

Mountain Biodiversity in Romania

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Abstract

There exists a strong link between mountain regions and biodiversity. These regions represent the most important source of regional and global ecosystems forming the core elements of environmental and sustainable development policies. Mountains operate as true refuge for endemic species but are affected by uncontrolled human actions, while alpine meadows are exposed to losses of traditional pasture practices. Mountains can be analyzed from the economic, ecological, environmental, social, cultural viewpoints and their multidisciplinary nature is acknowledged both in the academic milieu and by decision makers involved in territorial development policy. The negative impact of economic activities in mountain regions is becoming more visible, therefore, necessitating a sustainable approach to preserve the biodiversity and habitat in order to salvage the fragile ecological balance. The present paper gives an overview of the relationship between biodiversity and sustainability within mountain regions and its implications on the economic and social development process. By interpreting the finding of previous research and studies, the article presents the current knowledge of mountain biodiversity in Europe and Romania and its relationship with sustainable development process.

Keywords

Biodiversity; Mountain region; Sustainable development

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Introduction

The mountain areas covering about 22% of the Earth's surface (32 million km²), sustain directly about 13% of the world's population (915 million inhabitants), of them 70% is the rural population. Mountains provide approximately 60-80% of the water resources

of the Earth¹. Due to the unique natural exquisiteness, mountains host most of the protected areas. Thus, approximately 25% of the total land surface covered by mountains represent the permanent dwelling place of some rare species of fauna and flora, either relict or in peril (Blyth *et al.*, 2002, p. 494) or shaping unique habitats and ecological shelter corridors for forest species (Körner and Ohsawa, 2005).

The mountain regions hold 60% of the biosphere's reserves that contribute by 15-20% to the tourism activities at global level (Romeo *et al.*, 2021). They are covered by 23% by forests. They shape a living supporting life-environment of populations continuously and aggressively subjected to severe economic pressures (unemployment, migration, change of land use models, habitat fragmentations, deforestation, industrialization, mining pressure, pollution and uncontrolled exploitation of natural resources, and environmental degradation, water deficit, etc.) contributing to decreasing intrinsic values. Mountain regions are found in all continents, at all latitudes and within all types of ecosystems (from the arid desert and tropical rainforests to the polar zones).

Mountain regions are relevant and play an important role in the economic, social, environmental development, as well as in the culture and traditions of local communities. They provide ecosystem services, such as water provisioning and cycling to both mountain and lowland communities. They also host a high diversity of habitats and species highly adapted to extreme climatic conditions. Mountain ecosystems are fragile and vulnerable, and are severely threatened by land abandonment or intensified agriculture, infrastructure development and rapid climate change (Körner, 1985). The use and exploitation of natural resources within the mountains affect biodiversity, sometimes, causing inestimable damage to it (Zemp, Hoelzle and Haeberli, 2009), which are as follows:

1. *Impact of the agricultural sector on mountain biodiversity*: There are mutual and complex interactions between agriculture and mountain biodiversity. Agriculture affects biodiversity. The mountain biodiversity is one of the main element of the ecological production in agriculture field. On the one hand, sustains the crops and domestic livestock and the variety within them. On the other hand, components of wild biodiversity in agricultural provide and maintain ecosystem services that are essential to agricultural production. The heterogeneous mountain environment contributes to the evolution of a variety of agricultural cultures adapted to the environmental conditions and human needs. The cultivation of food crops (corn, potatoes, barley, sorghum, tomatoes, apples, etc.) and rearing of domestic animals (sheep, goats, etc.) originated from the mountainous regions. Over time, the genetic diversity of the plants and animals from the mountain region are on the increase due to the cultural diversity and extreme variations of the environmental conditions. Currently, the mountainous biodiversity is threatened by the continuing modernization processes of agricultural production, an aspect that leads to the pauperization of the ecosystem by using few sorts and lacking genetic variation². The expansion of

¹ https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/412/original/SynthesisReport_screen.pdf?1544437610

² According to a recent FAO estimate, 78% of the world's mountain area is unsuitable or only marginally suitable for growing crops.

agricultural production on untilled land triggers the destruction of habitats for some species and the deterioration of ecosystems, especially where the lands are not adequately exploited for agriculture. The mountainous agricultural ecosystems may bear invasions of some alien habitats thereby affecting local species and, implicitly, the local biodiversity as they are separated by valleys and mountain peaks (Romanian Parliament, 2003).

2. *Impact of the forestry sector on mountain biodiversity:* Mountain forests deliver ecosystem goods and service to millions of individual in mountain communities and adjacent lowland areas. Globally, 23% of the world's forests are located in mountain regions, covering 9 million square kilometers. Mountain forests and biodiversity provide many benefits, such as erosion control, improved water quality and quantity, carbon fixation, recreation and aesthetic appeal, timber, fuel wood and non-timber forest products (Mountain Partnership, 2020). The vast majority of the mountainous area is made out of the forest ecosystems of low and medium altitude. Under certain conditions, the mountain forests provide basic goods and services to local communities. The forest ecosystems within the mountain areas are threatened by the unsustainable methods of wood exploitation (uncontrolled, abusive wood-cutting, setting-up forest monocultures, etc.). The situation of forests in Europe appears to be relatively promising with respect to their biodiversity in the future. Approximately 10% of the forest area in Europe is in conservation areas. Nevertheless, an increase in area of conservation appears not to be the only remedy to protect forest biodiversity. While some authors concluded that conserved forests have higher biological diversity than managed plantations, others have found that some taxa or species profit from human-managed forests (Horák *et al.*, 2019).

3. *Impact of the tourism sector on mountain biodiversity:* During the past some years, tourist activities in the mountain region had important dynamics (winter sports, outdoor activities, etc.), a fact which led to extending the tourism infrastructure and tourism services. This affected rapidly the fragile ecosystems and the mountain biodiversity in an uncontrollable manner. For instance, the remodeling of mountain slopes for skiing and other winter sports has a strong impact on the integrity of the mountain ecosystems. The building of tourist infrastructure has resulted in the urbanization of some mountain areas with (total or partial) biodiversity loss.

4. *Impact of mining on mountain biodiversity:* Exploitation of ore, metal and other resources has a negative impact within mountain regions leading to severe water pollution and disturbance of the downstream areas. Moreover, the cutting of trees/plants and digging of the soil in areas where mining is practiced result into the destruction of landscapes, habitats, soil and agricultural lands. At the same time, rains wash away the land of open strip mining and the sediments pollute groundwater, poisoned fish, disfigure the rivers and rivulets, and generate flooding and landslides.

5. *Impact of the hydropower plants on mountain biodiversity:* The mountains and mountain lakes are frequently used in building power plants for generating electricity. Even if they represent an important source of renewable (green) energy, their design has negative impact on rivers and ecosystems in the vicinity. The creation of artificial lakes and the alteration of watersheds also affect negatively the habitats, ecosystems and valleys in the immediate proximity (Romanian Parliament, 2003).

6. *Impact of climate change on biodiversity:* Another process that has an important impact on mountain biodiversity is climate change. Mountain environments are very sensitive to climate change (Beniston, 2003). They appear among the most severely and rapidly impacted ecosystems, and can be affected by any change in temperature and precipitation patterns at all scales (Zemp, Hoelzle and Haeberli, 2009). Thus, global warming affects negatively mountain ecosystems by the retraction and sometimes extinction of some life forms from the alpine area. Endemic mountainous species pulled back at high elevations and some destroyed due to habitat loss. Changes in the precipitation periods and increase in temperatures have triggered the melting of glaciers and decline of snow-covered mountain areas, thus, reducing the capacity of rejuvenating waters. By a process of non-compliant water management process in the mountain areas, both low altitude and vicinity areas were subjected to water scarcities.

Moreover, air pollution influences negatively the mountain biodiversity. In the mountain areas, the high rates of precipitation results to the depositing pollutants from the atmosphere in soils and/or its accumulation in the snow layers affecting ecosystems and vulnerable species. Acid rain triggers the destruction of trees, although it involves intensive research and careful monitoring activities of pollutants and main sources (Rey and Gruia, 2016).

This paper addresses a number of problems relating to mountain biodiversity in Romania. Following an introduction outlining the overarching issues, a short summary is given on important factors that affected the biodiversity of mountain regions. The biodiversity of mountain is subjected to a phenomena correlated directly to the activities of the local communities (and not only): abandoning the area, tourism and winter sports development, infrastructure development, urbanization, soil compaction, etc.

Biodiversity of the Mountain European Area

In Europe, the mountain area covers 40% of the total surface area hosting 20% of the population³. On European continent, seven of the longest and highest mountain chains of the globe do exist, namely: the Alps (localized in the Central Europe), the Apennines (Italy), the Pyrenees (on the border between Spain and France), the Scandinavian Mountains (Sweden, Finland and Norway), the Carpathians (covering 7 countries with the shape of an ark from Slovakia to Romania), the Balkan Mountains (Croatia, Bosnia & Herzegovina, Serbia, Albania, Macedonia) and the Rhodope Mountains (Bulgaria). The main mountain regions from Europe and its countries are presented in table 1.

The extremely complex topography (south-oriented sheltered slopes, snow pockets, wind-blasted crags and rugged land covered by debris) explain the particularly rich biodiversity of the alpine areas (two-thirds of the plants are found in the mountain area) (Korner, 1985, p.93) (Table 2).

³ <http://www.turismulresponsabil.ro/wp-content/uploads/2017/01/2.-Danut-Ungureanu-Zona-montana.pdf>

Table 1: Mountain areas and the countries involved

<i>Countries involved</i>	<i>% of the EU territory</i>	<i>Regions</i>
Belgium, Germany, Denmark, Spain, France, Ireland, Portugal, the Netherlands, the United Kingdom	18.4	Atlantic
Estonia, Finland, Latvia, Lithuania, Sweden	18.8	Boreal
Austria, Belgium, Bulgaria, Czech Republic, Germany, Denmark, France, Italy, Luxemburg, Poland, Romania, Sweden, Slovenia	29.3	Continental
Austria, Bulgaria, Germany, Spain, Finland, France, Italy, Poland, Romania, Sweden, Slovenia, Slovakia	8.6	Alpine
Czech Republic, Hungary, Romania, Slovakia	3.0	Pannonian
Romania	0.9	Steppic
Bulgaria, Romania	0.3	Black Sea
Cyprus, Spain, France, Greece, Italy, Malta, Portugal	20.6	Mediterranean
Spain, Portugal	0.2	Macronesian

Source: European Union⁴

Table 2: Mountain chains in the alpine biogeographic region of Europe

<i>Mountains</i>	<i>Characteristics of the mountain biodiversity</i>	<i>Socio-economic characteristics</i>
The Pyrenees (430 km ²)	There are 60 types of habitats are present in these mountains (Habitat Directive ⁵). The mountains are characterized by numerous torrents, cascades and lakes. At elevations over 1,000 m, there are over 1,500 lakes. The diversity of the flora is exceptionally high: 3,000 species of plants, from among which at least 120 are endemic. There is vast diversity of birds and animals (over 40 species of mammals, including rare endemic species). One of the extinct species is the Pyrenees Ibex ⁶ .	The mountains are relatively low populated, the agricultural sector and sheep breeding being the main activities. In the past, the Pyrenees underwent an intensive deforestation process (and with visible traces mainly on the mountainsides). The beech was intensively used as firewood and in feeding the furnaces for ore extraction. Tourism is another economic activity of high intensity next to winter sports.

⁴ http://ec.europa.eu/environment/nature/info/pubs/docs/biogeos/Steppic%20Region/KH7809607ROC_002.pdf

⁵ The Habitats Directive ensures the conservation of a wide range of rare, threatened or endemic animal and plant species. Some 200 rare and characteristic habitat types are also targeted for conservation in their own right.

⁶ In January 2000, the Pyrenean Ibex was completely extinct. Nevertheless, scientists have attempted to clone this species by using DNA from one of the last females; such a clone died seven minutes after birth. Other sub-species survived: the Spanish western Ibex, or the Ibex Gredos, and the Ibex from the south-eastern part of Spain, while the Portuguese Ibex is extinct. The last Ibex from the Pyrenees disappeared

<i>Mountains</i>	<i>Characteristics of the mountain biodiversity</i>	<i>Socio-economic characteristics</i>
The Alps (1200 km.)	The forests are in relatively natural state as at high elevations they are true refuge and ecological corridor for many large species (bears, birds of prey). The grasslands and alpine meadows make up 25% of the mountain vegetation (the majority semi-natural, affected over time by moderate agricultural practices) and many of them are threatened by farmstead abandon. 84 types of habitats are listed, from among which 47 species of plants. The Alps have over 40% of the European flora but also 200 species of birds (which lay their eggs here) and other 200 migrant birds. The Alps represent one of the most biodiversity richest mountain chains from European, but also one which is heavily exploited.	In the Alps live over 11 million inhabitants mainly in the urbanized valleys. To them are added 100 million tourists visiting the Alps with tourist or recreational purposes. These phenomena exert an important pressure on the mountainous environment which has a particular fragility.
The Apennines (1350 km)	In the Apennines on the Italian side, during the last Ice Age the ice sheets advanced and after their meltdown the populations began their separate evolution. One of the species running the risk of extinction is the Abruzzo chamois (<i>Rupicapra pyrenaica</i> ornate) the reason being excessive hunting (450 individuals that are vulnerable to diseases and consanguinity).	The inhabitants are in small numbers and on a decreasing trend. Consequently, the traditional agricultural systems of cattle breeding are vanishing; however, efforts are made for repopulating the area due to the fact that these mountains are included in a network of interconnected national parks.
The Scandes (1400 km.)	The diversity of the species in the area of the Scandes is relatively low. Nevertheless, they represent an essential component of the European biodiversity due to their considerable size and the unaltered character. They are counted among the few locations in Europe where we might	The low presence of humans in the Scandes is not surprising. Some of the activities, such as river damming for generating hydroelectric power, reindeer herding, or the disappearance of summer grazing had negative impact at local level. However, the majority of the mountainous

before scientists could analyse the species accordingly, the taxonomy of this sub-species being controversial.

<i>Mountains</i>	<i>Characteristics of the mountain biodiversity</i>	<i>Socio-economic characteristics</i>
	discover authentic wilderness. 44 types of habitats are represented, 29 species of plants and 18 species of animals (Habitats Directive).	lands remain unperturbed by human presence, and therefore this remains one of the largest intact natural areas in Europe.
The Carpathians (1450 km.)	The habitats have a long tradition regarding the exploitation of lands but also sheep and cattle breeding. The Carpathians host many species, with a high level of biodiversity: over 3500 species of plants from among which 481 endemic species. Here we find large carnivores, a varied selection of small mammals, many endemic species from among which the Tatra pine vole and the Carpathian marmot. Over 300 species of birds (the Ural owl, the white-backed woodpecker, the black stork, etc.).	In the Carpathians live about 18 million individuals, who are exerting pressure on maintaining and preserving the biodiversity
The Balkans ⁷ (550 km.)	These mountains display a typical alpine character and have a strong Mediterranean influence regarding the make-up of the species. Over 60 types of habitat (Habitats Directive) with a considerable forests' component, with many endemic species of trees (the Balkan pine, King Boris fir, and the black (Bosnian) pine. The area contains a huge variety of plant species and numerous large carnivore populations, and species of birds of prey (in Rhodope is found the largest agglomeration of day birds of prey from Europe).	The population density is extremely low. The mountains are in remote areas and still unexplored.

Source: European Commission (2010)⁸

Most of the important-for-community habitats are found in the continental area (7,475), followed by the Mediterranean (2,928) and the Atlantic (2,747) ones. Regarding the special protection areas (SPAs), most of them are designated in the Continental region (1,478) followed by the Boreal (1,165). Nevertheless, the widest surfaces covered by important-for-community habitats are found in the Black Sea

⁷ They are constituted from three distinct mountain formations: the Rila Mountains, the Pirin Mountains and the Rhodope Mountains.

⁸ <https://op.europa.eu/ro/publication-detail/-/publication/9a738f76-c937-478d-b720-1562a53385e4/>

region (71.8%) and those of special protection in the Pannonian region (31.3%), according to Habitat Directive⁹.

In the mountain areas of Europe, the extensive agricultural practices, the transhumance, forestry, etc. have contributed to creating an important diversity of landscapes and cultures (Huddleston, Ataman and Fed'Ostiani, 2003). Nowadays, this biodiversity is subjected to a phenomena correlated directly to the activities of the local communities (and not only): abandoning the area, tourism and winter sports development, infrastructure development, urbanization, soil compaction, etc. The development of mountain tourism expanded practically over the entire continent, in parallel with the intensification of traffic and the building of the transport infrastructure (which turns into an important barrier for species migration¹⁰).

Damming the main rivers in the mountains for the hydropower sector or for irrigation has modified considerably the natural mountain environment. These activities influenced the biodiversity of the mountain areas, a fact mentioned in various reports and analyses at EU level. As might be seen, most mountain areas from Europe are in an unfavorable preservation state (60.68%) from among which 32.57% are in a very bad situation, a fact which should impose the implementation of swift and drastic measures required for rebuilding the state of the affected habitats (EEA Report No. 6/201¹¹) (Table 3).

Table 3: Numbers of habitat types in each massif classified by conservation status (no.)

<i>Massif</i>	<i>Favorable</i>	<i>Unfavorable (inadequate)</i>	<i>Unfavorable (bad)</i>	<i>Unknown</i>	<i>Total</i>
Apennines	47	26	3	8	84
Balkans/South-east Europe	32	27	23	1	83
Atlantic islands	11	12	7	1	31
Nordic mountains	22	13	27	2	64
Central European middle mountains (Belgium and Germany)	16	18	12	2	48
Eastern Mediterranean islands	13	18	6	8	45
Carpathians	10	21	18	2	51
Alps	14	37	35	7	93
French/Swiss middle mountains	11	22	37	7	77

⁹ The Habitats Directive ensures the conservation of a wide range of rare, threatened or endemic animal and plant species. Some 200 rare and characteristic habitat types are also targeted for conservation in their own right.

¹⁰ Yearly, about 150 million individuals travel in the Alps, from among which 83% travel on paved roads <https://www.eea.europa.eu/themes/regions/the-alpine-region/transport-climate-change-tourism/transport-climate-change-tourism/topics>

¹¹ http://ec.europa.eu/environment/nature/info/pubs/docs/biogeos/Alpine/KH7809637ROC_002.pdf;
http://ec.europa.eu/environment/nature/info/pubs/docs/biogeos/Steppic%20Region/KH7809607ROC_002.pdf

<i>Massif</i>	<i>Favorable</i>	<i>Unfavorable (inadequate)</i>	<i>Unfavorable (bad)</i>	<i>Unknown</i>	<i>Total</i>
Western Mediterranean islands	7	17	14	15	53
Central European middle mountains (Czech Republic, Austria, Germany)	4	15	32		51
Pyrenees	3	19	30	36	88
British Isles	1	7	52	4	64
Iberian mountains		6	3	77	86
Total mountains (no.)	191	258	299	170	918
Total mountains (%)	20,81	28,10	32,57	18,52	100

Source: European Environment Agency (2010)¹²

The negative effects of climate changes led in time to promote some actions that would counteract them and contribute to reinstating the natural balance. The effects of climate change phenomenon in European mountains (Kohler and Maselli, 2009) are illustrated as follows. Climate change is a reality in present. Some of the best evidence, such as melting glaciers, comes from mountain areas. Many scientists believe that the changes occurring in mountain ecosystems may provide an early glimpse of what could come to pass in lowland environments, and that mountains, thus, act as early warning systems. Because the mountains exist in many regions of the world and they occupy very different positions on the globe and differ in shape, extension, altitude, vegetation cover, and climate regime, they will, therefore, be affected differently by climate change. However, they share following some common features relating to climate change: mountain areas have a marked and complex topography and their climates vary considerably over short distances, temperature changes with altitude and melting of glaciers, the permafrost will trigger the release of loose rock and soil and exacerbate the danger of rockfall, debris and mud flows have a major role in influencing regional and global climates (IPCC, 2007).

Internationally, some legislation has changed the course. Since 1970 various international cooperation agreements regarding the mountain regions of Alps and Carpathians came into existence. In 1975, the European Commission under the *Directive on mountain and hill farming and farming in less-favored areas no. 75/268*¹³ acknowledged the necessity of supporting agriculture from mountain areas. In 1978, at the Conference of the EU Council of Ministers responsible with regional planning (CEMAT), launched was the official paper "*Pressures and regional planning problems in mountain regions*"¹⁴, which was the point of reference for all future development and regional planning strategies. After 2000, the mountain areas became important component of the regional development policy of the European Union. This

¹² <https://www.eea.europa.eu/publications/europes-ecological-backbone>

¹³ <https://www.sciencedirect.com/science/article/pii/0264837786900621>

¹⁴ http://www.bbsr.bund.de/BBSR/EN/Publications/IzR/2003/7DejeantPons.pdf?__blob=publicationFile&v=3

attention consisted of determining some areas where human actions of economic nature cannot take place; such areas were designed as protected areas. Many of the mountain areas were declared as protected areas under the influence of international programmes (Huddleston, Ataman and Fed'Ostiani, 2003). At EU level, these protected areas represent up to 33%¹⁵. For instance, *Natura 2000*¹⁶ is the European Network of Natural Protected Areas comprising a representative sample of wild species and natural habitats of community interest. It was constituted not only with the purpose of protecting nature, but also for preserving the natural riches on long-term basis and for ensuring the resources required for the socio-economic development¹⁷. The proportion of protected areas included in Natura 2000 differs from one country to another: Cyprus - 95%, Slovenia - 83%, Greece 82%, Italy - 81%, Slovakia - 79%, Austria - 78%, Spain - 73%, Czech Republic - 71%, Romania - 65%. In total, in the alpine region, there are 1,496 habitats of community importance (Habitats Directive¹⁸) and 365 areas of special protection (Directive Birds)¹⁹. These areas with special protection status cover about 40% of the total surface area of the alpine region.

Biodiversity of Mountain Areas in Romania

The status of protected area presupposes a mix of actions regarding the strengthening of conservation, restoration and sustainable valorization of biodiversity and landscape based on efficient management underlying harmonization of the natural capital with its habitats and species, by preserving and promoting natural values (Antonescu, 2017: 71).

The Earth Summit 1992 adopted the Convention for Biologic Diversity (CBD) and Romania ratified the Convention in the year 1994. As compliance, the Government of Romania promulgated the Law No. 58/1994 addressing the biologic diversity by which the following major objectives were set: conservation of biologic diversity, sustainable use of biodiversity's resources, and equitable distribution of benefits resulting from the use of genetic resources. The establishment of some protected natural areas under law was initiated with the purpose of obtaining a more efficient control over maintaining and protecting biodiversity (Popa, 2016). In Romania, the main categories of Protected Areas are established by Law No. 5/2000²⁰ encompassing the National Plan for Territorial Arrangement (PATN) in Section III (Protected Areas). In accordance with the law, Romania has 845 protected areas classified in IUCN Category-V (Table 4).

¹⁵ Only 5 % from the areas with high natural value are not included also in the category of less-favoured areas.

¹⁶ Natura 2000, the widest world network of natural protected areas. In order to fight against the loss of natural areas, Europe drafted two important laws: the Directive Birds (1979) and Habitats (1992). These laws are the founding milestones for the environmental protection policy and led to setting up Natura 2000 the largest network of protected natural areas in the world covering - 1 million square kilometres of land, (over 18% from the EU land surface) - 250.000 square kilometres of marine habitats (almost 4% of the EU marine habitats), respectively 27.000 habitats and 1.000 species are under special protection.

¹⁷ <https://natura2000.ro/ce-este-reteaua-natura-2000/>

¹⁸ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043>

¹⁹ European Topic Centre for Biodiversity (European Environment Agency):

<http://biodiversity.eionet.europa.eu/October2008>.

²⁰ Law no. 5/2000, Section III, Protected Area [Law no. 5/2000, section III, protected areas] [In Romanian].

Table 4: Romania's Protected Area System

<i>Type</i>	<i>IUCN Category/ International Designation</i>	<i>Number of Protected areas</i>	<i>Total area</i>
Scientific Reserve	I	53	101,288 ha
National Park	II	11	300,819 ha
Natural Monument	III	231	2,177 ha
Natural Reserve	IV	542	117,265 ha
Natural Park	V	6	326,305 ha
Biosphere Reserve Danube Delta	Biosphere Reserve	Retezat (II) Rodnei (II)	576,216 ha. 38,138 ha 47,227 ha
Wetlands of International Importance	Ramsar Site	Danube Delta Small Island of Braila	576,216 ha 20,455 ha
Natural Sites for Universal Natural Heritage	World Heritage Site	Danube Delta ²¹	732,220 ha
Special Areas for Conservation	SAC	None	
Areas for Special Protection of Bird	SPA	None	

Source: Lee and Middleton (2003)

After Romania's accession to EU, the Emergency Ordinance No. 57 of June 20, 2007 was promulgated to regulate the regime of protected natural areas and the conservation of natural habitats (updated in 2016). It determined the areas of major conservation interest, and also included in the National Strategy for Sustainable Development 2013-2030²². In order to protect biodiversity of the mountain areas, Romania ratified the Framework Convention on the Protection and Sustainable Development of the Carpathians (Carpathian Convention²³) in 2006 (Law No. 389/2006). The law stipulates that the Carpathian Mountains represent a unique natural wealth of impressive beauty and ecological value, an important reservoir of biodiversity, the area from which main rivers flow, an essential habitat and refuge for numerous endangered species of plants and animals, and the widest area covered by virgin woods in Europe (Gruia and Gaceu, 2021).

Romanian forests in the mountains area represent 65.25%, followed by forest hills with 26.67% of total (MAP, 2018). In terms of age-class distribution, 71% are maximum 80 years of age and 15% are older than 100 years, most of them are managed using different silvicultural systems that are typical to high forests with long rotation ages (over 100-120 years) (Nicolescu, 2022). The changes in the ownership structure after 1990 brought important challenges to the management of the forests. Due to forest land restitution, Romanian forestry moved from a heavily centralized sector to a multilayer type of governance, with more actors playing different and even

²¹ <https://en.unesco.org/biosphere/eu-na/danube-delta>

²² <https://faolex.fao.org/docs/pdf/rom195029.pdf>

²³ http://www.carpathianconvention.org/tl_files/carpathiancon/Downloads/01%20The%20Convention/1.1.1.1_CarpathianConvention.pdf

conflicting roles (Dragoi and Toza, 2019). The bioeconomy strategy must be considered as a vector to support new governance models needed to ensure the financial viability of forest management (Nichiforel, 2022).

In the National Strategy²⁴, it is shown that Romania displays a relative variety and proportionality of landscapes: 29.94% mountain massifs (elevations over 1,000 meters), 42% hills and plateaus (elevations between 300 and 1,000 meters) and 30% flatlands/plains (elevation under 300 m) (Antonescu, 2017). The total surface of the mountain area is 71,381.48 square kilometers (29.94% of total surface). The special biodiversity of the mountain area from Romania determined the inclusion of a share of 57% from its surface in the ecologic network Natura 2000. In the mountain area are found 197 Natura 2000 sites (habitats): respectively, 37% from national sites and 67% from the protected area. Romania's lands fall 54% under the Carpathian Mountain chains, mountains of mid-elevation (with an average of 1,136 meters) with only few peaks over 2,500 m²⁵.

In Romania the mountains represent the least disturbed parts having a low density of the inhabitant population residing in small localities, which are almost depopulated as a result of internal and external migration (Avădănei and Avădănei, 2016). This situation exists in the mountain area of 12 out of the 13 national parks²⁶ and of 10 out of the 14 natural parks²⁷: the forests from the mountain areas display increased biodiversity as there are 150 types of forest ecosystems differentiated depending on the species, the type and quantity of humus in the soil, the water and ionic stress of the soil, etc. Thus, forests shape important wood sources and other non-wood produces (berries, mushrooms, game, etc.). In Romania, surface covered by forests in the mountain area is 4.4 million hectares, from which about 40% ((World Bank, 2014) are private property, the rest being the public ownership of the State or under the territorial administrative units (National Institute of Statistics). In the mountain area of Romania, there are 948 local administrative units (30% of the country's surface), most of them in the counties of Harghita (9.38%), Hunedoara (6.92%), Maramures (6.77%), Alba (6.15%), Suceava (5.85%), Covasna (5.38%), and Brasov (5.1%). In the mountains, there are about 4.892 inhabitants (21.97 % of the total population) (World Bank, 2014).

²⁴ National Strategic Guidelines for the Sustainable Development of the Carpathians 2014 – 2020, <http://ier.gov.ro/wp-content/uploads/2018/12/Daniela-Giurca-Cracovia-2015.pdf>

²⁵ <https://biodiversity.europa.eu/countries/romania/green-infrastructure>

²⁶ 12 National Parks: four in the Oriental Carpathians (NP Rodnei Mountains, NP Călimani Mountains, NP in the Ceahlău Massif, NP Cheile Bicazului – Lacul Roșu (Red Lake) – Hășmaș Mountains), six in the Mid-Carpathians (NP Piatra Craiului, NP in the Coziei Mountains, NP Buila – Vânturarița, NP in the Jiului Gorge, NP Retezat, NP Domogled – Valea Cernei) and two in the Occidental Carpathians (NP Cheile Nerei – Beușnița, NP Semenic Mountains – Cheile Carașului).

²⁷ 10 Natural Parks: four in the Oriental Carpathians (NP Maramureșului Mountains, NP Mureșului Superior Gorge, NP Vânători Neamț which breaks through also in the Neamtului Sub-Carpathians, NP Putna-Vrancea), four in the Mid-Carpathians (NP Bucegi, NP Grădiștea Muncelului-Cioclovina, Geoparcul Dinozaurilor (Dinosaurs' Geo-park) – Hațegului Country, Geo-park Mehedinți Plateau which overlaps partially also with the areal of the Mehedinți Mountains) and two in the Occidental Carpathians (NP Apuseni Mountains, NP Cazanele Dunării-Porțile de Fier (Danube Cauldrons – Iron Gates). In the period 2007-2016 a series of changes were recorded regarding the surface of the protected mountain areas (increases or diminishments of the included surfaces).

Measures & Actions Supporting the Biodiversity in Mountain Areas of Romania

According to the *Strategy of the Romanian Academy for the next 20 years* (Zaman *et al.*, 2015), the general objective of evolution and development of the protected areas is represented by the protection, valorisation and recovery of the biodiversity, including ecosystem services that it provides (natural capital), by taking into account the intrinsic value it represents and the essential contribution to economic and social development (Zaman *et al.*, 2015). Thus, the general action framework aims at biodiversity conservation practices and at economic and social activities that would provide to local communities with the possibility of achieving their own requirement.

Romania ranks on the first position in Europe from the viewpoint of biodiversity and owns the last 100% natural ecosystems of the continent. Even though the national legislation translating the Natura 2000²⁸ in Romania does not provide for complete protection, and the implementation issues are identified frequently, a first measure would be the one of continuing with the implementation of these directives and compliance with the statutes of Protected Area in the mountain areas where these are set up.

Due to the important impact of the agricultural sector on the biodiversity from the mountain areas, a first action that might be supported financially is accessing the funds allocated for the mountain biodiversity by the Common Agricultural Policy²⁹ (CAP). Regarding the mountain area, after 2007, began the implementation of the following measures of CAP: Measure 211 – the less-favoured mountain area; Measure 212 – less favoured areas (others than the mountain area) and Measure 214 – agro-environment. The measures are financed by CAP and support the users of agricultural lands in areas characterised by unfavourable natural conditions, including here the compensation of income losses, and additional expenditures resulting from practicing extensive and ecologic agriculture (by protecting biodiversity, water protection, soil protection, diminishing polluting emissions and adjusting to the effects of climate changes).

In the current programming period, there are supported measures for promoting efficient use of resources and smart/sustainable growth favourable to inclusion in agriculture and in the rural areas, in accordance with the Strategy Europe 2020³⁰. The measures package for the current programming period addresses both the objectives of agro-environment and climate (Measure 10), to ecologic agriculture (Measure 11), and to areas faced with natural constraints (Measure 13). Farmers will benefit from funds of about 2.66 billion Euro (Measure 10 – 1.071 billion Euro, Measure 11 – 236.42 million Euro, Measure 13 – 1.355 billion Euro)³¹. These actions might contribute to maintaining the mountain biodiversity, which might be financed from community funds: keeping the youths in these areas, in parallel with encouraging increased birth-rates, professional training and adjusting vocational school curricula in accordance with the demand on the labour market, supporting businesses start-up by youths,

²⁸ https://ec.europa.eu/environment/nature/natura2000/index_en.htm

²⁹ <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/common-agricultural-policy>

³⁰ https://en.wikipedia.org/wiki/Europe_2020

³¹ <https://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%202007%20-%20Europe%202020%20-%20EN%20version.pdf>

promoting education-learning centres in the mountain areas for setting up didactic farms (these would provide learning material for the students and would contribute to the integrated valorisation of resources, from the perspective of the concepts of pluri-activity and sustainable development).

For the mountain areas faced with natural or specific constraints have been determined by the National Rural Development Programme 2014-2020, a series of compensation payments that are granted to users of agricultural lands placed in areas defined as eligible after concluding some yearly/multi-annual voluntary commitments. The compensation is aimed at:

- additional costs and income losses resulting from the enforcement of some extensive management measures on agricultural lands targeted on achieving some environmental objectives (biodiversity conservation, water and soil protection);
- additional costs and income losses resulting from the enforcement of practices specific to ecologic agriculture; and
- additional costs and income losses born by farmers because of natural and specific constraints which are present in areas with influence on agricultural production.

Recommendations for the Biodiversity of Mountain Areas

In the context of sustainable development, the following actions aimed at supporting the mountainous areas in Romania can be considered (Popescu *et al.*, 2022):

1. the local mountain population should to be involved in the specific activities, which preserve local economy, cultural identity and heritage, maintain biodiversity;
2. the improvement of infrastructure (all types of communications, dwellings, water supply, sewerage collection and use, waste management, electricity, gas, internet access, broadband network, work digitalization, education, medical and sanitary points, agriculture, water drainage systems, investments in isolated chalets etc.);
3. sustain the specific economic activities that have to stimulate young people and firms;
4. to provide some facilities for farmers;
5. to stimulate the creation of associative forms (associations and cooperatives) in order to assure the needed inputs, to increase production, and better promote the mountain products;
6. special measures to encourage the young farmers who grow more than 5 LU (livestock units); and
7. to sustain the tourism to improve their offer (to enlarge the accommodation capacity, facilities, service quality etc.).

The issue of biodiversity loss and the one about ensuring the sustainable development of local communities in areas declared as protected areas is very complex, both from the theoretic and practical viewpoints. At theoretical level, significant debates take place about the methods and techniques for evaluating and interpreting the existing issues of the area. From the practical viewpoint, not enough data and statistic information are supplied in order to support certain specific measures and actions of

political, economic and social nature. The acknowledged complexity of these issues and aspects regarding protected areas imposes currently a multi- and trans-disciplinary approach. At the same time, practitioners in the field of development resort frequently to holistic-type approaches. Their requirements are supported by the modern social sciences that consider that, over time, the localisation of economic activities and the environment are relevant categories for analyses and research (Turner *et al.*, 1993).

The interdisciplinary approach appears as necessary when environmental changes are evaluated, while the living conditions for humans are aimed in particular, along with the ones regarding the economic situation. The combination of knowledge from several fields brings its contribution to identifying the best measures leading to improving the living standard for the inhabitants of the mountain areas, being at the same time a challenge for all those involved. Any model should focus the attention on an objective of the study. The definition of the concept bears, in its turn, a multidimensional approach: well-delineated geographic areas, with specific characteristics (economic, social, infrastructural, etc.) of high biodiversity and particular issues for which specific actions/policies are required with the purpose of attaining a certain living standard. From the viewpoint of mountain research, the analysis of the pressure on the environment might be realised by a general and comparative analysis of the mountain regions based on demand, and by disaggregation at household level of some indicators specific to the mountain area.

The global models of analysis for the households' welfare in the mountain area resort, as a rule, to indicators regarding quality of life assuming the idea that development is based on universal values and not on localised experiences and different value systems. These indicators might reflect the basic elements of the subsistence means and the quality of institutions involved in promoting change. Because human activities (economic, social, cultural, etc.) cannot be omitted in this equation, we consider that the basic principle of any model should be: a conservation framework for development in which the conservation practices for the mountain biodiversity maintain both services of economic and social nature and the ones of protection for ecosystems and biodiversity.

Conclusions

In Romania, the mountain areas should play a strategic role in the economic and social development constituting a conducive environment, over time for maintaining the continuity and durability of the Romanian people. It is imperative that the development vision in the field of protected areas. The mountain areas offer a protection, valorization and recovery to the mountains' biodiversity, including ecosystem services they provide (natural capital). Thus, development should meet the protection requirements of the mountain environment because, in a contrary situation, biodiversity might undergo negative, sometimes irreversible, changes caused by the loss of habitats being caused by conversion of agricultural lands to urban areas, by the emergence of some invasive alien species, and by the overexploitation of natural resources. Over exploitation of services/products provided by biodiversity leads to influencing the natural balance with negative impact on human welfare and on the entire process of economic growth.

These mountain areas with high biodiversity should benefit from specific, multidimensional policy that would take into account the principles of sustainable development and would contribute to diminishing ecological and economic imbalances. The mountain policy might be considered as a true link that would ensure the good inter-community and interregional cooperation, as well as partnerships at national and international level.

To combat the negative factors having a direct or indirect influence on the biodiversity of mountain areas, a series of measures and actions are needed. Some important factors increase resilience to the major threats to mountain ecosystems. In addition to designating protected areas, measures to improve connectivity and ecosystem-based management are keys for conserving mountain ecosystems, particularly helping them to adapt to climate change. Another action is needed to minimize the risk of local extinction of several species and to counteract the effects of habitat fragmentation and changes in land use. At the same time, national cooperation across European mountain regions can support improved integrated management practices.

References

- Alfthan, B., Gjerdi, H.L., Puikkonen, L., Andresen, M., Semernya, L., Schoolmeester, T. and Jurek, M. (2018). Mountain Adaptation Outlook Series – Synthesis Report. United Nations Environment Programme (UNEP), and GRID, Nairobi, Vienna, and Arendal.
- Antonescu, D. (2017). Protected Area. In: Vlad, V. (Ed.), *Strategia de dezvoltare a României în următorii 20 de ani* (sinteză). Bucharest: Romanian Academy, ISBN 978-973-27-2756-0, pp.71-73 [In Romanian]. Available online at: <https://academiaromana.ro/bdar/strategiaAR/doc14/Strategia-Sinteza.pdf> [accessed on 12 February 2023]
- Antonescu, D. (2018). Biodiversity of the natural mountains heritage – present challenges and sustainable perspectives. Institutul National de Cercetari Economice 'Costin C. Kiritescu', Bucharest, Romania. Available online at: https://mpira.ub.uni-muenchen.de/84460/1/MPRA_paper_84460.pdf [accessed on 15 February 2023]
- Avădănei, V. and Avădănei, L. (2016). Mediocritas aurea – a possible and suitable solution for sustainable, smart and inclusive mountain development. *Journal of Montanology*, V: 69.
- Beniston, M. (2003). Climatic Change in Mountain Regions: A Review of Possible Impacts. In: Diaz, H.F. (Ed.), *Climate Variability and Change in High Elevation Regions: Past, Present & Future. Advances in Global Change Research*, vol. 15. Dordrecht: Springer. DOI: https://doi.org/10.1007/978-94-015-1252-7_2
- Beniston, M. (2003). Climatic Change in Mountain Regions: A Review of Possible Impacts. *Climatic Change*, 59: 5–31. DOI: <https://doi.org/10.1023/A:1024458411589>
- Blyth, R.E., Kaiser, M.J., Hart, P.J.B. and Edwards-Jones, G. (2002). Conservation with voluntary management in an inshore fishery. *Environmental Conservation*, 29: 493-508.

- Drăgoi, M. and Toza, V. (2019). Did Forestland Restitution Facilitate Institutional Amnesia? Some Evidence from Romanian Forest Policy. *Land*, 8(6): 99. DOI: <https://doi.org/10.3390/land8060099>
- European Commission (2010). Europe's ecological backbone: recognizing the true value of our mountains, EEA Report No. 6/2010. DOI: <https://doi.org/10.2800/43450>.
- FAO (2001). *Global Forest Resources Assessment 2000*, p. 512. Food and Agriculture Organization of the United Nations, Rome, Italy.
- Gruia, R. and Gaceu, L. (2021). Strategic element of post-pandemic development of the Romanian mountain agritourism. *Journal of Montology*, 12. Available online at: <https://montology-journal.eu/strategic-elements-post-pandemic-development-romanian-mountain-agriturism/> [In Romanian] [accessed 10 March 2023]
- Horák, J., Materna, J., Halda, J.P., Mladenović, S., Bogusch, P. and Pech, P. (2019). Scientific Reports. Biodiversity in remnants of natural mountain forests under conservation-oriented management. *Sci. Rep.*, 9: 89. DOI: <https://doi.org/10.1038/s41598-018-35448-7>
- Huddleston, B., Ataman, E. and Fed'Ostiani, L. (Eds.) (2003). Towards a GIS-based analysis of mountain environments and populations. Environment and Natural Resources Working Paper No. 10, FAO, Rome 2003. Available online at: <http://www.fao.org/3/a-y4558e.pdf> [accessed 21 January 2023]
- IPCC (2007). Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. Intergovernmental Panel on Climate Change, Geneva, Switzerland, p.104. Available online at: <https://www.ipcc.ch/report/ar4/syr/> [accessed 11 March 2023]
- Kohler, T. and Maselli, D. (Eds.) (2009). Mountains and Climate Change - From Understanding to Action. Geographica Bernensia, Bern, Switzerland.
- Korner, C. (1985). Alpine plant diversity: a global survey and functional interpretations. In: Arctic and Alpine Biodiversity: Patterns, Causes and Ecosystem Consequences. In: F.S. Chapin III and C. Korner (Eds.), *Ecological Studies*, Berlin: Springer, p.113.
- Körner, C., and Ohsawa, M. (2005). Mountain systems. In: R Hassan, R., Scholes, and N Ash (Eds.), *Ecosystems and human well-being: current state and trends*. Washington, DC: Island Press.
- Lee, T. and Middleton, J., (2003). Guidelines for Management Planning of Protected Areas. IUCN Gland, Switzerland and Cambridge, UK.
- MAP (2018). Raport privind starea pădurilor României în anul 2017 [Report on the state of Romanian forests in 2017]. Ministerul Apelor și Pădurilor, București. Available online at: <http://roifn.ro/site/rezultate-ifn-2/> [accessed on 11 January 2023]
- Mountain Partnership (2020). Why mountain matters for forests and biodiversity. Mountain Partnership, FAO, Rome, Italy. Available online at: https://sustainabledevelopment.un.org/content/documents/1915SDGs%20and%20mountains_forests%20and%20biodiversity_en.pdf [accessed 21 January 2023]
- Nichiforel, L. (2022). Forest Ownership and its Challenging Role in the Forest based Bioeconomy. In: Giurcă A. and Dima, D.P. (Eds.), *The Plan B for Romania's*

- Forests and Society*, Braşov: Editura Universităţii “Transilvania”, ISBN 978-606-19-1463-0, p.504.
- Nicolescu, V.N. (2022). Romanian Forests and Forestry: An Overview. In: Giurcă A. and Dima, D.P. (Eds.), *The Plan B for Romania's Forests and Society*, Braşov: Editura Universităţii “Transilvania”, ISBN 978-606-19-1463-0, p.504.
- Popa, I. (2016). Protected areas (forests) between strict protection and rural development engine. *Journal of Montanology*, V: 53 [In Romanian].
- Popescu, A., Dinu, T.A., Stoian, E., Şerban, V. and Cioca H.H. (2022). Romania's mountain areas – present and future in their way to a sustainable development, *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 22(4). Available online at: https://managementjournal.usamv.ro/pdf/vol.22_4/Art61.pdf [accessed on 11 January 2023]
- Rey, R. and Gruia, R. (2016). Responsible tourism in mountain area, an opportunity for local communities. *Journal of Montanology*, V: 37 [In Romanian].
- Romanian Parliament (2003). Framework Convention of 22 May 2003 regarding the protection and sustainable development of the Carpathians, Issued by the Parliament of Romania, Buchrest. Available online at: <https://legislatie.just.ro/Public/DetaliiDocumentAfis/76244> [accessed on 11 January 2023]
- Romeo, R., Russo, L., Parisi, F., Notarianni, M., Manuelli, S. and Carvao, S. (2021). Mountain tourism – Towards a more sustainable path. Mountain Partnership, FAO, Rome. DOI: <https://doi.org/10.4060/cb7884en>
- Turner, B.L., Clark, C.W., Kates, R.B., Richards, J.F., Mathews, J.T. and Meyer, W.B. (Eds.) (1993). *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years*. Cambridge: Cambridge University Press.
- Vasile, M. and Iordăchescu, G. (2022). Forest crisis narratives: Illegal logging, datafication and the conservation frontier in the Romanian Carpathian Mountains. *Political Geography*, 96: 102600. DOI: <https://doi.org/10.1016/j.polgeo.2022.102600>
- World Bank (2014). Romania Climate Change and Low Carbon Green Growth Program Component B Sector Report: Forest Sector Rapid Assessment. The World Bank, Europe and Central Asia Region, Washington, DC, USA. Available online at: <https://documents1.worldbank.org/curated/zh/832671468143712589/pdf/842620WP0P14660Box0382136B00PUBLIC0.pdf> [accessed on 11 March 2023]
- Zaman, G., Vlad, I.V., Vasile, V., Pavelescu, F.M.TH., Sandu, S. and Georgescu, G. (2015). Strategia de dezvoltare a Romaniei in urmatorii 20 de ani, 2016-2035, VOLUMUL I (The development strategy of Romania in the next 20 years), Vol. I, Ch. “Proiectul 6 – Economia si Calitatea Vietii”, Analiza situatiei existente a Romaniei in domeniul economiei (pp.235-263) (Project no. 6 –The Economy and the Quality of life). Bucharest: Editura Academiei Romane, ISBN: 978-973-27-2556-6. Available online at: https://www.researchgate.net/publication/299595759_Strategia_de_dezvoltare_a_Romaniei_in_urmatarii_20_de_ani_2016-2035_VOLUMUL_I_The_development_strategy_of_Romania_in_the_next_20_years_Vol_I_Ch_Proiectul_6_-_Economia_si_Calitatea_Vietii_Analiza_situa [accessed on 11 March 2023]

Zemp, M., Hoelzle, M. and Haeberli, W. (2009). Six decades of glacier mass-balance observations: A review of the worldwide monitoring network. *Annals of Glaciology*, 50(50): 101-111. DOI: <https://doi.org/10.3189/172756409787769591>.

Author's Declarations and Essential Ethical Compliances

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The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

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