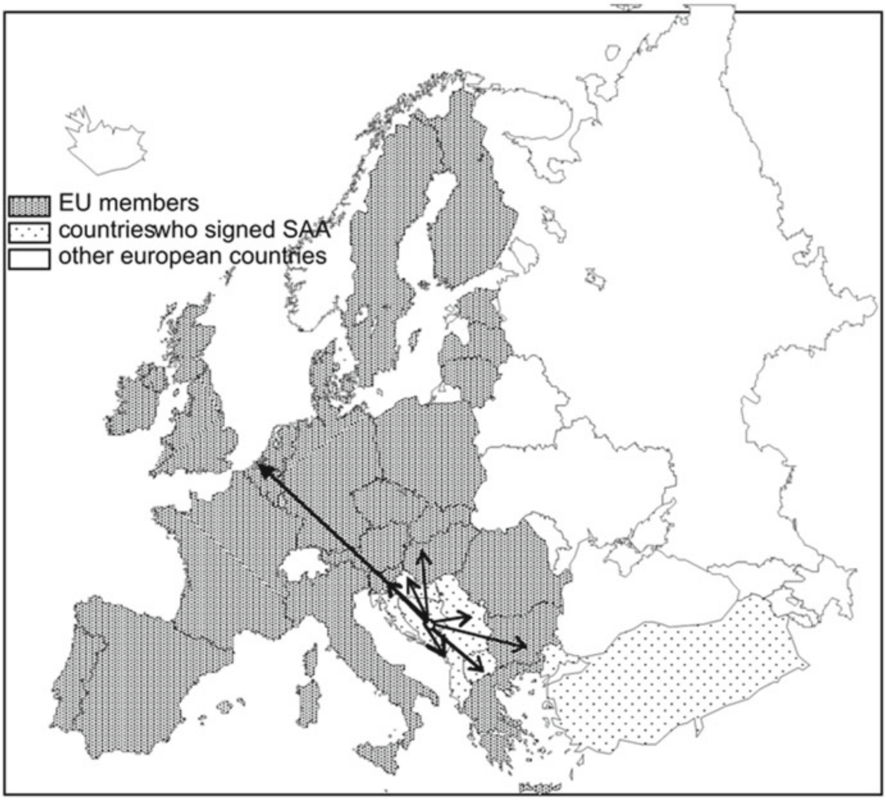

Fig. 21.1 Bosnia and Herzegovina and the United Europe

transformation. On the one hand, it is reflected by an intensive process of deagrarization, and on the other hand, by corresponding increase in number and share of employed people in activities of the secondary and tertiary sector. A fundamental "push factor" of social restructuring of the farmers was a stagnation of agriculture, which can also be seen from the lowest average annual growth rate of primary sector (1.6 %), twice as low as the average of total economy of Bosnia and Herzegovina (3.7 %) in 1991–2008. On the other hand, a superfluous agricultural population was obviously attracted by more dynamic growth of propulsive non-agricultural activities. This point is proved by the data on average annual rates of national income, secondary (4.0 %) and tertiary sector (4.4 %), in the period 1991–2008.

Compared to its regional partners, the economy of Bosnia and Herzegovina has the highest rate of real GDP in the region. However, the EBRD data on GDP, calculated according to purchasing power, show that GDP of Bosnia and Herzegovina per capita was USD 7.168 in 2007. The method of parity of purchasing power is more useful for comparison of standard of living between the countries, because it takes into consideration both costs of living and inflation. Within the context of regional development, Bosnia and Herzegovina is behind Croatia, Romania, and Bulgaria.

There are big changes in population structure and level of urbanization of Bosnia and Herzegovina. Accordingly, almost 2,000,000 inhabitants abandoned agriculture in the period 1953–2008, with corresponding consequences on the economic and social, respectively, sociogeographic development of the country. Thus, according to the 1991 census, Bosnia and Herzegovina had 16.7 % of urban population, and in 2008, the share of urban population was around 38.2 %. By means of the aforementioned models in Bosnia and Herzegovina, in 1991, and by using the census data, 5 urban settlements in which about 45 % of the population live were determined. A total of 34 urban settlements with up to 4,999 inhabitants were prevalent in the structure of the urban settlements, according to size. There were 48 medium-size urban settlements, from 5,000 to 19,999 inhabitants, and 2 urban settlements had more than 100,000 inhabitants. At the same time, 16.72 % of the urban population, 38.2 % of the total population, lived in 5 of the largest urban settlements of Bosnia and Herzegovina (Table 21.2).

In general, if we analyze the particular towns of Bosnia and Herzegovina as a unique urban system, we will reach edifying results. In order of size of urban settlements indicating hierarchical features of urban system, a certain irregularity is noticed, which was also present in the urban development of Bosnia and Herzegovina in previous periods. The first point noticed in order of size of urban settlements of Bosnia and Herzegovina is that Sarajevo, Banja Luka, Tuzla, Mostar, and Zenica, as the biggest urban settlements, are oversized compared to the others. There are unequal dynamics of increase in total population and urban population, as well as differences between single central settlements and the communities of municipalities in Bosnia and Herzegovina (Vrišer 1983, p. 129).

The highest growth of total population in the period from 1981 to 1991 was Sarajevo + 74,912 or 12.4 %; Zenica + 32,458 or 65.5 %; Banja Luka + 15,678 or 15.4 %; Tuzla +18,679 or 28.6 %; and Mostar +12,438 or 19.6 %. In 1991, large industrial centers of work were dominant in Bosnia and Herzegovina. Stronger cen-

Table 21.2 Structure of urban population of Bosnia and Herzegovina (BiH) in 1991 according to size of urban settlements

Size of urban settlements	Number of urban settlements	Percent of total	Population	Percent of urban population BiH	Percent of total population BiH
100,000 and more	2	2.1	279,400	16.7	6.3
20,000–99,999	10	10.6	743,985	44.4	16.9
5,000–19,999	48	51.0	541,651	32.3	12.3
2,000–4,999	34	36.1	107,819	6.4	2.4
Total	94	100.00	1,672,855	100.00	38.2

Source: Statistical yearbook of Bosnia and Herzegovina, Sarajevo 1991

ters of work had a special importance for the development of continuous urbanized zones. According to our analysis, these are the centers with 20,000 or more employed people. There were five such centers in 1991. Sarajevo is the biggest center of work, with more than 184,674 or 46.9 %; Banja Luka has 65,026 or 16.2 %; Zenica has 54,991 or 13.7 %; and Tuzla has 51,852 or 12.9 % of the total employed population in Bosnia and Herzegovina.

21.4 Modern Regional Development of Bosnia and Herzgovina

Regional developmental differences are the problem of the whole world. The European countries are also more and more unevenly developed, and thus developmental differences exist among different regions. Regional developmental differences in Bosnia and Herzegovina are characterized by regional polarization of population and function. If we discuss the importance of the share of active population by sectors of activities in regional centres, we will notice considerable differences. These differences originate from a number of factors, the most important of which are level of development and orientation to particular activities, which depend, in part, on stocks of particular natural resources. This aspect is best shown on examples in Bosnia and Herzegovina in which coal ensures more than 50 % of total energy consumption. It may be expected that future regional development will be carried out through the spatial plans.

Transition, the processes of economy and society restructuring, respectively, in Bosnia and Herzegovina, as a whole, are ongoing very intensively, but also under significantly deteriorated and special conditions. The standard transition package, applied more or less in most of the post-communist countries, was completed by the World Bank and the International Monetary Fund in line with the principles of neoclassical economic ideology. In transition from the post-communist to the market system, Bosnia and Herzegovina uses its significant natural-geographic traffic, as

Table 21.3 Share of active population (in %) in primary, secondary, and tertiary activities according to census from 2006 to 2008 in Bosnia and Herzegovina

Sectors	2006 (%)	2007 (%)	2008 (%)
Primary sector	3.1	2.7	2.7
Secondary sector	36.8	32.2	33.4
Tertiary sector	60.1	65.1	63.9
Total	100	100	100

Source: The State Agency for Statistics of Bosnia and Herzegovina in Sarajevo, March 2008

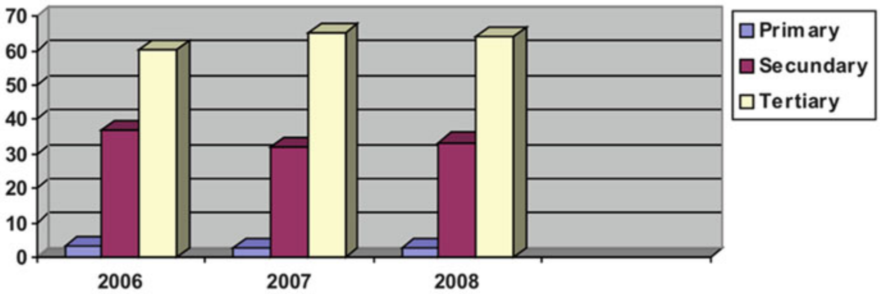

Fig. 21.2 Active population share (in %) in Bosnia and Herzegovina in primary, secondary, and tertiary activities according to the census from 2006 to 2008

well as demographic advantages. However, these processes were significantly slowed down and deteriorated by the Balkans war crisis from 1991 to 1995. In this context, the first private accumulation of capital is developing the fastest in fields of commerce, tourism and catering, finances, and intellectual services and the like, with considerably slower restructuring of industrial production, where a very strong dominance of state ownership and control is still present at the transition stage. In such economic circumstances, the processes of deagrarization, urbanization, deruralization, and restructuring of population toward tertiary and quaternary activities have been noticeably slow in the past years (Table 21.3, Fig. 21.2).

The socioeconomic orientation of Bosnia and Herzegovina was presented through analysis of employment by sectors. In 2006, the largest share of active population in Bosnia and Herzegovina was in the tertiary sector: 61.1 %. The secondary sector followed with 36.8 %, and the primary sector had 3.1 %. In 2008, there were 488,976 or 63.9 % of active population in the tertiary sector in Bosnia and Herzegovina, in secondary sector 1,990,060 or 33.4 %, and in primary 19,160 or 2.7 % of total active population. The secondary sector also represented the most developed activity in all municipalities of Bosnia and Herzegovina, although the share of employed population was reduced by 3.23 % compared to 2006, and in tertiary by 1.5 %. In 1999, the tertiary sector recorded increase in the active population share in the Tuzla valley by 7.1 %, the highest in the municipality of Banovići by 19.3 %, then Lukavac 15.4 %, Živinice 7 %, Tuzla 3, 3 %, and Kalesija by 2.8 %. The economic crisis that began after 1981 reflected most expressively on industry, which still had a primacy over all activities. At the end of 1991, closing down of industrial firms and dismissal of workers in mines and the chemical industry of Tuzla, Lukavac, and Živinice occurred (Nurković 2004, p. 16).

The focus of polarized development is the urban agglomeration of Sarajevo, respectively, the broader socioeconomic region, in which the dynamic processes of social-geographic transformation are ongoing under the influence of the leading Bosnian urban center. At the level of regions, such is the developmental plan of Sarajevo, in which more than 20 % of total population, about 18 % of the employed people and even two thirds, 67 %, of all investments in the long-term property of Bosnia and Herzegovina, are concentrated. The spatial plan of Bosnia and Herzegovina was prepared on the basis of methodology that has envisaged, among other matters, the sector, home, and regional line. Regionalization in Bosnia and Herzegovina did not exist, and in preparation of the plan the so-called planned regions were used. No special models were used in preparation of the plan, except some standard methods and techniques such Lorry's and the gravity models. It has been determined in the research that natural-geographic features had the greatest influence on the spatial arrangement of Bosnia and Herzegovina (Fig. 21.2).

In 2000, Bosnia and Herzegovina started to differentiate functionally as well. This change relates, first of all, to expansion of tertiary activities and infrastructure in suburbanized settlements. In their development in the period 1991–2008, the urban cores of Bosnia and Herzegovina acquired a character of relative decentralization. Suburban settlements express a tendency of faster increase in population numbers. These settlements experience stronger and stronger functional transformation because of the expansion of industrial firms. According to the mentioned model, more and less intensely urbanized settlements and rural settlements have been separated. All settlements that do not meet the mentioned criteria in the model have been included in a separate group. The status of town was gained by settlements with more than 2,000 inhabitants, less than 10 % of agricultural population, and with more than 50 % of workers in their place of living, although it has fewer than 10,000 inhabitants. After adoption of the spatial plan of Bosnia and Herzegovina in 1991, a very broad process of preparation of spatial plans for municipalities was begun, and a certain number of spatial plans for special areas were prepared as well (Fig. 21.3).

Apart from Sarajevo, the leading centers of polarization are also the macro-regional centers of Banja Luka, Mostar, and Tuzla, of which these towns are functional foci. Similarly, even more expressed disproportion between number of population, investments in long-term property, and number of employed people is also present at the regional level. Thus, according to demographic concentration and investments, four regions are distinguished in spatial plans: Sarajevo, Mostar, Banja Luka, and Tuzla. At the same time, a positive correlation between the analyzed indicators of polarized development of the regions and demographic development of the main core settlements is obvious. So, the leading centers of the regions preva-

Fig. 21.3 Modern regional development of Bosnia and Herzegovina

lent in polarization of population and functions in most cases are the demographically developed regional centers. By polarized development of population and function, specificities of regional development are seen in different functional orientation of regions, maintained by the socioeconomic structure of the employed population (Vresk 1981, 203).

21.5 Conclusion

Transition, the processes of economy and society restructuring in Bosnia and Herzegovina, respectively, in general, is ongoing very intensely, but also under significantly deteriorated and exceptional conditions. The standard package of transition, applied more or less in most of the post-communist countries, was completed by the World Bank and the International Monetary Fund (IMF), in accordance with principles of neoclassical economic ideology. With the transition from the post-communist to the market system, Bosnia and Herzegovina uses its substantial natural-geographic, traffic, and demographic advantages. However, these processes were significantly slowed and hindered by the Balkans war crisis from 1991 to 1995. Reforms of the socialist economy in Bosnia and Herzegovina have begun by establishing macro-economic stabilization, which was positioned as a strategic precondition for further reforms. This condition anticipated the problems of inflation, on which IMF particularly insisted, and introduced a set of monetary financial measures: restrictive monetary politics, convertibility of currency, financial discipline, and firm budgetary restraints. In 1996–2000, high economic growth rates were achieved, which in certain years exceeded 20 %. However, because of the socioeconomic structure, dominated by industry and mining and the undeveloped primary sector, such rates were not sustainable in the long term. Since 2000, the transition process of Bosnia and Herzegovina has been accelerated, mostly because of monetary stabilization (low inflation, stable currency, and low external public debt), price liberalization, and the reforms of the financial system. In 2007, economic development of Bosnia and Herzegovina increased, in real conditions, by 6.2 %, which is the highest increase in GDP in the past 5 years. Its average growth rate in this period was 5.2 %, in Bulgaria 5.6 %, in Serbia 5.5 %, in Romania 5.2 %, in Albania 5.0 %, in Croatia 4.6 %, in Macedonia 4.0 %, and in Montenegro 4.0 %.

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Part IV
Nature Protection, Conservation and Monitoring

Chapter 22
Applying Integrated Nature Conservation Management: Using Visitor Management and Monitoring to Handle Conflicts Between Winter Recreation and Grouse Species in Berchtesgaden National Park

Sabine Hennig and Michaela Künzl

Abstract Modern nature conservation management needs to interface between recreational interests and the objectives of conservation. Here, visitor management has a key role. However, the successful implementation of measures, which today need to be holistic, interdisciplinary, and moreover multidisciplinary (i.e., integrated), depends on well-founded data on recreational use and on nature. The data are usually provided by visitor monitoring, which ideally combines data collection methods as well as computer-based data handling methods (data modeling, statistical and spatial analysis, visualization etc.). By leveraging GIS, this approach allows identifying and characterizing (existing or possible) impacts of recreational use on the natural ecosystem.

However, combining visitor management and visitor monitoring as well as data collection and computer-based, data handling methods can often be improved to provide a basis for elaborating integrated management strategies. The questions is: How does the integration of visitor management and monitoring as well as the interplay of data collection and computer-based data handling methods appear in practice?

For European mountain protected areas, this is of special importance because mountain regions such as the Alps, the Carpathian Mountains, and the Balkan Mountains are, on the one hand, most important recreational destinations; on the other hand, these are regions that, because of their spectacular scenic beauty and

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high biodiversity, are a primary target of nature conservation activities in Europe. In response to this demand, this paper aims at answering the afore-outlined question, focusing on handling winter recreation and wildlife protection in the Alpine Berchtesgaden National Park (Germany).

Keywords Protected areas • Nature conservation • Visitor management • Visitor monitoring • Ecological impact and conflicts • Wildlife disturbance • GIS

22.1 Introduction and Background

Nature is a very important place for recreation. Being in natural surroundings and enjoying nature is one of the most popular ways to spend leisure time (see e.g. Opachowski 1999; Eagles et al. 2002). The literature outlines that, in particular, nature-based recreation has gained increasing interest in recent years. As a result, ever more people spend their spare time in nature enjoying diverse nature-based recreational activities, such as traditional (trekking, hiking, biking, etc.) as well as modern sports (Nordic walking, e-biking, etc.).

Areas of previously unspoiled nature are more frequented by visitors. In terms of temporal use patterns, people start their activities earlier in the morning and stay longer at night. This development is associated with a higher level of environmental impact such as habitat degradation, loss and fragmentation, as well as wildlife disturbance (Ingold 2005; Manning 1999; Scheuermann 2005).

Hence, in areas of concern this situation and the changes in recreational use, with their related effects on nature, must be considered carefully. Management measures are required that on the one hand treat recreation in accordance with the needs of nature and nature conservation and, on the other hand, recognize recreational demands while considering nature conservation issues.

To address this, integrated nature conservation management strategies are considered most useful. Integrated management, being described as holistic, interdisciplinary, and moreover multidisciplinary, encompasses methods and instruments originating from very different fields into one consistent structure or framework. It aims at examining different requirements coming from diverse points of view. In doing so, it provides a clear picture of all aspects of an organization or system, how these aspects affect each other, as well as associated risks, impacts, and conflicts. By using synergies and by concentrating resources, integrated management enables more efficient measures. At that, integrated management is a challenge to conventional practices, attitudes, and professional certainties, because it confronts (entrenched) sectoral interests and requires that resources are managed holistically for the benefits of all (Scheffler 2010).

Regarding the conflict between nature and recreational use, the application of integrated management strategies is of particular interest. As this approach is holistic, interdisciplinary, and moreover multidisciplinary, it supports people

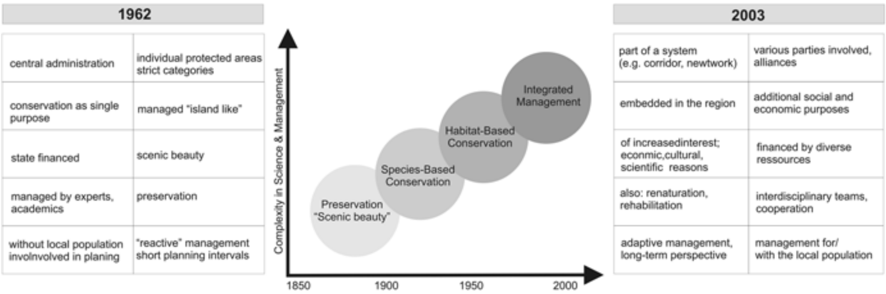


Fig. 22.1 Nature conservation concepts and their change over time (Adapted from Brüggemann 2004; Job et al. 2003)

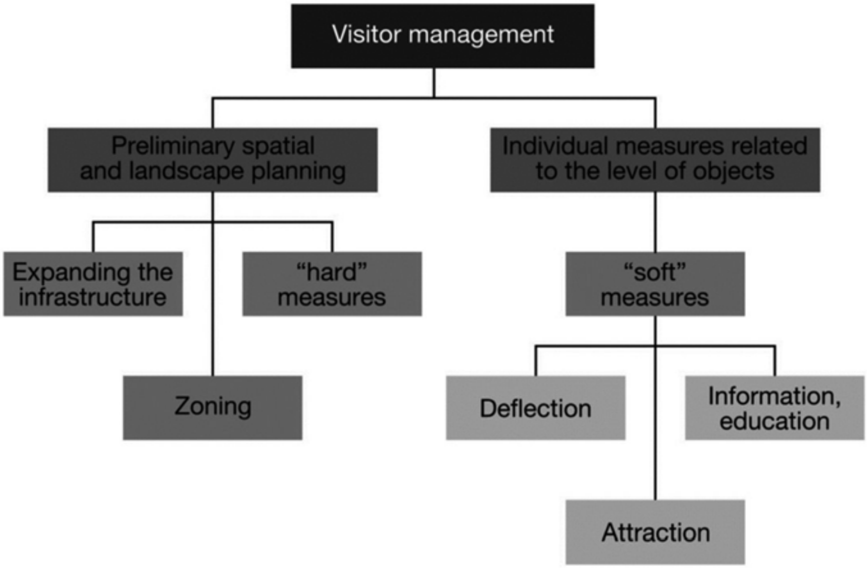
responsible to do justice to the requirements of nature conservation and recreation as well. To underline this, Fig. 22.1 shows changes in nature conservation management over time and compares conventional and integrated management.

To develop integrated management strategies regarding recreational use in protected and natural areas, visitor management is applied. Visitor management is a relatively new field of activity for handling demands of nature conservation as well as recreation toward sustainable development. It has emerged since the second half of the twentieth century, responding to the rapid growth and changes in the field of (nature-based) recreation. Today, it has become an ever more important aspect in protected area management.

Visitor management elaborates appropriate (integrated) measures (Fig. 22.2) balancing the ecological and social benefits and disadvantages that visitors bring (Newsome et al. 2004). However, it must be borne in mind that each recreational activity is different, as refers, for instance, to spatiotemporal use patterns, target groups, and required infrastructure. Further, each activity impacts the environment in a different way. Accordingly, visitor management needs to apply measures that address each recreational activity due to its impact, use characteristics, and target group.

The development of appropriate visitor management measures requires well-founded and up to date data, and an extensive understanding of recreational use and nature. Consequently, an essential part of visitor management is visitor monitoring (Worboys et al. 2005). Visitor monitoring entails the systematic and ongoing collection and analysis of data related to (nature-based) recreation, as well as on motives, needs, and conflicts involved. Thus, data gathered and analyzed can be quantitative, such as number and spatial distribution of the visitors, as well as qualitative, such as visitor characteristics and visitor behavior.

Visitor monitoring does not mean data collection for its own sake. It aims to assess and evaluate the recreational use made of an area in a targeted fashion, taking all aspects into account that relate to recreation as a whole, be they social, ecological, economic, or management related. At that, doing visitor monitoring, first and foremost, asks for clearly formulated objectives, concrete questions, and



Infrastructure:
siting, quality, and capacity of (recreational) infrastructure on site, sufficient parking near attractive grounds, provision of additional attractive features on site etc.
Zoning:
spatial-functional differentiation of areas ranging from intensive tourist use to „taboo“ spaces, spatial segregation of functions in terms of a differentiated infrastructure provision that includes not opening up ecologically endangered areas etc.
„Hard“ measures:
orders, bans, fines, commercial restrictions, user fees etc.
Deflection:
targeted landscaping, screening fences, ditches, wooden barriers, renaturation of trails, low wooden boards or round wood along the trails, fences etc.
Attraction:
attractively designed, well-kept and well-marked trail networks, playgrounds, BBQ sites, shelters, inns, viewing points, information centers, attractions along trails, themed guided walks (supported by digital devices), geocaching, educational trails with 2nd generation information boards etc.
Information/ education:
information folders (with suggestions for walks and hikes, and sketched maps, information on nature), books, special walking maps from which environmentally sensitive areas are omitted, seminars, events, talks, presentations, training multipliers, information campaigns in the media, signpost, information boards, educational trails, use of modern ICT (e.g. social media mobile apps leveraging GPS and location-based services) etc.

Fig. 22.2 Selection of visitor management measures (Adapted from Ausschuss für Bildung, Forschung und Technikfolgenabschätzung im deutschen Bundestag 2002; Hennig et al. 2013; Hennig and Großmann 2008; Job 1991; Scharpf 1998; Schemel and Erbguth 2000)

well-defined management expectations (Arnberger 2007; Muhar et al. 2002; Newsome et al. 2004).

Visitor monitoring, therefore, makes use of numerous data collection methods. Further, the use of computer-based data handling methods (storage, processing, analysis, visualization, modeling, simulation, etc.) is commonly acknowledged (Arnberger 2007; Hellmuth 2007; Manning et al. 2005). However, although it is fundamental to elaborating integrated management strategies, combining visitor management and visitor monitoring as well as data collection and computer-based data handling methods can often be improved. But, how does the integration of visitor management and monitoring as well as the interplay of data collection and computer-based data handling methods look in practice? This is presented by an example of visitor management and visitor monitoring in the Alps, that is, Berchtesgaden National Park.

22.2 Study Area and Study Objects

The Alps are not only (still) a relatively intact large ecosystem of international meaning, but also provide some of the most important tourism and recreational sites in Europe (Bätzing 2003). On the one hand, tourism and recreation are among the main economic factors for many Alpine regions; on the other hand, they have significant negative effects on this mountain range, because we see several changes in recreational use as just outlined. In consequence, according activities are becoming more and more opposed to existing nature conservation objectives.

In the Alps, especially, winter recreation has steadily gained interest during the past years. Particularly in the Bavarian Alps, ski-touring and snowshoeing are now attracting growing attention. This region, which is easily accessible from nearby and densely populated areas (e.g., Munich, Rosenheim, Augsburg), is very popular for winter recreation by the people living there. In some cases this has a negative effect on the environment, calling for management measures.

A prominent example, which requires management solutions, refers to the impact of ski-touring and snowshoeing on grouse species. For several reasons, management initiatives should focus on grouse species native to the Bavarian Alps.

Investigations on grouse population dynamics indicate negative trends. Today, all four grouse species native to the Bavarian Alps are designated as endangered species (Marti 2002; LWF 2005). They are listed in the Bavarian Red List (RL-BY) and the Conservation of Wild Birds Directive of the European Committee (VS-RL). In addition to other factors, this results from the degradation, fragmentation, and loss of habitat. Further, grouse are regarded as species with a high degree of sensitivity to disturbance, which is why experts draw special attention to the growing danger of disturbance by those enjoying recreation during winter season (time of year described as an energetic bottleneck for most wildlife) as well as spring (reproduction time with courtship and breeding, a key phase for species survival) (Bezzel et al. 2005; Marti 2002; Zeitler 2005). Moreover, for a number of other species grouse serve as umbrella species, and thus they have a key role in nature conservation work.

For developing and implementing prototype conservation management programs such as integrated management strategies (i.e., considering both recreational use and nature conservation) and evaluating their usefulness, large protected areas such as national parks are particularly suitable. These areas are mainly managed for conservation, scientific research, environmental education, recreation, and tourism (see IUCN Management Categories). According to their management objectives, *conservation* and *recreation*, especially national parks demand scientific research to provide management solutions that interface between the two concerns. Thus, Berchtesgaden National Park located in the Bavarian Alps is a satisfactory study area to develop an integrated management program example that takes into account wildlife (notably, grouse species) and winter recreation (such as ski-touring and snowshoeing).

22.2.1 Berchtesgaden National Park

The study area, Berchtesgaden National Park, is situated in the southeast of Germany. The only German Alpine national park (accepted by the IUCN as management category II) covers an area of about 21,000 ha. Ranging in altitude from 600 m a.m.s.l. (Lake Königssee) to 2700 m a.m.s.l. (peaks of the Watzmann Massif), the national park contains three elevation zones: the montane, subalpine, and alpine zone. As a natural landscape unit, Berchtesgaden National Park is part of the Northern Limestone Alps. It provides a home to numerous species of birds, plants, and other wildlife, including also several endangered species.

As one of the oldest holiday destinations in the Alps, the whole region, "Berchtesgadener Land," has a long history of tourism and recreational activities. Both are also today major functions in the area.

The natural world and spectacular Alpine scenery are what attract people to visit the region. Landscape attractions are viewing points, alpine meadows, wildlife observation points, and lakes. Further, the protected area provides about 240 km of official, marked trails, numerous visitor facilities, and services such as six national park information centers, nine Alpine huts, several options to stop for a bite to eat, and places to rest (Fig. 22.3).

Currently, more than 1.3 million people visit Berchtesgaden National Park every year, mostly in summer for activities such as walking, hiking, and mountain biking. However, visitor numbers are steadily growing, one reason being the increasing interest in winter recreation and related activities such as tobogganing, snowshoeing, and ski-touring (BayStMLU 2001; Job et al. 2003).

22.2.2 Winter Recreation: Ski-Touring and Snowshoeing

Winter activities, and in particular ski-touring and snowshoeing, have become very popular in recent years. In previous years, when performed only by a few people, both were classified as "ecologically tolerable."

Today, ski-touring is considered a major sporting activity, and snowshoe sales and expert observations show that interest in both activities has been growing remarkably (Scheuermann 2005; Zeitler 2005). Consequently, both are seen to cause environmental conflicts to a greater extent for several reasons:

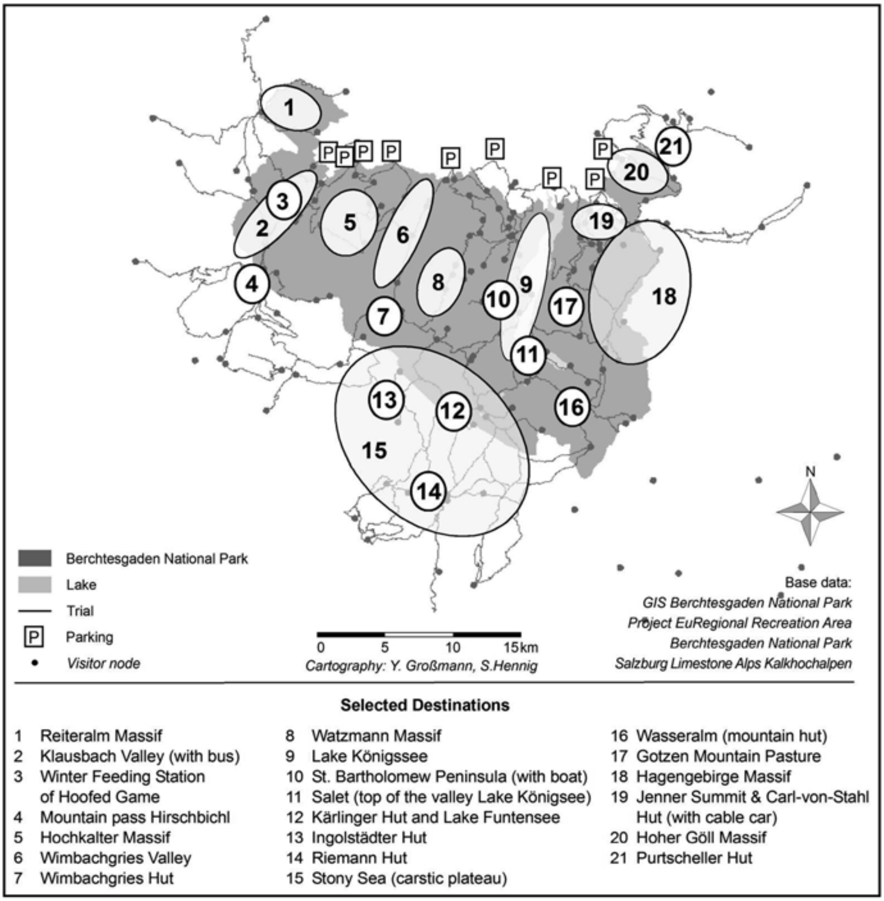


Fig. 22.3 Selected nature and landscape attractions in Berchtesgaden National Park and bordering regions

(i) Increased number of recreationalists
(ii) Changed temporal use pattern (earlier arrival, leaving later, etc.)
(iii) Expansion of the area used (mainly because an increasing number of people are taking part in these activities)

Moreover, ski-touring and snowshoeing, do not, as most summer recreational activities do, rely on specific man-made infrastructural elements (e.g., trails). In consequence, winter recreationalists cannot be guided and managed by leveraging infrastructure, that is, by providing a trail network tailored to the management needs of the respective area. Where visitors do ski-touring or snowshoeing usually depends, for instance, on their personal ability (skiing skills, fitness), snow situation, weather conditions, and avalanche risk. Basic information on both activities is provided in Table 22.1.

Table 22.1 General characteristics of ski-touring and snowshoeing (Ingold 2005; Scheuermann 2005)

	Ski-touring	Snowshoeing
Description	Ascents: physically exertive; descents: demand for large hill areas for ski run	Easy to learn, space intensive, off the beaten track
Reason	Access to winter landscape, physical exercise, nature experience	Solitude, nature experience, unspoiled nature (without any infrastructure)
Spatial distribution	In all elevation zones: valley to summits	Montane zone (below forest line), terrain without steeps
Abilities	Ability to ski off-piste, good navigation skills, good awareness of the risks of mountain environment in winter (e.g., avalanches)	
Season	November to May, peak season February to mid-April	January to March
Daytime	After daybreak to afternoon	Morning to late afternoon
Development	Strong increase: 70,0000 persons in the year 2000; 300,000 persons in the year 2005; with ongoing trend	Strong increase during recent years; alternative because of insufficient snow and for non-skiers

22.2.3 Wildlife: Grouse Species

There are four grouse species at home in the Bavarian Alps: (i) hazel grouse (*Bonasa bonasia*), (ii) rock ptarmigan (*Lagopus mutus*), (iii) black grouse (*Tetrao tetrix*), and (iv) capercaillie (*Tetrao urogallus*).

The four grouse species not only have very diverse habitat requirements but also are found in different elevation zones (Table 22.2). Depending on seasonal changes as well as different phases of life, specific habitat structures are required by the grouse for their courtship, breeding, raising young, feeding during spring and summer, and feeding during autumn and winter (Ingold 2005; LWF 2005).

22.3 Temporal and Spatial Use Characteristics of Ski-Touring and Snowshoeing

To develop effective visitor management measures that address conflicts between winter recreationalists and grouse requires, first and foremost, determining and characterizing the particular conflict situations. Only by knowing temporal and spatial aspects of recreational use and wildlife habitat use in detail it will become apparent if, where, and when the needs of grouse and winter recreationalists intersect, that is, if, where, and when conflicts exist.

Regarding the grouse species, large amounts of data and knowledge are available, referring, for example, to seasonal habitat requirements, mode of life, disturbance

Table 22.2 Ecological niches and temporal aspects of courtship and breeding of the grouse species in the Bavarian Alps

Vegetation (elevation zones)	Grouse species	Habitat	Courtship time	Breeding time
Crevice flora Dwarf-shrub heath Alpine meadow	Rock Ptarmigan *Lagopus mutus*	Transition area forest/ open land	Middle of March to middle of May	Beginning of June to beginning of August
Alpine meadow Krummholz association with single trees	Black Grouse *Tetrao tetrix*	Transition area forest/ open land	April to May	End of May to beginning of July
Mountain pasture Wood pasture Subalpine spruce forest	Hazel Grouse *Bonasa bonasia*	Typical forest species early successional stage of forest development	Middle of March to middle of May	Middle of March to middle of May
Mixed mountain forest with beech, fir, spruce	Capercaillie *Tetrao urogallus*	Typical forest species late successional stage of forest development	Beginning of April to middle of may	Beginning of May to middle of July

behavior in terms of response time, escape distance, and length (Ingold 2005; Künzl 2007; LWF 2005; Preuss 2005).

Concerning winter recreational activities, there is still a lack of information (e.g., number of ski-tourers and snowshoers, their spatiotemporal distribution, and spatiotemporal use patterns). Thus, visitor management decisions focusing on these activities are frequently based on estimates and generalizations.

In Berchtesgaden National Park, for providing information on spatiotemporal use patterns of ski-touring and snowshoeing data collection by visitor monitoring methods, and computer-based data handling methods (e.g., data management leveraging appropriate adequate data models, spatial and statistic data analyses, visualization) were central tasks. For digital data handling, GIS was used.

22.3.1 Visitor Numbers and Temporal Use Characteristics

In Berchtesgaden National Park, detailed data on ski-touring and snowshoeing were collected using common visitor monitoring methods, as described by Arnberger 2007; Hennig 2013, Muhar et al. 2002, and others:

(i) Counting parking ticket sales for information on visitor numbers (parking meters at six parking areas serving as starting points of both recreational activities: 2000–2012),

(ii) Observations by four time-lapse video systems for information on visitor numbers and modal split regarding recreational activities (at two starting points and two sites located in the park area: 2005–2006),
(iii) Observations and counting by personal random sampling for information on visitor numbers distinguished by the performed activity (at one starting point and two sites located in the park area: 2005–2006),
(iv) Expert knowledge gained through interviews with park rangers, alpine hut hosts, mountain guides, and literature research (continuously).

The data collected and analyzed reveal several new aspects regarding ski-touring and snowshoeing in Berchtesgaden National Park:

(a) Winter recreation shows steadily growing visitor numbers during the past few years.
(b) An explicit peak season, as typically outlined in the literature, does not exist; from the moment snow of sufficient depth and adequate conditions (e.g., no or low avalanche risk) is available, winter recreationalists can be observed on site.
(c) During the season, usually there is not one day without any ski-tourers being active in the area, regardless of weather conditions or avalanche risk.
(d) On peak days, in some areas of the national park the number of ski-tourers increased to 400; this number is almost the same as the number of daily hikers and bikers in some areas in summer season.
(e) Ski-touring is no longer an activity performed from early morning until afternoon as commonly stated in the literature (compare Table 22.1) as affordable technical equipment and interest in "night tours" and "moonlight tours" (regular's table at alpine huts) has steadily grown in the past years.

Based on the data collected as well as use characteristics of ski-touring and snowshoeing (daylight, temperature, snow conditions, avalanche risk, etc.), temporal use characteristics (concerning day, season) were derived (see Table 22.3).

22.3.2 Spatial Use

Spatial information on ski-touring and snowshoeing routes is generally available by sources such as maps and literature (e.g., tour guides). Regarding Berchtesgaden National Park, spatial data (gathered through expert interviews, and GPS mapping on site; Preuss 2005) are also held in the GIS of the national park administration. Thus, we identified 20 (main) ski-tours (including variations) in Berchtesgaden National Park (Fig. 22.3).

However, considering the peculiarities of both activities (e.g., not relying on existing trail networks), it is necessary to apply a particularly developed approach that provides spatial data suitable to identify and describe conflicts with the grouse in detail. This is outlined next regarding ski-touring.

Table 22.3 Temporal use aspects of ski-touring and snowshoeing (daytime–season matrix)

	05:00–08:00	08:00–14:00	From 14:00 until nightfall
November to mid-February		Ski-touring, snowshoeing	Ski-touring, snowshoeing
Mid-February to March	Ski-touring	Ski-hiking, snowshoeing	Ski-touring, snowshoeing
April to May	Ski-touring	Ski-touring	

In (analog and/or digital) maps, ski-touring ascents and descents are mainly represented by lines. Even though the individual recreationalist leaves a linear trace in the landscape when ski-touring, linear geometries do not reflect correctly the spatial use of this activity and, thus, do not meet the demands for analyzing ecological problems. More adequate solutions representing the spatial demand of ski-tourers are needed, requiring developing appropriate *spatial datamodels* based on a sound understanding of ski-touring:

Generally, where the recreationalists ascend strongly depends on landscape (forest, mountain pasture area, etc.), relief, and infrastructure (forest roads, hiking trails, etc.). So long as the terrain is more or less flat and no trees are in the way, recreationalists typically go straight ahead. As soon as the slope angles increases, ski-tourers ascending will begin doing so-called "kick-turns," which typically results in a line that climbs at a moderate angle of 20–30°, leaving a winding trace. After each snowfall, the ascent trace (in slope or steep terrain) varies depending on the person who goes there first. Others will use this trace, because tracing insnow is quite exhausting. Accordingly, the "spatial coverage" of ski-tour ascents must be considered (at least in some segments, e.g., no forest road, limitation by vegetation) being areal. Thus, polygon features are more the most suitable geometry type. Descending, people always go their own way. Accordingly, this is principally represented by areas (also in maps and tour guides). With slight changes, this concept is also applied for snowshoeing.

Based on this approach, it becomes possible to balance winter activities in the park area using GIS. For instance, about 9 % of the park area, core zone and buffer zone, are affected by ski-touring and snowshoeing. As an example, the spatial extent of ski-touring and snowshoeing at "Watzmann Massif" is presented in Fig. 22.4.

22.4 Conflicts and Integrated Management Measures

By combining information on seasonal or daily habitat use by hazel grouse, rock ptarmigan, black grouse, and capercaillie with information on ski-touring and snowshoeing (e.g., routes, temporal aspects, frequency of use), conflicts can be identified that can be individually named, characterized, and categorized based on spatiotemporal use intersection of grouse and recreationalists. Two conflict situations can be distinguished: one in winter, and one in spring. In both seasons, recreationalists pass through grouse habitat (Table 22.2).

22.4.1 Winter Season

During the winter months, ski-touring can be described as an activity that occurs throughout the entire day. Disturbances during this time cause the grouse resting in snow caves to startle and flee. In doing so, they waste precious energy reserves they would normally conserve. Nevertheless, in areas with regular presence of persons (e.g., traditional ski-touring routes), habituation can be observed (Ingold 2005).

Snowshoeing results in a completely different situation. Snowshoeing is characterized by particular use patterns mainly depending on the search for solitude, unspoiled nature, and an individual nature experience. Principally, no commonly known routes (as for ski-touring) exist, and thus snowshoers cause habitat fragmentation and disturbance to wildlife in wintertime that do not expect any human activities at all during this time of year. Because such activities do not follow any spatial or temporal pattern, grouse can rarely habituate, resulting in high disturbance potential.

22.4.2 Spring Season

In spring, depending on snow conditions (increased avalanche risk), ski-touring starts in the early morning with return around midday. At this time, during early morning hours, disturbance to grouses has serious consequences. It affects courtship, which is very disturbance susceptible. During this life-cycle phase the grouse will never habituate to disturbance. Hence, spring ski-touring deserves special attention.

Regarding the individual species, the impact on the birds differs, because the four grouse species occupy different habitats (i.e., elevation zones), and also courtship time varies (Fig.22.4).

The courtship of hazel grouse and capercaillie (middle of March to middle of May) takes places in habitats below the tree line. Less ski-touring occurs in these areas at this time of year because of spring snowmelt, and thus conflicts are fewer.

A different situation exists for rock ptarmigan and black grouse. During their courtship period (middle of March to end of May) they use habitats along and above the tree line. At just this time, ski-touring occurs at these elevations (so-called spring tours), which results in a high level of conflict between the grouse and winter recreationalists. In particular, for rock ptarmigan this involves a critical situation: in the Bavarian Alps they are currently endangered and, as outlined in the literature,

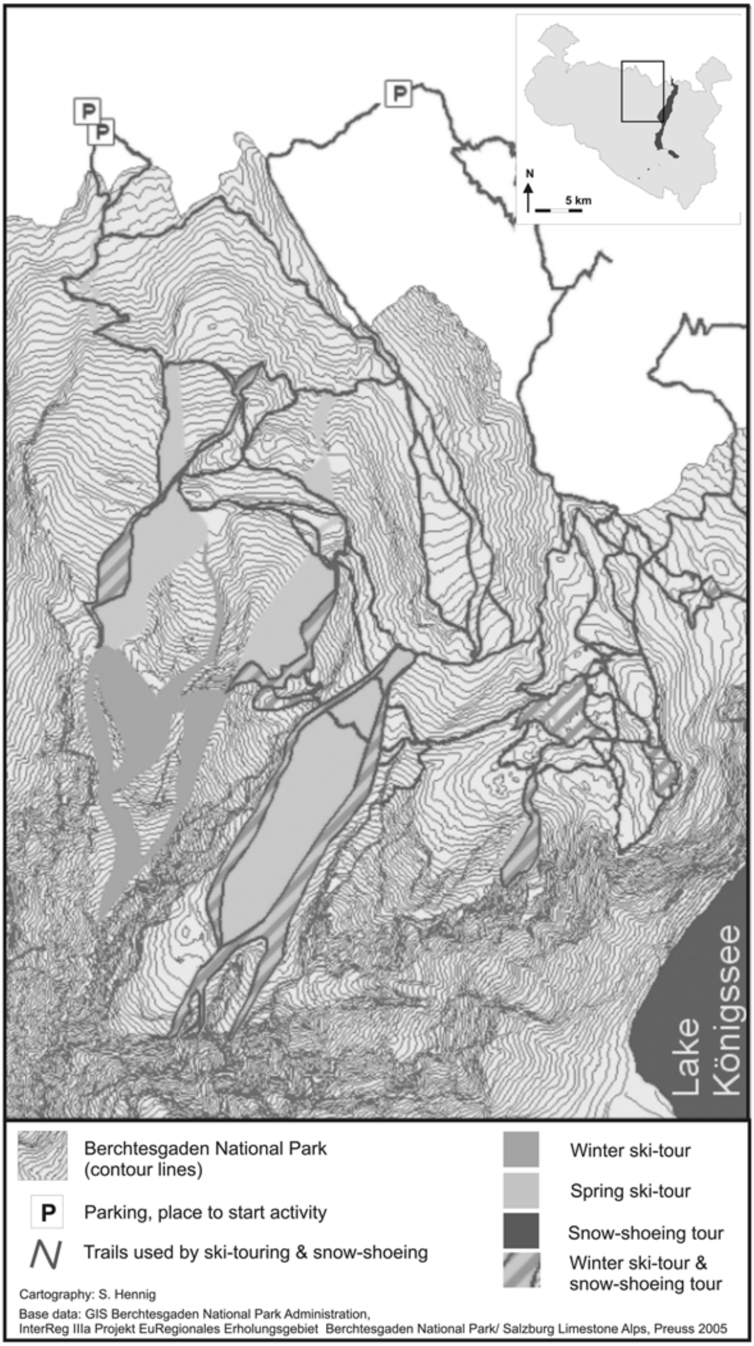


Fig. 22.4 Winter recreation at Watzmann Massif (area size, 24 km^2)

most affected by climate change. Nature conservation carries a high responsibility for this species (LWF 2005).

Finally, in the montane zone during springtime, usually there is not sufficient snow for snowshoeing and therefore conflicts are less likely.

For each conflict category and for each single conflict, individual measures have to be defined. Special attention has to be paid to suitable, practicable, and target-oriented actions. Measures must be tailored to address the individual conflict, its cause, location, and time. Particularly, modern visitor management measures such as communication (increasingly making use of modern ICT), environmental education, setting of infrastructural equipment, and stakeholder cooperation are of relevance to guide recreationalists and to concentrate activities in ecologically less critical areas (see also Fig. 22.2):

(i) The presence of park rangers on site
(ii) Information signs/boards at appropriate locations (informing visitors about nature, and the grouse, indicating where to go to causes as little impact as possible)
(iii) Vegetation clearing (providing suitable areas for ascending/ descending, and thus channeling the recreationalists)
(iv) Use of mobile apps (providing tour information as well as information on natural issues via mobile device leveraging GPS and location-based services)

Information and education measures should also lead to voluntary withdrawal of people in ecologically critical areas and at ecologically critical times. To support this, stakeholder cooperation is an important aspect. Suggestions to renouncement and behavior are more likely to be accepted in this way, as shown by projects such as "Ski-Touring Nature-Compatible" run by the German Alpine Association (Scheuermann 1999).

22.5 Outlook

Environmental impact is caused by the combination and the interaction of many different factors. Today, recreation is one of these factors. To do justice to the requirements of both the natural world and recreational use, integrated visitor management strategies are gaining interest. Spatiotemporal data that describe recreation and nature are a prerequisite to identify and characterize conflicts between the two and elaborate suitable, integrated management measures, requiring visitor monitor initiatives that apply not only data collection methods but also computer-based data handling methods.

For Berchtesgaden National Park, this chapter outlined an example for integrated visitor management with focus on spatiotemporal interaction of winter recreation and grouse species. Such management strongly relies not only on applying data collection methods, but also making use of computer-based data handling methods.

However, this is only one of many conflicts existing between recreational use and nature conservation. In Berchtesgaden National Park, impacts caused by summer recreation also exist. This demands evolving guidelines to give managers a helping hand on how to collect, manage, process, and analyze spatial, attribute, and temporal data on recreational use. Such data provide a basis to identify and describe environmental conflicts in detail, and to further establish appropriate measures. The individual but integrated handling of conflicts, keeping in mind the spatiotemporal aspects of recreation and nature, is important in the success and sustainability of nature conservation management, not only in Berchtesgaden National Park but also in other (mountain) protected areas.

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Chapter 23
Environmental Changes in the Maramureş Mountains Natural Park

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Abstract Maramureş Mountains Natural Park (MMNP) is the biggest protected area in the Romanian Carpathians, located in the north of the Eastern Carpathians along Romania's border with Ukraine. The Park displays a complex of richly forested mountain summits, a great diversity of ecosystems, and unique landscapes, which have led to its declaration as a protected area, under the Category V IUCN – Protected Landscape-Natural Park, in 2004. This chapter provides an update of the environmental changes related to the main human-induced pressures characteristic for this natural protected area. Although MMNP was declared later than other similar protected areas in the Romanian Carpathians (e.g. Apuseni Natural Park and Bucegi Natural Park, declared in 1990), its rich biodiversity, outstanding landscapes, and cultural heritage are no less significant and valuable. Therefore, the authors are seeking to identify and assess the historical and current human-induced driving forces encountered in MMNP (e.g. settlements expansion, deforestation, overgrazing, mining activities, touristic activities) that have driven the most significant environmental changes in the area (e.g. habitat, fragmentation, biodiversity loss, land use/land cover changes) to prevent their intensification and reduce their negative impact.

Keywords Romanian Carpathians • Human pressure • Environment • Maramureş Mountains Natural Park

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23.1 Introduction

Overall, the Carpathian Mountains are the largest, longest, and most twisted and fragmented chain in Europe, having its greatest extent in Romania (UNEP 2007). The Romanian Carpathians cover 54 % of the whole Carpathian Chain, stretching more than 910 km between the country's northern border (the Tisa Valley) and the Danube Defile (Sviniţa), including the Apuseni Mountains up to the Someş Valley. The average altitude is 1,136 m, the highest peaks reaching, in the Southern Carpathians, above 2,500 m. The mountainous area is fragmented into well-outlined mountain groups and massifs by transversal valleys that often follow the line of depressions or depressionary corridors (Bălteanu et al. 2006).

Similar to other post-communist countries, after 1990 Romania experienced radical socioeconomic transformations, which have brought about significant environmental changes at both regional and local levels. Thus, after the fall of the communist period, mountain areas were facing new environmental challenges in terms of increasing occurrence and magnitude of extreme weather events, biodiversity loss, habitat fragmentation, transboundary pollution, trade of endangered species, and waste management (Bălteanu et al. 2008). As a result, to protect the natural environment in the Romanian Carpathians, 22 major protected areas totaling approximately 1 million hectares, among which 12 national parks, 8 natural parks, and 2 geoparks, as well as some 600 reserves and natural monuments totaling more than 50,000 ha, were declared (Fig. 23.1) (Bălteanu et al. 2009; Geacu et al. 2012).

Maramureş Mountains are located on the northern border of Romania with Ukraine, built up on crystalline schists and flysh folds, rising up to nearly 2000 m (Farcău Peak, 1957 m) (Bălteanu et al. 2006). The massif's total surface (including the depressionary areas and border hills) covers about 150,000 ha, spreading over the northern part of the Eastern Carpathians. In 2005, the Maramureş Mountains were declared protected area, under the *Category V IUCN – Protected Landscape-Natural Park*, designated for the preservation of various distinctive landscape features such as forest-covered areas alternating with alpine meadows, unique flora and fauna developed within ecosystems that are still in equilibrium (forests, pastures, river bodies, lakes, and marshes), extended natural habitats, and a traditional way of life. Currently, the Park itself occupies 133,354 ha, ranked as the largest natural park in the Romanian Carpathians, and managed by the National Forest Administration-Romsilva. More than 70 % of the park area, excepting the built-up areas, was designated as a Nature 2000 Site within the European Eco Network–Nature 2000, namely, Special Protected Areas and Special Areas of Conservation. Moreover, among the mammals listed in Appendix II of the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive), in the park area all three large carnivore species (wolf, bear, and lynx) can be identified (Romanian National Forest Administration 2009).

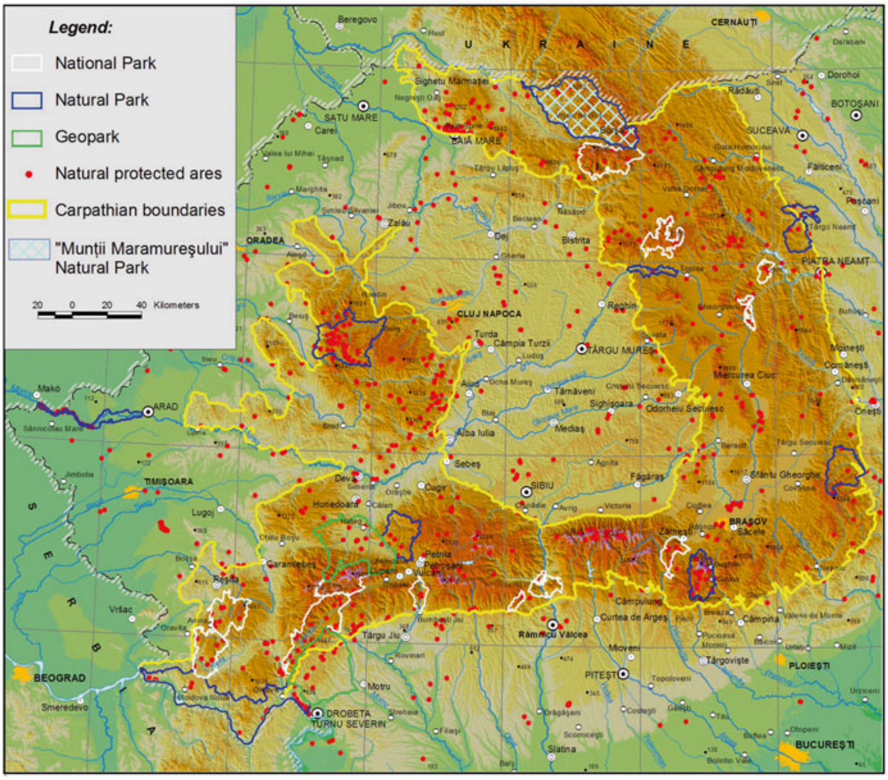

Fig. 23.1 Natural protected areas in the Romanian Carpathians

23.2 Environmental Changes in Maramureş Mountains Natural Park

The Romanian Carpathian Chain has been subjected to a wide range of environmental transformations from its long history of human influence upon its landscape, triggering a complex process of adaptation to natural and human-induced stressors. Under the current global environmental changes, the integrity of mountain systems as well as their ability to provide goods and services to the human society is becoming increasingly affected. The human impact on the mountain space has increased in intensity and magnitude during the past almost 25 years in terms of intense spatial development, land use/land cover changes, deforestation, etc. As a result, the main driving forces that trigger significant environmental transformations in the Maramureş Mountains Natural Park (MMNP) are largely related to settlement expansion, deforestation, overgrazing, mining activities, and tourist activities.

23.2.1 Settlement Expansion

The human communities in the MMNP are represented by eight small towns (Bistra, Petrova, Leordina, Vişeu de Jos, Moisei, Ruscova, Repedea, and Poienile de Sub Munte) and by two cities (Vişeu de Sus and Borşa) located mainly in the eastern areas, along the national roads and the main river streams, thus totaling nearly 80,000 inhabitants (2013). After 1990, increased human expansion triggered the growth of the inner-city built-up areas, largely in Borşa, Vişeul de Jos, and Vişeul de Sus localities because conditions were favorable for residential development, and, to a smaller extent, in Poienile de Sub Munte. More than 7,000 ha is prone to urban development, and the further extension of this area is increased by the social phenomenon of external migration, which consists of major investments of revenues provided by people working abroad. Overall, human migration resulted in significant population shrinkages during past years both inside the Romanian boundaries (especially toward the west of the country) and outside the country, mainly to France (34 %), Italy (26 %), Spain (19 %), etc. (Boar 2005) (Fig. 23.2). Moreover, nearly 35 % of the inhabitants from Borşa work abroad (e.g. in Italy, Milan), as they were required in construction and forest exploitation (Ilovan 2006). Thus, the migration phenomenon proved to be one of the leading causes of population decrease and aging (more than 80 %) (Romanian National Forest Administration 2009). The areas the most affected by the migration flows were the mining sites, especially after being shut down, thus shelving nearly 15,000 workers.

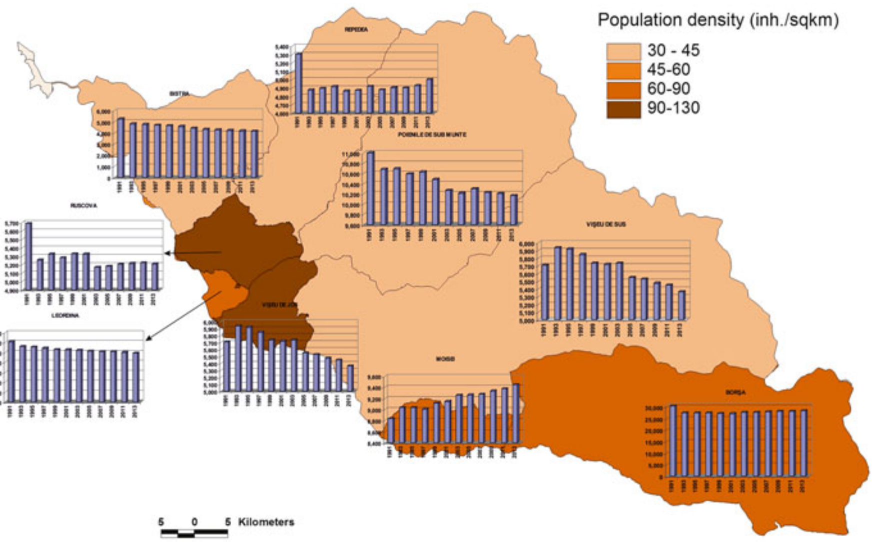

Fig. 23.2 Population dynamics in the Maramureş Mountains Natural Park (1990–2013)

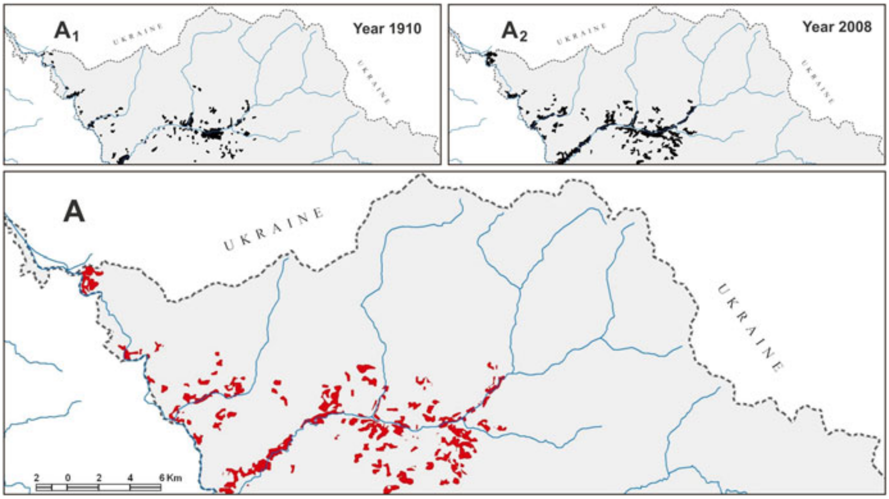

Fig. 23.3 Expansion of settlements (A) between 1910 (A_1) and 2008 (A_2) in northern part of the Maramureş Mountains Natural Park (Năstase et al. 2010)

Another important consequence of the migration process is the tendency to neglect the traditional architectural style of the area. People working abroad return to their villages of origin with new architectural approaches; some of these ideas can improve their welfare, while others go against the tradition of the area. Thus, the construction style and newly introduced materials considerably reduce the aesthetic value of the landscape and the traditional lifestyle, some of the major objectives MMNP is intended to value.

The northern half of the MMNP is characterized by settlements with an exclusive rural character (mainly focused around grazing and other agricultural activities), with households scattered on the slopes that go up to 700–800 m in altitude. Their nuclei, developed mainly in the depressionary areas, expanded over the nearby terrains in the hilly and mountain slopes that were, subsequently, subject to deforestation. In time, they have mainly evolved along the Ruscova and Frumuşeaua Rivers, as well as on the secondary streams of Ruscova River to the south of Repedea and Poienile de sub Munte settlements (Fig. 23.3) (Năstase et al. 2010).

Although the population in the study area has been subjected to significant decrease, human pressure upon natural resources is continuously growing, thus causing environmental transformations related to changes in both land use and land cover, mainly triggered by settlement expansion (urban sprawl) and deforestation.
Additional environmental consequences of the human settlement expansion are related to soil and water pollution caused by an insufficient or nonexistent water supply, the lack of sewage systems and waste management, and sawdust from the sawmills, etc.

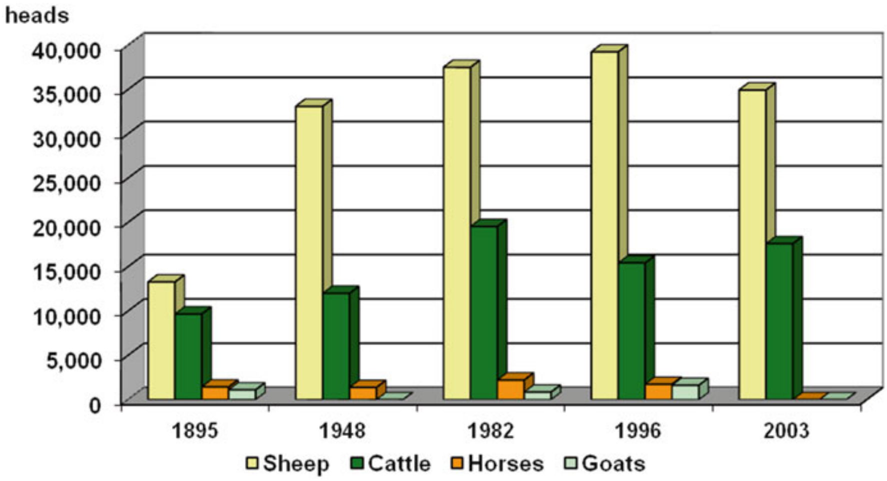

Fig. 23.4 Livestock dynamics in the Maramureş Mountains Natural Park

23.2.2 Overgrazing

The MMNP has always been an agricultural area, especially based on cattle breeding on the rich subalpine pastures and meadows. In the past 100 years, cattle (especially sheep) have tripled (34,342 heads in 2003) (Fig. 23.4), whereas, currently, as revealed by the interviews with local people, a significant decrease of the numbers of cattle and cutbacks in grazing have occurred. This situation has led the local population to assume other activities.

Intensive grazing or overgrazing has caused land degradation and, consequently, the reduction of biological diversity and pasture productivity in some areas such as Pop Ivan, Şerban, Poloninca, Paltin, Pietrosu Bardăului, Pecealu, and Bucovinca, against the dwarf mountain pine (*Pinus mugo*), thus affecting the upper forest limit.

Considering the biological importance and the scientific value of the dwarf mountain pine (Sparchez et al. 1977), in 1994 local authorities put it under strict protection. The dwarf juniper (*Juniperus nana*), another species of high ecological importance in the upper pastures, is now found only in very small areas: Pop Ivan, Şerban, Pecealu, Pietrosul Bradaului, and Farcău (Moisei 2000).

Other environmental changes related to overgrazing (Fig. 23.5) refer to habitat fragmentation by reducing the areas covered by native species (*Juniperus nana*, *Pinus mugo*, *Rhododendron myrtifolium*); biodiversity loss, such as Tisa (*Taxus baccata*), which used to cover larger areas, and is currently reduced to only two or three species because shepherds believe that its leaves (needles) are toxic for the animals (Resmeriţa 1963); and land degradation in the study area, related to gully erosion (Fig. 23.6), sheet erosion (mainly solifluctions), and shallow landslides.

Although the law forbids pasturing activities inside the forest area, the forest edges are always affected by intensive grazing and the expansion of the alpine pastures against the forest. In addition, increase in the occurrence and intensity of

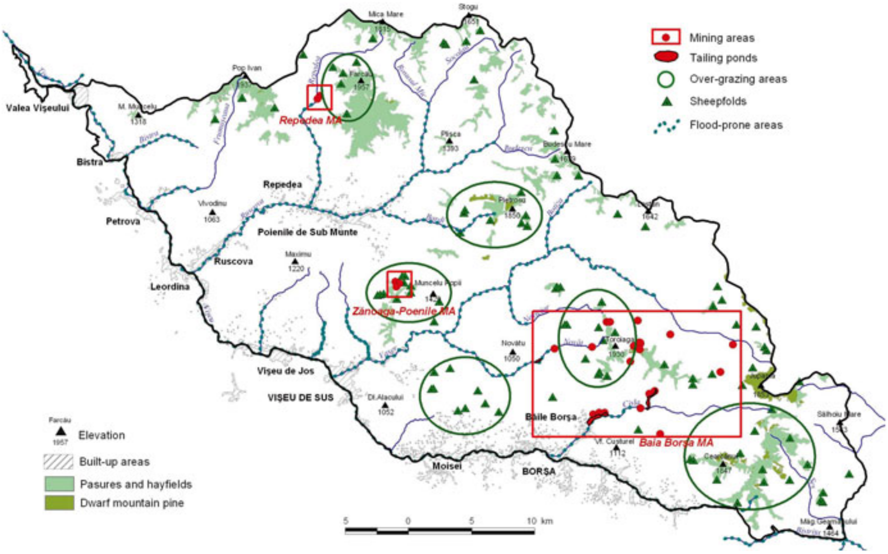

Fig. 23.5 Areas affected by mining activities, overgrazing, and floods in the Maramureş Mountains Natural Park

Fig. 23.6 Gully erosion and shallow landslides in the Vinderel Area. (Photograph by Gheorghe Kucsicsa)

flash floods is one more notable consequence of the overgrazing-driven processes (e.g. the 1998, 2000, 2008, 2010 floods that have affected basins with high torrential risk, such as Repedea/Vinderel, Socolău, and Cisla Valleys).

23.2.3 Deforestation

The forest is the main natural resource in the park area, both as ecosystem service and as a wood/non-wood products supplier, thus explaining the long tradition in timber harvesting. Given that industry is poorly developed in the Park area, the

Table 23.1 Property structure in Maramureş Mountains Natural Park

Owner	Manager	Land use category	Percent (%) of the MMNP surface
State property	National Forest Administration	Forest found	41.60
State property	Local public administrations	Agricultural land use, forest found	12.88
Legal persons (church, education units)	National Forest Administration, others	Forest found pastures, hayfields	0.43
Forest associations	Private forest district, National Forest Administration	Forest found	8.88
Private individuals	Others	Households, hayfields, forest found	36.21

Source: Romanian National Forest Administration 2009

forest economy attracts a major part of the available workforce. Apart from the industrial processing capacities, there are other traditional activities carried out by small manufacturers (e.g. sculpture, building of wooden houses and churches). Moreover, most individuals depend on wood as a heating or building material. The forest also provides non-wood resources for the local population (forest fruits, mushrooms, medicinal plants).

Under the application of the laws and administrative measures to restructure and privatize agriculture and land found after 1990, the transition from state and collective property to private ownership exposed the mountain environment to fundamental changes related to the property that triggered fragmentation of forest property and ultimately deforestation. The current socioeconomic conditions bring about the overbid of the economic function of the forest to the detriment of the protection functions that might lead to some contradictions between the conservation objectives of some biodiversity elements or landscape on one hand and the forest management plans on the other. All these particularly affect the forests that were given back to the former owners (as a result of the retrocession process) because of the lack of financial compensations for the forests with a biodiversity protection role (Table 23.1). Currently, in the northern half of MMNP, the forests cover about 45,000 ha, 1,500 ha more than in 1990.

The decrease of forest-covered areas was mainly caused by industrial exploitation of pine wood destined for the internal and external market. The areas most affected by deforestation are those located near settlements (Fig. 23.7).

Human activity in the Maramureş Mountains Natural Park always caused high pressure on woodlands, especially on beech and mixed forests. Significant human interventions on this area have begun ever since the first permanent settlements were established on the Park's boundaries and in the depressed areas, as well as along Ruscova Valley, thus giving rise to the timber harvesting activity. Notable forest logging activities were recorded throughout the feudalism period (Idu 1999). During the period from 1910 to 2006, the forest-covered area shrank by 14,500 ha, of which 4,800 was lost during the past 20 years, mainly before the establishment

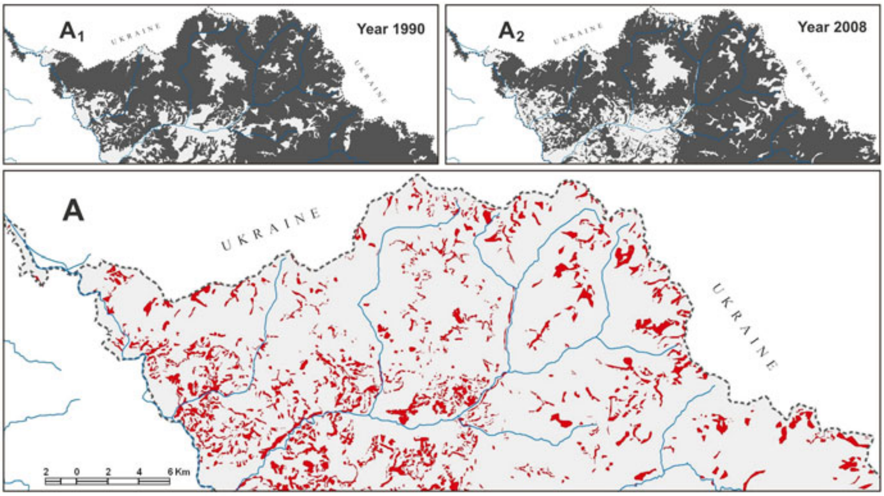

Fig. 23.7 Deforested areas (*A*) between 1990 (A_1) and 2008 (A_2) in the northern part of Maramureş Mountains Natural Park (Năstase et al. 2010)

of the protected area in 2004. Another phenomenon related to forest cutting is the uncontrolled exploitation of wood (Fig. 23.8) and inappropriate storage of leftovers (more than 90 small mills produce more than 43,000 m^3 sawdust along rivers and streams). The clear cutting with no subsequent afforestation is a rather frequent phenomenon that causes the fragmentation of terrestrial ecosystems along with forest fragmentation, thus threatening native flora and fauna whose main habitat is forest. Moreover, the removal of dead wood from the forest also jeopardizes fungi, the insect *Xylophilus*, and the habitats of moss and lichens, which are also strongly connected to the forest habitat, as well as Chiroptera and micro-mammals.

Studies conducted by the MMNP Administration revealed that the species most threatened by forest logging in the park area are the black stork (*Ciconia nigra*), the capercaillie (*Tetrao urogallus*), the black grouse (*Tetrao tetrix*), and the black woodpecker (*Dryocopus martius*). In 2007, the MMNP Administration requested, as support for decision making, a study on the quantification of ecosystem services and related goods. The study was carried out by Gund Institute for Ecological Economics, University of Vermont, USA. The environmental cost evaluation in relationship to forest goods and services revealed that water flow regulation and carbon sequestration bore the highest environmental costs (Table 23.2).

The annual value for carbon sequestration in forest ecosystems was based on primary data of standing timber volume and assuming an annual volumetric increment of 6 m^3/ha (corresponding to an annual growth in biomass of 342,765.18 t). The combined value of carbon sequestration from forests, hayfields, and alpine pastures result was substantially different, depending on whether pricing was based on an exchange rate of 31.6 RON (nearly 1 USD equivalent) per ton or a social cost of 205 RON (about 64 USD equivalent) (Ceroni 2007).

Fig. 23.8 Uncontrolled wood exploitation and forest logging in the Maramureş Mountains Natural Park. (Photograph by Mihaela Năstase)

Table 23.2 Evaluation of environmental costs in relation to forest services

Services	Value per ha/year (millions RON)
Carbon sequestration	26.4
Water flow regulation	43.2
Soil erosion control	3.1
Wildlife habitats	0.8
Fishing	0.7
Recreation	4.8
Cultural heritage	0.7
Traditional landscapes	0.6
Total	80.6

Source: Ceroni 2007

23.2.4 *Mining Activities*

A particular economic branch that had brought about significant environmental changes in the MMNP is related to mining, largely in the perimeter of the Toroiaga volcanic massif. Historically known for its mining activities of both base (Cu, Pb, Zn) and precious (Ag, Au) metals, this activity began before the Christian Era, and continued with the first important mine works related to complex raw metal exploitation in the seventeenth and eighteenth centuries; in 1855, three major mines were opened: Gura Băii, Burloaia, and Toroiaga. After a setback of mining during 1990–2005, in 2006 the activity in the region has been shut down and the area declared disadvantaged.

The environmental "fingerprints" of this activity shall exist for a long time, however (Fig. 23.9). Apart from the social impact related to unemployment, other consequences related to water pollution, the aesthetic visual impact of the wastes, heavy metal accumulations on Tâsla and Vişeu River banks, abandoned mine roads, tum-

Fig. 23.9 Tailing dumps in Toroiaga and abandoned mining infrastructure in Ivăşcoaia. (Photograph by Mihaela Năstase)

bling buildings, and biodiversity loss, especially that of aquatic species (amphibians, *Hucho hucho*), and habitat fragmentation have emerged.

Between 1994 and 2003, some historical events, related to the Colbu I, II, and Novăţ tailing ponds, repeatedly polluted the area with heavy metals. A noteworthy event was associated with the waste materials that resulted from the Baia Borşa mining area stored in Novăţ-Roşu tailing pond in the upper Vişeu catchment. In March 2000, the tailing dam failed, releasing approximately 100,000 m^3 contaminated water and 20,000 t mineral-rich solid waste, which was routed downstream through the Rivers Novăţ, Vaser, and Vişeu into the River Tisa (Bird et al. 2008). Accordingly, the unprotected tailing ponds from the Vinderel area are a source of pollution for the Repedea, Ruscova, and Vişeu Rivers.

23.2.5 Touristic Activities

Maramureş Mountains Natural Park is particularly attractive to the public because of its local particular values: the narrow gauge train ("Mocăniţa") along the Vaser Valley; the wooden churches; the wooden carved gates; the local traditions; its history and culture; and the scenic landscapes (Fig. 23.10). Thus, the Park area is visited for its cultural, historical, and traditional objectives, such as the wooden churches of Ieud, Rozavlea, Bogdan Vodă, etc., and the monasteries of Moisei, Bârsana, and Izvorul Tămăduirii, as well as the traditional feasts and celebrations throughout the year, such as the Daisies Fest from Repedea, the "Hora in Prislop," and Christmas. However, the main tourist attraction of the Park is the steam train and the narrow gauge railway that runs along Vaser Valley, attracting thousands of tourists every year.

Some studies carried out by the Park's Administration on the preference of tourists visiting Vaser Valley show that only a small share (nearly 25 %) is interested in the natural values. The insufficient tourism infrastructure in most of the Park's area, coupled with deficient promotion of the associated attractions, is among the leading causes.

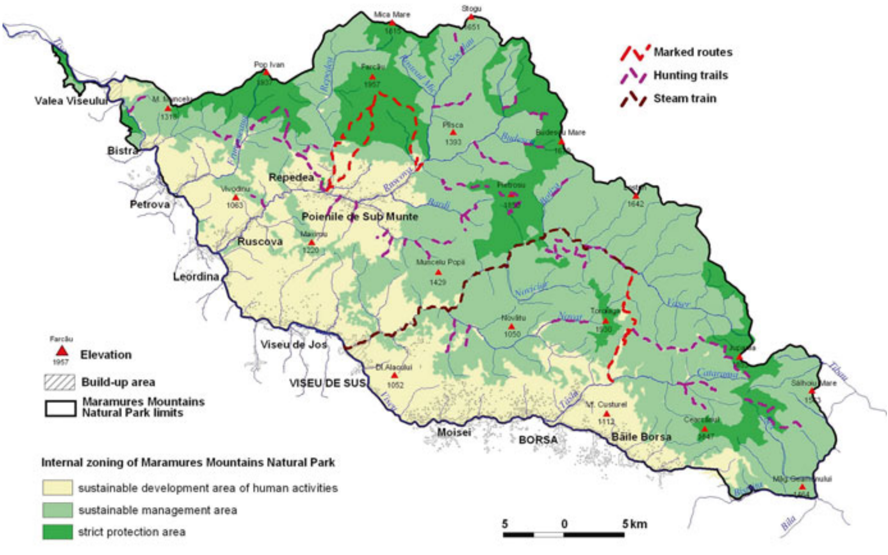

Fig. 23.10 The main tourist pathways in the Maramureş Mountains Natural Park

Over time, in the MMNP arguments between local stakeholders and visitors were experienced. Noteworthy are the conflicts involving tourists longing to visit Vaser Valley in larger numbers against the carrying capacity of the area, as well as touristic activities and biodiversity preservation activities. Moreover, MMNP offers unique opportunities for tourists to experience biodiversity, in general, and specific elements of fauna and flora, in particular. Given that another important attraction of the Park is provided by the rich hunting found, by organizing chasing campaigns, even poaching, a continuous decrease of specimens occurred, thus leading to habitat fragmentation and biodiversity loss.

In the summer of 2007, a survey aiming to evaluate the economic contribution related to recreation and tourism of 10,000 visitors to the Vaser Valley was carried out. The estimated contribution of the 10,000 visitors was 4,835,000.00 RON (approximately 1,500,000.00 UDS), of which the willingness to pay for the different guided tours and conservation programs was used to estimate the non-use values of wildlife habitat (799,867.44 RON), cultural heritage (736,994.45 RON), and traditional landscape (588,877.30 RON) (Ceroni 2007).

An important threat to the cultural and traditional heritage of the study area is turning away from the "wood civilization." The recently built modern houses with urbanized architectural style, contrasting with the traditional wooden architecture and the unique landscape, have generated conflicts, thus becoming unattractive to tourists. However, since the establishment of MMNP, the number of tourists has been continuously growing. For instance, on the Vaser Valley (the most important tourist attraction in the area), from approximately 6,000 tourists registered in 2005, the area reached up to 30,000 vistors in 2013.

Touristic activities could bring important benefits to this area in terms of developing Park infrastructure, through different service fees and local taxes for conservation, supporting local communities through rural tourism (chalets, hotels, and guesthouses), promoting the handcrafted products, and education.

Overall, the impact of tourist activities on the environment brings about other related concerns in terms of biodiversity loss, uncontrolled waste deposits, pollution, etc. However, as compared to the other environmental impact categories, tourism cannot be yet considered a pressure on MMNP, but rather a threat.

23.3 Conclusions

Human-induced landscape changes in the MMNP during recent years through tourism, deforestation, overgrazing, overexploitation of natural resources, etc. have led to the replacement of natural forest and pasture ecosystems with secondary meadow and scrub associations, thus affecting the floristic structure and composition. The environmental driving forces that are affecting the environment in the MMNP are a result of both historical and current economic development. No matter the type of pressure, whether directly or indirectly affecting the area under study, it triggers a wide variety of environmental transformations in terms of land use and land cover changes, land degradation, fragmentation of natural habitats, and biodiversity loss. Additionally, the loss of traditional architectural style, a component extremely difficult to preserve from the Park's Administration perspective, also represents a significant consequence of human impact on the landscape in the study area. All analyzed impact categories are critical for the local livelihood, thus leading to negative environmental consequences.

To reduce human impacts on the environment, the Management Plan of MMNP has established the internal zoning, which takes into consideration the biodiversity and landscape conservation on one hand, and the economic development of the area, through activities that barely affect the environment, on the other. Thus, internal zoning consists of three main concentric areas:

- The *strictly protected area*, spreading over 18,769 ha, in which all human activities are forbidden, except research-, education-, and eco-tourism-related activities. Inside this area it the intent to leave the natural phenomena and processes to develop naturally without any management involvement;
- The *sustainable management area*, which covers 79,585 ha, linking the total protection area with the areas of sustainable development of human activities;
- The *sustainable development area of human activities*, with an area of 35,000 ha, permits all human activities. It includes the Park's built-up area, as well as transport infrastructure, mountain pastures located outside the total protection area, and the localities suffering man-made changes.

The *sustainable management area* and the *sustainable development area of human activities* are mainly responsible for maintaining and encouraging traditional activities in terms of species, habitats, ecosystems, and landscape preservation and for limiting those human activities that trigger negative environmental impacts. Therefore, in-depth analysis of the human–environment relationships in protected areas could support further development and implementation of sustainable management strategies for environmental protection.

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Chapter 24
BEO Moussala: Complex for Environmental Studies

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Abstract The main areas of research at the Basic Environmental Observatory (BEO) Moussala, Rila Mountain, are the aerospace and terrestrial environment. The interactions between cosmic rays and the Earth's atmosphere, global change parameters and climate research, and natural hazards and technological risks are the objectives of the investigations.

Real-time measurements of basic parameters of space and atmosphere are carried out. The information is transmitted via a high-frequency radio-telecommunication system to the Internet and is stored in a database for further analysis within GAW, EURDEP, EUSAAR (ACTRIS), RECETOX, and UNBSS international networks.

On-line data and detailed information about BEO Moussala are available at: http://beo-db.inrne.bas.bg

In 2014, the scientific research carried out at peak Moussala celebrated its 55th anniversary.

Keywords High mountain observatory • Cosmic ray research • Greenhouse and reactive trace gases • Aerosols • Persistent organic pollutions • Environmental monitoring • Atmospheric processes

24.1 Introduction

The mountainenvironment as a field for climate studies and recently for climate change has become a global issue. The first high mountain research station in Europe, the High Alpine Research Station Jungfraujoch in the Swiss Alps, which was set up in 1932, laid the foundation for a chain of similar research stations.

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The peak Moussala is the highest peak of the Balkan Peninsula: 2925.4 m a.s.l. (42°10′45″N, 23°35′07″E). It is remote from industrial and vehicle pollution. Peak Moussala is reached by both Mediterranean and continental air masses because of its dominant geographic position over a vast area. Therefore, it provides prospects for complex and comparative research of the impact of multiple influences.

BEO Moussala (Stamenov et al. 2007) was built as a facility with a modern infrastructure and all basic appliances for scientific investigation. Local and long-range air transport (fine and ultrafine aerosols, coarse particles, and gas pollutants), gamma-ray background, climate change, and cosmic rays—all these phenomena are monitored. Data for 38 substantial atmospheric and space parameters are stored in a database for retrospective analyses and modeling.

Real-time data are provided via the local measurement system and the telecommunication system to the database.

24.1.1 Climate Notes

The peak Moussala is the coldest place in Bulgaria. Positive average temperatures occur for about 3 months annually. The average wind speed is one of the highest in Bulgaria. The absolute humidity is very low but the relative humidity is high (Table 24.1).

24.1.2 The Station Chronology

1959: Cosmic Ray Station was set up on peak Moussala
1983: Cosmic Ray Station destroyed by fire
1993: French-Bulgarian integrated project OM2 was started for monitoring and management of high mountain ecosystems
1999: Cosmic Ray Station was reconstructed and renamed the Basic Environmental Observatory Moussala
2002: BEO Moussala given Centre of Excellence Award
2003: BEO Moussala attained ISO certification
2007: BEO Moussala became a Pan-European Research Infrastructure
2010: BEO Moussala became a Regional GAW station

Table 24.1 Basic meteorological parameters

Meteorological parameter	Value
Annual mean temperature	−3.1 °C
Prevailing wind direction[a]	N–NE
Monthly mean wind speed	4.9–10.5 m/s
Annual mean wind speed	7.5 m/s
Annual mean rainfall	1000–1300 mm

[a]BEO measurements (2003–2014)

The idea of constructing a Cosmic Ray Station on the peak Moussala was proposed by the prominent Bulgarian scientist Acad. G. Nadjakov and the famous Hungarian physicist Acad. L. Yanoshi. It was realized in 1959. The Bulgarian School of Cosmic Rays was developed during a long period of productive common scientific work with the Hungarian group of physicists. The names of the leading scholars Prof. L. Mitrani, Prof. N. Ahababyan, Prof. I. Kirov, and Prof. J. Stamenov stand out in this group. Unfortunately, in 1983 the Moussala Cosmic Ray Station was destroyed by fire.

The station was rebuilt in 1999 with the financial support of the Bulgarian Ministry of Environment and Water and has become a modern research facility. The measurements restarted, keeping up the tradition in cosmic ray research and adding environmental monitoring via the French-Bulgarian project OM2 (funded by the French Ministry of Exterior and Centre National de la Recherche Scientifique).

From 2003 BEO Moussala was certified by ISO 9001 “Quality Management” (No. 3312/0) and ISO 14001 “Environmental Management” (No. 357/0).

In July 2007 BEO Moussala was validated by EC and European Science Foundation (ESF) survey as Research Infrastructure (# 563) of pan-European importance.

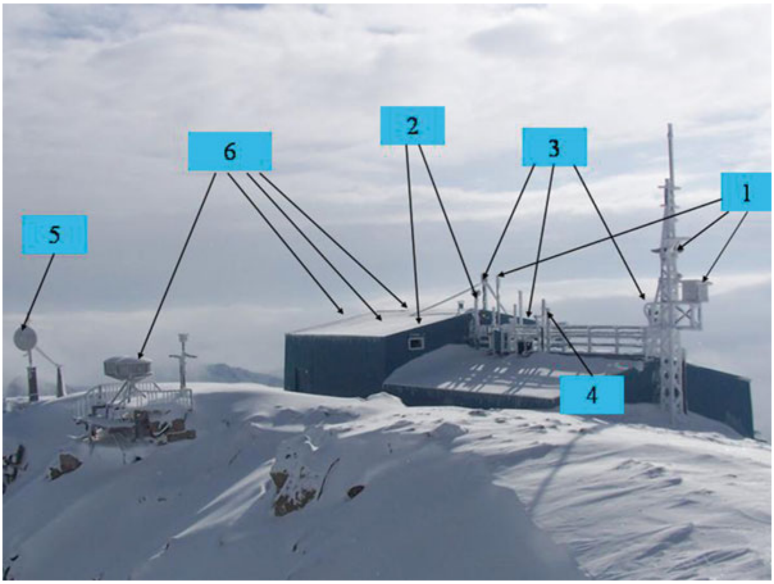
The technological status of the Observatory was improved substantially consequent to the successful implementation of the HIMONTONET FP5 and BEOBAL FP6 projects. The participation in FP6 EUSAAR and ACCENT projects has created the basis for further development of applied monitoring methods. BEO Moussala received the Center of Excellence Award in 2002. For its unique location in Eastern Europe, as well for the high-quality measurements it carried out, the station was accepted as a Regional Station (2010) in the GAW network. A team of physicists, engineers, and technicians came together and contributed to the scientific findings at BEO Moussala.

The main feature of BEO Moussala station, after this long history and experience, is its complexity: from cosmic rays investigation to high-mountain monitoring and environmental research.

24.2 Environmental Measurements at BEO Moussala

The aerosols, the greenhouse gases, reactive trace gases, and persistent organic pollutants (POPs) are responsible for the radiation forcing of the atmosphere and hence they affect the climate. The precise measurement of these parameters is the main objective of BEO Moussala and provides prospects for climate change studies.

The measurement systems at BEO Moussala (Photograph 24.1) were basically set up in the period 2003–2007 in the frame of the EC projects. Some new devices (SMPS, SEVAN) were installed in 2008 and 2009 (see the following text). Since the beginning, the automatic measurement equipment has been connected to a local network, and the telecommunication system BEO-INRNE has provided real-time data to the Internet.



Photograph 24.1 BEO Moussala measurement station. *1* Automatic Weather Station (Vaisala), *2* atmospheric gas analyzing system (Environnement S.A.), *3* aerosol measurement system (TSI, Itf-Leipzig), *4* gamma background measurement (Technidata), *5* telecommunication system (2.4 GHz) INRNE-BEO, *6*Cosmic Rays Research Systems

Since December 2013 a new international project has been launched, with more than 20 participants, including BEO Moussala (BACCHUS: Impact of Biogenic versus Anthropogenic emissions on Clouds and Climate: toward a Holistic UnderStanding). Also an agreement was signed to participate in another international project involving a network of high mountain observatories named VAO-II (R & D): Trends of greenhouse gases and aerosols, and spatiotemporal deposition of persistent environmental pollutants (TP I/02), launched in May 2014.

24.2.1 Vaisala Automatic Weather Station (AWS)

The Vaisala AWS has been operating since August 2003. It is equipped with basic sensors for air temperature and relative humidity, atmospheric pressure, wind speed, wind direction, and precipitation. The AWS provides important information for atmospheric conditions for the other systems. The sensor collector transmits the

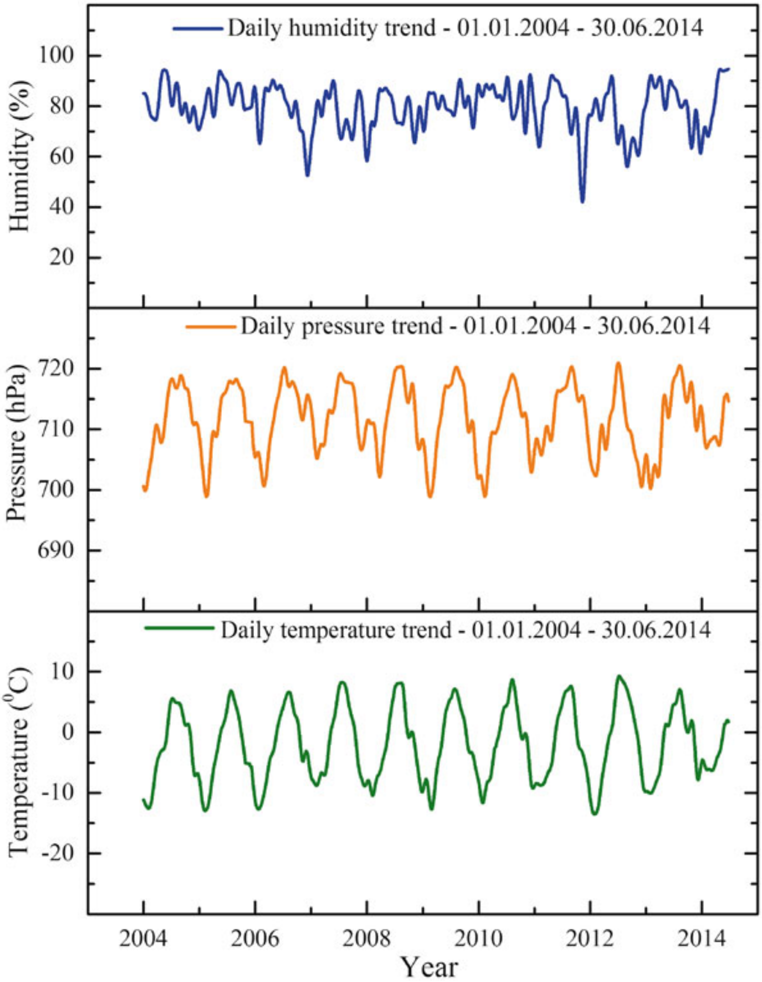


Fig. 24.1 Seasonal variation of meteorological parameters at the Basic Environmental Observatory (BEO) Moussala, 2004–2014

data to the computer. Data acquisition and transfer repeat every 10 min. The AWS is designed for heavy weather conditions. Figure 24.1 shows the trends from 2004 to 2014. Wind rose data up to 2014 show that the prevailing wind direction was north-northeast (Fig. 24.2).

A new color camera rotating 360° is installed at the station to view cloud cover on the peak.

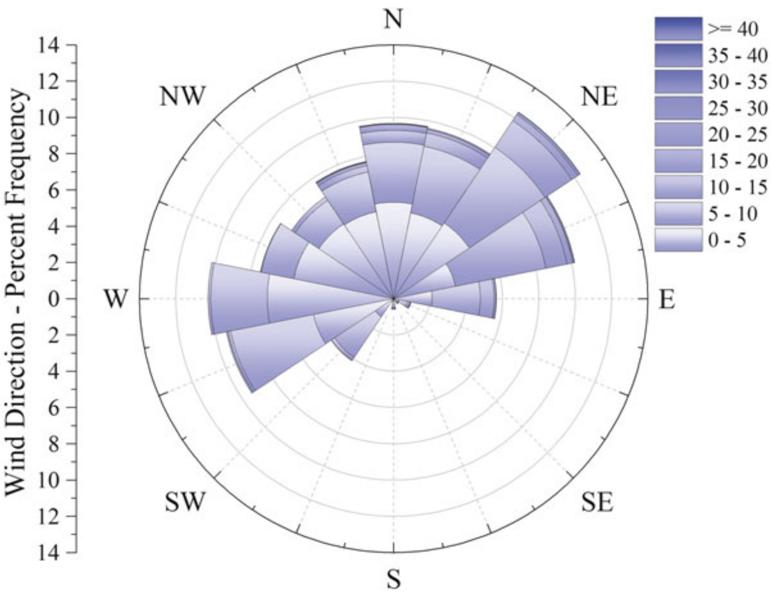


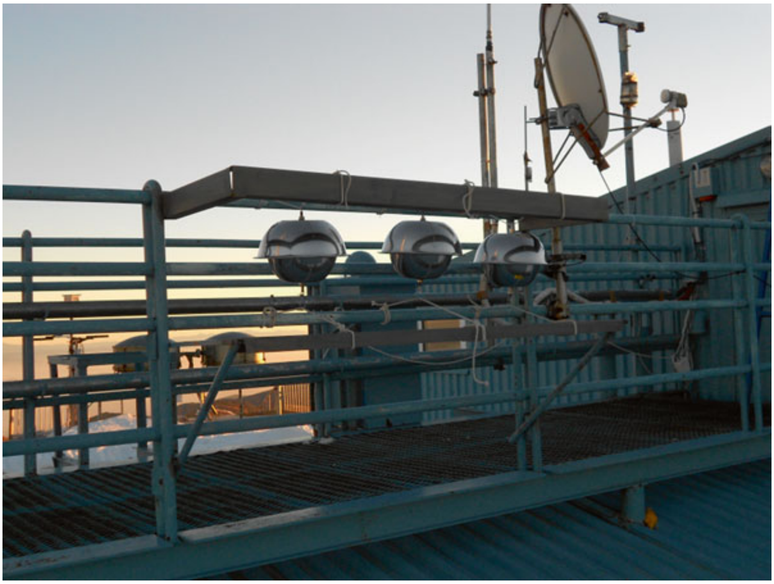
Fig. 24.2 BEO Moussala wind rose, 2004–2014

24.2.2 POPs Passive Air Sampling

Since 2009, passive air samplers (Photograph 24.2) have been installed in the frame of the international project MONET (MOnitoring NETwork) for measurement of POP compounds in the ambient air. This network has been organized by the Research Centre for Toxic Compounds in the Environment (RECETOX), Masaryk University, Brno, the Czech Republic, where the collected filters are analyzed.

Because of their harmful effect on the environment and human health, it is important to monitor pollutant origin and air transport over Europe. The passive air samplers consist of two protective stainless-steel hemispheres with different diameters (30 and 24 cm) mounted on a common axis, with a filter mounted on the equatorial plane between them. The air flows freely in the opening between the spheres and through the filter, with the pollutants being trapped within it. The filters are made of white polyurethane foam (PUF) with a density of 0.030 g cm^3 (type N 3038; Gumotex Breclav, the Czech Republic) acting as a sorbent. The filters are of circular shape, 15 mm thick, with a diameter of 150 mm.

Passive sampling yields information on the long-term pollution at specific locations (Pribylova et al. 2012; Klanova et al. 2006) and is thus a suitable tool for estimating the spatial and temporal variations and trends of the POPs atmospheric concentrations. Polyaromatic hydrocarbon (PAH) levels in the atmosphere are presented in Fig. 24.3.



Photograph 24.2 Passive air samplers at BEO Moussala

24.2.3 Atmospheric Gas Analysis System

Greenhouse and trace gases measurements, which are important for climate change investigation, are performed by an atmospheric gas analyzing system (Table 24.2). BEO Moussala was named a regional GAW Station in 2009 and provides data from the gas analyzers and from the meteorological measurements to WDCGG (http://gaw.kishou.go.jp/wdcgg/). The first results of ozone data analyses were published, showing a possible method for pollutants tracking.

24.2.4 BEO Moussala Aerosol Measurement and Devices

Scattering and backscattering coefficients of aerosols and aerosol size distribution are measured by integrating the Nephelometer and Scanning Mobility Particles Sizer (SMPS).

24.2.4.1 Scanning Mobility Particles Sizer

The SMPS is a spectrometric scanning measurement system for fine and ultrafine particles that was put into operation in November 2008. The measurement range is from 10 nm to 1 μm (Fig. 24.4). Its sensitivity and measuring range allow measuring

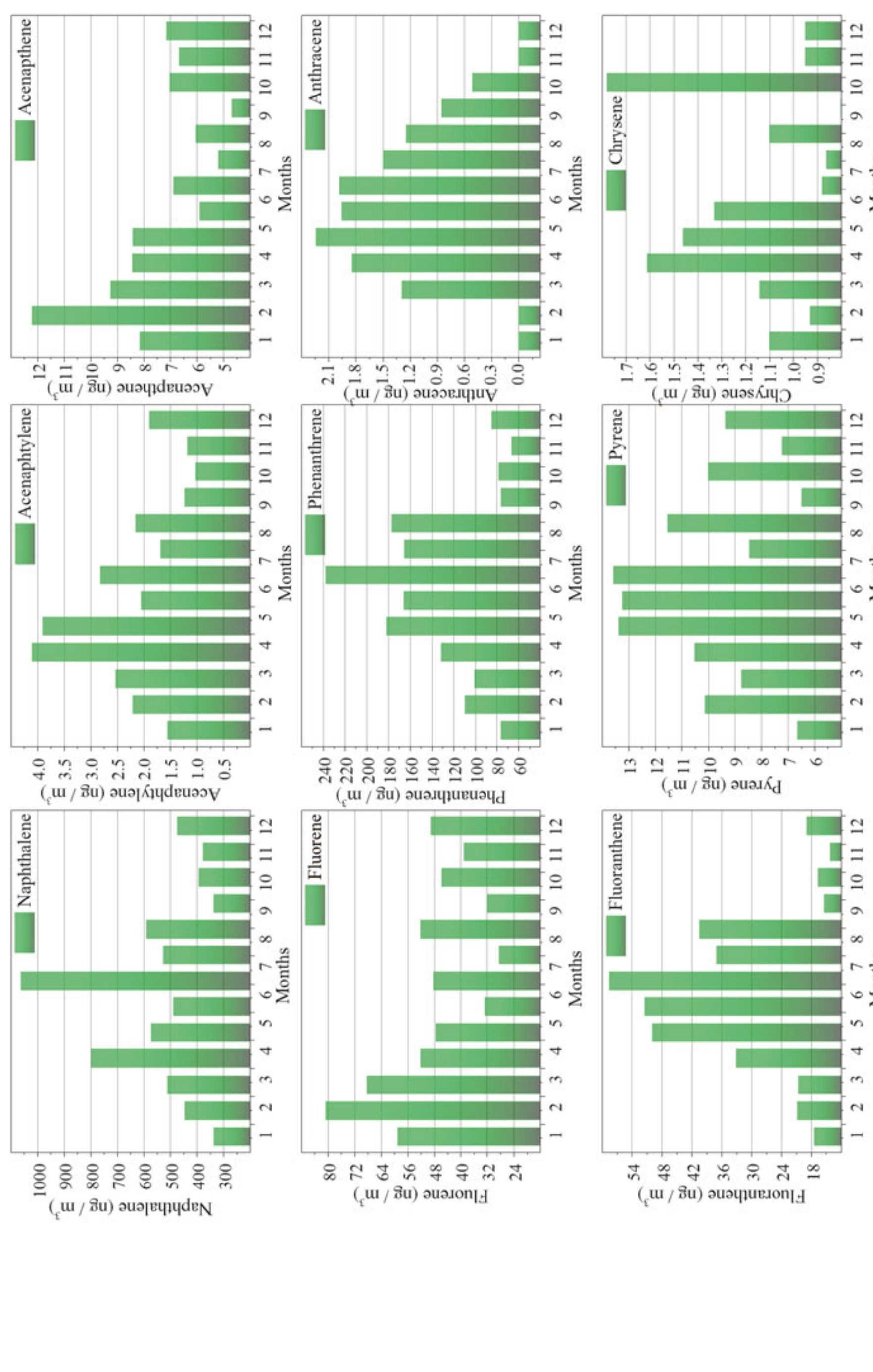


Fig. 24.3 Seasonal variability of polyaromatic hydrocarbons (PAH) levels in 2009–2011 (ng/m^3)

Table 24.2 BEO Moussala gas analyzers

Gas	Device	Measurement range
NO	AC32M	NO-NO_2-NO_X from 0.4 ppb to 20 ppm
CO	CO12M	CO from 50 ppb to 200 ppm
SO_2	AF22M	SO_2 from 0.5 ppb to 10 ppm
O_3	O342M	O_3 from 0.4 ppb to 10 ppm
CO_2	CO12M	CO_2 from 1 ppm to 2000 ppm

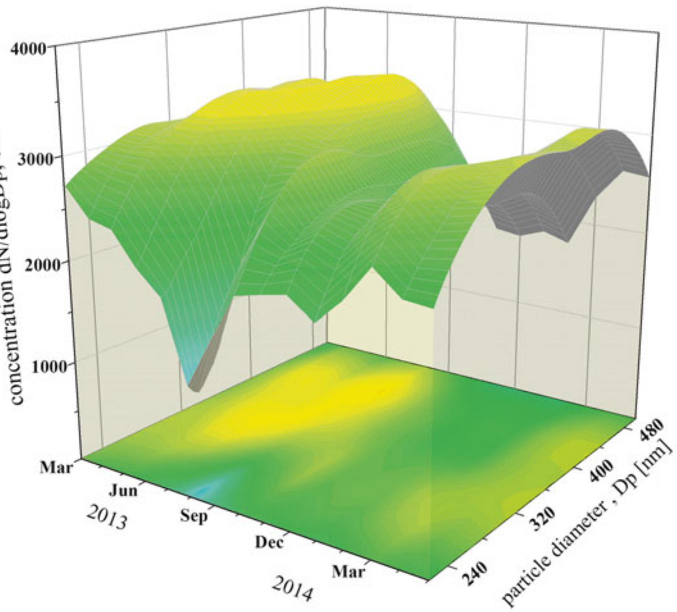


Fig. 24.4 Seasonal aerosol size distribution at BEO Moussala, 2004–2014

of the most sensitive part of the atmospheric composition, subject to local and distant pollutants.

24.2.4.2 Nephelometer TSI 3563

The TSI 3563 is a measurement device for scattering and backscattering coefficients of ambient aerosols/pollutants. It was put into operation in March 2007. Light scattering gives precise data for the amount of particulates/dust in the air. TSI 3563 measures at three wavelengths, 450 nm (blue), 550 nm (green), and 700 nm (red), which are sensitive to different particle size scattering and pollutants.

Since June 2012, thanks to the project ACTRIS and a signed agreement for a long-term loan from the GMD division of NOAA, an absorption photometer, CLAP (Continuous Light Absorption Photometer), for real-time measurements was installed at BEO Moussala. CLAP is a filter-based instrument to derive information on aerosol absorption coefficients that indicated increased absorption during the Saharan dust event, March 31, 2013 (Fig. 24.5).

24.2.5 System for Measurements of Radioactivity in Aerosols

The system includes an air turbine, a filter device, a press for preparing the samples for measurement, a Ge spectrometer, and a program for analysis of the gamma spectra. All these components have been developed in INRNE. The air turbine allows 1500–1800 m^3 per hour to pass through the fiber filter, which is type FPP-15-1.5 with high efficiency, 94–99 %. The filter size is 50×50 cm. After sampling, the filter is

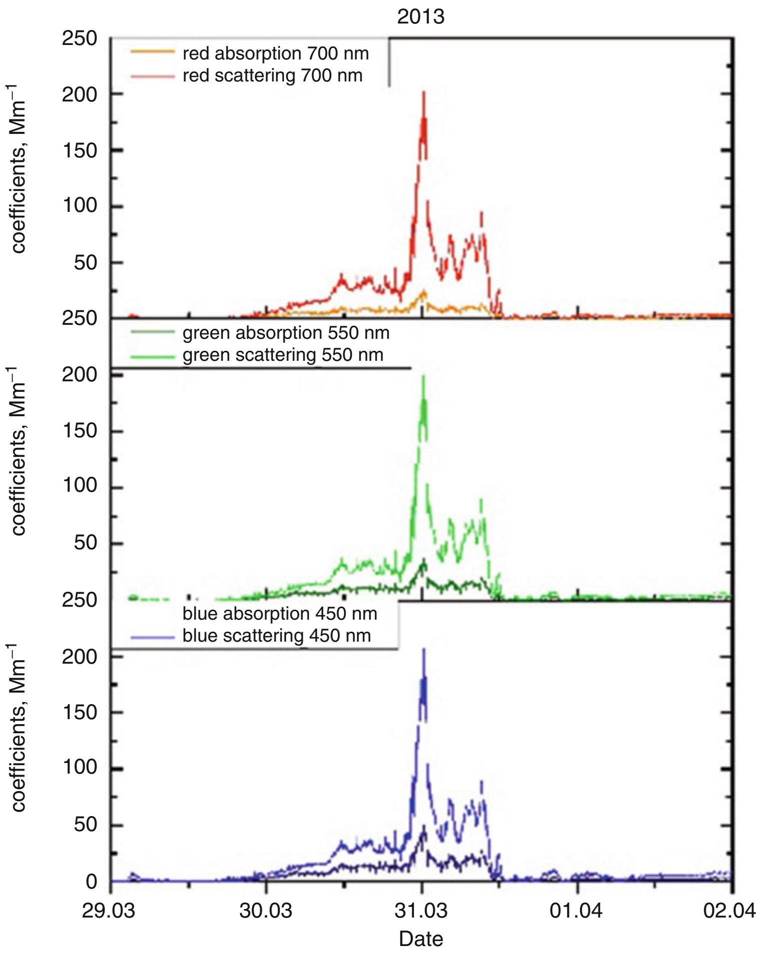


Fig. 24.5 Absorption coefficient during Saharan dust event, March 31, 2013

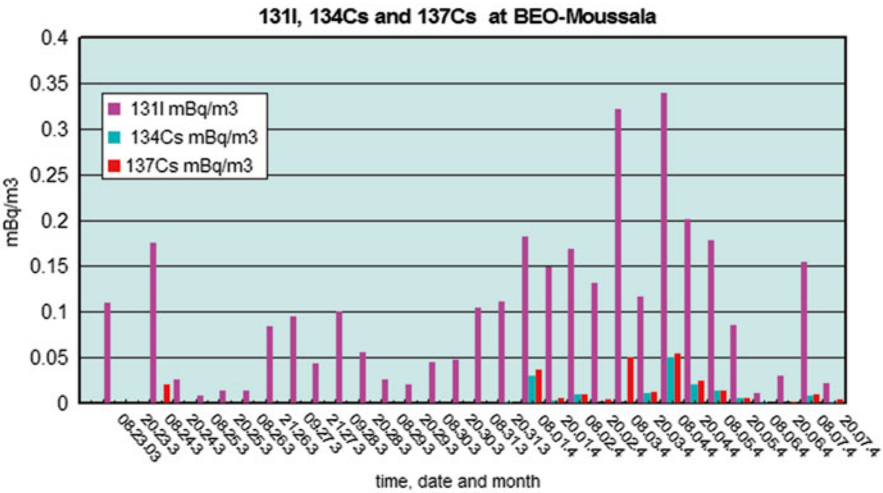


Fig. 24.6 Measured activities of some isotopes from the Fukushima accident at BEO Moussala

compressed to a pill with diameter of 57 mm and thickness of 15 mm. The appearance in the atmosphere of ^{7}Be is a result of a deep spallation reaction as a process of interactions between high-energy cosmic particles with the atmosphere. The quantity of ^{7}Be gives information for a powerful atmospheric process, the intrusion of high atmospheric layers. From the results obtained during recent years, several conclusions can be drawn:

– ^{7}Be integral quantity for a specific place is determined by several factors, mainly by atmospheric processes (including intrusion from stratosphere to troposphere), and changes in the intensity of cosmic rays (solar and galactic).
– ^{7}Be quantity (as a tracer for air mass origin) could serve as additional information for short-term meteorological prognoses

Activity of the U-Th products was detected in the aerosols at peak Moussala, including ^{7}Be, which is a well-known product of the cosmic rays. Typical products of human activity, such as ^{134}Cs, ^{137}Cs, and ^{131}I, were been detected after the Fokushima accident (on 23 March 2011, 2 weeks after the accident) (Fig. 24.6).

24.2.6 BEO Moussala Gamma Background Measurement

24.2.6.1 IGS421B1 Gamma Probe

Ambient equivalent dose rate is measured by the IGS421B1 gamma probe consisting of three Geiger-Muller counting tubes with a sensitivity range from 10 nSv/h to10 Sv/h. Data from gamma-ray background monitoring during the Fukushima accident are shown on Fig. 24.7. This figure shows that the background radiation is within acceptable limits.

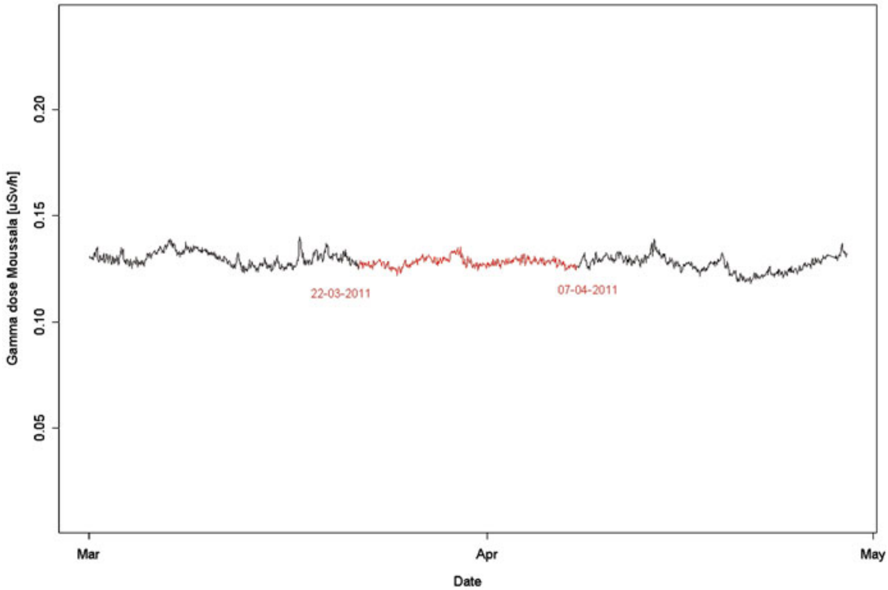


Fig. 24.7 Gamma-ray background near Moussala peak during the Fukushima accident

24.2.6.2 Online Measurement of the Spectrum of Gamma Rays at Moussala Peak

An Na(I) spectrometer was installed in BEO Moussala for online measurement of the spectrum of gamma rays in the air at peak Moussala. The size of the detector is ~ϕ50 × 50 mm, energy resolution ~8–10 %, and measured interval of gamma rays 100–6500 keV. Using such an energy interval it is possible to observe the main isotopes of natural and human-origin radioactivity, including those possible from nuclear accidents. At the same time the background of cosmic gamma rays with energy 2800–6500 keV is also monitored. All systems work automatically, and every 2 h one spectrum is recorded. The measurements could be controlled, changed, and observed from everywhere by means of the Internet with a program for remote management. A typical spectrum is shown in Fig. 24.8.

The intensities of gamma rays at 609 keV, 1120 keV, 1764 keV, and others, which arise from the daughter nuclei of ^{222}Rn, manifest changes with time. There are two possibilities for such behavior: the first could be seasonal fluctuation, and the second is possibly some connection with seismic activity. The continuous background of cosmic gamma rays in the interval 2800–6500 keV also has some changes in intensity. There are possible connections with astrophysical processes in space or in the upper layer of the atmosphere. More long-term monitoring, about 2 to 3 years, and comparison with data from other devices at BEO-Moussala will help to clarify an explanation of the observed phenomena.

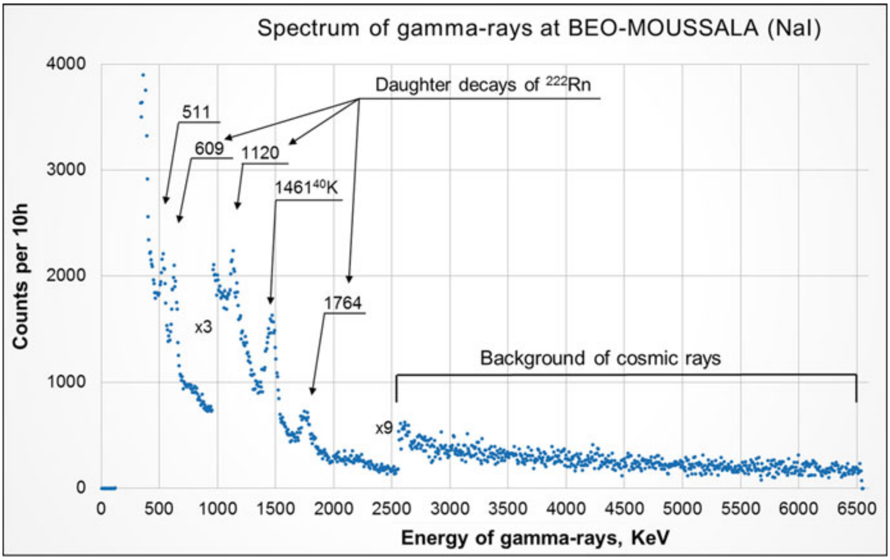


Fig. 24.8 Typical spectrum of gamma rays at BEO Moussala (NaI)

24.3 Cosmic Ray Research at BEO Moussala

24.3.1 Muon Telescope

The telescope has been operating since August 2006. It has a surface of 1 m^2 and an energy threshold of 0.5 GeV. The time variations of cosmic ray muon flux are measured continuously in five directions. Connecting the instrument to the existing networks (Neutron Monitors and Muon Detectors Network) for cosmic rays and space weather studies, after the upgrade of the data acquisition software, is planned. These data are also used for probable correlations research between cosmic ray (CR) intensity and environmental parameters.

As a new beginning of the old cosmic rays station, the first observations of space weather were performed in 2012. This event coincided with the period of the most active solar activity since the Muon telescope became fully operational, as a part of the current 24th solar cycle observations. There are registered Forbush events with different magnitude, caused by particle flux decrease resulting from the impact of solar flares and arrival of cosmic mass ejections (CMEs) on modulation of galactic cosmic rays. The time of arrival and extreme values of the largest Forbush events detected with the Muon telescope and SEVAN are shown in Table 24.3.

The biggest challenge for BEO Moussala is to complete uninterrupted and precise measurements with both detectors, the Muon telescope and SEVAN, until the end of the current 24th solar cycle and to extend observations beyond it into the next cycle. For this purpose, a full maintenance and data acquisition system upgrade of the Muon telescope was completed in August 2013 (Tchorbadjieff et al. 2012).

Table 24.3 List of the largest Forbush events, detected on Moussala in 2012

Event began: time in hours UTC	Time of extreme hours UTC	Magnitude of extreme (%)	Solar event
24.01: 16:00	24.01: 21:16	4 %	M8/2b flare
08.03: 11:30	08.03: 22:35	5+ %	X5/3B flare
12.03: moon	13.03: 01:38	3 %	M8 flare
23.04: evening	26.05: 03:50	4 %	C-Class CME
04.09: 01:00	05.09: 00:34	2.5+ %	M1 and C8/2f flares
31.10: 17:00	01.11: 15:26	2 %	B9/Sf flare + 2CMEs

24.3.2 SEVAN

This cosmic ray detector is a part of the developing SEVAN network (until now including Armenia, Bulgaria, and Croatia). The SEVAN detector and the network have been developed in the CRD–YPI as an element of the Instrument Development Program for the International Heliophysical Year.

One of the major advantages of this multi-particle detector is probing of the different populations of the primary cosmic rays, which initiate particle cascades in the terrestrial atmosphere. Fluxes of neutrons and gammas, charged components of low energy, and high-energy muons are measured by a basic detector of the SEVAN network. This diverse information provides the opportunity to estimate the energy spectra of the highest energy solar cosmic rays and distinguish very rare events of direct solar neutron detection.

24.4 Cosmic Rays and Climate

The influence of CRs on the climate was suggested lately as a topic in many scientific reports as explaining the variations in the climate through the processes of the cloud cover formation.

One of the main features of BEO Moussala is complex research of cosmic and environmental parameters. The correlation between CRs and the initiation of lightning is recently being investigated (Chilingarian et al. 2009; Erlykin et al. 2010; Gurevich and Zybin 2002; March and Svensmark 2000; Ney 1959; Svensmark and Friis-Christensen 1997; Stozhkov 2003).

Data obtained from the new device, the BOLTEK EFM-100 Atmospheric Electric Field Monitor, could be used for research on the relationship between the intensity variations of cosmic rays and thunderstorms (Fig. 24.9).

Figure 24.9 shows the measured values of normal, high, and very high electric fields, and the moment of the thunder event.

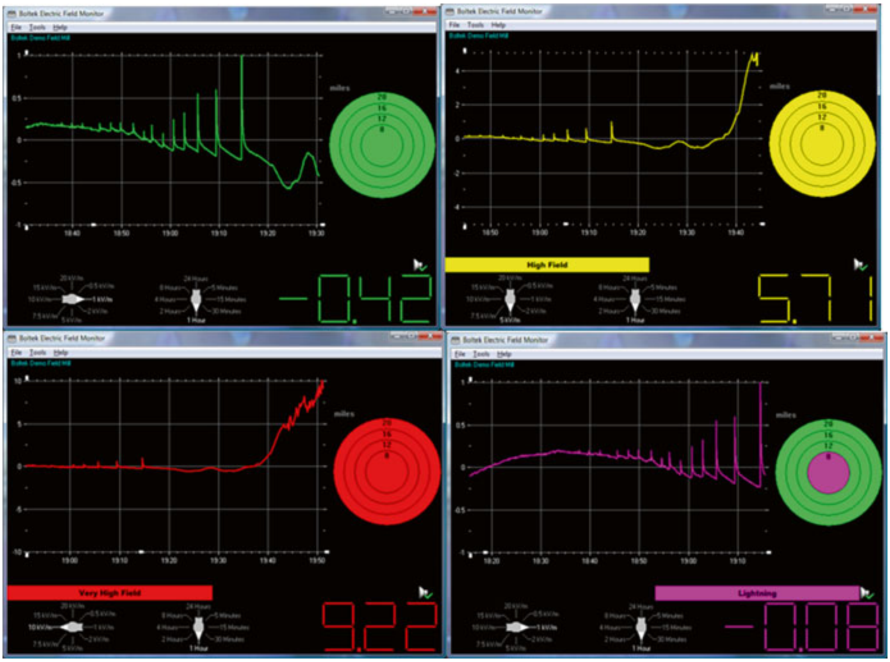


Fig. 24.9 BOLTEK EFM-100 Atmospheric Electric Field Monitor

24.5 Telecommunication and Information System INRNE-BEO

The main task of the telecommunication system is to collect, transmit, and archive the measured data in the SAP database (MaxDB), which is enlarged by the following:

- Stored data retrieval in accordance with the needs and permissions of the users
- Packing/unpacking
- Compressing/decompressing
- Raw data processing for visualization and presentation in human-readable format

The information system is a complex software system providing data flux control, data storage, and data quality control. In state of implementation is the Data Acquisition Quality Assurance System (DAQAS). The system was developed in the UFS Zugspitze GAW station for improved data flow control and calibration processes.

24.6 Conclusion

The peak Moussala is an important reference point for assessment of anthropogenic influences in the large Southeast European region. BEO Moussala is a facility with modern infrastructure for scientific investigations. Data for 38 parameters are stored for real-time retrieval, retrospective analyses, and modeling.

The BEO Moussala is a research complex, and data quality is an issue that remains focus needing persistent and continuous efforts.

The devices for cosmic rays research, the AWS, and the gas and aerosol measurement systems allow carrying out precise study of atmosphere parameters and cosmic rays. The connection between the atmospheric events and cosmic ray flux is a prospective field for investigation.

The BEO Moussala information system including the measurement systems, the high-frequency telecommunication system, and the database can be used in situ or by remote access by the international scientific community.

The BEO Moussala has a long tradition as a high mountain scientific facility, and its future mostly depends on the process of scientific collaboration and integration in the global research area.

The study of high mountain environmental parameters (meteorology, atmospheric physics and chemistry, background radiation, and cosmic rays) measured at BEO Moussala provides the possibility for complex evaluation of anthropogenic and biogenic impacts on the climate.

Acknowledgments BEO "Moussala" is one of the four mountain observatories in Europe at this altitude and unique in its southeastern part. It was established by the large international projects BEOBAL, EUSAAR, and ACTRIS, and is supported by the Bulgarian Ministry of the Environment and Water.

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Chapter 25
Research of Field Evidence for Late Quaternary Climate Changes in the Highest Mountains of Bulgaria

Emil Gachev

Abstract The highest Bulgarian mountains, Rila (2925 m a.s.l.) and Pirin (2914 m a.s.l.), provide groups of relatively well preserved glacial landforms from late Pleistocene and Holocene cold phases, several small recent perennial ice features, and still well preserved forest ecosystems at the tree limit that can serve as a source for valuable environmental records. Results of our latest studies show that in Rila valley glaciers reached their largest extent during the Last Glacial Maximum (LGM) stage (23,000–19,000 BP), when the Equilibrium Line Altitude of the glaciers was at around 2150–2250 m a.s.l. and the longest glacier tongues went down to 1150–1200 m a.s.l. Traces from several stages of glacier retreat were also found and described.

Another important aspect of environmental change consists of the observation of current environmental phenomena to evaluate local climate change during the past decades and at present. This chapter presents some of the results of research efforts in this field that have been achieved up to the present.

One of the aims of this chapter is to propose incorporation of high mountain environmental change research from all the interested Balkan countries in a network for regional studies and modeling, and, if possible, to establish a workgroup dedicated to this topic.

Keywords Global change • High mountains • Field indicators

25.1 Introduction

Global climate change has recently appeared to be probably the most debated problem not only among the scientific community but also among the entire society at a planetary scale. As a result, environmental reconstructions have registered rapid progress during the past several years. Although entire sets of global climate models

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and scenarios concerning various past and also future periods have been developed, there is still a serious deficit of regional and local data in this area of knowledge. And here is the very tricky moment in studying climate–global changes in the state of the atmosphere that cause quite different local reactions because of the unique combination of specific topography, biotic environment, and human impact at each location (Fig. 25.1). Thus, regional and local response to global changes is very hard to predict without knowing in great detail the current regional and local environmental setting. This problem is of pragmatic importance:–understanding the mechanism of local response will give us the chance to correctly suggest, estimate, and evaluate future changes in our environment.

The present chapter is focused on regional and local environmental change studies in the highest mountains of Bulgaria with the aim of a short review of what has been done and what should be done in the future.

25.2 Bulgarian Mountains: A Target Area for Paleoclimatic Research

The most serious difficulties when trying to reconstruct environmental conditions of the past come from the impacts of human activity. In the context of climate, this is a "vicious circle:" we want to evaluate the changes in climate for some of which we suspect the human factor, and at the same time civilization has destroyed evidence of the natural conditions in the past. This problem is valid for most of Europe, where only in isolated and barely accessible areas is nature sufficiently preserved to tell us what the climate was like in the past. In this aspect the Balkan region has an

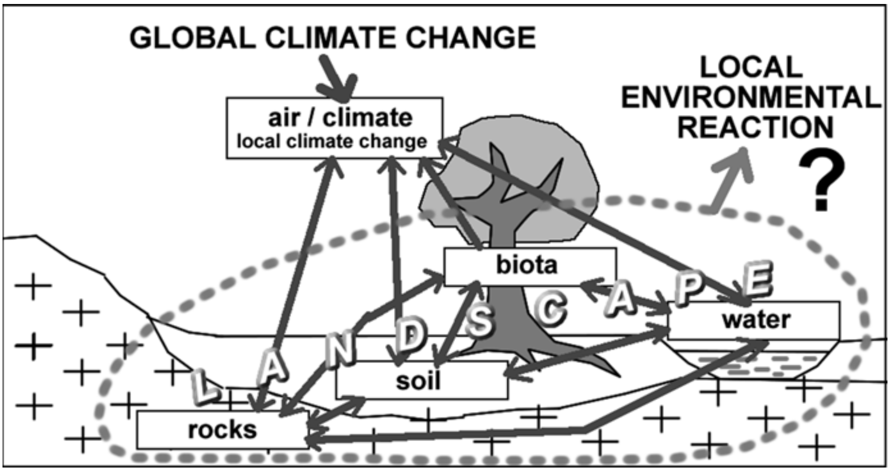

Fig. 25.1 General scheme of the interaction "global change–landscape system"

advantage because here vast areas are occupied by mountains of various height, lithology, and present local climate, and that many of them are still relatively wild in nature.

Although Bulgaria is not as mountainous as some of the neighboring countries, here are found some of the highest mountain ranges, the most prominent being Rila, with Musala peak (2925 m a.s.l.), the highest point of all the Balkan peninsula, and Pirin (2914 m a.s.l.), the third highest after Mt. Olympus in Greece. These two massifs provide remarkable geomorphic traces of past glaciations from the cold phases during the late Quaternary, which makes them very appropriate for paleoclimatic research. Alpine and subalpine areas that are spread above 2200 to 2300 m a.s.l. represent an environment of harsh and marginal nature conditions that is very sensitive and vulnerable to climate changes.

In fact, concerning the diversity of applicable research methods, the target area for environmental change researches in Bulgaria should be broadened to include Rhodope mountains, Central and Western Stara planina, Vitosha, and the mountains along Bulgaria's western border (Fig. 25.2). Evidence from past glaciations at lower elevations is quite rare, but in mid- and low-mountain areas the focus should be on forests as indicators of past natural changes because the Bulgarian mountains host the best preserved forest communities in the country.

Another key aspect of environmental change studies concerns monitoring of the present state of the environment: by this means we can make comparisons to natural states in the past and also directly measure present environmental change, marking the trends in contemporary development of the landscape. Here once again mountains are in a leading position, especially the alpine zone, because of the strong activity of present natural processes, highest sensibility to environmental changes, and still quite limited human impact.

25.3 Types of Indicators and Research Methods

Because of the insufficiency of data from direct climatic measurements in the spatial as well as in temporal aspect, environmental change studies in high mountain areas on a regional and local scale are based most of all on the existence of field evidence that indicates different conditions in the far or near past. According to research methods that have been used at present, such evidence can be summarized in several categories (Fig. 25.3).

Of course, instrumental measurements also are an important part of the studies. The start of climatic records in the high mountain area of Rila date from 1932, when a meteorological station at Musala peak was opened. However, as noted in Table 25.1, the number of climate stations in our country at altitudes above 2000 m a.s.l. is very small.

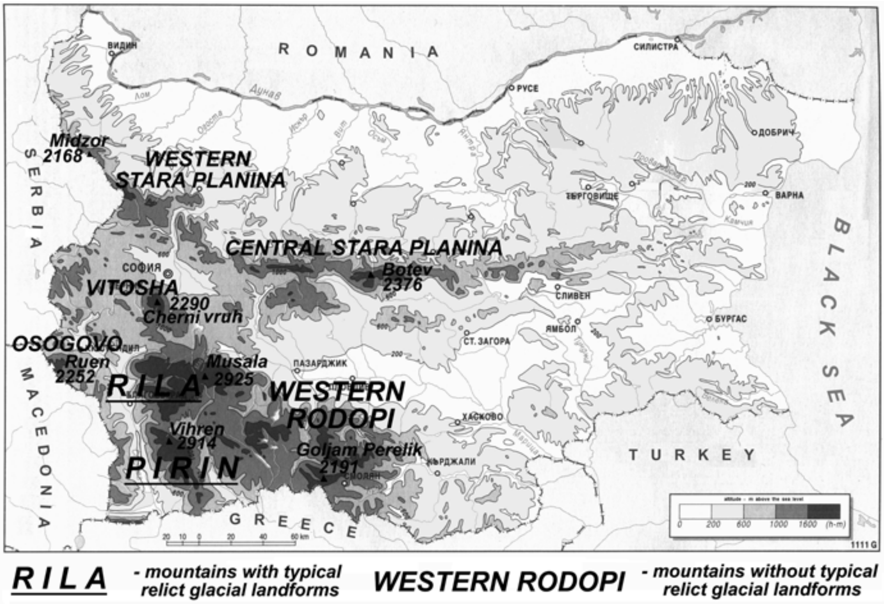

Fig. 25.2 Key mountain areas for environmental change studies in Bulgaria

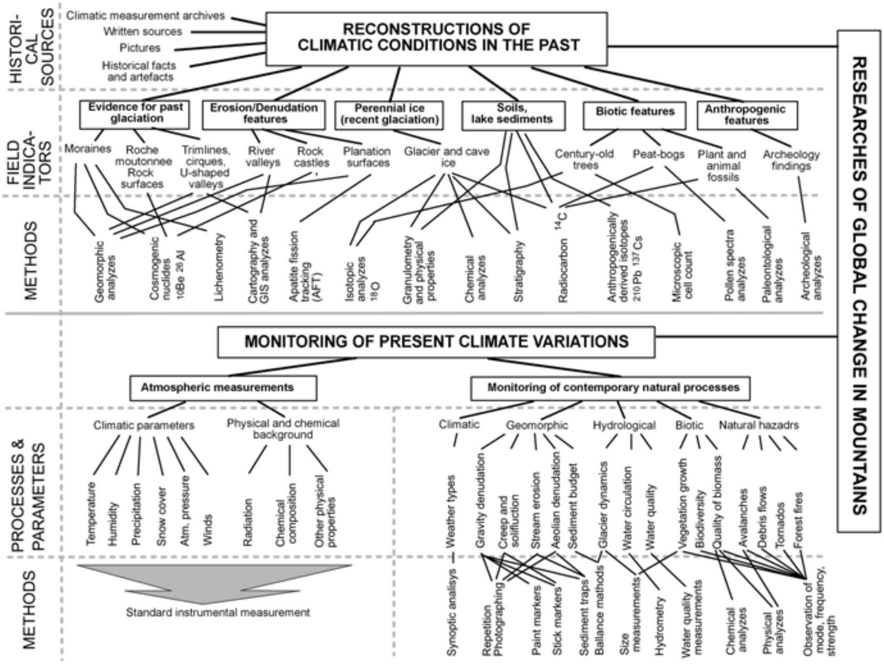

Fig. 25.3 Field evidence for evaluation of environmental change and main methods for research

Table 25.1 Distribution of climatic stations in high mountain areas above 2000 m a.s.l

Station	Altitude (m a.s.l.)	Location	Period of operation
Musala peak	2925	Rila	1933–present
Golemia Kazan	2450	Pirin	1957–1961
Kalin dam	2390	Rila	1956–1975
Musala hut	2389	Rila	1940–1990
Botev peak	2376	Central Stara planina	1940–present
Cherni vruh	2290	Vitosha	1935–present

25.4 Previous Geographic Studies in Rila and Pirin

High mountains have attracted the interests of naturalists since the beginning of nineteenth century AD. The first explorer who made natural descriptions of Bulgarian mountains was Boue (1840). Cvijic (1896, 1908) was the first to describe the relict glacial landforms in Rila, and Louis (1930, 1933) described and analyzed glacial morphosculpture and planation surfaces in the mountains. Leutelt-Kipke (1932), with a team of students from Innsbruck, made the first bathymetry mapping of glacial lakes in Rila (Musala Lakes) and measured water quality (temperature, salinity, ion concentration). In the 1950s and 1960s, studies were carried out by Bulgarian geographers. Ivanov (1954) and Glovnia (1958, 1961, 1962) made detailed descriptions and mappings of relict glacial landforms in Rila massif. Peev studied avalanches in Pirin and mentioned the existence of a “firn glacierette” in Bajuvi Dupki cirque in the northern part of the mountain (Peev 1956). Vladimir Popov from the Institute of Geography–BAS carried out a 4-year monitoring program of the cirque Golemia Kazan in Pirin (1957–1961), which was the most prominent study of this type for its time. Along with the detailed geomorphic mapping, systematic climatic observations were organized in the cirque and a small building was erected. Popov (1962, 1964) was the first to describe and measure Snezhnika, a perennial snow patch that lies at 2400–2450 m a.s.l. He explained the existence of these embryonic glacial features in Northern Pirin with the specific lithology (white karstified marbles) and topography (shading by high vertical rockwalls). In past decades glacial landforms in Rila were studied by Velchev (1995, 1999), Baltackov and Cherkezova (1991), Baltackov (2004), and in Pirin by Choleev (1982). All these authors relied on relative dating of relict landforms based on geomorphic evidence, standing on the position of the occurrence of two main glacial stages: Rissian and Würmian. An important contribution to the issue was the detailed study and mapping of subalpine and alpine grassy vegetation in Rila made by Rusakova (1990), and the palinological researches of peat bogs and lake sediments performed by Bozhilova (1972, 1995), Bozhilova et al. (2002), Bozhilova and Tonkov (2000), Tonkov and Marinova (2005), and Tonkov et al. (2002, 2006), through which the basic changes of the vegetation in Rila and Pirin during the Holocene were shown.

In 1992–1998 a French-Bulgarian project called OM2 came into force in Rila mountain. The project included much monitoring research in different components and characteristics of environment (radiation background, chemical contamination, biodiversity, etc). Results were published in the journal "OM2 series" issued by the Institute of Nuclear Research and Nuclear Energy (INRNE)–BAS. The main result of the project was the opening in 1999 of the Basic Environmental Observatory (BEO) "Musala," a station for complex environmental monitoring situated at 2925 m a.s.l. on the very top of Musala peak. Although the OM2 project was not attended by geographers, the field and instrumental data obtained during its performance served as a good basis for geographic studies. BEO "Musala" is governed and managed by INRNE, and since 2002 has been obtaining climatic and air quality data that are available online (see Stamenov et al., this volume).

In the years since 1994, a team from the Center for Landscape Research in Dresden (Germany) has been conducting systematic environmental observations in Northern Pirin. Some of the main activities of the program have been dendrochronology studies at timberline to evaluate recent changes in tree growth of *Pinus heldreichii* as a result of local climate change, and regular measurements of the size of the glacieret "Snezhnika" in Golemia Kazan cirque (in September, during the stage of annual firn mass minimum), which, for the period of observation, showed variation between 1 ha (2006) and 0.4 ha (1994). In 2006 a group of researchers from Dresden, led by K. Grunewald, in cooperation with specialists from the Institute for Space Research of the Bulgarian Academy of Sciences (BAS), made three core drills in the firn body and took samples for absolute dating and chemical analyses. A drill in the central part of Snezhnika registered 11 m thickness of the ice mass. At this time the moraine ridge that surrounds the snow patch was also studied: layers of primitive soil were found on the crest to date from the early Middle Ages, whereas the formation of the ridge in its present configuration is suggested for the Little Ice Age (LIA; fifteenth to nineteenth centuries AD) when the snow patch must have been quite larger (Grunewald et al. 2008). This monitoring program is still ongoing, and in 2007 two temperature data loggers were installed in the cirque to measure local temperature.

25.5 Review of Achieved Results

25.5.1 Researching Environmental Conditions of the Past: The Glacial Evidence

Although relict glacial landforms, especially in Rila, were subject to numerous studies, still no common interpretation of their distribution has been done for the whole Rila and Pirin mountains, and results obtained about environmental settings of the past have not been summarized on a regional scale, especially by comparison with glacial evidence from adjacent mountain massifs. That is why the Institute of Geography participated in two terrain studies in 2007 and 2008, dedicated to a study of former glaciations in Rila. The first fieldwork was initiated and organized by the Geosciences Institute, University of Tubingen, Germany, and led by Prof. Joachim Kuhlemann. For 9 days all main valleys of Rila mountain were searched and moraine features were described and mapped. Samples were also taken for cosmogenic nuclide dating (^{10}Be) to estimate the absolute age of glacial deposits. Results showed that most terminal moraines in the valleys of the Rila mountains date from 18 to 16 ka BP – the very end of the LGM and the beginning of the Late Glacial. Just for the outermost ridge of the moraine above the Beli Iskar village, an age from the beginning of the LGM (24 ka BP) was obtained (Kuhlemann et al. 2013). The main conclusion from this study is that most landforms from the relict glacial complex are quite new with the oldest moraine features dating from Late Würmian (LGM) and the newest probably from the cold phases during the Holocene. No glacial accumulative landforms were registered from earlier glacials (e.g., Riss or Mindel) as some of the previous authors suggested, although there are geomorphic traces of previous glacial stages, such as parallel trough valley trimlines and some old cirque shoulders.

Analysis of the positions of LGM terminal moraines and of the configuration of trimlines in the analyzed river (for which aerial photographs were also studied), showed that the equilibrium line altitude (ELA) of Rila glaciers during their maximum spread (LGM) had been lying at 2150 to 2250 m a.s.l., with a gradual rise from northwest to southeast. Considering a temperature lapse rate of −0.6 °C/100 m altitude, this should mean that average temperatures during the coldest phase of the LGM were about 6 °C lower than at present. Compared to the Alps and the mountains of the Western and central Mediterranean, the LGM equilibrium line in Rila was situated much higher, and differences between north and south aspects were quite small. These results suggest a considerable smaller moisture supply in Rila Mountain during the LGM and support the hypothesis of a compensatory warm advection from the south in the eastern Mediterranean as a response to the cold northerly advections in Western Europe for this period (Fig. 25.4). Obtained ages of moraines indicate that in the context of prevailing southwest winds during the coldest phase of the LGM, most favorable conditions for glaciation in Rila existed in the beginning and in the end of the cold episode when air mass transition from the NW prevailed, but at lower temperature levels (Kuhlemann et al. 2013).

To study the newest traces of glaciation, a field survey was held in summer 2008: its task was to research the morphology of the bottom of Ledeno Ezero, the highest lake in Rila, situated at 2709 m a.s.l. On the created detailed bathymetry map (second after the one made by the Austrian team of S. Leutelt-Kipke in 1932), a well-outlined crescent-shaped ridge can be identified underwater in the shallow SW part of the lake (Fig. 25.5). The crest rises up to 2 m from the shallow part of the lake bottom, its highest point lying 2.1 m under the water level. Geomorphic indications, meteorology records, and historical sources support the hypothesis that this ridge represents a relatively young moraine feature, formed probably by a perennial snow patch (micro-glacier) during the Little Ice Age (LIA). Today there are no perennial snow patches in Rila, and some small spots of last winter's snow may survive the summer only in years colder than average, but historical sources say that the presence of firn bodies was common in the beginning of the twentieth century.

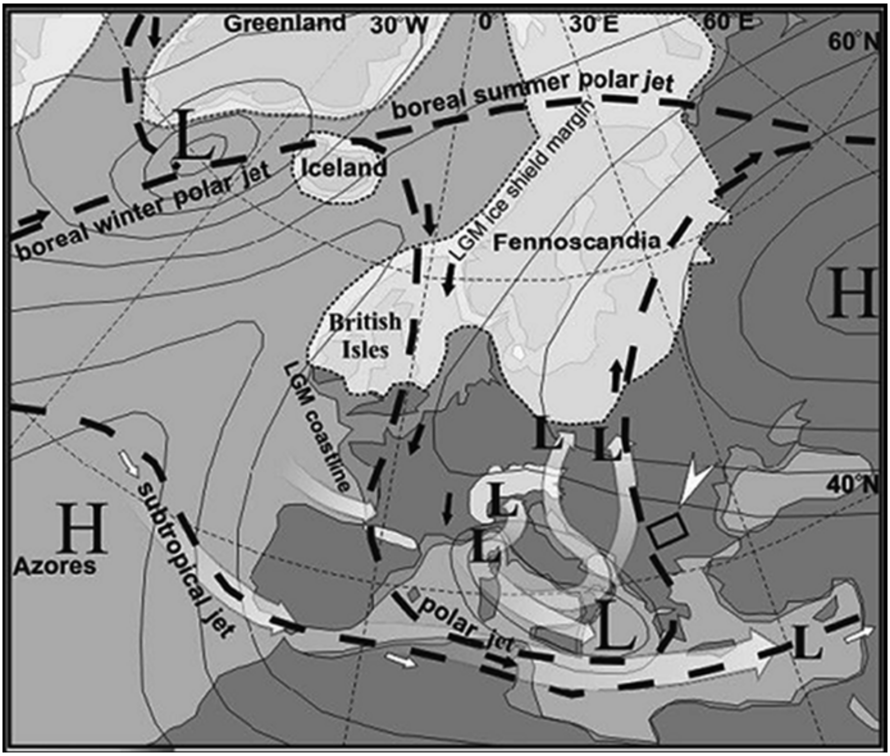

Fig. 25.4 Sketch map of Europe, showing the outline of LGM ice sheets, coastlines, and potential cyclone tracks (*L*) postulated on the base of the new ELA isoline pattern (After Kuhlemann et al. 2008) (*The *hatched line* for a preferential flow of the jet stream in the high troposphere is only a hand-fitted tentative estimate; Mediterranean cyclone tracks are marked in *white*)

Thus, Radev (1920) wrote about "a patch of snow that never disappears at the SW end of Ledeno ezero," that is, just at the location where the ridge was found, and Louis (1930) mentioned "several small glaciers in the high areas of Rila and Pirin." All this information suggests that climatic conditions in the highest cirques of Rila are marginal in relationship to embryonic forms of glaciation (i.e., the present equilibrium line altitude in Rila is not far above the highest peaks), and a small but continuous drop in temperatures will cause their formation. However, for the period of instrumental observation (1933–2008), temperatures at Musala peak were ranging between −1.7 °C and −4.0 °C and showed a general trend of warming, although there was a shift of four contrasting short-term trends, toward a decrease (in the 1930s and 1940s), an increase (in the 1940s–1960s), a decrease (in the 1960s–1970s), and finally a period of sufficient increase (since 1980). Average annual temperatures at Musala have shown a cyclic variations over a range of about 0.5–1.5 °C with a duration of 3 to 5 years. In general, when looking at sliding averages (10-year intervals) it appeared that the rise of temperature for 1998–2008 compared to 1933–1943 has been about 0.5 °C, and for 1998–2008 compared to 1958–1968 was about 1.0 °C (Nojarov 2008).

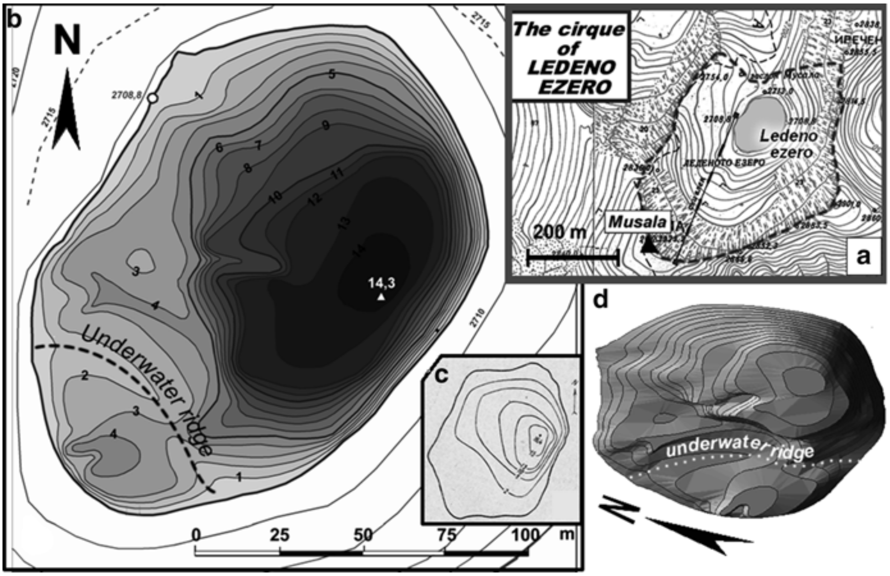

Fig. 25.5 Bathymetry map of Ledeno ezero (the Icy Lake) (Gachev et al. 2008). At the *bottom* on the *right* is the first map made by S. Leutelt-Kipke (1932)

Although there are no measured data in the Bulgarian high mountains before 1933, regional climatic evidence surely indicates that the climate was much colder in about 1910 and suggests that long-term average temperatures were more than 1 °C lower than at present; this should be considered as a maximum temperature for the formation of perennial snow patches in the higher areas of Rila Mountain.

Clear traces of a greater extent of the embryonic forms of glaciation can be observed also in Pirin, in Golemia Kazan cirque. Snezhnika glacieret is surrounded by a well-outlined moraine ridge situated at some distance away from the present ice margins even in years when the size of the firn body during minimum is relatively high. As already mentioned (Grunewald et al. 2008, 2011), the crest should have been formed in its present shape during the LIA. Such a hypothesis is supported by the state of the lichen cover on the crest (partly but evenly developed), which indicates that at present the ice margin during minimum never reaches the crest (no fresh material has been added), and on the other hand no other moraine ridge is observed further down the cirque bottom; the next ridge in the sequence is quite old (weathered, corroded, and covered entirely by lichen), undoubtedly several thousand years in age (most probably Würmian, as first stated by Popov 1962). As in Rila, this larger extent of Snezhnika in the past is a result of climate conditions with lower annual temperatures and probably higher precipitation. The role of each of these climatic factors over the extent of glaciation is hard to differentiate, but it is certain that they both are of great importance. The influence of temperature on the dynamics of perennial snow patches can be clearly seen when comparing the size fluctuations of Snezhnika in the past several decades and air temperature (Fig. 25.7).

25.5.2 Monitoring of Present Geomorphic and Hydrologic Processes

In 2003 the Institute of Geography launched the project “Models of contemporary periglacial morphogenesis,” in which detailed 3-year observations were planned to be carried out on a comparative basis in four key areas: Musala area in Rila Mountain, Vihren area in Pirin Mountain, Livingston Island in the Antarctic, where the Bulgarian Antarctic base is operating, and Spitzbergen Island in the Arctic (Stefanov et al. 2003). The project was carried out in 2004–2007, and because of the severely restricted funding by the Ministry of Education’s Council for scientific research, project activities were carried out to a very limited extent and were concentrated only in the areas of Musala and Vihren peaks. According to the treaty for collaboration signed between INRNE and the Institute of Geography, all research activities in Musala area has become part of the BEO “Musala” observation of terrestrial processes. Activities under this particular project included measurements of water chemistry of Musala lakes, detailed environmental mapping in GIS of Musala cirque, and setting up polygons for monitoring of weathering and slope denudation (solifluction).

An important step forward was the incorporation of Bulgarian research on high mountain geomorphic processes into the global networks of the International Association of Geomorphologists (IAG/AIG). The research team from the Institute of Geography was accepted to participate in the global network SEDIFLUX (sediment source-to-sink fluxes in cold environments). The network aimed to establish worldwide observations and quantitative measurements of contemporary geomorphic processes in Earth’s high latitudes and high altitudes to evaluate current climate fluctuations and trends.

At the fourth science meeting of SEDIFLUX in Trondheim (Norway) in 2006, the Institute successfully promoted Musala area (the upper parts of Musala and Maritsa cirques) for inclusion in the global network for research of present sediment transfer processes in cold environments that should be built up in 2009–2012 under the coordination of the newly established IAG/AIG workgroup SEDIBUD (sediment budgets in cold environments). Now the Musala area is one of the several high-altitude and high-latitude key test sites worldwide (Fig. 25.6), which should contribute to a special global change database for cold environments and where observations should be performed following a unified methodology according to the commonly approved SEDIFLUX Manual (Beylich and Warburton 2007). The Musala area is the only place in Southeastern Europe that is included in the SEDIBUD network of test sites. For now, all sites included in the network must find their own funding for research. Under present conditions this is still a difficult task, so research continues at an insufficient pace.

Since 2008, researchers from the South-West University of Blagoevgrad, Bulgaria, and Bulgarian Academy of Sciences have been performing regular measurements of perennial snow and ice bodies in the Pirin mountains (Gachev et al. 2009; Gachev, 2014) to complete the results obtained by Grunewald et al. (2008).

Fig. 25.6 SEDIBUD global network of test sites (preliminary list, 2008): *1* Cape Bounty (Canada), *2* Botn í Dýrafirði (Iceland), *3* Tindastöll (Iceland), *4* Hrafndalur (Iceland), *5* Örravatnrústir (Iceland), *6* Fnjóskadalur (Iceland), *7* Hofsjökull (Iceland), *8* Austdalur (Iceland), *9* Kangerlussuaq (West Greenland), *10* Mittivakkat-Sermilik (Greenland), *11* Zackenberg (Greenland), *12* Petuniabukta-Sermilik (Spitsbergen), *13* Scottelva-Svalbard (Norway), *14* Moor House, North Pennines (UK), *15* Erdalen (Norway), *16* Kidisjoki (Finland), *17* Latnjavagge (Sweden), *18*Bodalen (Norway) *19* Pasterze (Austria), *20* Musala Area (Bulgaria), *21* East Dabka (India), *22* Godley Valley (New Zealand), *23* Potrok Aike (Argentina)

The area of the Snezhnika glacieret, which is situated at 2400–2450 m a.s.l. under the NW wall of Vihren, was measured in the autumns of 2008–2014 (results presented in Fig. 25.7). The other glacieret in the Pirin mountains, Banski Suhodol, located 2600–2710 m in the cirque with the same name, was studied for the first time in 2009 and has been regularly monitored since then (Gachev and Gikov 2010). In October 2012, fresh glacial striations were found on bedrock surfaces near the glacieret, which were exposed for the first time during the period of observations. This has been the first direct evidence for the presence of a glacier-type dynamic motion for the glacierets in Pirin (Fig. 25.8). The importance of temperature over the regime of perennial ice bodies is well illustrated by the close relationship between air temperature and the size of Snezhnika in periods of minimal ice extent with annual air temperatures (Fig. 25.7). Musala peak is used as a reference parameter for estimating temperature conditions, because there is a strong correlation between temperatures in the highest parts of Rila and Pirin (Nojarov and Gachev 2007), and temperatures in the bottom of Golemia Kazan are about 2.6 °C higher than those at Musala.

The firn body seems to react with a small delay (about a year), probably in relationship to higher (or lower) volumes of ice left from the previous melt season. Sadly, the present analysis excludes the precipitation factor, because there have been no instrumental measurements of climate since 1961 and the great differences in the regime do not allow using precipitation data from Musala peak. If taking into

Fig. 25.7 Variation in interannual size of the Snezhnika micro-glacier and its relation to air temperature

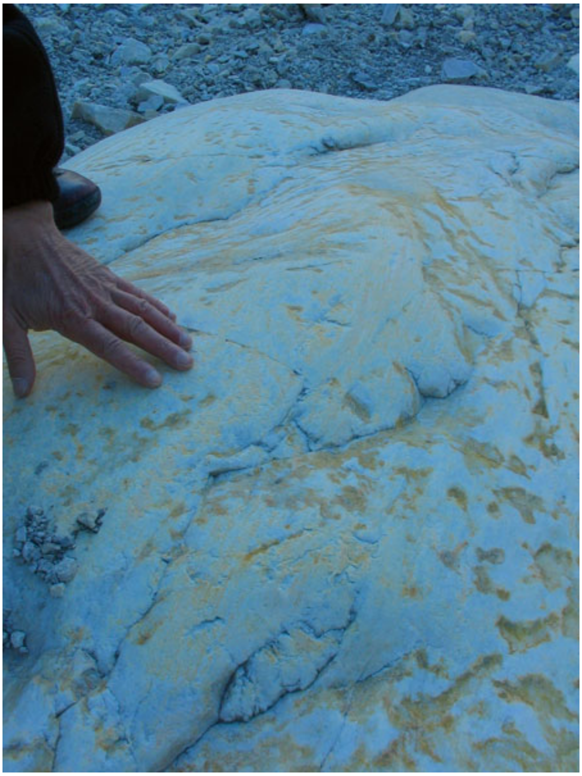

Fig. 25.8 Field measurements of slope gravity processes (Golemia Kazan cirque, Pirin Mountains)

account the fact that a decrease of annual precipitation in the past 40 years is observed in SW Bulgaria as a whole (Velev 2002), a suggestion can be made that the observed much smaller sizes of Snezhnika in 1996 and 2005 in comparison to 1959 (as seen in Fig. 25.7) were caused mainly by the lesser amounts of precipitation, as air temperatures for these particular years differed slightly. The other glacieret in the Pirin mountains, Banski suhodol, located at 2600-2710 m in the cirque with the same name, was studied for the first time in 2009, and has been regularly monitored since then (Gachev and Gikov 2010). In October 2012 fresh glacial striations were found on bedrock surfaces near the glacieret, which were exposed for the first time during the period of observations. This has been the first direct evidence for the presence of a glacier-type dynamic motion for the glacierets in Pirin (Fig. 25.8).

25.6 The Future: Prospects and Expectations

Future activities within the framework "Himont research" should follow the conceptual guidelines of global climate change studies. Research in the Bulgarian mountains needs to be incorporated in a joint effort extending to a regional scale, possibly within the Carpatho-Balkan region. Thus, we recommend initiation and building up of a Balkan workgroup for high mountain environmental studies with a focus on climate change and its local impact on the diverse mountain landscapes of the Balkans. To have a regional look is the only way to properly understand and interpret results from local studies, not only those made in Bulgaria, but elsewhere. Creation of a network of scientists from the Balkan countries will make it possible to elaborate regional climate change models, assessments, and forecasts. For this purpose, a regional mountain environmental change database should also be established.

Priorities in the future development of research in Bulgaria will be placed on a steady broadening of the spatial extent of research and the range of methods used. After 2011, we broadened our study area also including regular monitoring and research of small glaciers in mountains of the western Balkan peninsula: Prokletije (in Albania and Montenegro) and Durmitor (in Montenegro). In particular, ten possible small glaciers were described for the first time in the Albanian parts of Prokletije. During the last years, we have established close contact and collaboration in the field of glacial geomorphology with colleagues from the University of Belgrade (Serbia), the Geographical Institute in Ljubljana (Slovenia), and the Universities of Timisoara and Suceava (Romania).

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25.7 Conclusion

The Bulgarian high mountains Rila and Pirin provide valuable field evidence for estimations of past climatic conditions. Available geomorphic traces from past glaciations suggest that during the coldest phase of LGM average temperatures were at least 6 °C lower than at present, and during the Little Ice Age were 1 to –1.5 °C lower than at present.

Today the alpine zone represents a marginal environment with intensive occurrence of geomorphic processes that can serve as a tool to assess present climate fluctuations. On this basis the Musala area is included in the global network of SEDIBUD test sites for establishment of monitoring these processes following a standardized methodology.

Among the most sensitive field indicators for current environmental changes are perennial snow bodies in Pirin, for which a character of small glaciers was proved (Gachev 2014, Gachev et al. 2015 in press). At present the marginal position of the alpine zone determines an absence of such features in the highest areas of Rila and their presence in Pirin at lower altitudes because of specific lithology and topography. Research in Musala cirque (Rila) and Golemia Kazan cirque (Pirin) shows that very little change toward cooler and damper climate conditions will cause formation of micro-glaciers in Rila, whereas further warming and drying will threaten the existence of perennial snow patches in Pirin.

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Part V
Networks and Strategies for Mountain Regions

Chapter 26
Models and Strategies for Sustainable Management of Mountain Territories in Central and Southeastern Europe

Georgi Zhelezov

Abstract This chapter describes strategies for sustainable management, development, and use of the potential of mountainous areas in Central and Southeastern Europe. The research concentrates the experience of single countries or groups of countries connected with organization and optimization of human activities in various economic areas. Interaction between different programs or initiatives is a key moment for Balkan countries in determination and foundation of the Balkan convention for sustainable development of mountain regions. We have a good experience of the Alpine Convention and relevant experience with the Carpathian Convention as an example.

Keywords Mountains • Convention • Strategy • Transborder cooperation

26.1 Introduction

The development of new strategies for sustainable management and use of the potential in mountainous areas of Central and Southeastern Europe is a key element in the conceptions of the different international and regional programs. The investigation observes the experience of single countries or groups of countries connected with organization and optimization of human activities in various economic areas. The experience from a good practice of the Alpine Convention and Carpathian Convention can be used in future initiatives. The process of interaction between different programs or initiatives is an important moment for Balkan countries in determination and foundation of the Balkan convention for sustainable development of mountain regions. The problems detected in the present models for regulation of these activities are important for future development of the mountainous regions.

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26.2 Specific Mountain Legislation

Specific legislation concerning mountains exists only in countries with a well-developed state policy for mountain regions such as Italy, France, and Switzerland. First was the Swiss law on investments in mountain regions (LIM) adopted in 1974 and amended in 1997. The Italian Constitution from 1948 defined mountains as areas with specific needs. Mountainous municipalities in Italy were defined in 1971 and in 1994 the Law on Mountains was adopted. The first determination of mountains in France was in 1961, followed by the law on mountains in 1985.

In Spain, a definition of mountain regions was prepared in 2002 during the International Year of Mountains. Regarding candidate countries and new Member States of the EU, Mountain Laws are at various stages of preparation and adoption. In Poland the Mountain Act from 1986 was repealed in 1989. Various acts have been prepared since then but none was adopted. Mountain legislation can be at a subnational level, such as the Law on High Mountains in Catalonia (Spain) adopted in 1983 and the Law on Aposeni Mountains (Romania) dated from 2000.

The Federal Chancellors of Austria presented a “Special Initiative for Mountain Region” in 1979, but after that it was enlarged by including other regions in the country in 1985 and renamed the “Initiative for Authentic Regional Development.” In certain countries legislation covers agriculture in mountain areas, as in Austria where since 1972 there has been a special program for farmers in mountain areas, which later included also other parts of the country, and in Spain where the Law on Agriculture in Mountain Areas was adopted in 1982. In other countries legislation may cover specific agricultural activities, such as milk production.

The general view and detailed analysis of the problems and politics related to the mountain regions is presented in the investigation and report of the Nordic Center for Spatial Development titled “Mountain areas in Europe: Analysis of mountain areas in EU member states, acceding and other European countries” (2004). The expert team observed and compared the different aspects of mountain regions in Europe, including definitions and criteria for “mountain” and specific politics in different countries.

26.2.1 Mountain Law in Southeast European Countries

In 2007, the Government of Romania adopted a law to establish the Romanian National Agency for Mountain Areas. Special offices devoted to mountain issues will be set up in the local departments of agriculture and rural development in the 28 counties with mountain areas. In this new structure, professional training centers will support the establishment of professional mountain farmers’ organizations. The creation of this national body for mountains followed an intensive lobbying process by parliamentarians and civil society.

In Turkey, the government is working with partners such as the International Fund for Agricultural Development to boost employment and foster new businesses in the remote mountainous regions of Diyarbakir, Batman, and Siirt provinces. The project supports new non-farming opportunities and expands existing profitable businesses by improving access to markets.

26.3 Regional Conventions

26.3.1 Alps Convention

The Alps are considered as a region of extreme importance belonging to all Europeans. For that reason, these mountains must be protected and their condition should be improved. Their natural recourses, biodiversity, and landscapes must be managed and protected and the environment must be preserved. However, it should be guaranteed that the human societies of the Alps may continue to live and work in these territories. The most important element of the whole system is sustainable economic and social development of the people in the Alpine region. It is important that local and regional authorities participate directly in implementation of the Alpine policy, taking into consideration the principle of subsidiarity in the frame of genuine politics of transnational and interregional cooperation.

Practical implementation of the Convention and its parameters requires determination of several specific priorities instead of preparation of new measures as the only way of true cooperation beyond the borders of the single countries. The efforts should be united, and the funds should not be spent only economically. Establishment of a permanent secretariat should assist the beginning of the Convention until the strengthening of the system for observation and information for the Alps and Alpine net of protected areas.

The Alpine Convention intends to maintain the interest toward these regions and the hopes of the people living in the Alpine region. In Europe and in the world, the value of these regions increases because they are a source of water with primary importance for the world.

26.3.2 Initiative Carpathian Ecoregion (Carpathian Convention)

This initiative is a coalition of NGOs and research institutes that have worked for environment protection and sustainable development of the Carpathians mountain region, using the characteristics of biodiversity and opportunities for integration with social and culture factors. The region includes seven Carpathian countries. The activities were carried out in working groups for biodiversity, tourism, communications, ecological education, development of rural regions, etc.

26.4 Transborder Initiatives Between Bulgaria and Neighbor Countries

26.4.1 Transborder Ecological Network Between Bulgaria and Greece

The first transborder ecological network was established between Bulgaria and Greece in 2007. They used the conception of a Paneuropean ecological network, which is a part of the Paneuropean strategy for biological and landscape diversity.

26.4.2 Euroregion in Western Balkan Mountain Between Bulgaria and Serbia

The region geographically is described as Western Balkan: it includes seven municipalities in Bulgaria and four in Serbia. The basic natural component of the region is biodiversity. The central point of interest is natural territory and its management. The form of institutionalization is the Transborder Forum as an independent platform for dialogue. There is a signed letter of the mayors of participating municipalities. The letter is supported by Ministries of Foreign Affairs in the two countries and brought for ratification in the Governments.

26.4.3 Green Network Strandzha/Yildiz Between Bulgaria and Turkey

The network will develop as a mechanism for transborder integrated management of the whole ecosystem (transborder region). The basic aims follow:

- Improvement of the competitive power of the region
- Development of potential, important for the network regions using the opportunities for application for concrete projects
- Improvement of information base for the local people who are connected with the problems of sustainable economical development
- Establishment of the structure for coordination and interaction between transborder partners
- Future development of this partnership

Structure of green network Strandzha/Yildiz

- Central coordination group
- Basic "knots" or participants in their public council
- Connection between participants and mechanism of interaction
- Territory covered by the network

26.4.4 International Cooperation of Bulgarian Mountain Regions

National Park “Central Balkan,” Nature Park “Vitosha,” Biosphere Reserve “Sreburna,” protected area “Kalimok-Brushlen,” etc. are partners and participate in the transnational program for cooperation in Southeastern Europe (SouthEast Europe Transnational Cooperation Programme). The activities are connected with monitoring, management of protected areas, development of ecotourism, and education courses, which are a priority for the institutions.

The Bulgarian-Swiss program for protection of biodiversity and the GEF project support the elaboration of management plans for protected areas such as the three national parks “Rila,” “Pirin,” and “Central Balkan,” and the Black Sea wetlands as a part of international projects. The subject of these projects is renovation of important nature habitats. The Ministry of Environment and Water has helped in activities connected with announcement of new protected areas.

There have been a number of education activities and programs connected with change of human consciousness about the importance of nature protection activities. Centers for nature protection have been established and equipped. Administrative capacity has been developed in regional structures of the Ministry of the Environment, which is responsible for protection of biological diversity, management, and control of protected areas as a part of the projects.

Bulgaria is the first country with two national parks in the network PAN Parks, the national park “Central Blakan” and the national park “Rila.” This is a great success for the country and proof of the unique Bulgarian nature: economic development connected with high quality of tourist services in accord with sustainable development.

The Ministry of Environment and Water supports the initiative “green belt” of one of the greatest nature protection organizations in the world: the International Union for the Conservation of Nature (IUCN). The initiative is orientated toward protection of important nature habitats at country borders between East and West Europe and the integration of these places in the ecological network.

Bulgaria together with other Balkan countries participated in development of the idea for the Balkan Green Belt. Protection and sustainable development of the mountain regions at the Bulgarian border (West Balkan, Kraiste, Osogovo, Vlahina, Maleshevska, Ograzhden, Belasista, Slavianka, Rodopi, and Strandzha) are key elements in the conception and will be very important for realization of the biggest nature protection initiative in United Europe. The basic points of the project “Green Belt” are these:

- Popularization of the territories of the Green Belt and wide help for social support in the process of protection
- Collection of basic information for biological diversity in the regions of Green Belt
- Creation and coordination of national working groups for Green Belt
- Preparation of the projects for sustainable development of the regions in Green Belt

Realization of the initiative for mountainous regions is connected with development of two general structures, centers and programs and source of financing.

26.4.4.1 Centers and Programs for Education

There are centers for investigation and education connected with inventory, analysis of mountain tendencies and directions, new ideas for development, education in research, and recourse management in countries with wide mountain regions. These centers are very important for development and realization of the policies on mountain regions. Using the important information, they encourage the innovations and conditions of the management of mountain resources. Investigation centers are solid in Austria, France, Italy, Norway, and Switzerland and also in some new member countries as Romania and Slovakia. There are similar instruments in more Alpine countries. Education centers are oriented toward agriculture, mountain guiding, and skiing. Strong policies connected with the mountain regions is a part of investigation centers. We need effective regional or national institutions and centers for education, and investigations and training for development of the understanding of questions connected with mountain regions in different countries, whether members or nonmembers of the European Union.

26.4.4.2 Funding

Mountain development funding is still inadequate, despite the increasing awareness of the importance of mountains and the persistently high incidence of poverty, food insecurity, and vulnerability of mountain populations, particularly in the developing world. Traditional funding sources and approaches are important, but these may fail to recognize and address the specificities of the mountains and mountain people. There is also undoubted potential to tap newer, more innovative financial mechanisms for mountain development, such as debt-for-nature swaps, payment for environmental services, and microfinance opportunities. Payment for environmental services, which compensates local land users, has increasingly been used to manage biodiversity in mountains in recent years. For example, the Regional Integrated Silvopastoral Approaches to Ecosystem Management Project, initiated by local NGOs and financed by GEF, uses payment for environmental services to encourage silvopastoral practices in degraded pastureland in the mountains of Colombia, Costa Rica, and Nicaragua. Participating land users receive direct annual payments for the environmental services they generate. Initial results show that payment for environmental services has induced positive land use changes such as improved water quality and increased bird and ant species diversity.

The Mountain Partnership is providing information about the availability of funds for mountain activities from all possible sources on an ongoing basis. Its searchable funding database on the Mountain Partnership website contains details on the various thematic and regional areas of mountain development supported by financial institutions, foundations, multilateral development banks, and donor agencies around the world. The database is complemented by online resources and tools that offer tips, practical suggestions, and guidelines for funding and proposal writing.

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Chapter 27
Science Networks for Global Change in Mountain Regions: The Mountain Research Initiative

Astrid Björnsen Gurung

Abstract The Mountain Research Initiative (MRI) promotes and coordinates research on global change in mountain regions around the world. In its eight years of existence it has actively participated in the design of an international research agenda. The Global Change and Mountain Regions (GLOCHAMORE) Research Strategy, a product stemming from an FP6 Support Action, is at the core of the MRI. It identifies gaps and formulates priorities for future activities in mountain research. Through its regional networks, MRI catalyzes the interdisciplinary research described in the GLOCHAMORE Strategy. Within the European network, the recent establishment of the Science for the Carpathians (S4C) initiative is an encouraging signal for the strong will and interest of research communities to steer mountain research toward international and interdisciplinary collaboration. Mountain scientists working in the Balkan Region could take the Carpathian initiative as an example to build up a science network in and for Southeastern Europe.

Keywords Global change • Mountains • Scientific network • Europe • Research coordination

27.1 Origin of the Mountain Research Initiative

The International Geosphere-Biosphere Programme (IGBP) workshop on mountains held in Kathmandu, Nepal, in 1996 set the first milestone in the history of the Mountain Research Initiative (MRI). The workshop report highlighted that mountain systems are at risk and need special attention, in particular with respect to the possible impacts of global change. It pointed out the need of intensified, collaborative, and coordinated research to be fostered through an international research program (Becker and Bugmann 1997).

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IGBP joined forces with the International Human Dimensions Programme (IHDP) on Global Environmental Change and the Global Terrestrial Observing System (GTOS) during the following years to collaboratively define the objectives, approach, and activities of this new research program: the Mountain Research Initiative. The final product of this joint effort outlines the four dimensions of research activities that were determinant for the formal establishment of the MRI (Becker and Bugmann 2001):

1. Long-term monitoring of environmental change in mountain regions (e.g., meteorological and cryospheric indicators, plant communities, soils, and freshwater ecosystems)
2. Integrated model-based studies of environmental change in different mountain regions
3. Process studies along altitudinal gradients
4. Advice for sustainable land use and natural resource management

In brief, the MRI strives for a better understanding of mountain system processes and functions under global change, which is then translated into specific recommendations for furthering sustainable development in mountain regions around the globe. The notion was never that MRI as an institution would direct such a program but rather that MRI, both as institution and as a community of researchers, would facilitate the emergence of such research through the promotion and coordination of research funded and conducted by myriad agencies and individuals around the world.

27.1.1 Actions at Global Level: Design of an International Research Agenda

Only in 2001 was an MRI Coordination Office established in Berne, Switzerland, at the Swiss Academy of Sciences using funding from several Swiss agencies and the ETH. The first Executive Director, Dr. Mel Reasoner, set out to foster and coordinate research of the four types listed here. He set the scene by producing the first comprehensive compendium of past and current research on “Global Change in Mountain Regions” (Huber et al. 2005). This 700-page book provides an overview of what is known and what directions research should take in the future.

A further milestone in the MRI history was the successful launch of the Global Change in Mountain Regions (GLOCHAMORE) project. This FP6 Specific Support Action (2003–2005) translated the global goals of IGBP Report 49 into much more specific disciplinary objectives coupled to a recommendation for inter- and transdisciplinary research approaches. Targeting UNESCO Mountain Biosphere Reserves around the world, the project included more than 250 scientists and managers of Biosphere Reserves worldwide and was coordinated by MRI and by the University of Vienna. The GLOCHAMORE Research Strategy (Björnsen 2005), the project’s final product, is an integrated and implementable research strategy to better understand the causes and consequences of global change in mountain regions around the world. The Strategy is a consensus document developed through consultation with the international community of scientists and biosphere reserve managers.

27.1.2 Implementing the GLOCHAMORE Research Strategy

In 2006, after completion of the GLOCHAMORE project, the MRI moved from strategy development to implementation through the initiation and support of regional networks of global change researchers. As MRI is a promotion and coordination effort, it cannot simply "do" the research necessary in a region, but must induce research groups and individual scientists to fill the scientific gaps defined by the GLOCHAMORE strategy. Thus, four program activities are at MRI's core:

1. MRI strives to enlist key scientists promoting inter- and transdisciplinary research through their national or multinational research funding agencies. By engaging these champions, MRI can vastly improve its effectiveness.
2. MRI supports the formation of new research partnerships and catalyzes groups and individuals to develop project proposals to funding agencies. This is a direct and efficient way to create the kind of research defined in the GLOCHAMORE Strategy.
3. MRI facilitates the development of peer-reviewed papers on specific key scientific issues. These contributions to the literature focus the community's attention on some of the most important issues in mountain regions.
4. MRI distributes relevant information to researchers on global change in mountains. By increasing the flow of information to these researchers, MRI seeks to create additional interaction and a stronger sense of community.

27.2 MRI Europe: A Regional Network for Global Change Research in Mountains

A large part of the MRI activities occurs through the three regional networks: MRI Africa, MRI American Cordillera, and MRI Europe. Within these regional networks MRI attempts to catalyze global change research in the thematic fields defined in 2001 and specified in the GLOCHAMORE Research Strategy. It does so principally through the development of new funding proposals, but also through the engagement of regional leaders and the development of regional-specific communication products. The functioning of MRI's regional networks and their scientific output can be illustrated with the example of the European network (http://mri.scnatweb.ch/networks/mri-europe/).

In 2006, the MRI undertook a first attempt to initiate the "Global Change Research Network in European Mountains." At the outset, MRI attempted to use place rather than discipline as an organizing paradigm. Shortly after the publication of the GLOCHAMOREstrategy, the MRI invited scientists and managers associated with the European Mountain Biosphere Reserves that had participated in the GLOCHAMORE project to attend a meeting in Zurich (May 3–4, 2006) to translate the GLOCHAMORE strategy into a program appropriate for Europe. The assumption underlying this approach was that the global change-related issues were more completely owned by those managers than by disciplinary scientists. These managers would therefore have an interest in promoting an inter- and transdisciplinary research program in their Biosphere Reserves and in linking those programs together into a network. For manifold reasons, the hoped-for launch of a global change research network in European mountains did not, however, ensue from this meeting. The assumption that Biosphere Reserve managers were central to the implementation may have been simply wrong. Some Biosphere Reserves had long, rich histories of research, and it is plausible that those managers saw no particular benefit to them or their constituencies in "standardizing" research at their sites to some international standard. In other sites, research was but one of many managementconcerns, usually of lower priority. In yet others, the site was essentially managed by researchers and therefore had no administrative apparatus through which stakeholders could make their concerns manifest. Thus, although Mountain Biosphere Reserves remained quite logical sites for global change research, their management did not prove to be a useful starting point.

Thereafter, MRI took quite a different approach, one focused on scientists, regardless of their affiliation with place, and on funding. MRI announced another meeting for 1–2 February 2007 on global change in European mountains, but this time with a subtitle emphasizing funding through the European Commission's 7th Framework Programme for Research and Development (FP7). Furthermore, it made no assumptions regarding an optimal structure for implementation, but rather asked researchers how they wished to proceed. This meeting drew ten times as many participants as the earlier meeting. At the occasion of this February meeting, the MRI Europe science network was officially launched (Fig. 27.1).

As defined by its network members, it aims to connect and support global change researchers working in different mountain regions in Europe. Networking meetings

Fig. 27.1 The European network devoted to organizing mountain research in Europe, MRI Europe, was launched in early 2007 (http://mri.scnatweb.ch/en/networks/mri-europe)

Fig. 27.2 Thanks to the initiative of a group of devoted scientists, the Science for the Carpathians (S4C) network was launched in 2008 (http://carpathianscience.org/)

convened by MRI and its regional partners allow participants to exchange ideas and to locate opportunities for collaboration. By fall 2008, MRI Europe had grown to almost a thousand active scientists.

27.2.1 Science for the Carpathians: Working toward a Research Agenda for the Carpathians

The Science for the Carpathians (S4C) initiative developed within the European network at an unprecedented speed. In spring 2008 a group of researchers with a mandate from the Interim Secretariat for the Carpathian Convention (UNEP-Vienna) requested the MRI's assistance in organizing science in the Carpathian region. The MRI worked with the Jagiellonian University, the European Academy Bolzano, Joanneum Research, the University of Applied Sciences Eberswalde, and the Humboldt University zu Berlin to organize the first S4C meeting in May 2008 in Kraków, Poland. The goal was to set the stage for a new science network for global change research in the Carpathian mountains (Fig. 27.2). The workshop aimed at defining the current status of global change research in the Carpathians, at drafting a research agenda for topics relevant to the region, and at establishing an active science network.

In the wake of the S4C launching workshop, the initiative became visible through various means and occasions. The S4C electronic Newsflash informing more than 300 network members about current and future activities in the field of Carpathian research is complemented by a S4C website (http://mri.scnatweb.ch/networks/mri-carpathians/) documenting its progress. Part of the progress is the growth of the "S4C List," a simple spreadsheet with names and expertise of the numerous network members that actually embody the initiative. As a product from the Kraków workshop, a synthesis paper on "Global Change Research in the Carpathian Mountain Region" with 15 coauthors has been published (Björnsen et al. 2009). The paper reviews the current status, identifies knowledge gaps, and suggests avenues for future research. As such, it is the first step toward a Carpathian Research Strategy.

Fig. 27.3 Encouraged by the coordination efforts of other regions, the South European Mountain Research network (SEEMORE) started to operate in 2009 (http://mri.scnatweb.ch/en/networks/mri-europe-south-eastern-europe)

From the same occasion, a workshop report was compiled by the Institute of Geography and Spatial Management, Jagiellonian University, and published by the MRI Berne Office (Ostapowicz and Sitko 2009). These products testify the interest, willingness, and active support of the S4C community to give the Carpathian mountain research a new impetus and profile.

To sustain the S4C network on a long-term basis, the initiative needs to be formally established in the region. For that purpose, shortly after its launch in May 2008, the S4C initiative received the support of the Conference of Parties of the Carpathian Convention at their meeting in Bucharest in June 2008. To sustain the science initiative on a long-term basis, a second S4C Meeting was scheduled for 9–10 June 2009 at the Slovak Academy of Sciences in Bratislava targeting at (i) the formation of a S4C Steering Committee, (ii) the preparation of the first Forum Carpathicum, scheduled for 15–17 September 2010 in Kraków, Poland, and (iii) the discussion between representatives of National Science Academies and Carpathian scientists on the long-term establishment of S4C.

27.2.2 Southeastern European Mountain Research Network

The evolution of the Carpathian science network is an encouraging example for other regions that have undergone strong political, historical, and environmental changes during the last decades. Although the mountains of Southeastern Europe are plentiful and host diverse cultures and habitats, the global change researchers of this region have not become very visible within the European science community. With the emerging European funding opportunities and new options to establish research partnerships within Europe, it is high time to give mountain science in the Balkan area a profile (Fig. 27.3). Examples from other mountain ranges such as the Carpathians can be taken as a model. Specific priorities, structures, and operational modes, however, need to be freshly defined by the research community of the Balkan region.

Countries covered by the South Eastern European Mountain Research Network (SEEmore) are Albania, Bosnia and Herzegowina, Bulgaria, Croatia, Greece, Macedonia, Montenegro, Romania, Serbia, Slovenia and Turkey. The research network is also open to mountain scientists from outside Southeastern Europe who have expertise or a research interest in the SEEmore region.

Similar to the history of the MRI, great things start with a good idea and grow with the commitment of individual researchers working toward concrete activities.

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