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4.1 Water management, water pollution and flood control

The Carpathian area has a rather varied surface with high and medium-high mountains, forelands and basins in between. This fact determines water management in the region as regards the ability of the area to supply the demand for water. The variety of configurations in this mountainous terrain makes the landscape rather heterogeneous. Thus, some parts of the region have ample water supply, while others have to cope with shortage of water. Water bases with abundant supply concentrated in one place are located either in stretches along the river valleys or in patches over the karstic areas where significant quantities of good quality karst water can be found. The watershed between the Black Sea and the Baltic Sea draws along the North-western Carpathians, and this fact highly influences the spatial structure of water management. The rivers Oder and Vistula flow into the Baltic Sea, the Danube and its tributaries take the water of most rivers in the Carpathian into the Black Sea. The river Dniester also flows into the Black Sea catching water from the rivers of the North-eastern Carpathians along Ukraine. Such huge water supply is an extremely valuable natural resource. From the 1960s and 1970s onwards it was, however, exposed to great hazards due to the impact of various forms of pollution (*Table 9*).

While the smaller streams, rivers and creeks, of the higher mountains were very clean and had a high ecological value, the heavy industry with intense water demand (such as chemical industry) settled along the bigger rivers and caused very serious damages due to water pollution. The immense ecological disaster of the river Tisza was part of this process. The burdening of rivers with organic matter along the industrialized regions in the Carpathian area reached its peak in the first half of the 1980s. In general the concentration of organic pollution in the rivers of this area exceeded that of the rivers in Western Europe. River Oder and its tributaries are heavily polluted, in addition to those flowing from the cachment area of river Danube, Vah, Nitra, Hron, Sajó, Hornad, Somes, Mureş, Olt, Jiu. Significant improvement has taken place since recent years in Poland, the Czech Republic, Slovakia and Hungary. Lakes especially in the higher areas of the Carpathian Mountains are of great natural value. Approximately 200 pristine glacier-carved lakes can be found in the North-western Carpathian Mountains.

Subsurface waters are becoming increasingly significant in the water management of the region. In the Hungarian territory of the Carpathian Mountains drinking water is gained mainly via river bank filtration, and stored in 5 large water bases within the region. The first of these is found on the river Danube, in

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the western periphery of the region (with a theoretical capacity of 100,000 m^3 per day). The second is found in the Ipoly valley (with a capacity of 30,000 m^3/day), functioning as an important reserve for Salgótarján and the settlements in the Zagyva valley. The third water base is found near Sajószentpéter, the ballast-filled the Sajó valley, but its water is polluted by the nearby industries and therefore its use for community purposes is rather limited. The fourth water base is located not far from here, near the mouth of the river Bodva, with a capacity of 10,000 m^3 per day. The fifth water base is in the ballast-filled Hornad valley. Only half of this last base lies within the region's boundaries, the other half belonging to the Great Plain. About 70% of its 50,000 m^3 par day capacity is used primarily to supply of town Miskolc. This example shows that the large quantity of groundwater supplies near river basins in the Carpathians gain an increasingly important role mainly due to the fluctuation of stream regime.

Table 9

Overview of the subdivision of the Carpathians into rivers basins and their characteristics (2006)

River	Total drainage area (km^2)	Drainage area within the Carpathians (Study area) (km^2)	Proportion of the total Study area (%)	Affected Carpathian countries	Estuary
Danube	817,000	180,095	85.7	All Carpathian countries	Black Sea
Dniester	76,860	7,336	3.5	Ukraine	Black Sea
Vistula	194,000	21,054	10.0	Poland, Slovak Republic, Ukraine	Baltic Sea
Oder	125,000	1,772	0.8	Czech Republic, Poland	Baltic Sea

Source: Implementing an international mountain convention. An approach for the delimitation of the Carpathian Convention area.

Another important type of ground waters is the karst water that is spatially concentrated in the limestone covered areas of the Carpathians, where larger quantities to be found. Nowadays, this valuable source of freshwater supply is only exploited to a limited extent.

Problems regarding the water supply of the Carpathians are mainly related to the significant variations in the available water quantity (depending on the amount of precipitation in dry or rainy years). Another kind of problem is caused by the strong dependence of the region's water supply on the water outside the borders

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of the countries embracing the Carpathian Mountains. For example, not more than about 26–28% of the water of the Sajó, Bodva and Hornád rivers can be used in Hungary. The example shows how the use of water is limited by the fact that in the neighbouring countries industrial water has flown back into the rivers in a highly polluted state for several decades now, therefore no serious improvement can be expected in the quality of water until the turn of the millennium.

The limitations on the production of good quality water were recognized as early as the 1980s, and these enforced the introduction of more economic technologies as far as water use was concerned both in the industry and agriculture. At the same time, the improvement of the quality of life went together with the construction of water mains in the settlements. By 1988 this significantly increased the proportion of communal water consumption relative to industrial and agricultural consumption.

Thus, the European Commission's new Water Framework Directive is of crucial importance from the perspective of the future developments in the water management of the Carpathian Mountains. The Directive aims at bringing together land-use policies and water management programmes in this innovative form of internationally implemented integrated river basin management. As there Charpathians are a vital source of freshwater in Europe, this process is of great importance for the Carpathian Mountains. With emphasis added on achieving good ecological status of water, the implementation of the Directive requires appropriate water management.

4.1.1 Water pollution

The quality of surface waters can be rated as medium. Regarding the permitted levels of water use our observation is that some streams or sections are overloaded. The pollution from rapidly developing settlements near river basins means an increasing hasard. As far as pollution sensitivity is concerned, certain alluvial cones providing drinking water are considered particularly sensitive. However, the entire network of the river valleys in the Carpathians is extremely sensitive to the hazards of all kinds of pollution. Regarding emission limits to surface waters, the catchment areas of the rivers as well as the built reservoirs together with catchment areas have been qualified as protected receivers. The diffuse impact of pollution sources together with the contaminants washed into streams from agricultural areas – the more and more intensively used chemicals – bring about hazards in the widening river valleys in mountains of medium height and especially in the hilly areas. Rivers arriving at the edge of high mountains slow down, and they start fill up their basin, thus, the risk of dangerous floods increases. At the same time river basins have been greatly silted up due to the

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slowness of the flow. The river takes the characteristics of stagnant water, which fact leads to the process of eutrophication. The case of the river Sajó, flowing into Hungary from Slovakia exemplifies this process, because the burdening of the river continued in Hungary.

The river Sajó has been receiving industrial wastewater and communal sewage from the surrounding urban areas. Due to the diffuse impacts of pollutants washed in from agricultural lands the river is also contaminated with agricultural chemicals. By the late 1960s the river had been polluted to such an extent that it became most polluted river in Europe, with hardly any wildlife. Thanks to the domestic and foreign efforts made to improve water quality (construction of water treatment plants, modernization of industrial technologies, etc.) a slow recovery could have been observed. Since 1990 a sudden improvement in water quality has occurred when the paper mill of Gömörhorka was closed down, and this condition continues to the present day.

In the Hungarian reach of the Sajó, the impact of industrial wastewater and communal sewage coming from Kazincbarcika and Miskolc is particularly detrimental for the indices of oxygen and nutrients content of the waters. Since the construction of the municipal water treatment plant in Miskolc the load on the river has been reduced thanks to the new biological unit. The process of self-purification and the diluting effect of the river Hornád have both contributed to the improvement of water quality. High nutrients content, characterizing all along the river, has led to instances of eutrophication in recent summers. This process exemplifies the quality changes in the streams of the Carpathians in its hilly areas and areas with mountains of medium height.

Elimination of water pollution is particularly difficult due to the fact that the process of canalization hardly meets the increase in the environmental burdening from settlements. High costs represent the biggest obstacle in the slow progress of canalization.

4.1.2 Flood and flood control

Floods have increasingly endangered the environment in the last few decades all, yet especially the Carpathian region is exposed to such hazards. In the Carpathians, stream regime influences flood risks as well as other factors of water management. However, there is a drastic growth in the risks of environmental catastrophes rooting in the global climate change. Thus, it is very important to have enough information regarding the extremely changeable stream regime of rivers in the Carpathians. It can be classified along three major types. Rivers in the high mountains have the lowest level of water, when snow almost entirely holds back precipitation. High water occurs at the beginning of summer, when snow and ice

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melt in the mountains and high water risk is further increased by the more and more frequent rainstorms bringing extra amount of precipitation and resulting in disastrous floods. The lowest water output of rivers in mountains of medium height also occurs in winter. Snow, however, melts earlier in these areas, thus the level of water in these rivers advances rapidly and causes the danger of inundation.

The water output of rivers in hilly areas is the biggest in spring, however, their level often rises even in winter when the snow melts in the lower areas and there is little evaporation. At that time the danger of inundation increases. In summer and fall there is little precipitation, and evaporation is high, therefore the water output is the lowest at that time.

Flood control in the Carpathians means mainly the construction of dikes that reach across the borders. The capacity of storing flood waters is relatively small. Most of the damages caused by floods are due to changes in the use of land, unregulated development of urban areas, the economic utilization of flood areas and the weaknesses of the institutional system. Floods in the Carpathians call the attention to immunent risks of environmental disasters. The modified Vásárhelyi Plan developed in Hungary could be an example of up-to-date flood control.

4.2 The hazards of deforestation

The forests of the Carpathians are part of Europe's natural heritage; their ecosystems show a unique genetic diversity and variety of species. Such wealth demands increased attention and protection. More than 50% (106,183 km^2) of the studied area is forested: 49,44% is broad-leaved forest; 27,43% is coniferous forest; and 23,13% mixed. The largest forested territory belongs to Ukraine, where 91% of land is forest. 40,9% of Slovakia is forested; its biggest part is broad-leaved forests (58,2%), and the ratio of coniferous forests is 41,8%. In Romania 69% of forested lands is brad-leaved forests and 31% coniferous. Thanks to the Carpathians, Romania has an extremely large biodiversity in Europe, with 3,100 indigenous plant species of which 60 tree species can be found here.

The ratio of forest areas in Hungary (18.2%) can be rated as medium level in comparison with the EU member states. (Comparison made in 1990: Magyar Tudománytár [Hungarian Scientific Repository] 2003). The proportion of forest areas is particularly high in the Hungarian part of the Carpathian region, more than 52% over the whole territory. In the core areas of the mountains this figure is much higher, between 88–94% and as low as 25–38% in the basins and river valleys. These variations in the ratio are also true, of course, for the constituting counties (e.g. in Borsod-Abaúj-Zemplén and Heves counties the level of afforestation is nearly 60%, in Pest and Nógrád counties over 40%).

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Approximately 65% of the forests are used for economic purposes, where typical activities include – among others – logging and hunting. Another 34% is under protection; the long-term protection of these forests is a national or regional interest.

After the change of regime there were significant changes in the ownership of the forests in the Carpathians. As a result of market interventions, a large proportion of the region's forests became private property, while protected areas have remained state property. For example in Slovakia from 2,002,130 hectares of forested area only 830,555 hectares remained state property. This new ownership structure makes it more difficult to accomplish the goals of a uniform forest management in the Carpathians. Felling pursued in the interest of quick profits may cause serious damage in some areas (e.g. felling precious tree species without proper replacement, increased danger of erosion due to clear-felling, elimination of ecological corridors, etc.), therefore forest owners should assume more responsibility for the long-term maintenance of this natural asset. In the past decade, the so-called "wind-felling" has occurred more and more frequently especially in the coniferous forests of the high and medium high mountains of the Carpathians. Wind-felling is deforestation caused by extreme windstorms, as a result of which felling proceeds almost continuously. Such destructions occur almost everywhere from the North-western Carpathians to the Southern Carpathians (e.g. High Tatras).

Forest management includes a lot of distinctive activities in the Carpathian region as well. Besides providing wood, forests have functions that are becoming more important recently in fields like energetics, environmental protection, welfare and hunting. Changes in the roles of forest have been accelerated within the region since the second half of the 20th century.

On the one hand, the number and size of national parks, protected landscapes and conservation areas have increased and, on the other hand, forestries have suffered a gradual narrowing of their scope of activities, while always stricter environmental and protective regulations have been introduced setting new limitations to their work. In the early 1970s the so-called resort forests'used for various recreational purposes (resting, walking, excursions) which are important tourist attractions in the region began to increase both in number and area.

4.2.1 Soil degradation, erosion

The most serious soil degradation processes in the Carpathian region are attributed to the increasing acidity of the soil Significant acidification has been observed in the vicinity of industrial areas caused by the air pollutants emitted. Such is the impact of the industrial agglomeration near Ostrava, Katowice, Cracow, the

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valley of the river Vah, the industrial area near Košice, Miskolc, and the industrial centres in Romania. Erosion caused by the wind hit primarily the plough lands. Erosion caused by water threatens most of the area (at least 70%) to a great or medium extent. Deforestation has badly damaged the steeper slopes for some time now, while flood areas are threatened by the accumulation of heavy metals as well. Erosion caused by water is very strong in the Carpathians; a large area is eroded in the Czech Republic and Slovakia, in the Eastern and Southern Carpathians as well as in the territory of the Transylvanian Basin in Romania, in South Poland and in the Hungarian region of the Carpathians. Thus, there is an increased risk related to erosion caused by water even compared to the other member states of the European Union. From an environmental perspective, the long-term effect of erosion caused by water is the most dangerous. The decrease in the humus content, the diminishing of the surface soil and the structural deterioration gradually decreases potential (natural) fertility, adsorptive and buffer capacity as well, therefore, the soil becomes more sensitive to acidic materials, and gradually loses its ability to absorb nutrients. This is a great problem in the entire region of the Carpathians. The fact that mountainous soils that are originally of worse quality are especially strongly sensitive to the process, further increases the risk. Thus, the deterioration of the soil indirectly accelerates forest decline (decreasing absorption of nutrients, spread of various forms of mycosis etc.). The risk of erosion will supposedly grow progressively.

4.3 The potential impacts of climate change

The entire region of the Carpathians, but especially its southern, south-eastern peripheries, is particularly threatened by a potential climatic change. This is the area where the aridity index line (A=1) runs, separating the arid and humid areas in the climate of plough lands. At present the entire region still belongs to the humid climate, but a 0.5–1 °C increase in temperature would push the line of aridity index significantly towards the inner parts of the hilly area. This would lead to marked changes in the climatic optimum of both potential vegetation and vegetation culture (field crops and certain tree species). Such a modification in the climatic ranges would damage or even destroy the conditions in which field crops and certain tree species can grow. The most valuable forest vegetation can be found in the area of the Carpathians. However, the aforementioned aridity index line makes our climate increasingly changeable. The vulnerability of the forest ecosystems is further enlarged by the vagueness of the long term climate forecast. In the case of indigenous leafy hardwood trees there are 80–120-year-long periods of forest management planning. Harmful effects do not spare pine-forests in the

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high mountains of the Carpathians. The results of research works justify that closed forest-lands have to be preserved as long as possible. Damages may be reduced by means of accumulating biomass, promoting the formation of humus and introducing natural forest management.

4.4 Air pollution

In the 1950s and 1960s, the extent of air pollution reached unacceptably high values especially in Eastern-Central European countries, precisely in the extensively industrialized regions of the Carpathian Mountains. The source of pollution was the heavy industrial basis built from Katowice to Kosice through Miskolc along the valley of the Jiu river. The most polluted industrial large regions, the Czech and Polish Silesia, the industrial region in Košice and Miskolc where the dust and the emission of SO_2, NO_X and CO_2 exceeded many times the emission norms. A significant part of the air space of the Carpathians was further burdened because at that time Romanian industry entirely lacked all forms of air filter equipments. The crisis of these heavy industries in the 1980s and the structural transformation of the economy triggered by the change of regime led to a considerable decrease in the emission of air pollutants.

This territory including several connecting regions with polluted air divided up from the 1990s onwards; and traffic became an increasing source of air contamination.

Air pollution affects mainly the densely populated areas and larger settlements of the Carpathian region. There is a nearly complete overlap between the densely populated areas and the most polluted ones. The total area is relatively small, but the number of inhabitants is high. Although air pollution damages agricultural areas, natural values and material assets as well, it remains primarily a health problem.

In the last 10 years the formerly dominant industrial (mainly heavy industrial) and power plant emissions have shown a radically decreasing trend. Their impact, however, is still observable in some towns, where large industrial plants or power plants are still in operation. The polluting effect of energy consumption by households and public institutions is easily proved with the help of data collected in the heating season, and this effect is quite significant in the larger towns. In the towns and the vicinity of busy motorways or main roads, traffic is the main cause of air pollution.

After 2000 the emission of air pollutants decreased significantly. Nevertheless, the air space around the earlier mentioned industrial regions (Košice, Ostrava, Miskolc, Cluj and Bihor counties in North Transylvania) is still polluted.

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Immission levels have significantly decreased in mountainous areas (2001 Slovakia: concentration of SO_2 on the Chopok 0,90 μg (m^3). The maximum concentration of NO_x has become 30% lower than the allowed limit. According to the forecasted data regarding 2010, subsiding extra sulphur-dioxide will be less than 50 tons/km^2 in the Carpathian region in the Czech Republic, Poland and Ukraine. Before 1990 this data reached 500 tons/km^2 in the most polluted Polish, Czech, Slovakian and Hungarian regions. Air quality improvement plays a crucial role in decreasing health damages due to environment pollution, diminishing potential climate changes, and the risks of forest decline.

By 2004 the number of people living in 'polluted' areas decreased considerably as compared to 1997 but there was a sharp increase in the number of those living in 'moderately polluted' areas. On the whole, pollution now affects fewer people and its concentration is also smaller.

4.5 The environmental impacts of Carpathian industries, transport and agriculture

The Carpathian region used to be the basis of heavy industry in Eastern-Central European countries. It was characterized by low technological level and caused serious environmental damages. It was typical in the 1960s–70s that the processing of 2.4 tons of raw material by the industry produced 1 ton of primary industrial waste and refuse. Consequently, the vast majority of the industrial waste was accumulated in the largest heavy industrial areas in the Carpathian region. Because of the abundance of natural resources this environmental degradation caused by the industry continued across the border, in the Slovak and Polish parts of the Carpathian region as well, leading to an extended destruction of forests all over the Carpathian region.

Traffic meant a similarly heavy load on the environment. Road traffic developed rapidly but the cars had low capacity and strongly polluted the air. This, together with the presence of heavy industry in the Carpathian region contributed to the worsening of the situation. The air and the waters were heavily polluted, and waste accumulated on the dumpsites both legal and illegal.

In the Carpathian region conditions for agricultural production are less favourable than on the Great Plain primarily because of the hilly surface, and farmers have no alternative but to adapt themselves to the special conditions of the landscape. At the same time, the varied soil, surface and regional climatic conditions are most suitable for a great variety of agricultural activities, mainly in the river valleys and at the foot of the hills.

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Efforts have been made to improve the quality of the soil with chemical fertilizers. Thus, by 1983 (the peak in artificial fertilization in the agrarian regions of Eastern-Central European countries) the use of fertilizers in some weaker agricultural parts of the Carpathian region increased to 40 times the amount used in the early 1950s. This increased the acidity of the soil and the nitrate content of ground water all over the region.

4.6 Nature conservation in the Carpathian area

The Carpathian region is very rich in natural assets. The region's most specific value is its liminal function as a kind of transitional area and a link between the hilly areas and the lowland, ensuring the migration of species living on the plain. The area is crossed by important ecological corridors, between the Carpathian Basin and the Carpathian Mountains. As the national borders are not easily accessible, it contributed for a long time to the conservation of the natural ecological conditions and the maintenance of biodiversity, the great variety of the landscape, nature and culture in the area. Thus, the Carpathian Mountains together with the Carpathian Basin are one of the regions in Europe with the largest biodiversity that abound in species, which hardly occur in the territories north or west of the Carpathians. The proportion of forested land is very favourable in the region. Even in the least forested Hungary (18,2% of its entire territory is forests) 52% of the areas that belong to the Carpathian region is forested, whereas in the core areas of mountains this proportion is 88–94%. Forests help maintain biodiversity especially in those border areas where multidirectional impacts add up, for example in the foreground of the Northern Carpathians the Gemer-Torna Karst with Carpathian, Pannonic and sub-Mediterranean impacts. The large number of endemic species in the flora and fauna of the Carpathian region is one of its greatest assets. This fact strengthens the position and importance of nature conservation. The number of national parks, the size of areas under protection and protected natural values increases rapidly.

Development of the Natura 2000 network is important in the process of nature conservation in the Carpathian region. This network links valuable natural sites and habitats into a more or less related chain. The areas of the Natura 2000 spread out on 2,6 million hectares in 2004 (*Tables* 10–12).

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Table 10

Large-scale protected area types in the Carpathians (Alpine Network for Protected Areas, 2004)

Country	National Parks	Nature Parks/ National Nature Parks	Protected Landscape Areas	Landscape Parks/ Regional Landscape Parks	Area (ha)	Total
Czech Republic	–	–	3	–	195,610	3
Hungary	3	–	7	–	161,113	10
Poland	6	–	–	12	525,321	18
Romania	10	5	–	–	597,308	15
Slovakia	9	–	11	–	787,942	20
Serbia	1	–	–	–	63,608	1
Ukraine	–	7	–	9	304,392	16
Total	29	12	21	21	2,635,294	83

Source: Implementing an international mountain convention. An approach for the delimitation of the Carpathian Convention area. Bolzano 2006.

Table 11

Overview of the number and total area of the Ramsar regions in the Carpathian countries

Country	Total N° of areas in the country	N° of which lie whithin the Carpathian Ecoregion (N°)	Area (ha)	Ha of which lie within the Carpathian Ecoregion (ha)
Czech Republic	11	1	43,432	11,500
Hungary	23	2	117,228	2,151
Poland	9	0	90,455	0
Romania	2	0	664,586	0
Slovakia	13	5	38,943	2,326
Serbia	5	0	40,837	0
Ukraine	33	1	744,651	29

Source: Implementing an international mountain convention. An approach for the delimitation of the Carpathian Convention area. Bolzano 2006.

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Table 12

Overview of the IBA in the contract states of the CC (Birdlife International, 2005)

Country	Total number of areas in the country	Thereof in the study area	Area (ha)	Thereof in the study area (ha)
Czech Republic	16	3	627,853	125,380
Hungary	43	7	1,466,244	308,800
Poland	81	4	2,966,277	204,194
Romania	44	13	655,727	126,049
Slovakia	32	22	1,216,737	1,150,898
Serbia	40	n/a	101,500	n/a
Ukraine	141	3	2,486,864	222,107

Source: Implementing an international mountain convention. An approach for the delimitation of the Carpathian Convention area. Bolzano 2006.

4.7 National parks in the Carpathian area

The Carpathian region is one of the richest areas in Europe regarding the amount of natural values. The first national park was established in Romania, in the Retezat Mountains, in 1935. In 2004, there were 29 national parks in the Carpathian region (*Table 10*). In 2005, two more national parks were established in Romania (Bulia-Vãnturarita and the Jiu Valley National Park). Three national parks can be found in the Hungarian region of the Carpathians, however, there are five national parks altogether in the study area of the project. Fertő–Hanság and Körös–Maros National Parks also belong here, thus, altogether there are 33 strictly protected areas. An important characteristic feature of the region is that 12 national parks have been created along the national borders. The foundation of such cross-national parks is enhanced by the rich biodiversity and social circumstances. Before 1989 natural values in these areas were protected by means of political isolation, nevertheless, nowadays it is international cooperation towards nature protection that helps preserve these areas in their original beauty and use.