The highest peak in the Carpathians - Gerlachovský Štít (The Gerlach mountain - 2655 m above sea level) - photograph by Jadwiga Czernecka

Report on water resources and natural disasters (climate change) and flood risk mapping

Institute of Meteorology and Water Management
BRANCH OFFICE IN CRACOW

Cracow, October 2007

Authors:

Walczykiewicz Tomasz

Barszczyńska Małgorzata

Biedroń Ilona

Czernecka Jadwiga

Kubacka Danuta

Rataj Celina

Paluszkiewicz Bartłomiej

Table of Contents

List of Figures

List of Tables

1. Status of waters in Carpathians

1.1. Introduction

The Europe is characterized by transboundary of its water resources, not only river but also natural lakes. Some of them are subject to international cooperation.

The Carpathian Mountains constitutes watershed between Baltic Sea and Black Sea. Within the Carpathian Region borders Poland, Slovakia and Ukraine are belonging partly to the basin of the Baltic Sea and partly to the Black Sea (Poland only 0.1% of the total territory). The rest of the countries (Austria, Czech Republic, Hungary, Romania, Serbia) belongs to the Black Sea basin. The Baltic Sea is a semi-enclosed water body, connected to the North Sea by narrow and shallow straits around Denmark and Sweden. The exchange of water with the open sea is limited, and it takes about 25-30 years for all the water in the Baltic Sea to be replaced. The Black Sea, located between Europe and Asia, is one of the most remarkable seas in the world. The Black Sea covers a total area of 423,000 km^2 and its coast is shared by Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine. The Sea's basin covers an area of about 2.0 million km^2, equivalent to one-third of Europe's area. The Danube is the most common of the Sea's tributaries in terms of runoff and catchment area; however, the Sea has other important tributaries as well. The Black Sea basin includes Europe’s second largest river (Danube) which flows through the Carpathian Region. The Carpathian waters generally flow to Black sea. The Carpathian arc is supported by Danube from the south, Prut and Siret from the East as well as Dniester.

The Carpathian rivers have rain-snow regime with floods in spring (April-May) coming from snow melting and floods in summer (June-July) coming from intensive rainfalls, especially in the western part. In the southern part spring outflow has dominance. Within this region there are cascades of international, transboundary problems which cover local and global level. The transboundary rivers raise a few issues additional to the above – there is a question of whether river flooding in Poland is exacerbated by logging in the Sudeten Mountains, for example.

There is difference between the Baltic Sea basin, where the Vistula and tributaries and also small parts of the Oder practically flow through one country, and the Black

Sea basin, where the Danube and it’s tributaries flow through several countries within the borders of the Carpathian Region (Austria, Slovakia, Hungary, Serbia and Romania). It is important to underline that within Carpathian Region all countries except Serbia and Ukraine are the member states of European Union. During the past decades, nitrogen and phosphorus loads have reduced the water quality of the Black Sea and caused significant damage to this unique ecosystem, including decline in its fishery. Poor water quality and deficient coastal zone management have also reduced tourism revenues. Nutrient loads come from all over the Black Sea basin, in particular through the Danube. Losses and deterioration of wetlands in the Black Sea and the Danube have also contributed to the poor water quality.

The Baltic Marine Environment Protection Commission (HELCOM) is the secretariat of the parties to *the Convention on the Protection of the Marine Environment*, or *Helsinki Convention*, which was signed on 22 March 1974. The parties to this convention committed themselves to protection of the marine environment of the Baltic, including mitigation of land-based pollution and to combating marine pollution from oil. Taking into account political changes and changes in international environmental and maritime law, a new convention was signed in 1992 by all the states bordering the Baltic Sea and the European Community. A Strategic Action Plan for protection of the Baltic Sea, called *the Joint Comprehensive Environmental Action Program for the Baltic Sea* (JCP) has been prepared by HELCOM. The Program's measures include:

- policy, legal and regulatory measures,
- institutional strengthening,
- investments in point source and non-point source control,
- management of coastal lagoons and wetlands, recognized as natural pollution traps and as providing variable levels of treatment of biodegradable waste, as well as habitat for diverse flora and fauna,
- applied research,
- public awareness and environmental education.

Cooperation on issues that affect the Danube goes beyond the issue of navigation that prompted the Vienna Convention (1948). In 1994 *the Danube River Protection Convention* was signed by most riparian countries, committing the countries to cooperate for the protection and sustainable use of the Danube. This treaty charged the International Commission for the Protection of the Danube River (ICPDR) with implementing the Danube Convention. The ICPDR' s secretariat is in Vienna. The GEF works with the ICPDR toward the goal of increasing transboundary cooperation in the Danube basin and reducing nutrient effluent to the Danube.

The Black Sea Commission is charged with implementing the Convention for the Protection of the Black Sea against Pollution, an agreement among the six countries bordering on the Black Sea. This Convention was signed in Bucharest in April 1992 and ratified by the legislative assemblies of its signatories: Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine. Known as *the Bucharest Convention*, the document includes a basic framework of agreement and protocols addressing control of land-based sources of pollution, dumping of waste and joint action in case of accidents (such as oil spills). The Black Sea Commission has a permanent secretariat in Istanbul (the Istanbul Commission). The GEF also works with the Black Sea Commission, in this case toward rehabilitation of the Black Sea ecosystem through control of eutrophication and hazardous substances, among other measures.

1.2. Water policy

An understanding of the European water policy is useful to explain major aspects in the evolution of the Member States water policies. As everyone knows European directives are legally binding and directly applicable in the Member States. The directives are transposed integrally in the national law within compulsory deadlines.

If they are not properly transposed and applied, the Member States at fault are condemned and sanctioned by the European Court of Justice.

The EU Water Framework Directive 2000/60/EC (WFD) introduces new and different approaches towards water management, both for the members who recently joined the EU as well as for the older EU-member states. The WFD has far-reaching consequences at institutional, organisational and technical levels. The central feature of the WFD, around which all its other elements are arranged, is the use of river basins as the basic unit for all water planning and management actions. This recognises that water respects physical and hydrological boundaries, but not political and administrative limits. Mainly through the development and implementation of River Basin Management Plans, the WFD’s overall environmental objective is the achievement of ‘good status’ for all of Europe’s surface- and ground-waters within a 15-year period. As a consequence, WFD implementation will involve a vast range of stakeholders, ranging from individual consumers, major water-using sectors such as agriculture and industry, and secondary uses like water-based recreation, to water supply/treatment companies, scientists, nature conservationists and the authorities involved in planning land and water use at local, regional, national and international levels. The Water Framework Directive:

- sets uniform standards in water policy throughout the European Union and integrates different policy areas involving water issues,
- introduces the river basin approach for the development of integrated and coordinated river basin management plans for all European river systems,
- includes public participation in the development of river basin management plans encouraging active involvement of interested parties including stakeholders, non-governmental organizations and citizens,

- stipulates a defined time-frame for the achievement of the good status of surface water and groundwater,
- requests a comprehensive ecological assessment and classification on the basis of the composition and abundance of the aquatic fauna and flora taking into account the type-specific reference conditions of the water body,
- includes the definition of lower environmental objectives for heavily modified water bodies,
- introduces the economic analysis of water use in order to estimate the most cost-effective combination of measures in respect to water uses.

1.3. Natural hazards

Some natural hazards are weather events related to climate and water (floods, flash floods, thermal extremes and droughts). Each hazard is in same way unique. For example flash floods are short-lived, violent events ,affecting relatively small area. Others like droughts develop slowly but can affect relatively great area. An extreme weather event can involve multiple hazard at the same time or one by one. Floods can occur anywhere after heavy rain events. Floodplains are vulnerable and heavy storms can also cause flash flooding. Flash flood can occur even after a period of drought when heavy rain falls onto hard ground. (the water cannot penetrate).

The primary cause of an drought is a deficiency of rainfall. Drought is different from other hazards in that it develops slowly. In some case droughts are recognize too late for emergency measures to be effective.

1.4. New policy initiatives

New policy initiatives of EU are related to the natural hazards. The next directive with the river basin approach is the directive on the assessment and management of floods. The Directive was enacted on 18 September 2007. The objective of the Directive is to reduce and manage the risks which floods pose to human health, the environment, infrastructure and property. It will provide for flood mapping in all areas with a significant flood risk, for coordination within shared river basins, and for producing flood risk management plans through a broad participatory process.

A preliminary flood risk assessment shall be undertaken to provide an assessment of potential risks based on available or readily derivable information, such as records and studies on long-term developments, in particular climate change. Member States shall, at the level of the river basin district or unit of management prepare flood hazard maps and flood risk maps, at the most appropriate scale. Flood hazard maps shall cover the geographical areas which could be flooded according to the following scenarios: (a) floods with a low probability, or extreme events scenarios; (b) floods with a medium probability (likely return period ≥ 100 years);(c) floods with a high probability, where appropriate. Member States shall establish flood risk management plans coordinated at the level of the river basin district or unit of management. Flood risk management plans shall address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans may also include the controlled flooding of certain areas in the case of a flood event.

While "drought" means a temporary decrease in water availability due for instance to rainfall deficiency, "water scarcity" means that water demand exceeds the water resources exploitable under sustainable conditions. In a context where changes in climate are foreseen in spite of significant EU mitigation efforts, this trend is expected to continue and even worsen, as underscored in the recently adopted Commission Green Paper on adaptation to climate change. EC adopted also on 18th of 1July 2007 COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL entitled "Addressing the challenge of water scarcity and droughts in the European Union". This Communication also responds to the request for action on water scarcity and droughts from the Environment Council in June 2006.

1.5. General overview of the Carpathian waters

Table 1: Length of the main river [km]

RIVER	LENGTH River length (estimation by Geographical Information System [km])	LENGTH WITHIN CARPATHIAN REGION River length (estimation by Geographical Information System [km])	PERCENTAGE
Aluta	607	434	71%
Danube	3173	921	29%
Dniester	1359	479	35%
Dunajec	249	249	100%
Great Morava	359	170	47%
Hornad	258	258	100%
Hron	261	261	100%
Maros	747	747	100%
Morava	324	312	96%
Oder	840	164	20%
Prut	1001	277	28%
Sajo	185	185	100%
San	455	455	100%
Siret	583	302	52%
Tysa	923	849	92%
Vah	390	390	100%
Vistula	1024	310	30%
Warta	795	126	16%

The map below shows the main rivers in the Carpathian region.

Figure 1: The main rivers in the Carpathian region

Total area of the Carpathian Region is about 447 thousand km^2. The map below shows the Carpathian Region on a background of European political map.

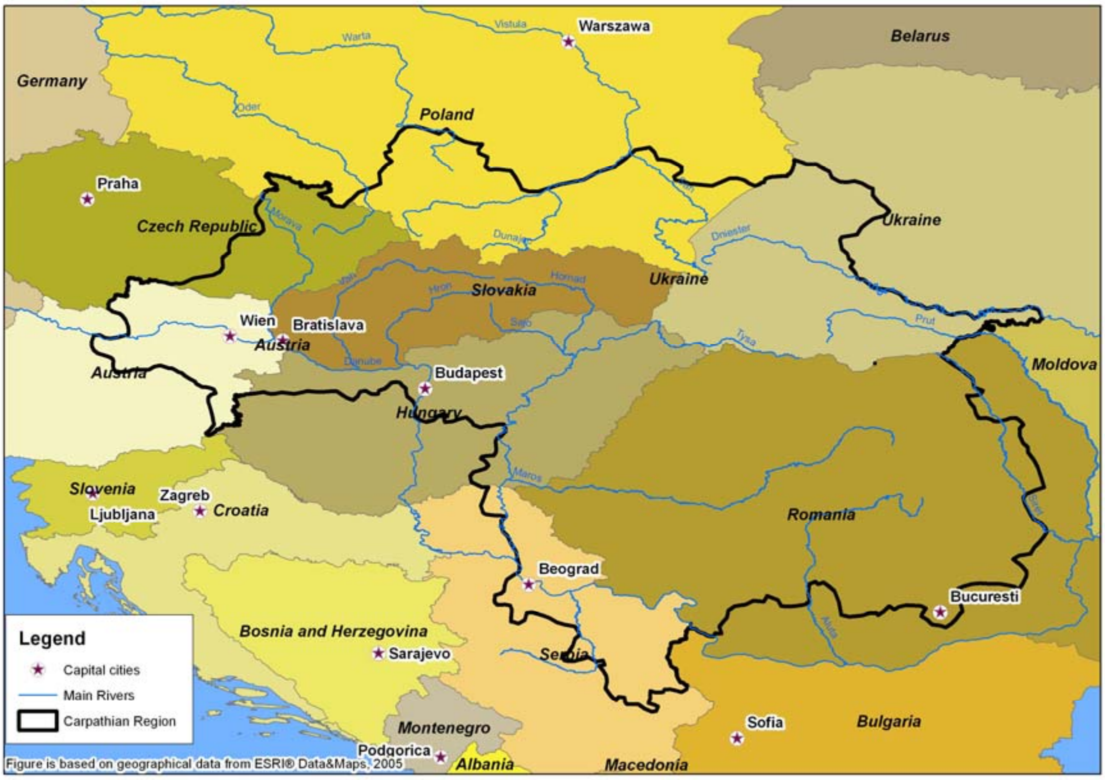


Figure 2: Carpathian Region on a background of European political map

Table 2: The percentage share of each country within the Carpathian Region

COUNTRY NAME	AREA WITHIN CARPATHIAN REGION [km^2]	PERCENTAGE
Austria	23145	5,2%
Czech Republic	21632	4,8%
Hungary	53935	12,1%
Poland	45568	10,2%
Romania	166977	37,4%
Serbia	30406	6,8%
Slovakia	48936	10,9%
Ukraine	56421	12,6%
SUM	**447021**	**100%**

The analyzed Carpathian Region includes not only the Carpathians but also lower geographical regions which are essential in issue of water resources and extreme environmental effects. The Region outlining was based on expert analysis which include: hydro-meteorological, geographical and political criteria.

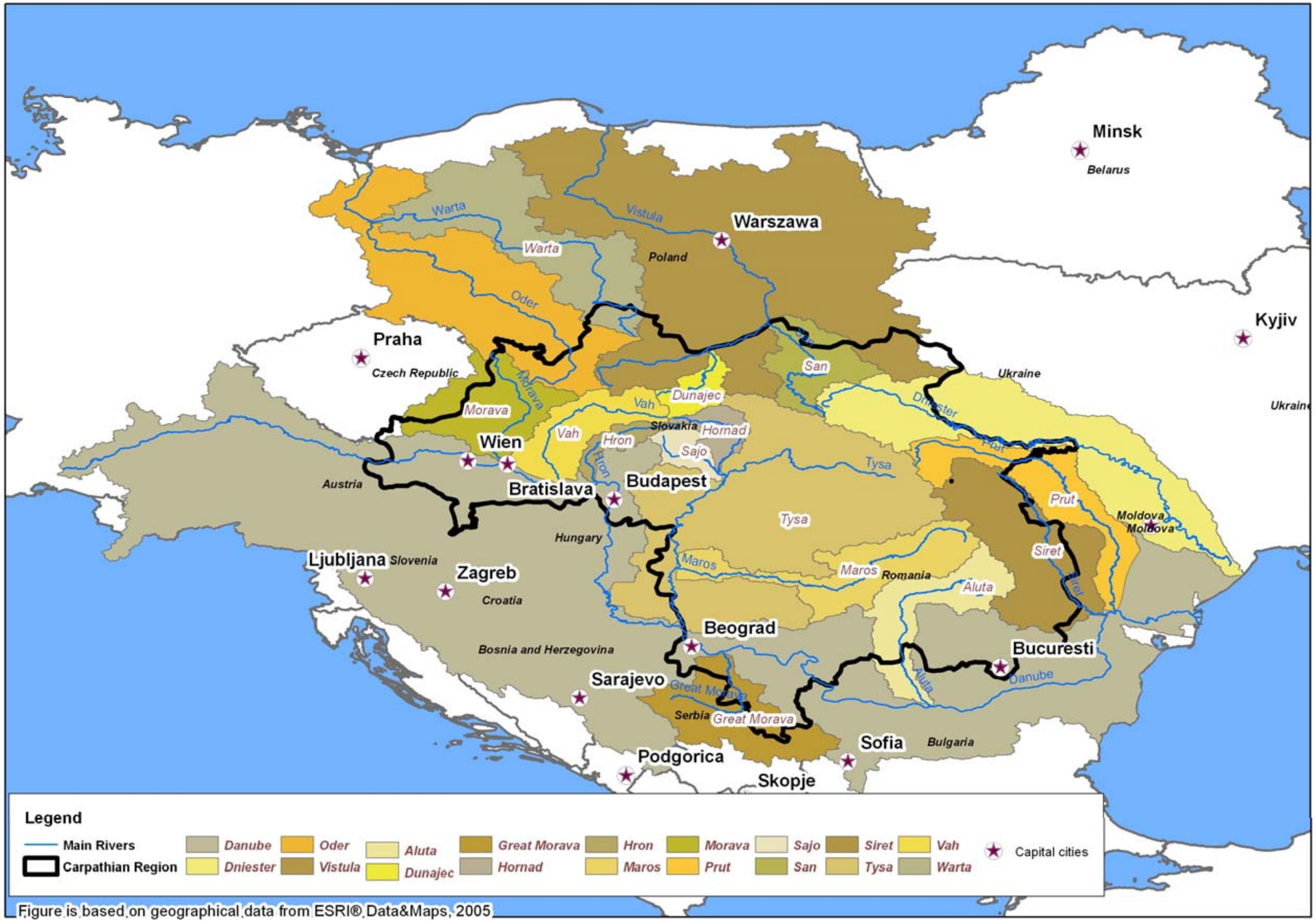


Figure 3: River basins in the Carpathian Region

Table 3: Surface area of the river basin

RIVER	AREA River basin surface area (estimation by Geographical Information System [km^2])	AREA WITHIN CARPATHIAN REGION River basin surface area (estimation by Geographical Information System [km^2])	PERCENTAGE
Aluta	25259	20645	82%
Danube	804480	360671	45%
Dniester	72905	20913	29%
Dunajec	6753	6753	100%
Great Morava	30641	7476	24%
Hornad	6911	6911	100%
Hron	5366	5366	100%
Maros	31706	31706	100%
Morava	26476	20648	78%
Oder	116860	14132	12%
Prut	29761	9214	31%
Sajo	12506	12506	100%
San	16969	14381	85%
Siret	44272	34482	78%
Tysa	166300	157107	94%
Vah	20394	20394	100%
Vistula	194545	48652	25%
Warta	47241	3155	7%

In the Carpathian Region there are 18 main river basins, 7 of them are entirely located in this region. The other, such as Oder, Warta, Vistula and Prut, have only the small percentage of their surface area located in the Carpathian region. The main in this region is the Danube and the majority of Carpathian rivers are its tributaries with the largest the Tysa. Rivers of the northern edge of Carpathian belong to the Baltic sea catchment’s area, the rest and the majority of all located in this region are the Black Sea catchment’s rivers.

2. General Description on the base of the Carpathian arc

2.1. Situation of water resources in Carpathians

2.1.1. The Baltic Sea Basin

The Baltic Sea is threatened by overfishing, eutrophication, industrial pollutants, untreated sewage and invasive species. Eutrophication is stimulated by the heavy load of runoff from agriculture in the riparians of the Sea's tributary rivers, especially from the western countries. Destruction of wetlands in the western part of the catchment (done to meet the needs of expanding agriculture and food production) has had a long-term deleterious effect on nutrient balances. Industrial/municipal contaminants include a significant load of pollution from untreated human waste, toxic materials and metal, the latter legacies of unrestricted and environmentally unregulated industry, especially from the eastern countries.

The Upper Vistula basin is the Poland richest in water (24% of all resources). A specific feature is non–uniform distribution of the resources in the basin and large time variability. In the Carpathians, natural falls and a small retention capacity of the river valleys cause, during heavy rainfalls, a violent surface runoff bringing about sudden big, water rising in rivers and streams.

Table 4: The main rivers in Baltic Sea Basin

River	Country (spring of the river)	Length [km]	Tributary	Surface area of the river basin [km^2]
Dunajec (Dunajetz)	Poland	249	Right of the Vistula	6 753
San	Poland	455	Right of the Vistula	16 969
Vistula	Poland	1024	-	194 545
Warta	Poland	795	Right of the Oder	47 241
Oder	Czech Republic	840	-	116 860

The Dunajec – the Polish-Slovakia border - photograph by Tomasz Walczykiewicz

The Dunajec near Szczawnica – the Polish-Slovakia border
- photograph by Bartłomiej Paluszkiewicz

The water resources of the Carpathian rivers constitute current and potential water resources on both regional and national scale. Assuming the average annual flow-rate as the basic index of surface water resources the flow rate of the Vistula under the mouth of the San river reaches approximately 445 m^3/s. Upon balancing the available resources of underground waters, they are estimated at 25,8 m^3/s.

The Oder is the second major river in Poland. The third largest river is the Warta, a right tributary of the Oder. Generally speaking the Oder is not rich in water but on the contrary flooding is very frequent. Thanks to the river regulation the Oder is the best inland waterway in Poland.

The Czorsztyńskie Lake – artificial reservoir on the Dunajetz – photograph by Tomasz Walczykiewicz

2.1.1.1. Droughts and floods

Variability in the surface runoff is significant for both the regional economy and agriculture; it has also an important social dimension, especially during low and high runoffs. In the 20th century particularly low levels occurred in the years 1904, 1921, 1930, 1951, 1959, 1961, 1983, 1984, 1992, 2003.

The Carpathian Vistula is a zone with precipitation and runoff exceed the mean values in Poland. Due to the mountainous type of the river basin it causes high flood hazard. The highest annual precipitation reaches 1675 mm in the Tatra Mountains.

Important factor determining the flood hazard in the basin is the growing settlement over the last years with concentration along river valleys which in fact have lost their natural functions of draining high waters. Dating back from the 10th to 19th centuries about 70 disastrous floods came upon those areas. In the 20th century the floods took place in 1903, 1934, 1970, 1976, 1997. The great flood in 1997 was not only related to the nature phenomena but also to a poor condition of many facilities of passive and active flood protection. After the flood in 1997 the Polish government adopted the National Plan of Reconstruction and Modernization. A $ 200 million loan agreement was signed with the World Bank in order to give financial support. The main objective of the program was to offer aid to people who suffered losses during the flood, reconstruction of towns, settlements and modernization of infrastructure in the areas affected by the flood.

2.1.1.2. Water use

The basic water supply source within the Upper Vistula basin are the resources of surface waters. More than 70% is used for industrial purposes, in that number 90% is consumed by power sector. Agriculture uses about 6% of water and the remaining 14% is used by municipal waterworks. The contaminants contained in the municipal sewage are one of the basic factors affecting the quality of surface waters. Large population density in the western part of the Carpathian Vistula, lack of the satisfactory capacity of treatment plants as well as their inefficient operation bring high contents of the organic compounds. Big amounts of biogens running off to rainfall water courses from arable lands, green lands, woodlands are significant in the overall balance. The main source of mineral compounds in the Upper Vistula is hard coal mining. The coal wastes produced by the coal mining sector constitute near 60% of all industrial wastes in the western part of that region. The Upper Vistula basin is a zone of intensive activity of a large number of industrial sectors which are characterized by high water consumption and causing contamination of surface and underground waters. Less populated is the north and east part of the Upper Vistula basin. Woodlands cover 32% of the area. Agriculture is highly dispersed and the average area of a single farmstead is very low (4 ha). The cultivated crop structures are responsible for creating condition for considerable soil erosion related to intensive surface runoff.

Many sewage treatment plants are already being built. Compared to 1985 the volume of sewage subject either to biological treatment or to more extensive removal of biogens has increased more than 60% in the Upper Vistula river basin. Important activities regarding municipal wastes have already been undertaken, within the framework of the Waste Water Treatment Program.

2.1.2. The Black Sea Basin

The Black Sea, located between Europe and Asia, is one of the most remarkable seas in the world. The Black Sea covers a total area of 423,000 km^2, and its coast is shared by Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine. The Sea's basin covers an area of about 2.0 million km^2, equivalent to one-third of Europe's area. The Danube is the most important of the Sea's tributaries in terms of runoff and catchment area; however, the Sea has other important tributaries as well.

The Danube in Budapest by night – photograph by Bartłomiej Paluszkiewicz

This part of the Carpathian region includes the part of the Danube river basin and the part of the Dniester basin.

Within the Carpathian Region the Danube can be divided into two parts - The Upper Danube Basin which flows to the east of Vienna and the Middle Danube Basin confined by the Carpathians in the north and in the east.

Table 5: The main rivers in the Black Sea basin

River	Country (source of the river)	Length [km]	Tributary	Surface area of the river basin [km^2]
Aluta (Olt)	Romania	607	Left of the Danube	25 259
Tysa (Tisa, Tisza)	Ukraine	923	Left of the Danube	166 300
Horanad (Hernad)	Slovakia	258	Left of the Sajo	6 911
Hron (Garam, Gran)	Slovakia	261	Left of the Danube	5 366
Maros (Mures)	Romania	747	Left of the Tysa	31 706
Morava	Czech Republic	324	Right of the Danube	26 476
Prut	Ukraine	1001	Left of the Danube	29 761
Siret (Syret)	Ukraine	583	Left of the Danube	44 272
Vah (Vag, Waag)	Slovakia	390	Left of the Danube	20 394
Great Morava	Serbia	185 (359 including West Morava	Right of the Danube	6 126 (30 641 includig West and South Morava)
Dniester (Nistru, Tyras, Nester)	Ukraine	1359	-	72 905

The Danube in Budapest – photograph by Bartłomiej Paluszkiewicz

The Danube in Vienna – photograph by Tomasz Walczykiewicz

The Tysa river basin is the largest sub-basin in the Danube river basin and the longest tributary of the Danube. By the flow volume is the largest (after the Danube) in this region. Average medium annual flow at the mouth to the Danube is 776 m^3/s.

The Tysa – photograph by Tomasz Walczykiewicz

The typical for the Tysa is the wide fluctuation between low water levels and high water levels. At the mouth it reaches 11 times (371 m^3/s to 3.867 m^3/s) ,in Szolnok 53 times and Vásárosnamény 84 times.

The Tysa near Solnok, area between floodbanks – photograph by Bartłomiej Paluszkiewicz

The Great Morava in Serbia was previously recognized from its meanders. After canalization of the river the length was shorten from 245 km to 185 km. The depth of the river in the mouth is about 10 m, width reaches 220 m and annual medium flow is 245 m^3/s.

The Carpathian Dniester area covers a number of medium-height mountain ranges lying parallel to each other, with gentle slopes. This section of the Dniester is typical by significant variations in riverbed levels. The Dniester basin, covering 12% of Ukraine. It flows into Moldova before re-entering Ukraine 50 km before its mouth in the Black Sea. Numerous waterfalls occurs every 2-3 km in the Upper part of the Dniester. This part of the Dniester basin has a well-developed and dense hydrographic network.

The Hortobagy National Park - photograph by Tomasz Walczykiewicz

2.1.2.1. Droughts and floods

The years between 1984 and 1993 constituted the driest period in this region since 1881. For example Hungary can be identified as an “affected country” under the terms of the UNCCD.

Table 6: Some of major drought events in the Danube river basin

Drought event	Description
1968	Hungary-rainfall February-July on the level of 10% of normal
1971	Very dry summer
1973	Low winter rain and snowfall
1975	Dry winter
1988-1992	Rainfall deficiency with only short wet periods
1992-1993	Very dry hot summer in 1992

There are two main region within this part of the Carpathians prone to frequent flooding: the Tysa valley and the Danube valley.

There have been 75 extreme flood events in the Danube in the last nine centuries. Some of those floods are listed below.

Table 7: Some extreme flood events in the Danube river basin

Flood event	Description
1838 March	Icy flood in Budapest
1879 March	Flood in Szeged (HU)
1888,1919 Spring	Flood in the Tysa valley
1925 December	Flood in Koros valley,
1932 Spring	Flood in the Tysa Valley
1941 February	Icy flood in the Danube
1947 December	Icy flood at the upper Tysa
1954 July	Dyke bursting at Szigetkoz
1956 March	Icy flood at the Danube
1965 April-June	The biggest summer flood at the Danube until than
1966 February –April	Icy flood at the Berretyo
1970 May July	The biggest Tysa valley flooding until than
1974 June	Flood in Koros valley
1974 October	Big flood in the valleys of Ipoly, Zagyva-Tarna, Sajo, Hornad and Bodrog
1980 July	Flood in Koros valley
1989 May	Extreme flood of Horand
1991 August	Danube flood with record high level in Szigetkoz

Source Sustainable water use in Europe report 21–European Environment Agency, 2001

Within this region floods as natural phenomena are the most common disasters. High floods occurred in 1970, 1975, 2005, and 2006. The grave flood hazard exists on the plains situated in the deepest part of the Carpathian Basin. The Tysa river basin together with its tributaries drains the largest part of the Carpathians. In the Carpathian basin flooding waters rushing down from the surrounding Carpathian which often resulting in high river stages of extended duration. The regulation of the Tysa began in the 1840s under the Austro-Hungarian empire and covered the large area of the original catchment. The river was shorten by 453 km. Generally water works have been finished in 1880. It was done in order to get good arable land and to protect villages from the floods. After that the river became navigable. Now this is one of Europe's most unique ecosystem with the wide biodiversity. The last great change was creation of the great artificial lake (Lake Tysa) in years 1973 - 1990. The large area of the Danube wetlands are nowadays under the pressure of navigation, hydropower and agriculture as well as new developments. It brings new risks regarding floods. About 80% of historical flood plains of the Danube River basin have been lost within the last 150 years. Typical downstream conditions are in Hungary, were 96% of surface waters and floods are generated outside the country. In the upstream parts close to the Carpathian arc 28-36 hours after rainfall water level rise 8-10 meters. In Hungary the area of protected floodplain reaches 21200 km^2, which is 23% territory of the country - the length of defense infrastructure is 4200 km^2. Generally between 1998 and 2005 river catchments in the Carpathian region were affected by floods from 3 to more then 6 times. The changes in forestry patterns are introduced as well as the great plan of the flood plain reactivation. Flash floods in the mountain part typically occur in the spring - summer period of time. Some of those, which have been recorded recently, were extreme from the precipitation intensity and flood effects points of view. The ice phenomena occurs on almost all the mountain rivers and their evolution during the January – March period and also in December determines great level variations, exceeding sometimes the warning levels. In 2006 in Carpathian Danube basin due to heavy rainfalls and snow melt high water levels were registered in the downstream and as well as upstream parts of the rivers. The level of the River Danube in Austria and of many rivers to the north of the country was critical. A state of emergency was declared for the whole area of the South Moravian department in Czech Republic. In Hungary the third highest level (861 cm) in the Danube was recorded (867 cm in 1876 and 848 cm in 2002).

The Dniester has specific flow regime, featuring up to five flood events annually. During these events, water levels in the river may increase by 3-4 m, and sometimes more at times of intensive rainfalls. Another characteristic feature of Dniester is the fact that flow volume, recorded during a flood event, are significantly higher than those occurring during a spring high-water period.

From the history of observations, the largest and most intensive flooding event occurred in September 1941. Another exceptional flood event occurred in June 1969.

2.1.2.2. Water use

In the Middle Danube Basin the core problems are unsustainable agricultural practices, not sufficient management of municipal sewage and waste and in many cases industry. Eutrophication is a problem for all slow flowing rivers in that region. It causes the oxygen depletion. In some tributaries of the Danube high nitrate concentration are seen as a potential human health hazard. Hazardous substances are accumulated in sediments. The problem of toxic waste depositories was extremely underlined during the major spill of cyanide-rich mine tailings near Baia Mare in Romania in 2000 caused the major ecological damage to the Tysa. Pollution of the water with heavy metals, exist in Sasar, Crisul Negru, Crisul Alb and Aries river basins in Romania, where are important mining perimeters with rocks which reach the surface and which are washed by the precipitation. On the other hand many of water bodies from Carpathian areas of the Romania are undisturbed by the major anthropogenic pressure. Generally they are in a high and good status, providing good environment for species and representing high ecological value.

The Tysa in Solnok – photograph by Bartłomiej Paluszkiewicz

On a local scale microbiological contamination is a major problem in the Danube basin because river itself as well as tributaries receive untreated waste water from municipalities. Large organic loads discharge in river valleys due to slow river flow and oxygen depletion may result in elimination of aquatic plants and animals. On the contrary the fast flowing Danube and its tributaries are unaffected by such issue. The Danube is characterized by a high number of hydrotechnical structures. It causes possible transboundary impacts. The typical is case the Gabcikovo-Nagymaros. The project was agreed in 1977 by Czechoslovakian and Hungarian governments to eliminate flooding, provide clear water energy and create possible navigation of the river as a part of Rhine-Main-Danube Canal. The plan was to divert part of the river into artificial canal at Dunakiliti in Hungary to the hydroelectric power plant near Gabcíkovo (now in Slovakia). Because of the protest in Hungary justified by environmental problems and the problems to the water supply to Budapest. This case was referred to the International Court of Justice in the Hague. Only the part of the project – Gabcikovo Waterworks have been finished. In 1997 The Court stated that the project agreement is still valid. The dispute is not solve.

In Serbia case according to the materials of the Regional Environmental Center for Central and Eastern Europe, this country has plenty of freshwater, but distribution varies across space and time. It is estimated that about 8 percent of all available surface water originates within Serbia. The remainder comes from outside national borders through the Danube, Sava, Tysa, Drina and other rivers. Existing groundwater resources in Serbia amount to 244 m^3 per capita per year. Total abstraction is about 180 million cubic meters per year. The extraction of groundwater exceeds the natural capacity of replenishment in certain aquifers, leading to reduced levels of groundwater. Groundwater resources are of special significance for Serbia, as they provide up to 90 percent of the water supply for households and industry and about 70 percent of drinking water. In many areas of Serbia, groundwater cannot be used for drinking purposes without prior treatment. This is particularly true in certain areas close to the Morava and the Danube in the Vojvodina Region.

Household surveys show that around 84 percent of the population in Serbia has running water. According to the findings from the Public Health Institute of the Republic of Serbia, 29 percent of samples from water supply systems did not satisfy physical, chemical or bacteriological standards in 2001. The sewage system in

Serbia serves only about 33 percent of the country's population, insufficient for adequate protection of water quality. According to a 2003 World Bank report, sewage systems serve 45 percent in urban areas of Vojvodina, 76% in the cities of central Serbia and about 22% in rural areas of Serbia. Only 28 towns in Serbia have municipal and industrial wastewater treatment plants. The water quality in Serbia is generally low and is deteriorating. Examples of very clean water of Class I and I/II are rare, and those that exist are found mainly in mountainous regions.

The Dniester in Ukraine is mainly polluted with ammonia, oil products, chromium, copper, zinc and magnesia. The chromium and ammonia content is increasing. Water quantity and water quality became as the limiting factors of usage of water resources and sustainable development. With respect to the potential water resources (1.6 km^3 of water in a year per an inhabitant) Ukraine is one of the poorest countries in Europe. The large volume of pollutants (oil products, sulphates, chlorides, organic matter, pesticides, heavy metals and so on) have been thrown down into the waters together with a sewage waters. The river inundations are one of the most frequent hazards in Ukraine.

About 79% of the total population is connected to the centralized water supply systems (house and yard connection). While coverage in urban areas in about 92.7%, coverage in rural areas reaches only 49.4%. Drinking water supply fails to meet the standards of drinking water, which poses a major threat to the public health. In 1997, about 260 settlements consumed water that did not meet the standards. The situation in rural areas is worse. The smaller tributaries are more heavily polluted than the main river. Waste-water treatment is a major problem in Ukraine. The major problem in rural areas is that most waste water is discharged untreated. The urban problem, however, is the poor quality and inefficiency of waste-water and sludge treatment due to the technical state and capacity of existing installations.

The Tysa - hydropower plant - photograph by Tomasz Walczykiewicz

2.1.3. The main lakes of the Carpathian region

Natural lakes are in small numbers. Generally there are about 450 lakes in the mountain part of the Carpathian region with summary surface area 4 km^2.

The most of them are postglacial mountain lakes. The greatest and the deepest are in the Polish part of the Tatra mountains, where are 190 natural lakes. In that number there are 43 postglacial lakes above 1 ha area.

The Neusiedler See is the largest lake situated in the northern part of Burgenland province, i.e. in the easternmost part of Austria, on the border with Hungary. The unique steppe landscape on the eastern fringe of the Alps forms the western edge of the Little Hungarian Plain.

Table 8: The biggest lakes in the Carpathian Region

Lake	Surface [km^2]	Country
Neusiedler (Neusiedlersee)	315	Austria, Hungary
Synewyr	0.07	Ukraine
Morskie Oko	0,3492	Poland
Czarny Staw Gąsienicowy	0,1794	Poland
Wielki Staw Polski	0.3414	Poland
Rosu	0,127	Romania

The Neusiedler See Lake – the marina in Morbisch - photograph by Tomasz Walczykiewicz

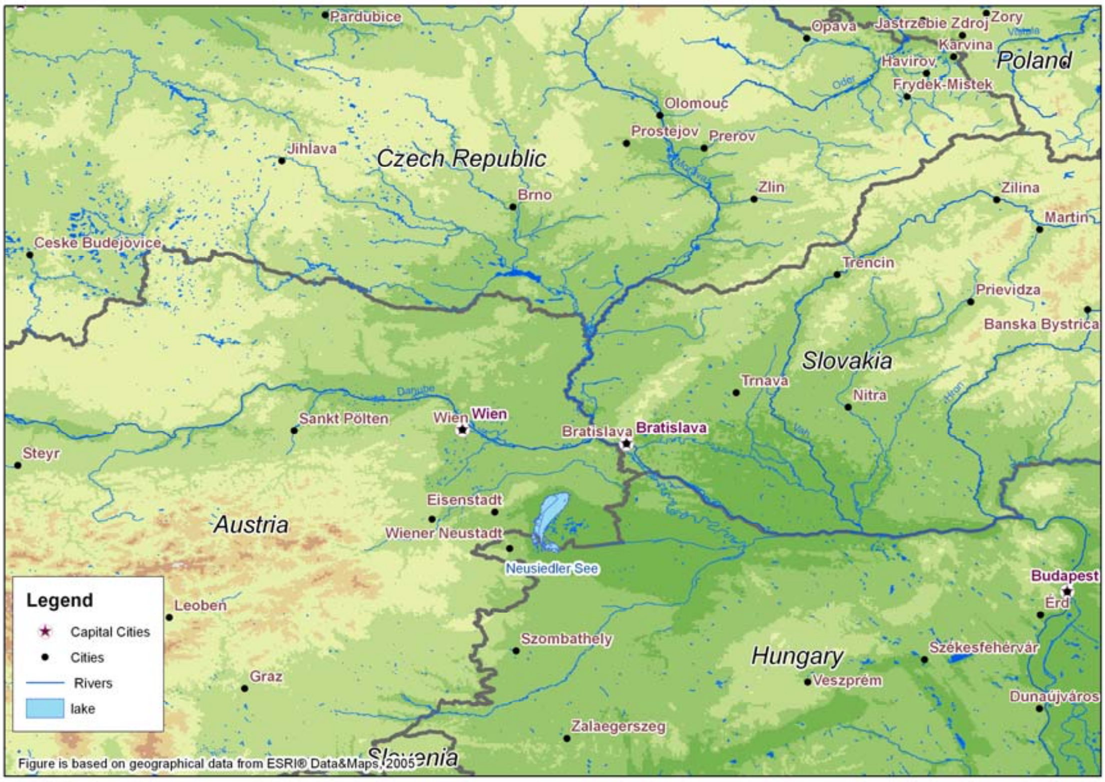


Figure 4: The Neusiedler See Lake – topography map.

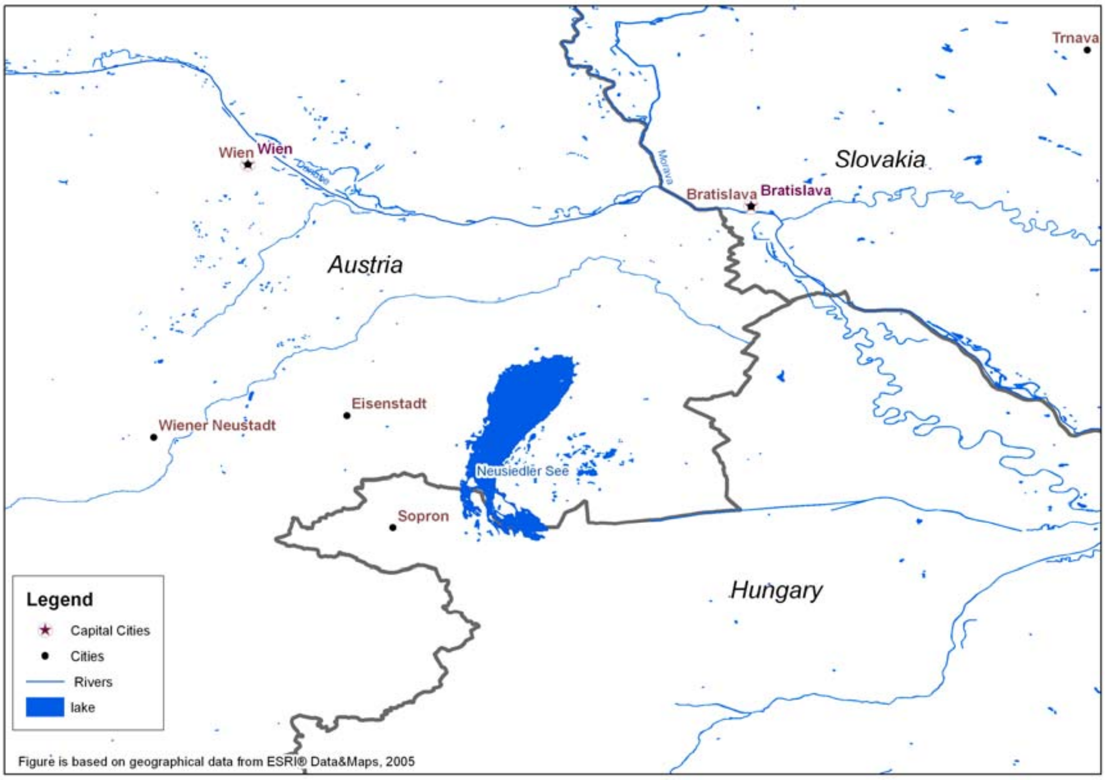


Figure 5: The Neusiedler See Lake.

Satellite photograph of Neusiedler See Lake

http://upload.wikimedia.org/wikipedia/commons/a/a4/Neusiedler_Lake_satellite.png

The Neusiedler See Lake is a second largest lake in Central Europe. The lake covers area of 315 km^2, where 240 km^2 is on Austrian and 75 km^2 is on Hungarian side. From north to south, the lake is about 36 km long, and it is between 6 km and 12 km wide from east to west. Unique for this ecosystem is the depth of the lake which isn’t more than 2 meters. Low water level causes a problem for sailing and commercial shipping, as boats hit the ground more frequently and mooring sites can become temporarily unusable. Most of the lake is surrounded by reds which serve as a habitat for and are harvested in winter as soon as the ice is solid enough. The reed is sold for various purposes, mostly related to construction and housing. Water quality is determined by temperature, wind, the amount of salt and mud emanating with the ground water from the sediments.

A previously sandy beach invaded by reeds.
Source - http://en.wikipedia.org/wiki/Image:Reedbeach_edit1.JPG

2.1.4. Transboundary groundwaters in the Carpathian Region

In the Carpathian region there are located 16 the most essential transboundary groundwater bodies. The biggest of them is located in south-west part of the region, on the borderland between Romania, Serbia and Hungary. The second biggest groundwater body is situated in the east of Carpathian Region on the borderland between Romania and Moldova. In the northern part the most significant groundwater body is located on the border between Poland and Ukraine. The rest of bigger groundwater bodies are located in the middle part of Carpathian region.

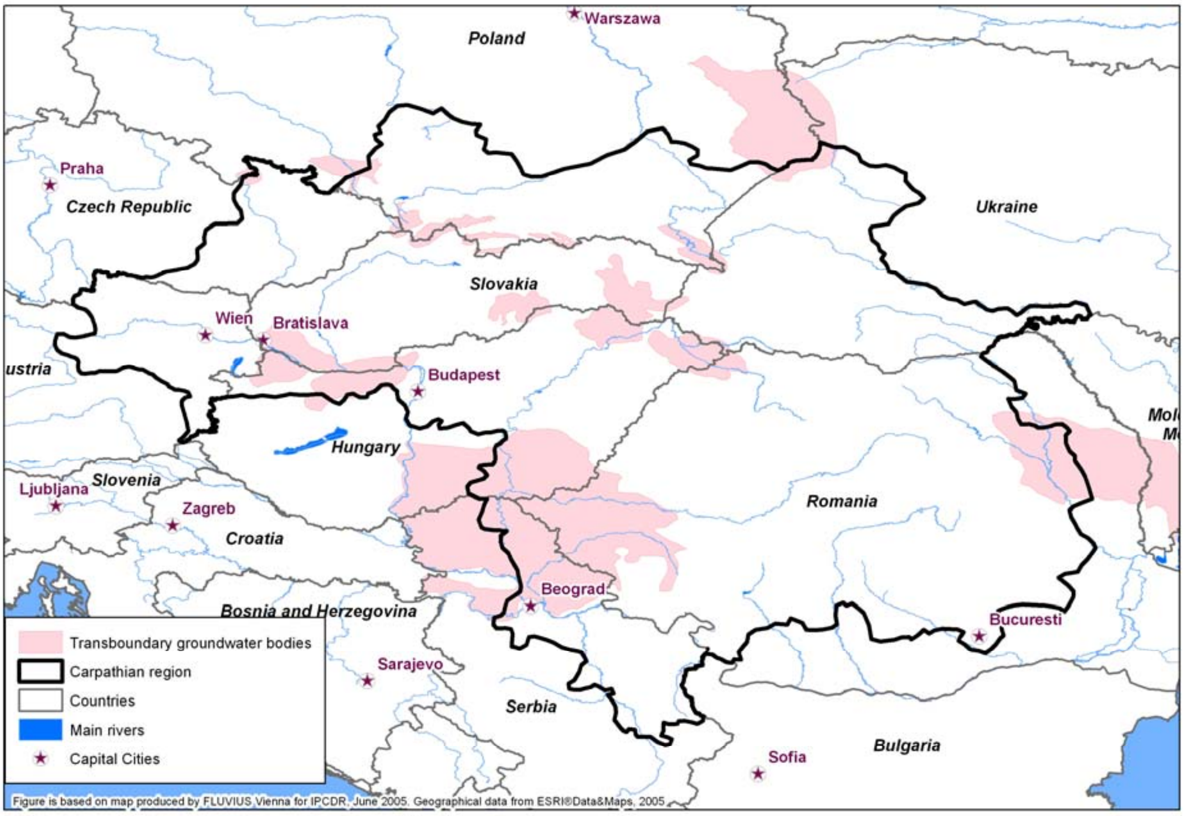


Figure 6: Transboundary groundwaters in the Carpathian Region

2.1.5. Habitat and species protection areas

In the Carpathian region there are located 48 habitat and species protection areas of Nature 2000. The classification was based on the protection area quantity. In the Carpathian region there are 10 determined protection areas of over 50.000 hectares surface area, 15 areas with the surface area between 10.000 – 50.000 hectares and the rest of them (23 protected areas) are smaller than 10.000 hectares. The biggest amount of that areas are located in the highest part of the Carpathian – The West Carpathian on the Polish and Slovakian part. In the Ukraine part, as a result of international agreements between Carpathian countries, there are also determined 3 protection areas. One of them – “The Carpathian National Park” with the surface area over 50.000 hectares is located on the borderland between Romania and Ukraine. The huge centre of protection areas is also located in the Upper Danube river basin.

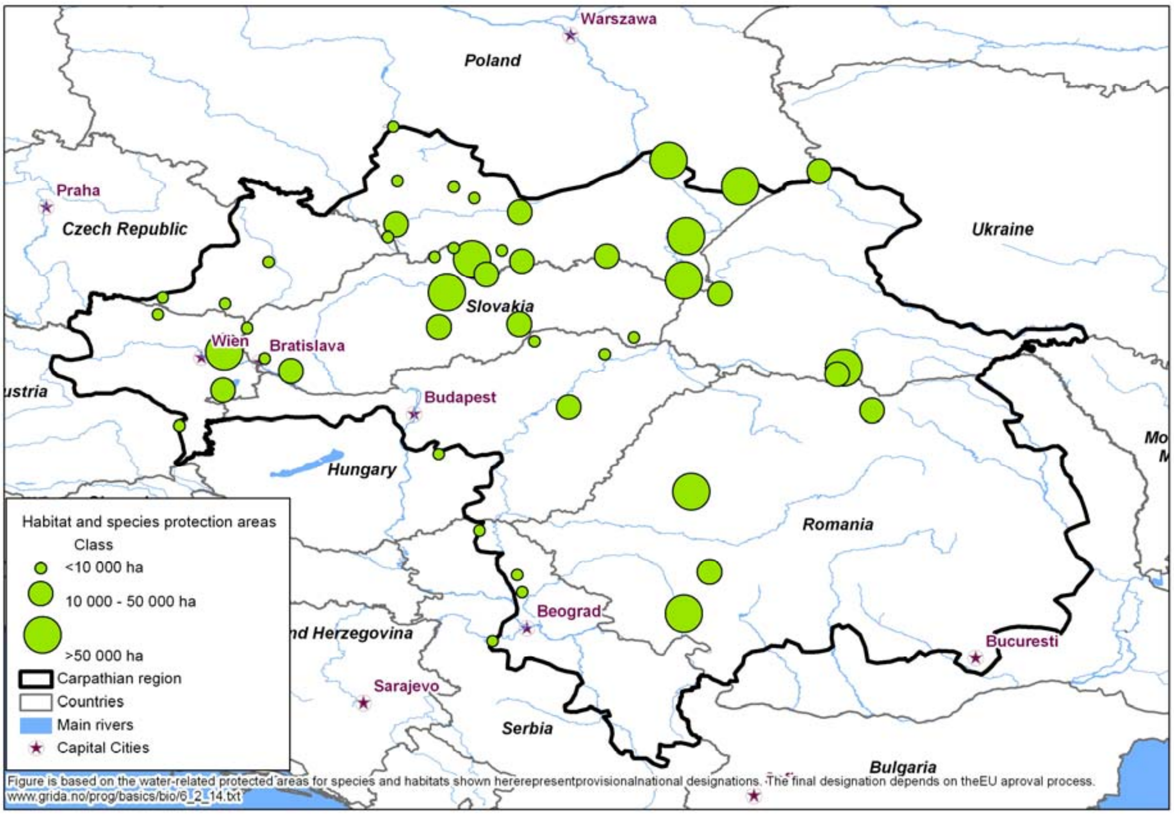


Figure 7: Habitat and species protected areas in the Carpathian Region

2.2. The water “reservoir” Carpathians - water tower for surrounding areas

The Carpathian Mountains are the eastern wing of the great Central Mountain System of Europe, curving 1500 km along the borders of Austria, the Czech Republic, Slovakia, Poland, Ukraine, Romania, Serbia and northern Hungary. The Carpathian Mountains are divided in three ranges: Western Carpathians (Western and Eastern Beskidy with the highest “Gerlach Mountain”, 2655 meters above sea level, in High Tatras), Eastern Carpathians (with the highest “Pietrosul Mountain” 2303 meters above sea level) and Southern Carpathians (with the highest “Moldoveanu Mountain” 2543 meters above sea level. The Carpathians are also the boundary for “Great Hungarian Plain” occupying the middle part of the mountains – in the Tysa valley.

Romania contains by far the largest area of the Carpathians, and forms the eastern and southern boundaries of the region. Large extension from west to east and diverse relief, the Carpathians also shows great differences in climate. The precipitation in whole region of the Carpathians ranges from < 500 mm to > 2000 mm based on differences in the of the relief, especially the differences in the extent of exposure to the predominantly westerly winds, as well as the differences in altitude. The shape of the Carpathian arc as well as the distribution of the precipitation has strong effects on the surface run-off and the discharge in the streams. The hydrologic regime of the Carpathian rivers, in particular the discharge regime, is distinctly influenced by the regional precipitation patterns.

The water resources in the Carpathian region show a large variability in terms of groundwater quantity. Within that region exist a large number of transboundary aquifers.

The wetlands in the Carpathians also represent valuable drinking water reserves for millions of people.

For these reasons we can define the Carpathians as a water tower for the whole region.

The main Carpathian rivers which form these conditions are listed below:

- The Tysa
- The Morava
- The Velika Morava in Serbia
- The Prut
- The Vah is the left tributary of the Danube
- The Dniester
- The Vistula
- The San
- The Dunajec

The characteristics linked with the water “Reservoir” Carpathians are shown in the figures below.

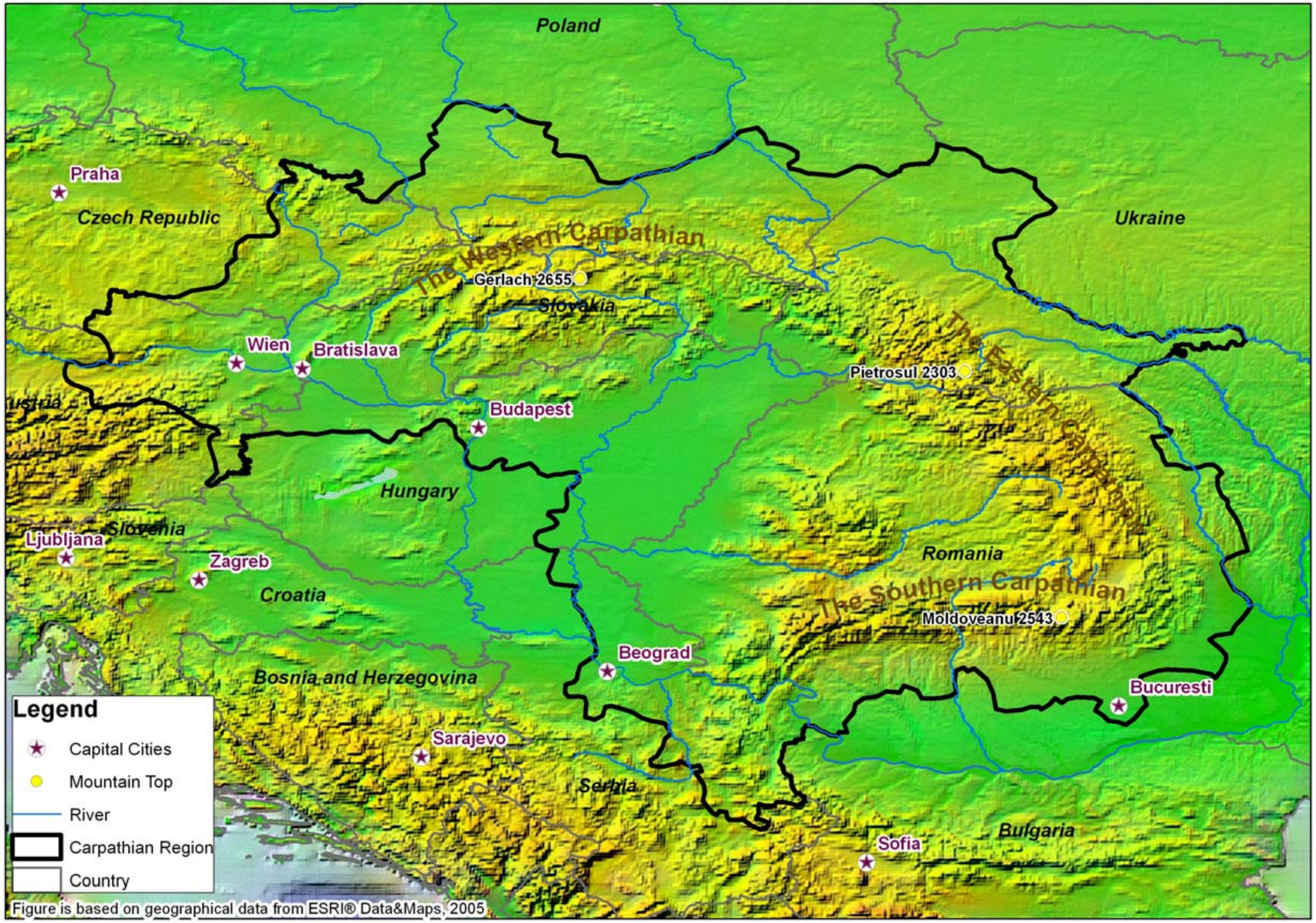


Figure 8: The relief of the Carpathian Region

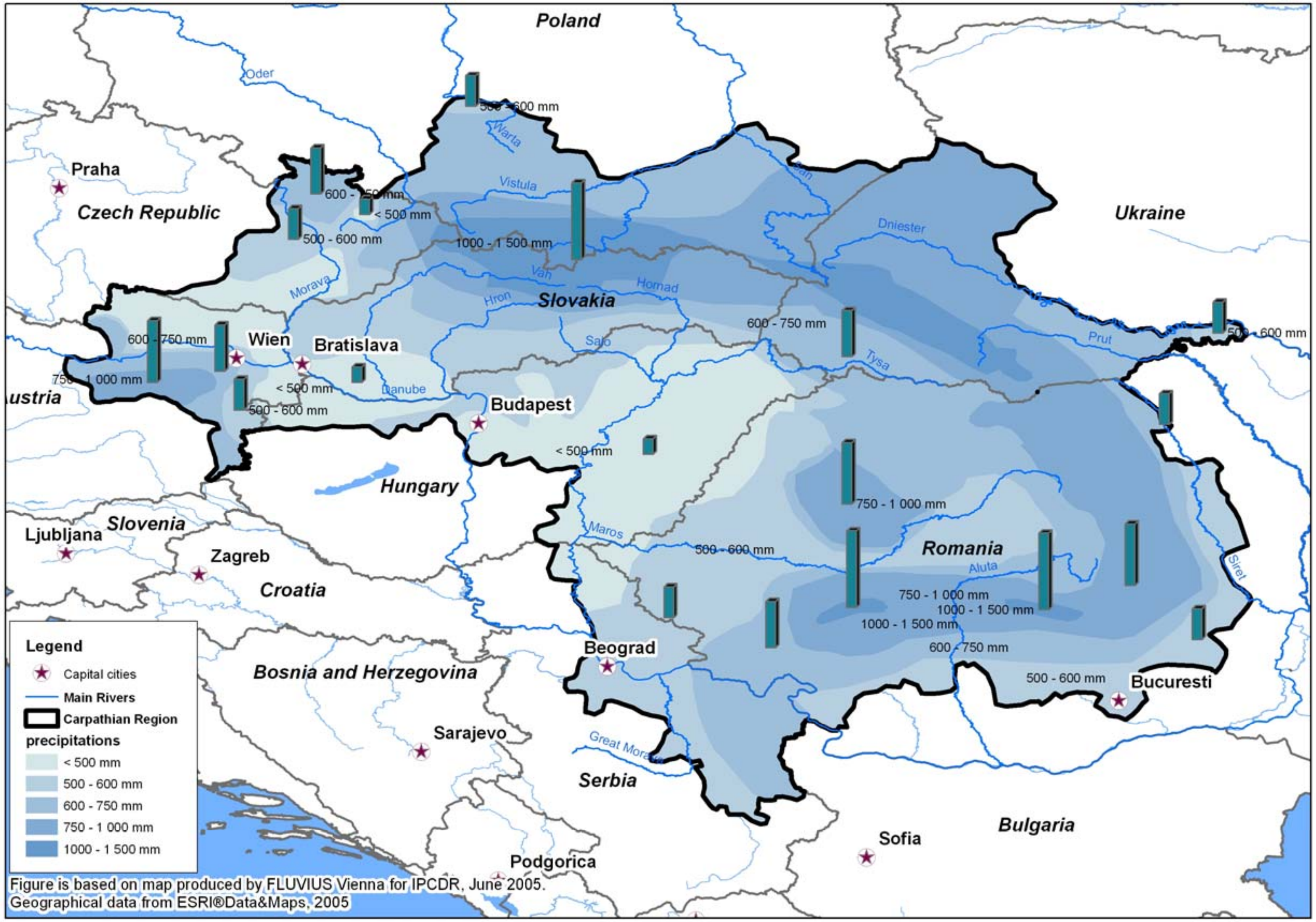


Figure 9: Annual precipitation in the Carpathian Region

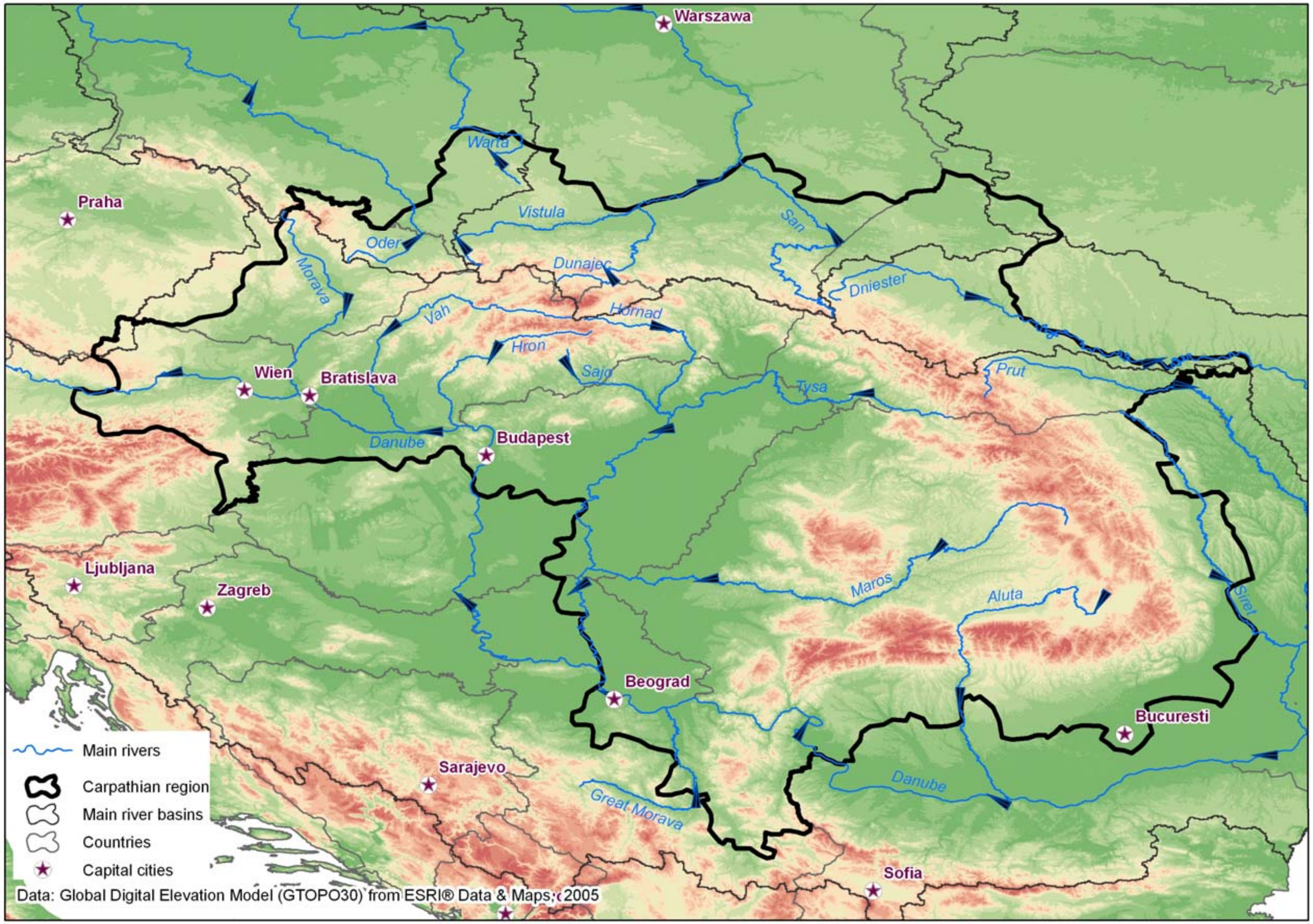


Figure 10: Flow direction of main rivers in Carpathian Region: The Carpathians - water tower for surrounding areas

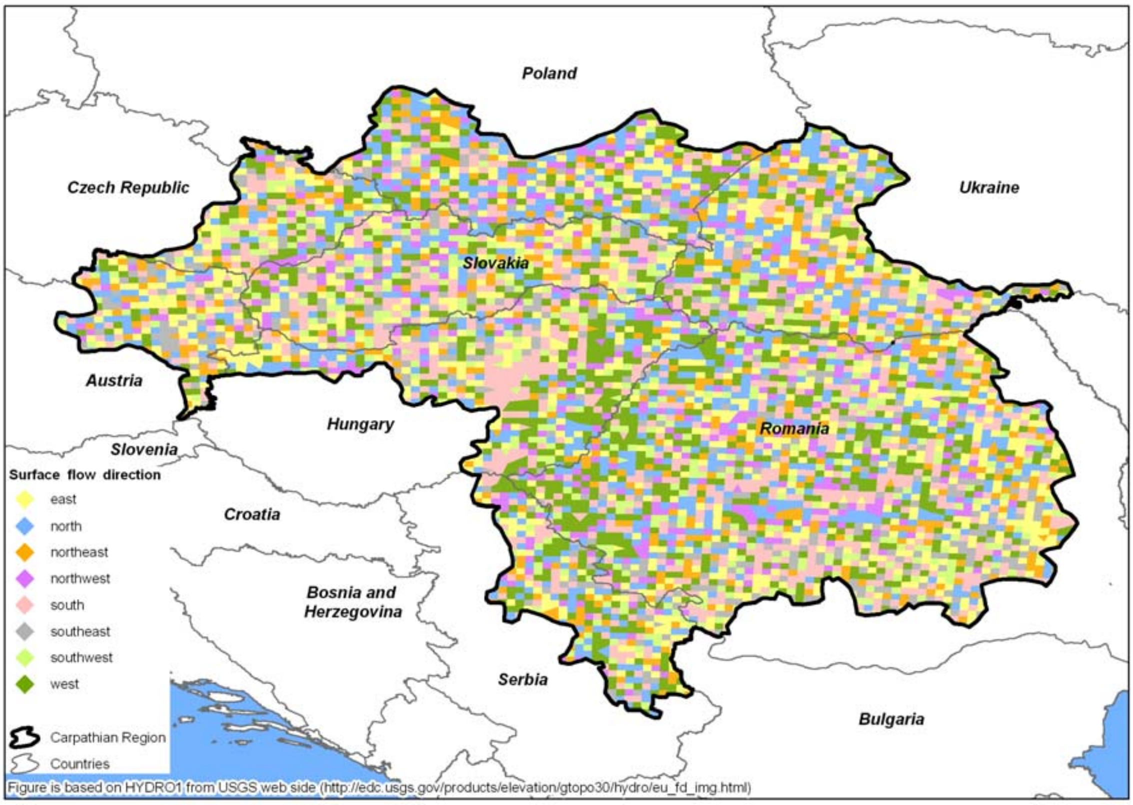


Figure 11: Surface flow direction (slopes) in Carpathian region

Table 9: **The percentage share of slopes within the Carpathian Region**

Surface flow direction (slopes)		Participation of each flow direction [%]
northwest	↖	8,1
west	←	17,7
southeast	↘	8,3
east	→	15,6
south	↓	17,4
northeast	↗	9,0
north	↑	15,8
southwest	↘	8,2
SUM		**100**

2.3. Background data

2.3.1. Inhabitants

The analysis of population density is based on data from ESRI® Data & Maps, 2005. Original data were concerned NUTS3 – third level of Nomenclature of Units for Territorial Statistics.

In the Carpathian Region population density is about 120 person per sq. km, so in the whole area live about 55 million people. But population is bigger in and around big cities (Cracow – more than 750 thousand people, Vienna – more than 1,5 million people, Budapest – about 1,7 million people, Bucuresti – about 2 million people) and in agglomerations like Silesia in Poland (about 3 million people).

Definitely bigger population density is in the northern Carpathian region (besides west part in Austria), than in central and southern parts of examine region (Figure 12).

In the region we can notice that almost in all river catchments population density is contained between 109 (the Danube) and 170 (the Vistula) person per square kilometer. In Oder catchment population is the biggest – 308 person/km^2 because of Silesia region. Very small population density equals 49 is in small part of Elbe catchment (Figure 13).

In analysis based on particular river basins small population density is in Danube tributaries - Siret, Aluta, Maros, Tysa, Hron – less than 100 person/km^2, definitely bigger is in the Danube and it's rest tributaries and another river basins – between 101 and 170 person/km^2. The list of total population and population density in river basins in the Carpathian Region is contained in table below and Figure 14.

Table 10: Population density in main river basins in Carpathian region:

River basin	Population [person]	Area [km^2]	Population density [person/km^2]
Danube	**39419416**	**360670.6**	**109**
Aluta	1692716	20653.7	82
Great Morava	757644	7501.4	101
Hron	438134	5366.0	82
Maros	2313273	31706.3	73
Morava	2859685	20629.1	139
Prut	995839	9225.8	108
Siret	3145624	34467.4	91
Tysa	13309705	157118.8	85
Hornad	714882	6911.2	103
Sajo	1229336	12505.8	98
Vah	2640396	20394.1	128
Dniester	**2315949**	**20912.8**	**111**
Dnieper	**219793**	**1847.0**	**119**
Elbe	**39773**	**811.7**	**49**
Oder	**4346926**	**14132.0**	**308**
Warta	716827	3143.2	228
Vistula	**8289729**	**48651.1**	**170**
Dunajec	934488	6752.9	138
San	1630414	14364.4	114

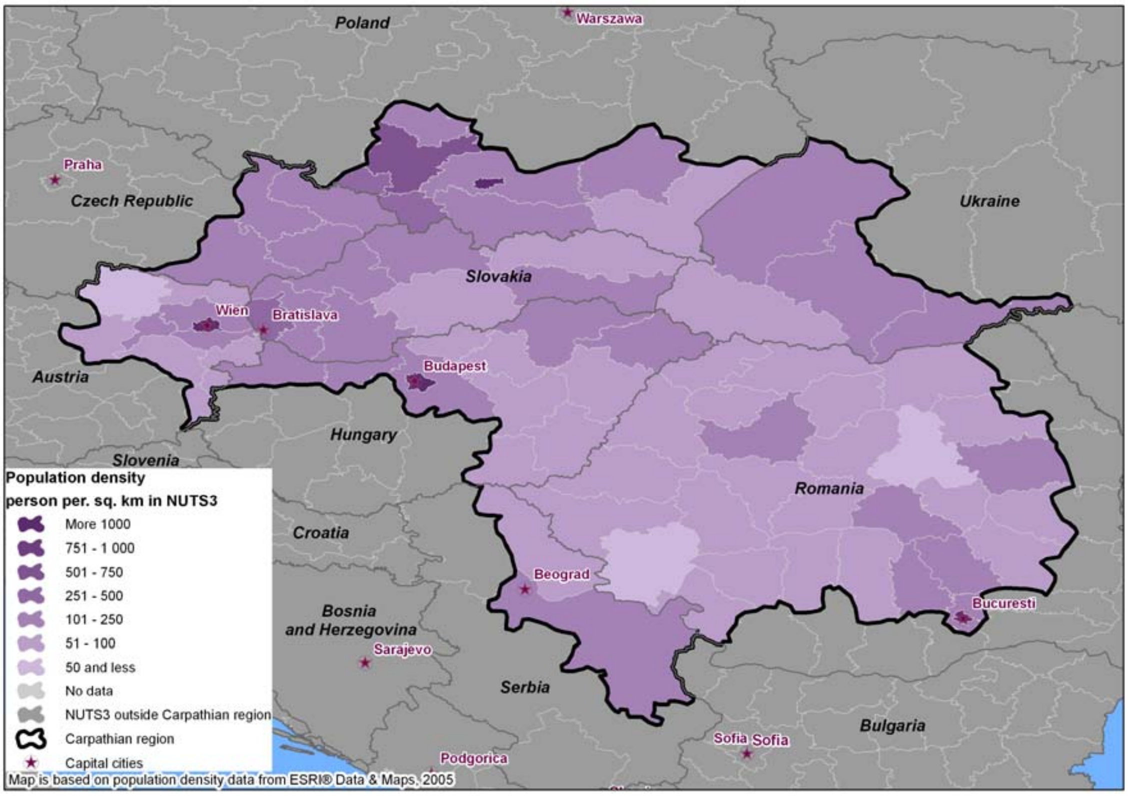


Figure 12: Population density in NUTS 3 in the Carpathian Region.

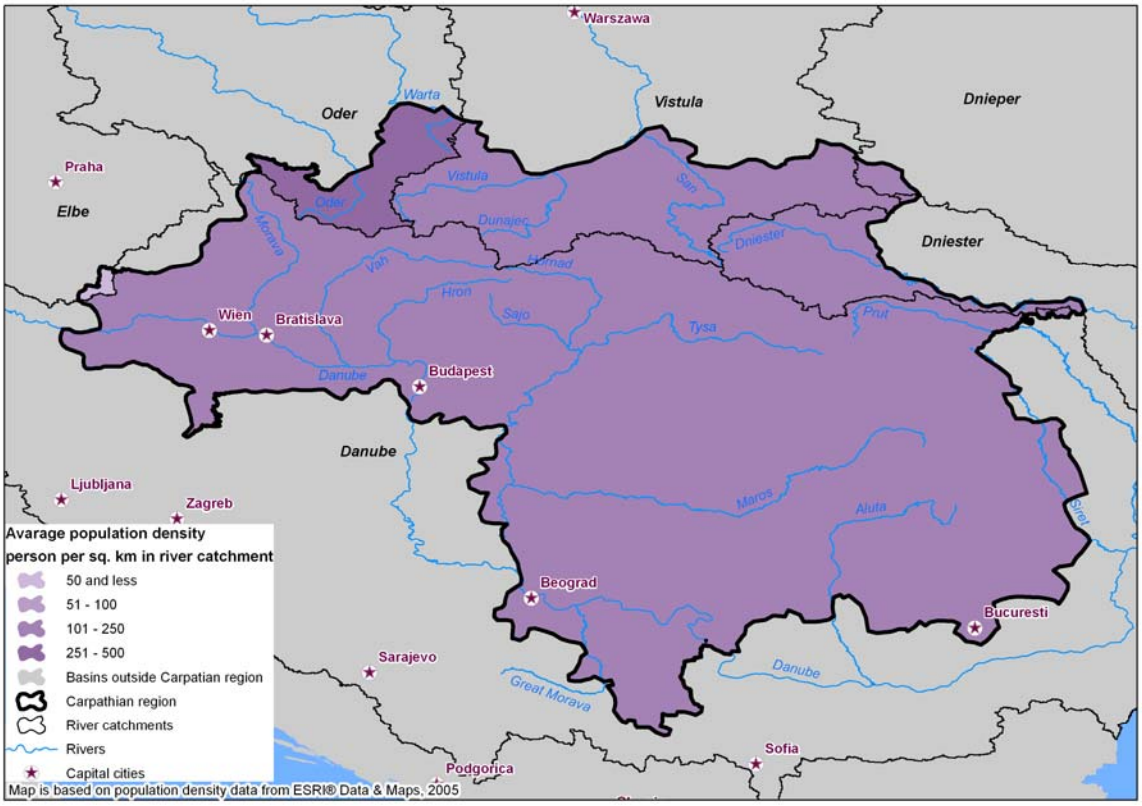


Figure 13: Population density in river catchments in the Carpathian Region.

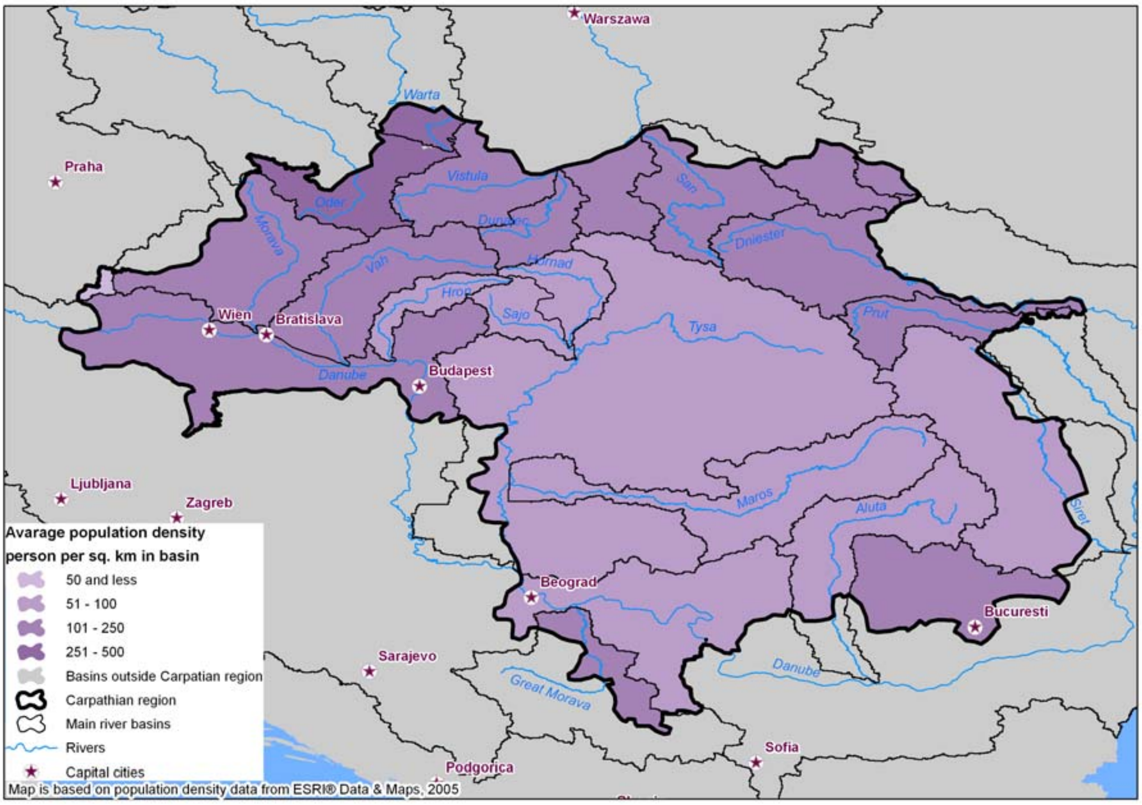


Figure 14: Population density in main river basins in the Carpathian Region.

2.3.2. Annual precipitation

The map on the next side shows average total annual precipitation since 1950 to 1980 in the region.

2.3.3. Temperature

Average seasonal temperatures in Carpathian region in 1961 – 1990 are listed in the Figure 16 and table below – data from International Research Institute for climate prediction web sides:

http://iri.columbia.edu/forecast/net_asmt/images/limits/Eur_amj_Tclm.html,
http://iri.columbia.edu/forecast/net_asmt/images/limits/Eur_ond_Tclm.html

Generally temperature trends in Carpathian region is similar in some parts for each season. In Eastern Carpathians average temperature is always the lowest in the region, and warmer parts are located in Danube and Tysa valleys.

In column "Participation" there is data concerning total area of Carpathian region with particular partition of average temperature in each season.

Table 11: Average seasonal temperature in Carpathian region.

Temperature [^{o}C]	Participation [%]			
	Spring	Summer	Autumn	Winter
between -10 and -5	-	-	-	2,67
between -5 and 0	-	-	1,73	58,58
between 0 and 5	-	-	76,30	38,75
between 5 and 10	8,71	-	21,97	-
between 10 and 15	76,09	20,75	-	-
between 15 and 20	15,20	74,24	-	-
between 20 and 25	-	5,01	-	-
TOTAL	**100**	**100**	**100**	**100**

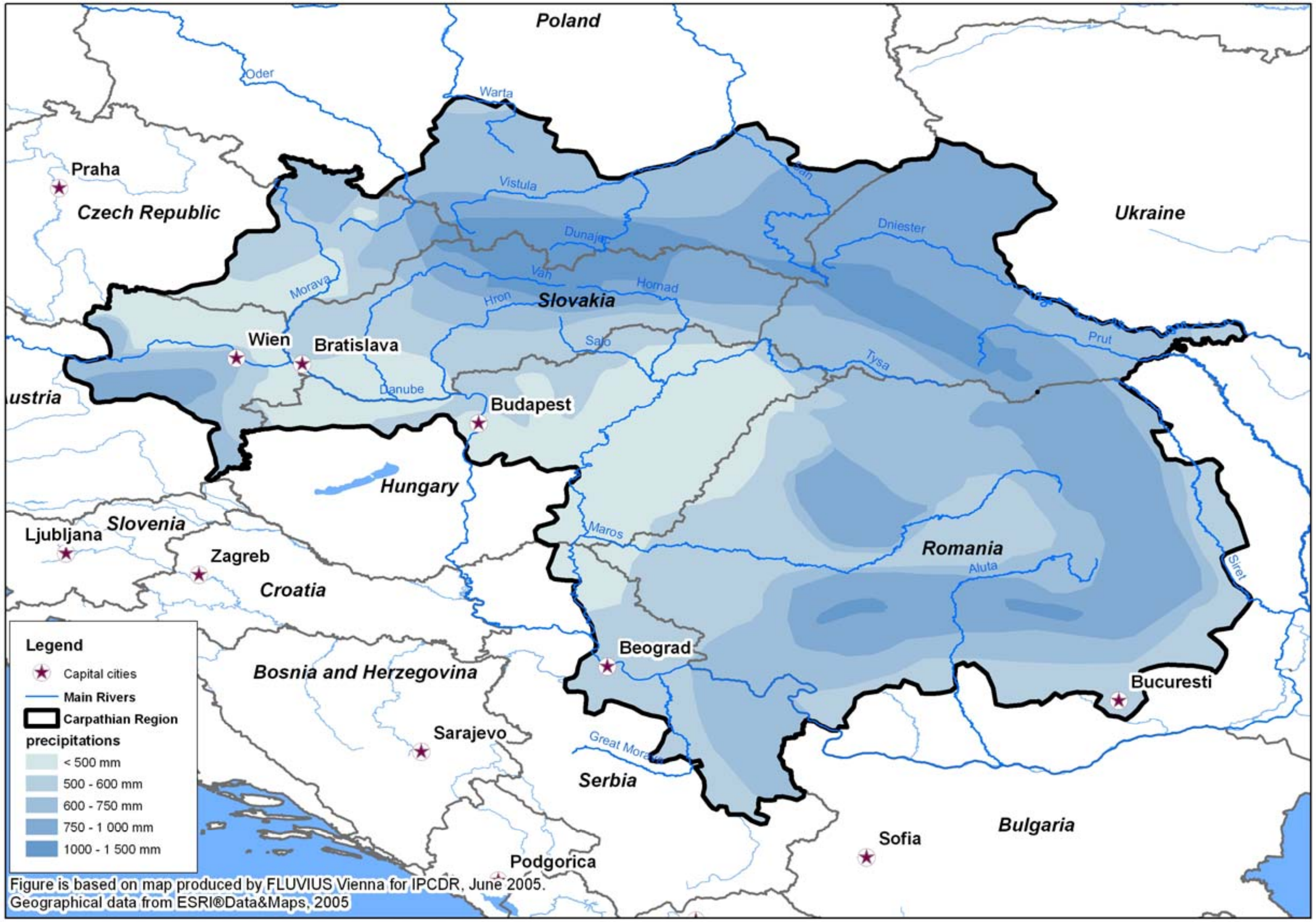
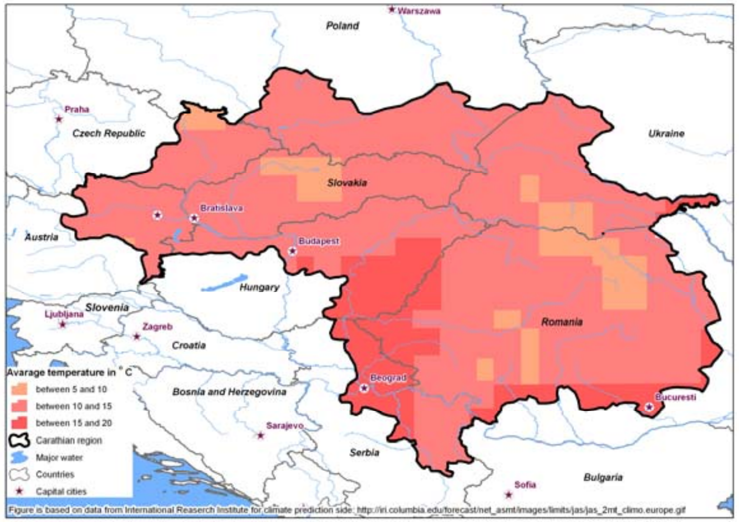
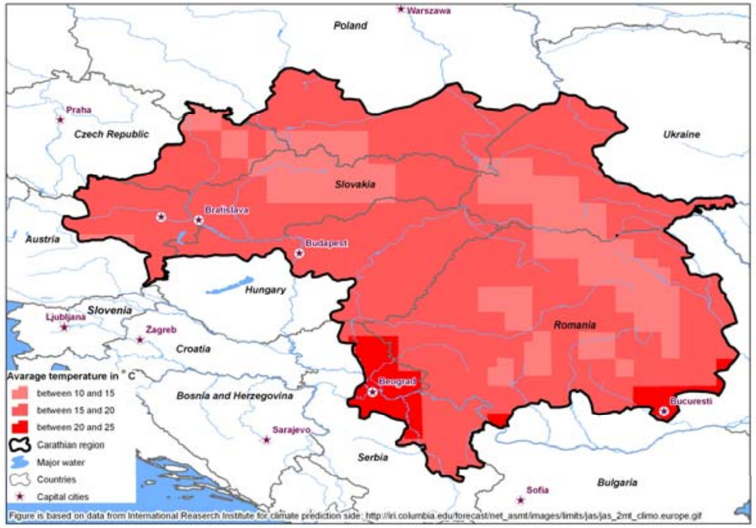


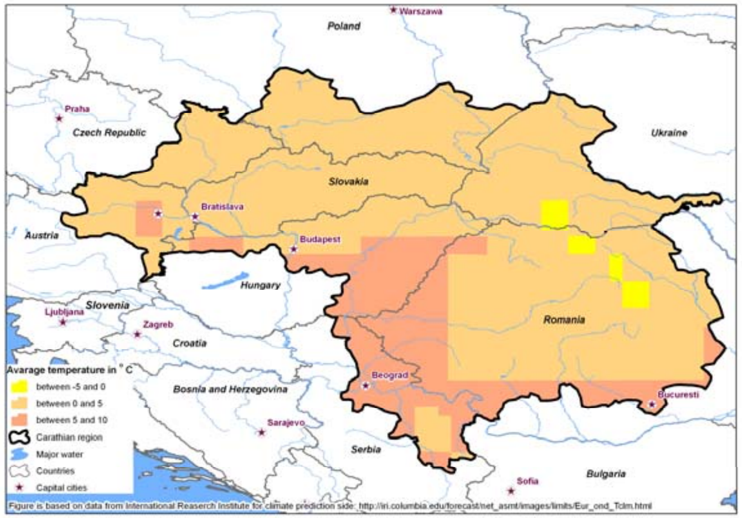
Figure 15: Annual precipitation in the Carpathian region



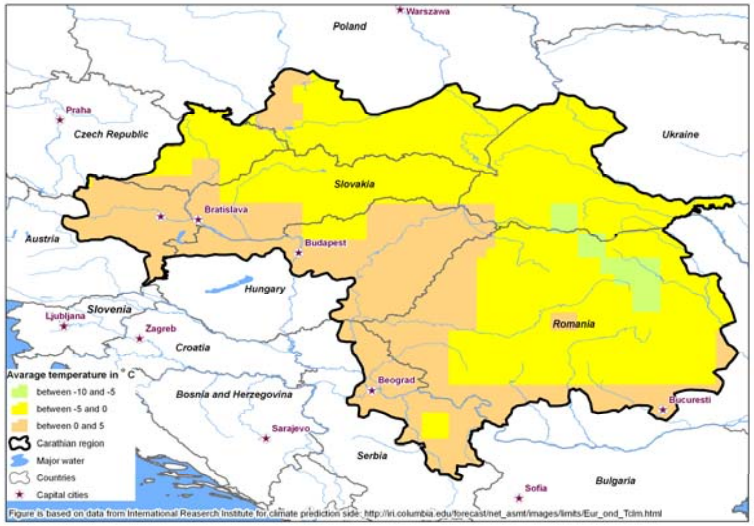
Average temperature in Spring



Average temperature in Summer



Average temperature in Autumn



Average temperature in Winter

Figure 16 Seasonal average temperature in the Carpathian Region

2.3.4. Land Cover

Land cover data was based on EEA Corine Land Cover 2000 shapefile (http://www.eea.europa.eu/). Carpathian region contains only 12 of all 23 classes which are covered in database. The original data covers only the volume and class name of each land cover area – the generalization was done on the needs of this report.

Table 12: The list of Classnames in Corine Land Cover 2000

Value	Classnames	Generalized Classnames	Areas located in Carpathian
1	*Tree Cover, broadleaved, evergreen*	*Forest and semi natural areas*	X
2	*Tree Cover, broadleaved, deciduous, closed*	*Forest and semi natural areas*	√
3	*Tree Cover, broadleaved, deciduous, open*	*Forest and semi natural areas*	X
4	*Tree Cover, needle-leaved, evergreen*	*Forest and semi natural areas*	√
5	*Tree Cover, needle-leaved, deciduous*	*Forest and semi natural areas*	X
6	*Tree Cover, mixed leaf type*	*Forest and semi natural areas*	√
7	*Tree Cover, regularly flooded, fresh water*	*Forest and semi natural areas*	X
8	*Tree Cover, regularly flooded, saline water*	*Forest and semi natural areas*	X
9	*Mosaic: Tree Cover/Other natural vegetation*	*Forest and semi natural areas*	X
10	*Tree Cover, burnt*	*Forest and semi natural areas*	X
11	*Shrub Cover, closed-open, evergreen*	*Forest and semi natural areas*	X
12	*Shrub Cover, closed-open, deciduous*	*Forest and semi natural areas*	X
13	*Herbaceous Cover, closed-open*	*Forest and semi natural areas*	√
14	*Sparse herbaceous or sparse shrub cover*	*Forest and semi natural areas*	√
15	*Regularly flooded shrub and/or herbaceous cover*	*Wetlands*	√
16	*Cultivated and managed areas*	*Agricultural areas*	√
17	*Mosaic: Cropland/Tree Cover/Other natural vegetation*	*Agricultural areas*	√
18	*Mosaic: Cropland/Shrub and/or grass cover*	*Agricultural areas*	√
19	*Bare Areas*	*Forest and semi natural areas*	√
20	*Water Bodies*	*Water bodies*	√
21	*Snow and Ice*	*Forest and semi natural areas*	X
22	*Artificial surfaces and associated areas*	*Artificial surfaces*	√
23	*No data*	*No data*	X

All analyses were done on generalized classnames such as:

- Forest and semi natural areas
- Agricultural areas
- Water bodies
- Artificial surfaces
- Wetlands

In all Carpathian region there are over 56% of agricultural areas and over 42% of forest and semi natural areas, almost 2% constitute the rest land cover areas (table below).

Table 13: Participation of each land cover area in the Carpathian Region

Generalized classname	Percentage participation [%]
Agricultural areas	56,10
Artificial surfaces	1,52
Forest and semi natural areas	42,21
Water bodies	0,15
Wetlands	0,01

There have been done also two another analysis concerning percentage participation land cover of each Carpathian country part and the river catchments. The results of analysis show that strongly part of Hungary (82,2%) and Serbia (72,5%) cover agricultural areas. Also in other countries, except Slovakia, this value oscillates between 45-60%. The only exception is Slovakian region, where the main part of the country cover forest and semi natural areas (52,9%). The least area covers are water bodies and wetlands (wetlands are located only in Poland and Ukraine).

The land cover analysis with the reference to the river catchments gives us similar quantities of percentage coverage in Carpathian Region. In all catchments the primary values are agricultural areas (from 53,1% in the Oder river catchment to 64,1% in the Dniester river catchment) and forest and semi natural areas – both this two coverage classes take about 95% of all region. The results of analysis are shown below on tables and figures.

Table 14: Percentage participation of each land cover area in Carpathian country parties

		Percentage participation of each Land Cover area [%]							
		Austria	Czech Republic	Hungary	Poland	Romania	Serbia	Slovakia	Ukraine
LAND COVER	Forest and semi natural areas	46,5	39,6	14,4	47,0	48,9	25,9	52,9	43,7
	Artificial surfaces	1,8	1,9	3,3	2,5	1,1	1,4	0,9	0,6
	Agricultural areas	51,3	58,4	82,2	50,2	49,9	72,5	46,0	55,6
	Wetlands	0	0	0	0,1	0	0	0	0
	Water bodies	0,5	0,1	0,1	0,2	0,1	0,2	0,2	0,2
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

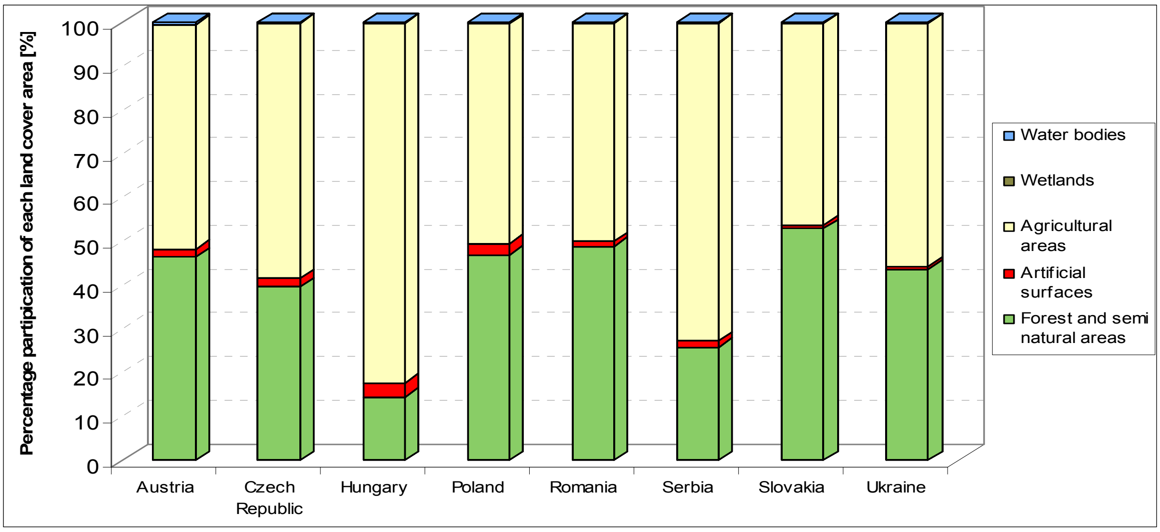


Figure 17: Percentage participation of each land cover area in Carpathian country parties

Table 15: Percentage participation of each land cover area in Carpathian river catchments

		Percentage participation of each Land Cover area [%]			
		Danube	**Dniester**	**Oder**	**Vistula**
LAND COVER	Forest and semi natural areas	42,4	35,1	41,0	44,4
	Artificial surfaces	1,5	0,4	5,6	1,2
	Agricultural areas	56,0	64,1	53,1	54,2
	Wetlands	0,00	0,02	0,06	0,00
	Water bodies	0,1	0,4	0,2	0,2
	Total	**100**	**100**	**100**	**100**

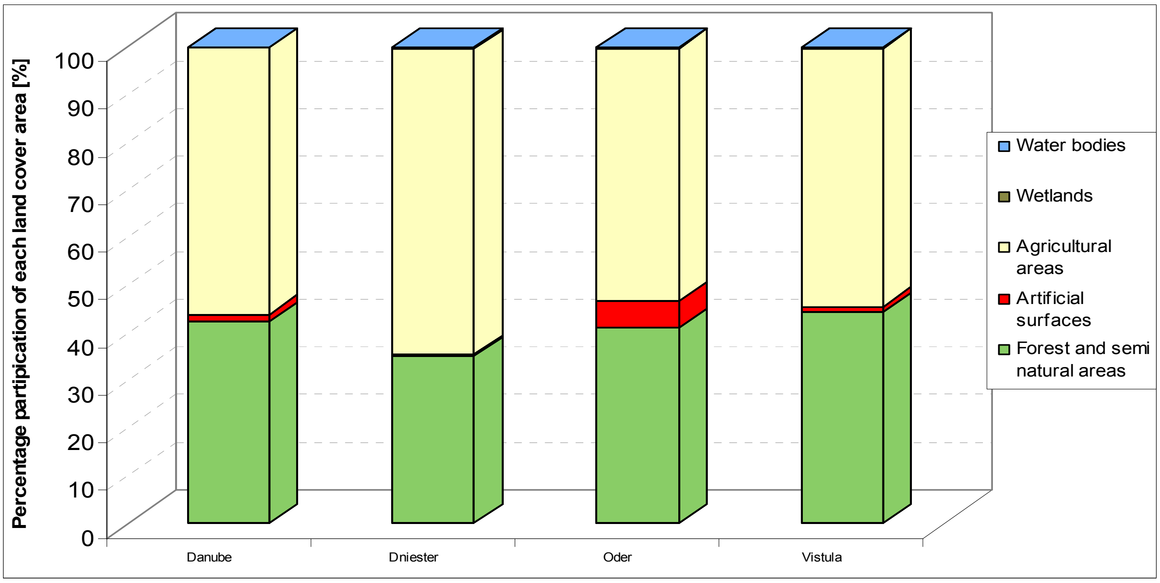


Figure 18: Percentage participation of each land cover area in Carpathian river catchments.

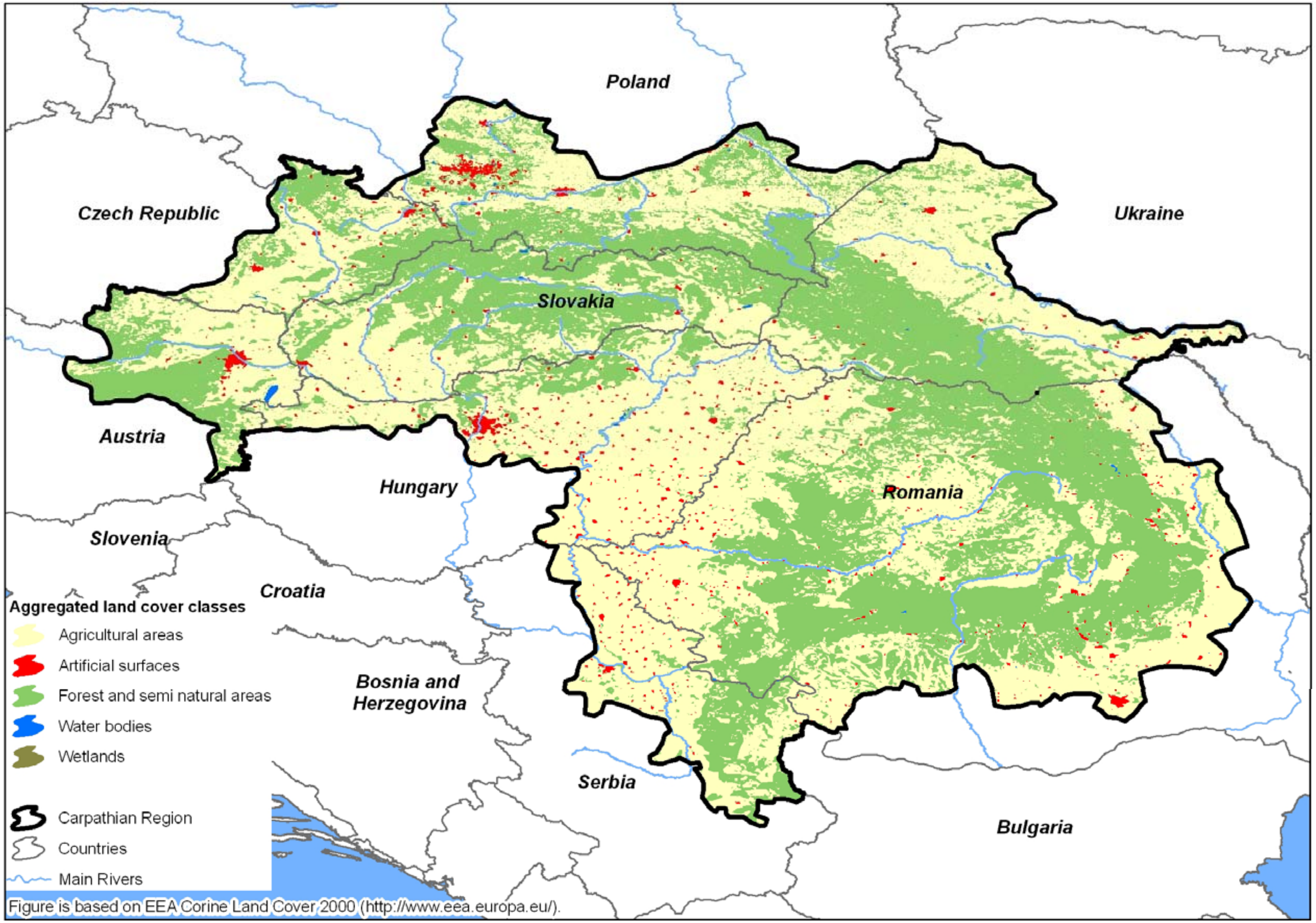


Figure 19: Land Cover in the Carpathian Region – countries

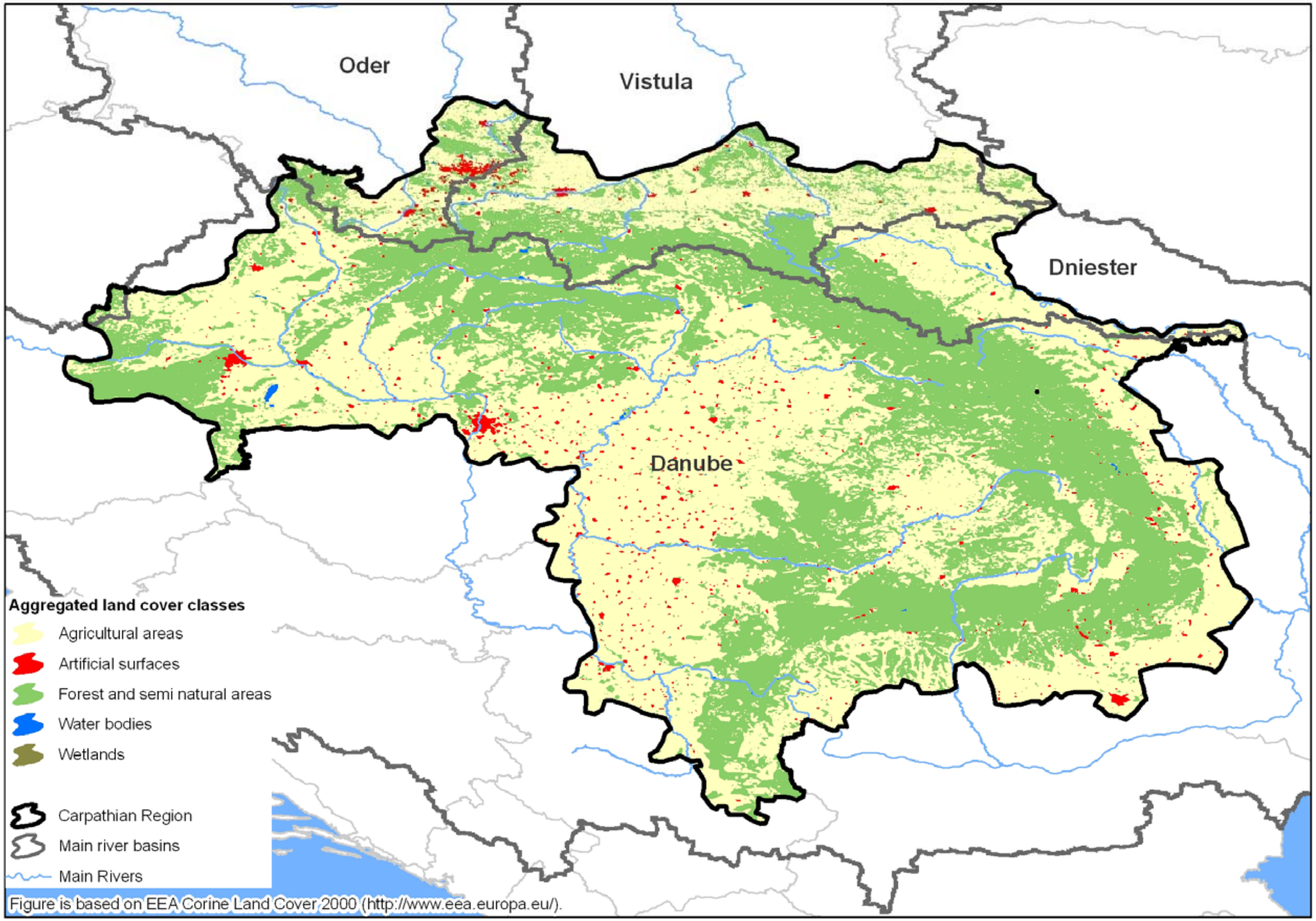


Figure 20: Land Cover in the Carpathian Region – river catchments

3. Short description of pressures and impacts

3.1. Water quality

3.1.1. Significant point sources and diffuse sources

The percentage share of diffuse sources with reference to river catchments in Carpathian region approximately fluctuates around 55% of whole area in each river catchment. The biggest amount of diffuse sources based on “corine agricultural areas” are located in the Dniester valley (almost 60%) and the less of them are in Oder river catchment (nearly 50%). With the reference to significant point sources, most of them are situated in the biggest - Danube river catchment (172 of all 194). The most densely situated point sources are in Silesian Industrial area in Poland and also in Romanian part, where huge amount of them are located very sparsely. In Dniester river catchment there are no identified significant point sources - it is caused not only by the smallest catchment area but also lack of data of Ukraine region.

Table 16: Percentage participation of diffuse sources in each river catchment

Diffuse sources - percentage participation in each river catchment [%]					
		Danube	**Dniester**	**Oder**	**Vistula**
	Cultivated and managed areas	0,555	0,596	0,501	0,516
Significant point sources - number of points [-]					
		Danube	**Dniester**	**Oder**	**Vistula**
	Industrial	87	-	4	14
	Agricultural	13	-	-	-
Municipal	Municipal (WWTP 10 - 100 PE)	19	-	18	26
	Municipal (WWTP > 100 PE)	39	-		
	Municipal (untreated 10 - 100 PE)	9	-		
	Municipal (untreated > 100 PE)	5	-		
	Total	**172**	**0**	**22**	**40**

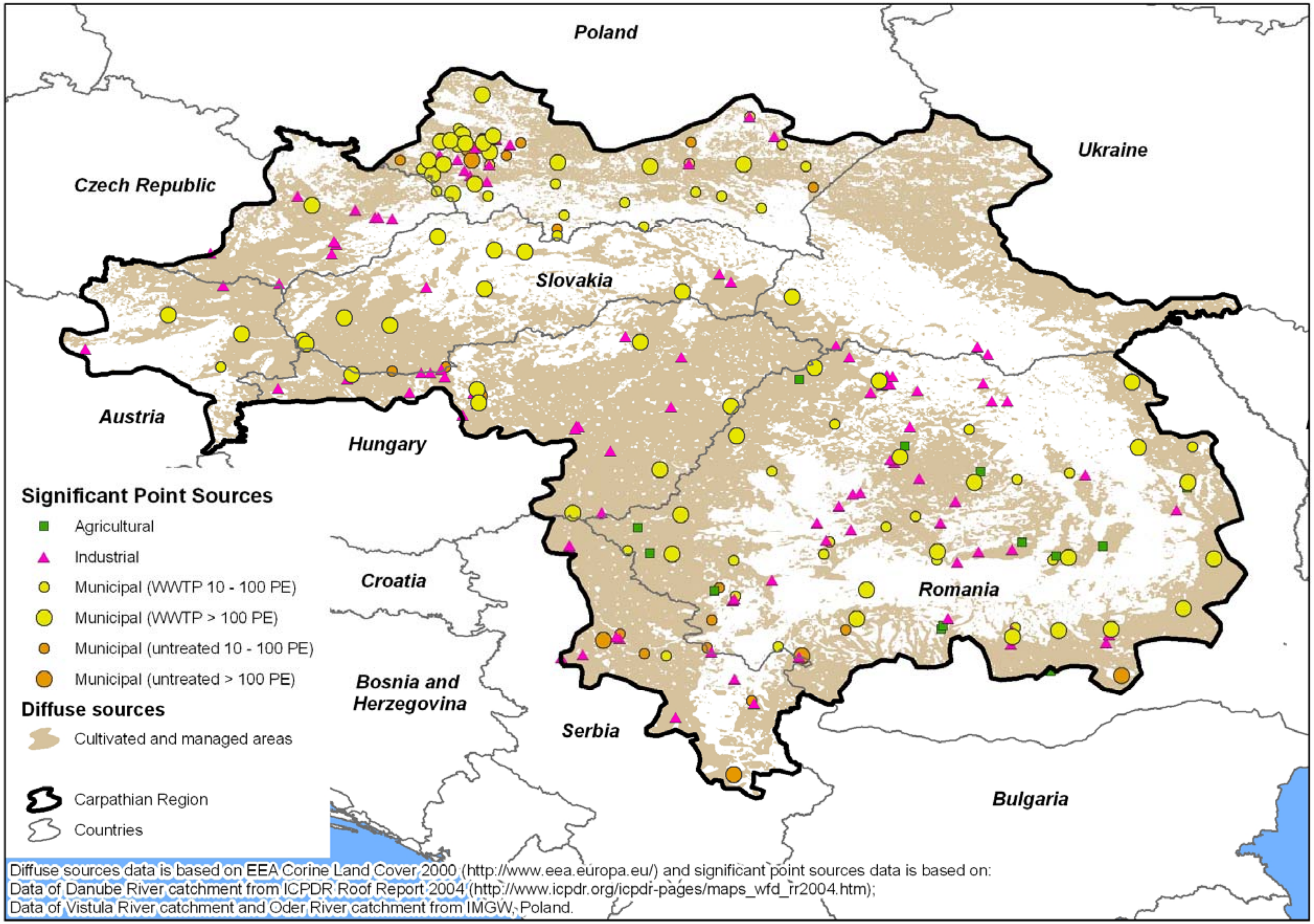


Figure 21: Significant point sources and diffuse sources in the Carpathian Region

3.1.2. Risk of failure to reach environmental objectives

Data about risk of failure to reach the Environmental Objectives for Danube River Catchment is from ICPDR Roof Report 2004 and for Oder and Vistula River Catchment are from IMGW, Poland.

There was no data for Dniester, Prut, Great Morava rivers, the Tysa on section in the border between Ukraine and Romania, section downstream the Maros, and upper sections of the Oder and the Sajo.

Organic Pollution

At risk of failure to reach the Environmental Objectives are the Danube along the border between Romania and Serbia, and downstream the Horn to border of Carpathian region.

Water bodies not at risk are almost for every spring rivers' sections. A good status of water with regard organic pollution are San and Dunajec rivers, the Tysa and it's tributaries: Hornad and Sajo Rivers. There are only three short sections in Hornad at risk and possibly at risk. Mostly at risk of failure to reach environmental objectives in this range are: Siret, Vah and Vistula rivers.

Nutrient Pollution

Taking into consideration nutrient pollution, the problem doesn't apply all the San, and the Upper Dunajec, the Danube in western part of the region, springs sections of Siret, Aluta, Maros, Hornad, Horn and Vistula rivers. Water bodies not at risk of failure to reach the Environmental Objectives are also in the middle pats of Carpathians rivers.

Hazardous Substances

Water bodies which are visibly at risk or possibly at risk of failure to reach the Environmental Objectives in means Hazardous Substances are: the Danube along the border between Romania and Serbia, almost all Aluta, Tysa and Vah rivers, and in half the Morava.

Not at risk in this issue are all Polish water bodies, almost on their all length: the Siret, the Maros (only in estuaries section is possibly at risk), and the Hornad.

Hydromorphological Alterations

The highest risk of failure to reach the Environmental Objectives in Carpathian water bodies is in means hydromorphological alterations. Many of them are at risk or possibly at risk. Only San and Dunajec rivers aren’t at risk.

Risk of failure to reach the Environmental Objectives for water bodies – Figure 24 - Figure 22.

Configuration of percentage length in means of each element for rivers are in table below.

Table 17: Configuration of percentage length in means of pollutions and hydromorphological alterations for main rivers

River	Organic pollution	River sections quantity	Participation	Nutrient pollution	River sections quantity	Participation	Hazardous substances	River sections quantity	Participation	Hydromorphological alterations	River sections quantity	Participation
Aluta	at risk	1	61%	at risk	1	29%	at risk	1	17%	at risk	2	36%
	not at risk	2	39%	not at risk	2	71%	not at risk	2	17%	not at risk	1	15%
	possibly at risk	0	0%	possibly at risk	0	0%	possibly at risk	2	66%	possibly at risk	1	48%
Danube	at risk	0	0%	at risk	2	31%	at risk	1	28%	at risk	5	64%
	not at risk	3	68%	not at risk	2	33%	not at risk	2	15%	not at risk	1	3%
	possibly at risk	2	32%	possibly at risk	2	37%	possibly at risk	6	57%	possibly at risk	3	33%
Dniester	no data	1	100%	no data	1	100%	no data	1	100%	no data	1	100%
Dunajec	at risk	0	0%	at risk	1	31%	at risk	0	0%	at risk	0	0%
	not at risk	1	100%	not at risk	1	69%	not at risk	1	100%	not at risk	1	100%
Great Morava	no data	1	100%	no data	1	100%	no data	1	100%	no data	1	100%
Hornad	at risk	1	5%	at risk	2	64%	at risk	1	5%	at risk	1	87%
	not at risk	3	88%	not at risk	2	28%	not at risk	3	88%	not at risk	1	13%
	possibly at risk	2	7%	possibly at risk	1	8%	possibly at risk	1	7%	possibly at risk	0	0%
Hron	at risk	1	67%	at risk	1	67%	at risk	2	45%	at risk	1	81%
	not at risk	1	29%	not at risk	1	28%	not at risk	1	51%	not at risk	1	19%
	possibly at risk	1	4%	possibly at risk	1	4%	possibly at risk	1	4%	possibly at risk	0	0%
Maros	at risk	3	47%	at risk	3	48%	at risk	0	0%	at risk	2	16%
	not at risk	3	46%	not at risk	3	45%	not at risk	1	93%	not at risk	4	45%
	possibly at risk	2	7%	possibly at risk	2	7%	possibly at risk	2	7%	possibly at risk	4	39%
Morava	at risk	2	19%	at risk	1	62%	at risk	4	44%	at risk	1	63%
	not at risk	3	78%	not at risk	1	34%	not at risk	4	32%	not at risk	1	37%
	possibly at risk	1	3%	possibly at risk	1	4%	possibly at risk	2	24%	possibly at risk	0	0%
Oder	at risk	1	30%	at risk	1	22%	at risk	0	0%	at risk	1	30%
	not at risk	0	0%	not at risk	1	8%	not at risk	1	31%	not at risk	0	0%
	no data	1	70%	no data	1	70%	no data	1	69%	no data	1	70%
Prut	not at risk	2	14%	not at risk	1	15%	not at risk	0	0%	not at risk	0	0%
	possibly at risk	0	0%	possibly at risk	0	0%	possibly at risk	2	14%	possibly at risk	0	0%
	no data	2	86%	no data	1	85%	no data	2	86%	no data	1	100%

River	Organic pollution	River sections quantity	Participation	Nutrient pollution	River sections quantity	Participation	Hazardous substances	River sections quantity	Participation	Hydromorphological alterations	River sections quantity	Participation
Sajo	at risk	0	0%	at risk	1	35%	at risk	1	27%	at risk	1	37%
	not at risk	1	64%	not at risk	1	29%	not at risk	1	37%	not at risk	0	0%
	possibly at risk	0	0%	possibly at risk	0	0%	possibly at risk	0	0%	possibly at risk	1	28%
	no data	1	36%	no data	1	36%	no data	1	36%	no data	1	35%
San	not at risk	1	100%	not at risk	1	100%	not at risk	1	100%	not at risk	1	100%
Siret	at risk	1	87%	at risk	3	43%	at risk	0	0%	at risk	4	23%
	not at risk	1	13%	not at risk	4	57%	not at risk	2	92%	not at risk	0	0%
	possibly at risk	0	0%	possibly at risk	0	0%	possibly at risk	1	8%	possibly at risk	4	77%
Tysa	at risk	0	0%	at risk	1	7%	at risk	1	19%	at risk	3	27%
	not at risk	3	72%	not at risk	2	24%	not at risk	0	0%	not at risk	0	0%
	possibly at risk	0	0%	possibly at risk	3	41%	possibly at risk	3	53%	possibly at risk	3	45%
	no data	2	28%	no data	2	28%	no data	2	28%	no data	2	28%
Vah	at risk	2	27%	at risk	2	26%	at risk	2	26%	at risk	2	90%
	not at risk	2	23%	not at risk	2	22%	not at risk	2	23%	not at risk	1	5%
	possibly at risk	3	50%	possibly at risk	3	52%	possibly at risk	3	51%	possibly at risk	1	5%
Vistula	at risk	2	60%	at risk	1	74%	at risk	0	0%	at risk	2	61%
	not at risk	3	40%	not at risk	2	26%	not at risk	1	100%	not at risk	3	39%
	no data	0	0%	no data	1	0%	no data	1	0%	no data	1	0%
Warta	at risk	2	47%	at risk	2	46%	at risk	0	0%	at risk	2	48%
	not at risk	1	53%	not at risk	2	54%	not at risk	1	100%	not at risk	1	52%

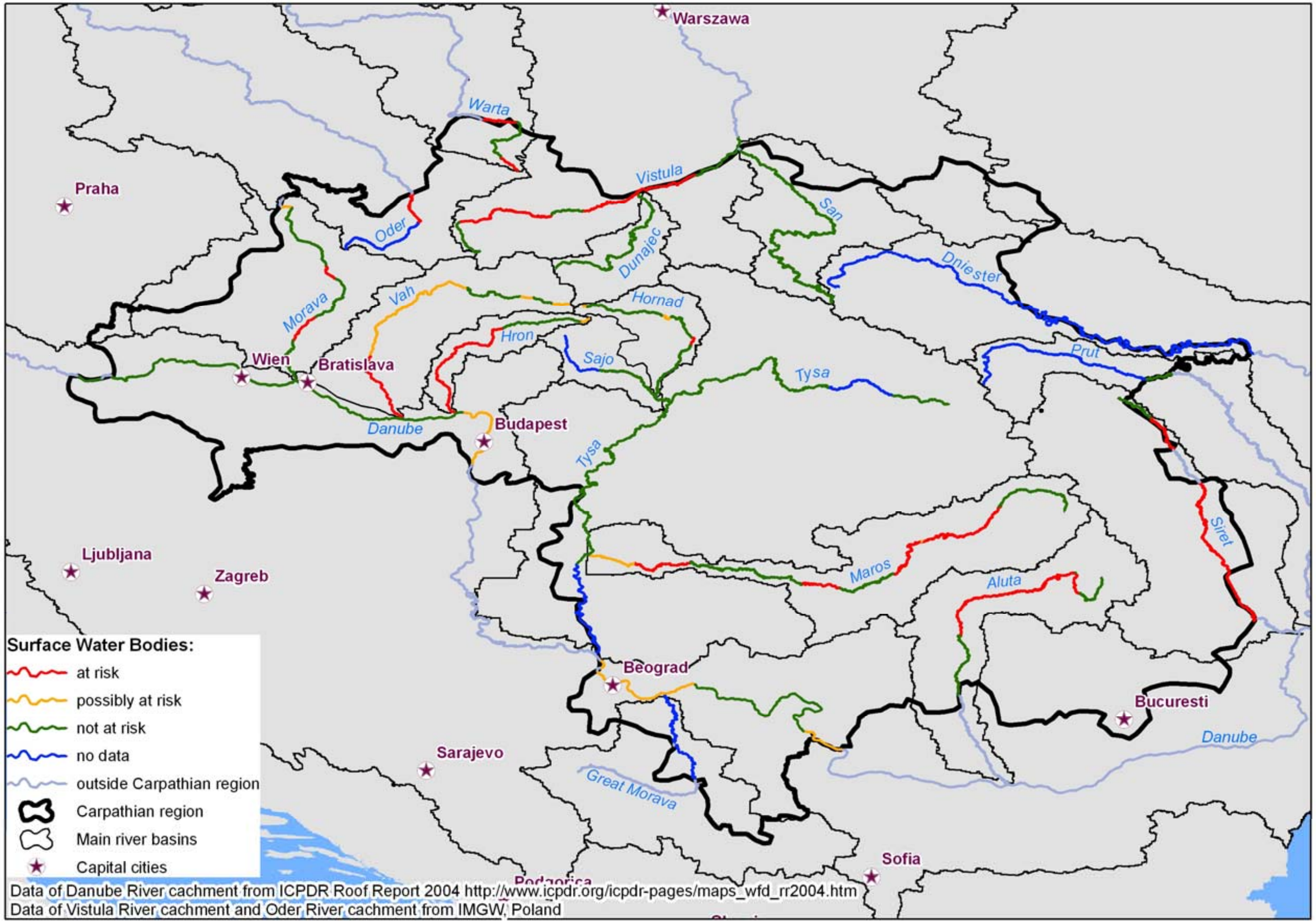


Figure 22: Risk of failure to reach the Environmental Objectives – Organic Substances

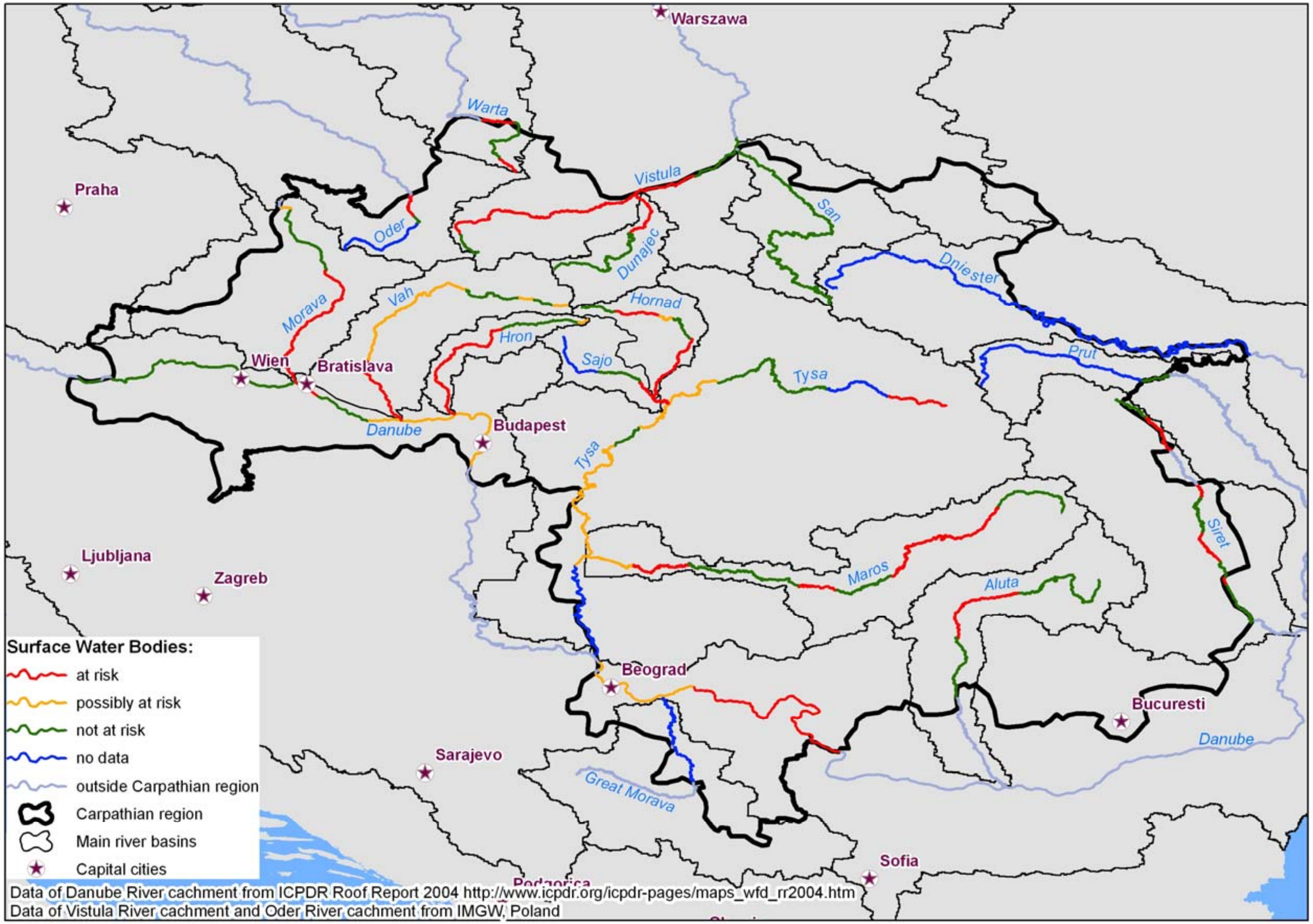


Figure 23: Risk of failure to reach the Environmental Objectives – Nutrients

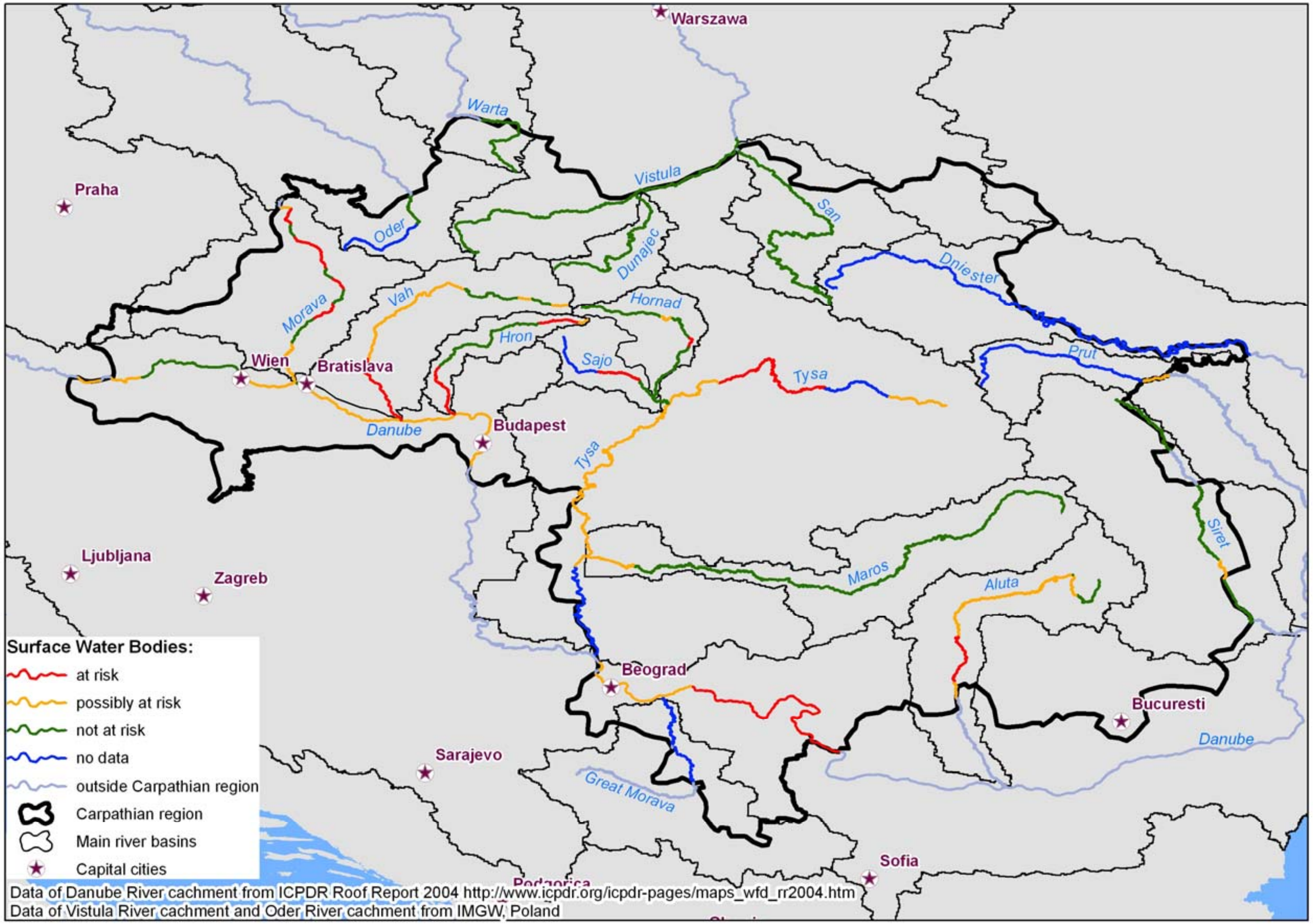


Figure 24: Risk of failure to reach the Environmental Objectives – Hazardous Substances

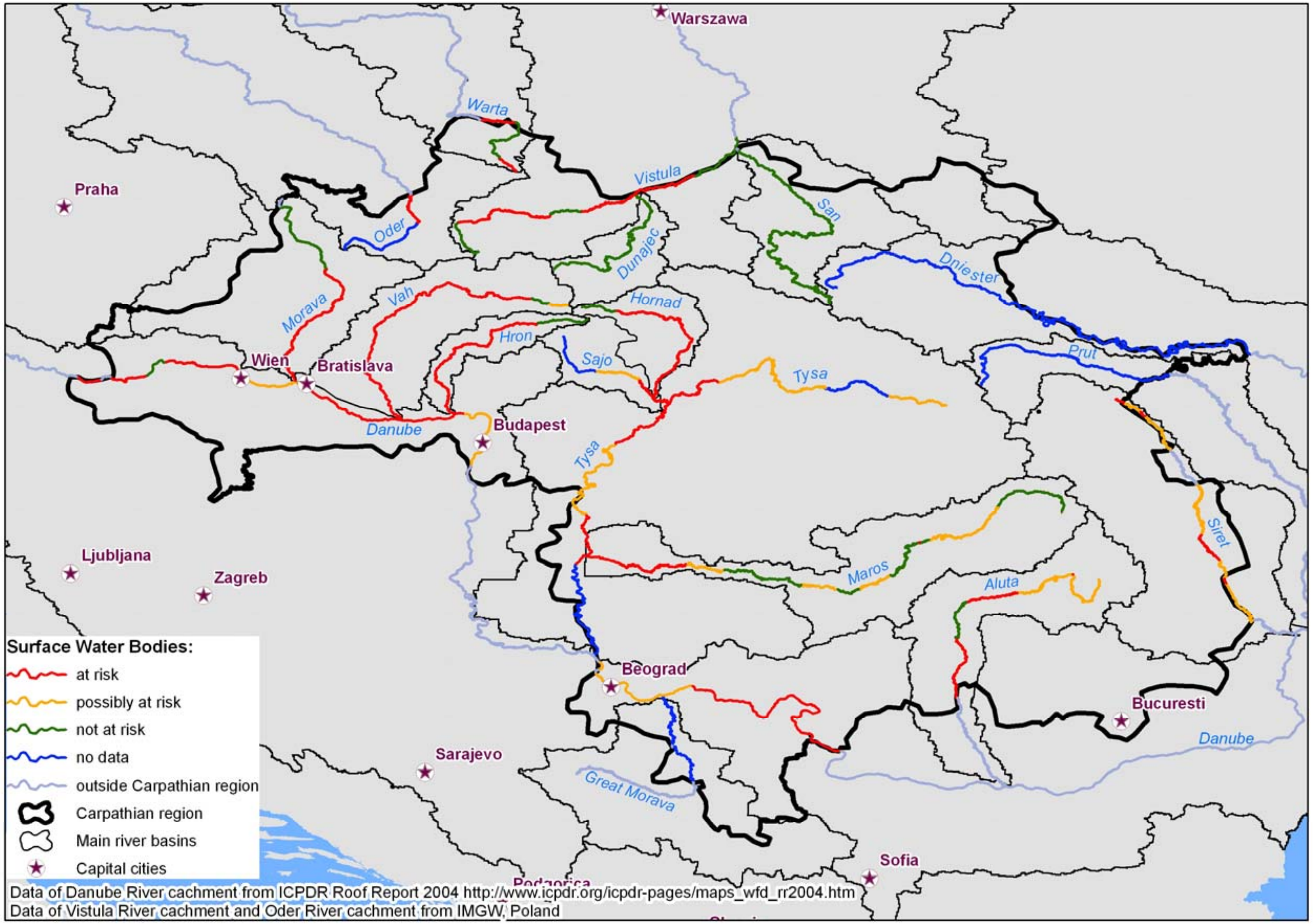


Figure 25: Risk of failure to reach the Environmental Objectives – Hydromorphological alterations

3.1.3. Water quality monitoring

In the Carpathian Region there are 381 points of water quality monitoring which belong to European Environment Information and Observation Network – Eionet.
The tables below show quantities of water quality monitoring stations in each river catchment and country.

Table 18: Amount of water quality monitoring stations in Carpathian river catchments.

CATCHMENT	QUANTITY
Danube	331
Oder	18
Vistula	32
Dniestr	No data

Table 19: Amount of water quality monitoring stations in Carpathian countries.

COUNTRY	QUANTITY
Austria	68
Czech Republic	29
Hungary	64
Poland	38
Romania	91
Serbia	36
Slovakia	55
Ukraine	No data

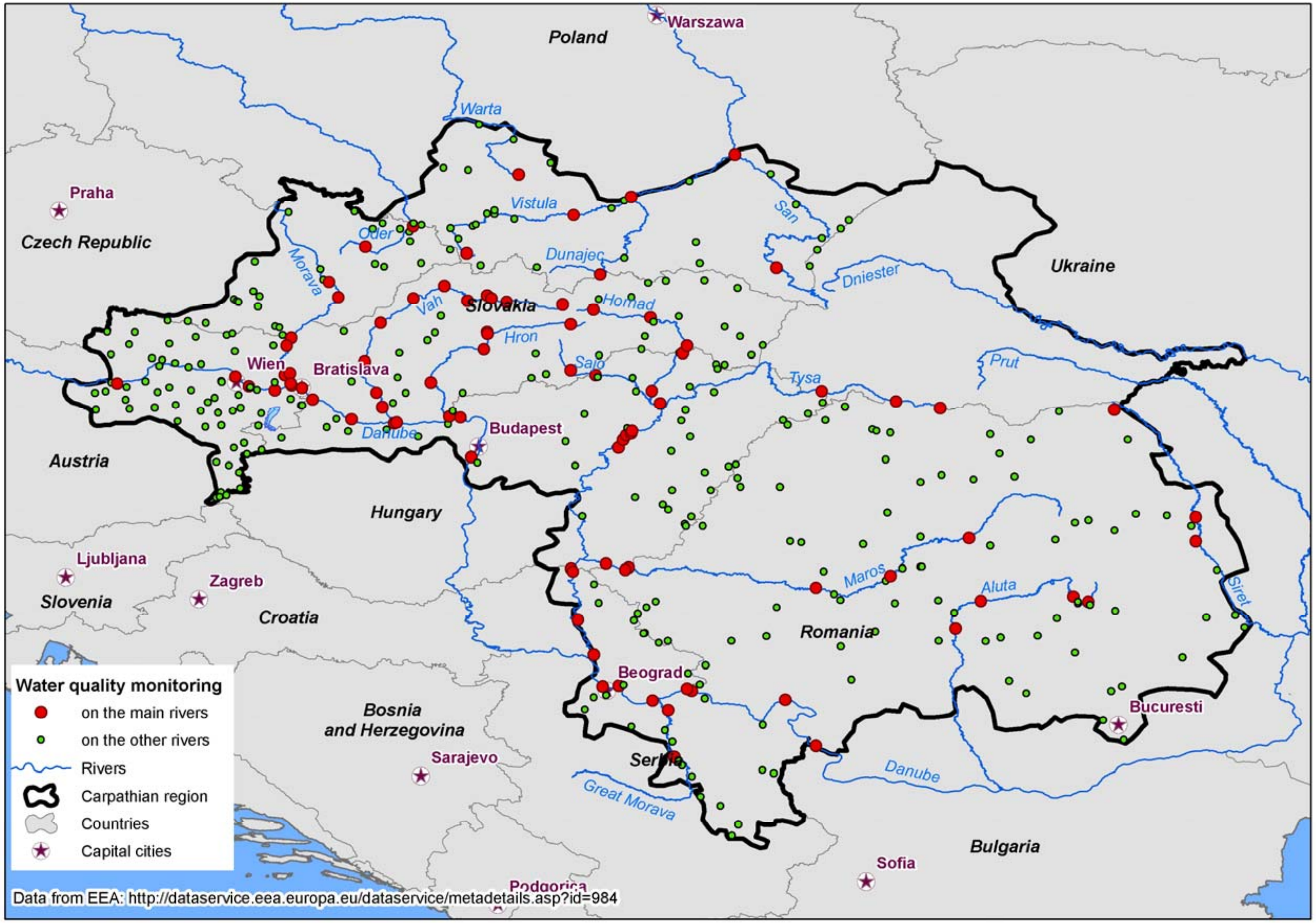


Figure 26: Water quality monitoring stations in Carpathian region

3.2. Hydromorphology

The main rivers in the Carpathian Region have been hydromorphologically modified by human activity (Figure 28). The map shows only main rivers classification – Danube, Vah, Morava, Hornad, Tysa, Aluta, Great Morava, Maros, Prut, Vistula, Dunajec, San, Oder rivers. Basing on information, which are coming from WFD classification and country reporting, it can be consider that many of river stretches, especially in the Black Sea basin are modified. Long section of rivers are used as waterways. Danube, the main river of the region, is joined through the canals with other river network (i.e. Danube-Main Canal - connection to the Nord Sea, Danube-Tysa-Danube Canal). In order to make the river navigable, the meanders were cut off in several places, the main channel was straightened and lateral dams were built to narrow the river's width. Consequently, in some parts of the river, the length of the watercourse was shortened considerably. Additional artificial waterways were also built along the Danube for transport purposes[1].

Many rivers have been regulated due to flood and draught protection and also for industry or electricity production usage.

Large hydropower dams have major impacts on flow regime, sediment transport and the characteristics of water and sediment in downstream rivers. In the Carpathian region the Iron Gate I is the largest single hydropower dam along the river Danube. It is situated in 943 km of the river in the Romanian-Serbian border. The high of the dam is about 60 m. The picture 27 shows impact of damming the river on flow regime[2], i.e. lay out of the Iron Gate high and low flow backwater zones in the Danube and in the Tisa, Sava and Morava. The inset shows the Danube drainage basin and position of the Iron Gate dams.

The second largest hydropower dam is the Gabcikovo Dam located in 1846 km close to Bratislava, near the Slovakian-Hungarian border. It diverts approximately 80% of the Danube water into the reservoir. Due to ecologists' protests only a part of the project has been finished.

---

[1] Source: http://www.unesco.org/water/wwap/wwdr2/pdf/wwdr2_ch_14.pdf
[2] Source: http://www.aseanenvironment.info/Abstract/41015211.pdf
Influence of hydropower dams on the composition of the suspended and riverbank sediments in the Danube Gerard Klaver, Bertil van Os, Philippe Negrel, Emmanuelle Petelet-Giraud

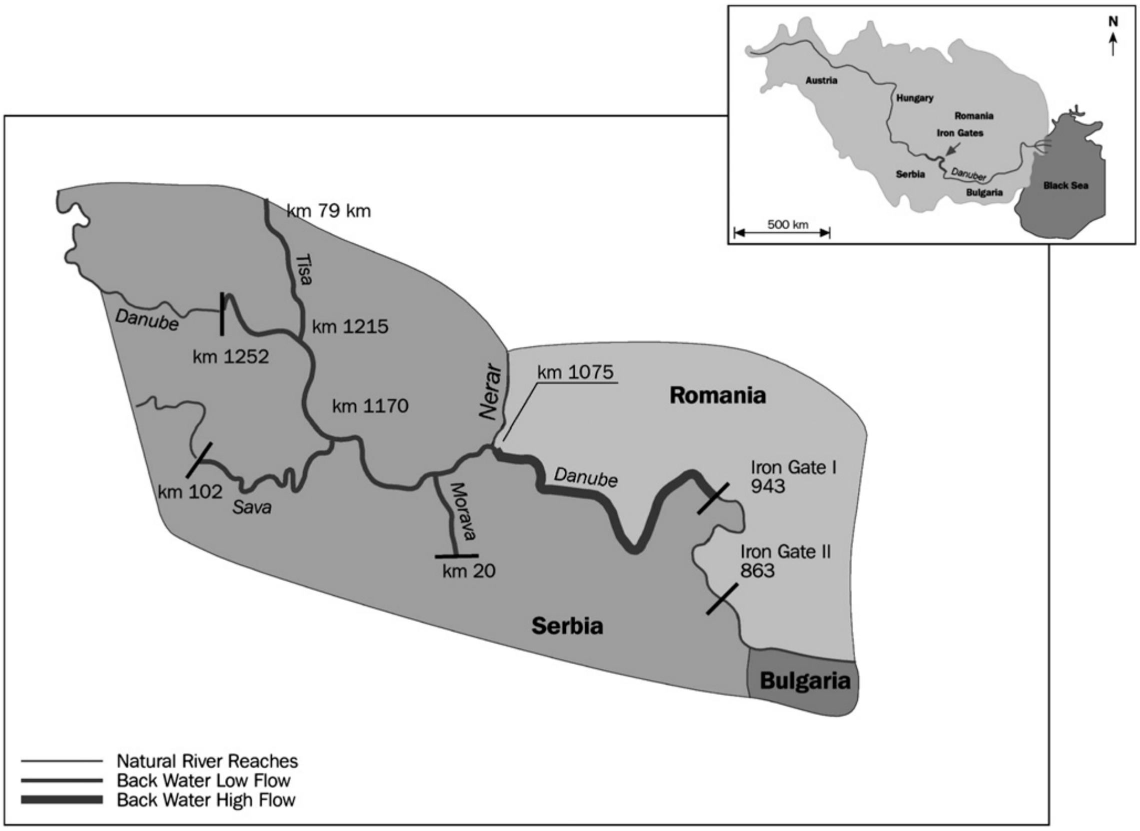


Figure 27: Danube drainage basin and position of the Iron Gate dams.

The other hydropowers in this region do not have so big impact on the riverbed. They are situated e.g. on San, Dunajec, Tysa, Dnieper.

The cause of hydro morphological changes is also the flood protection system. The system is based on flood embankments and in some places it is interrelated with the chain of hydropower plants, barrages and reservoirs. Europe's largest flood defence network was created in the Tysa with regulation of rivers, construction of flood embankments and flood walls, system of drainage canals, pumping stations and designated flood detention reservoirs (polders) completing the system. The map (Figure 28) shows some of large polder areas - some of them are natural. It is worthy to stress the fact, that 80 percent of the historical floodplain on the large rivers of the Danube river basin has been lost during the last 150 years[3].

[3] International Commission for the Protection of the Danube River (ICPDR), Action Programme for Sustainable Flood Protection in the Danube River Basin, Final Draft IC/082, November, 18th, 2004.

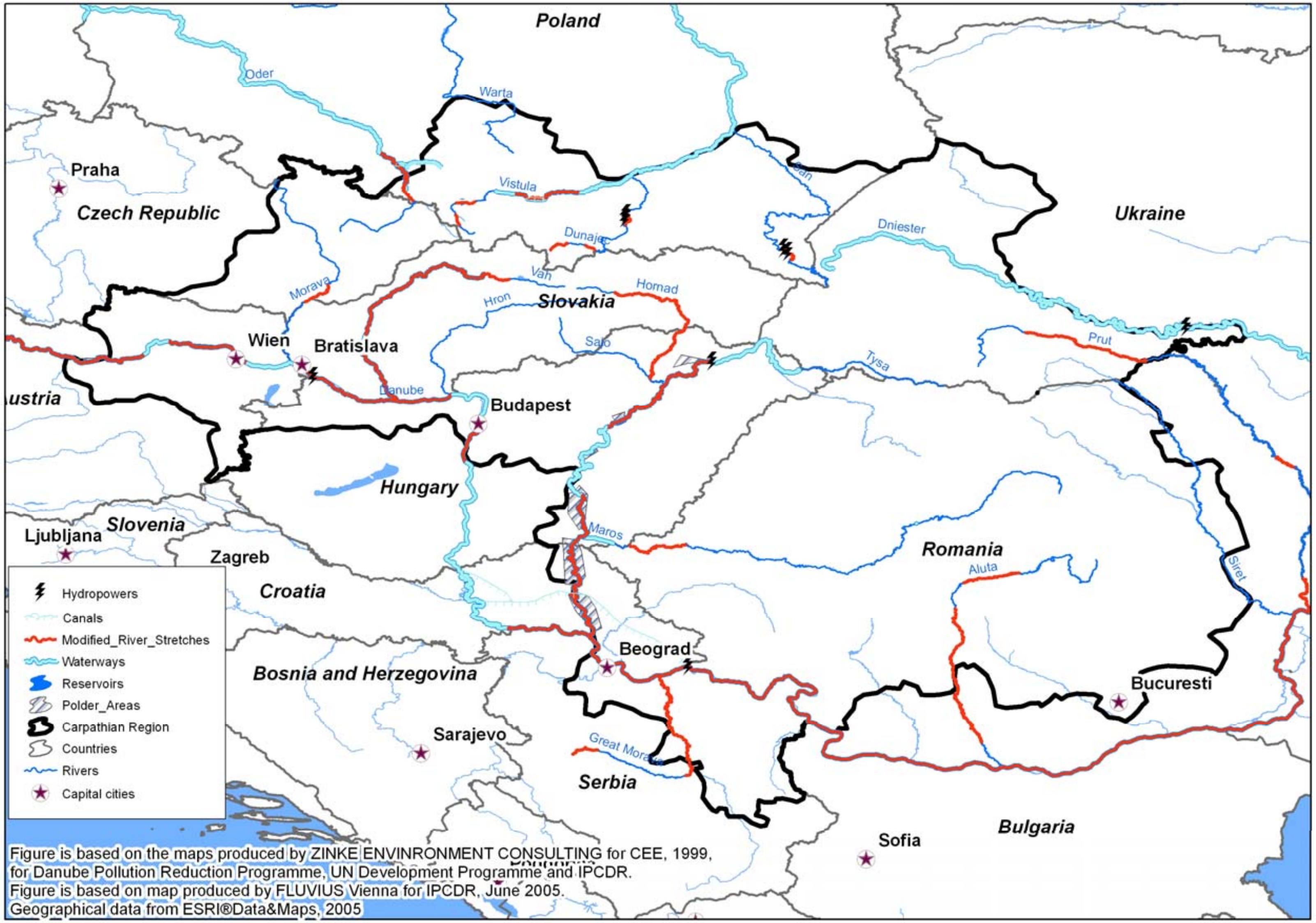


Figure 28: Hydro morphological changes in Carpathian region

3.3. Water quantity

3.3.1. Significant water abstractions

Most of all 190 significant point sources are located in northern part of the Carpathian region – in Vistula and Oder river basins. At least of them are in Ukraine and Austria – only 7 points.

Table 20: Participation of significant water abstractions in countries.

Country	Quantity of significant water abstractions in each country
Austria	1
Czech Republic	9
Hungary	21
Poland	70
Romania	52
Serbia	19
Slovakia	12
Ukraine	6

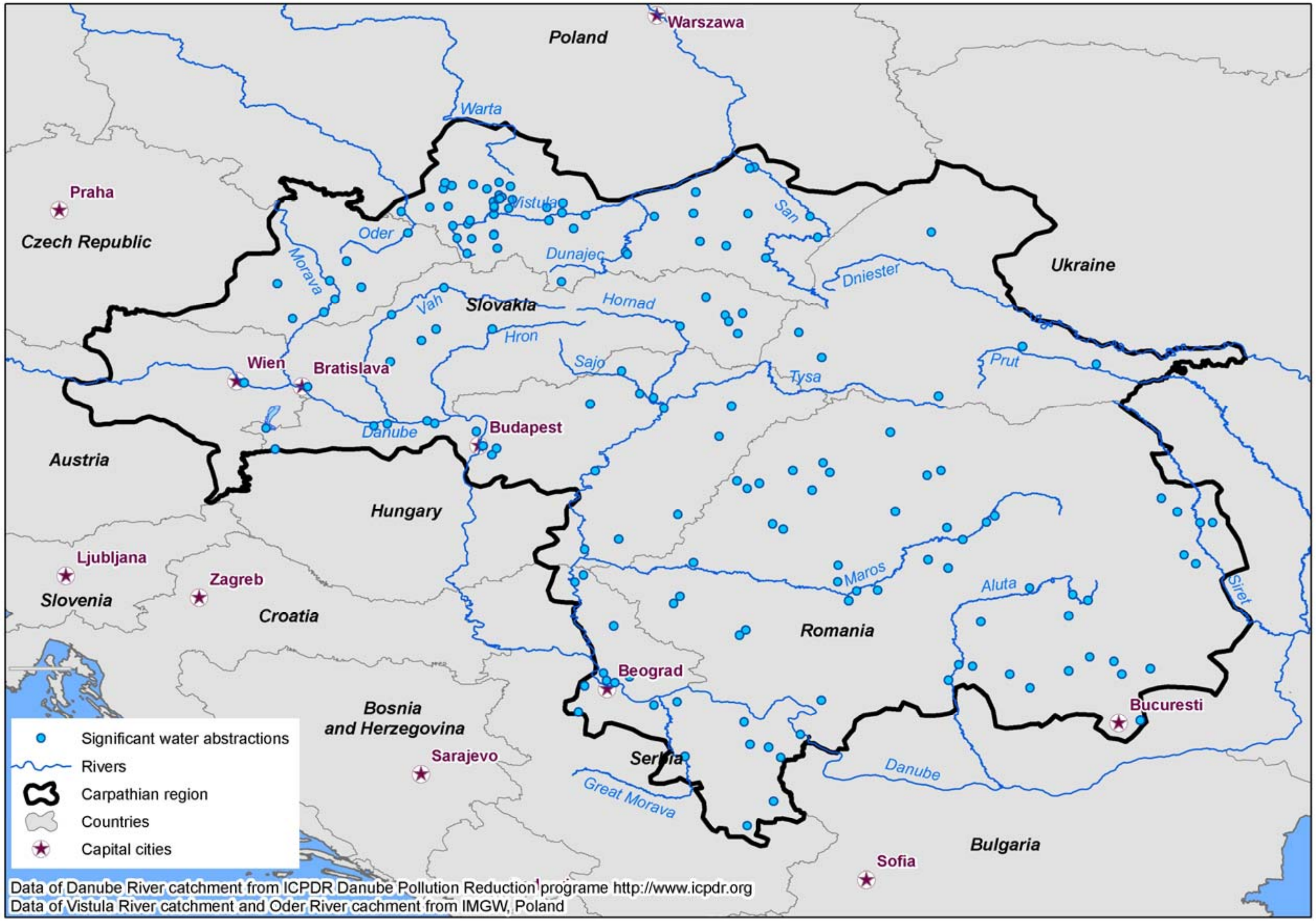


Figure 29: Significant water abstractions in the Carpathian Region

3.3.2. Water quantity monitoring

The map below shows the main gauging stations located on the main rivers in the Carpathian Region.

Table 21: Quantity of gauge stations in each country

Country	Quantity of gauge stations
Austria	2
Czech Republic	1
Hungary	5
Poland	37
Romania	3
Serbia	4
Slovakia	4
Ukraine	2

Table 22: Quantity of gauge stations in each river catchment

Catchment	Quantity of gauge stations
Danube	43
Oder	6
Vistula	31

Table 23: Quantity of gauge stations in main river basins

Basin	Quantity of gauge stations
Aluta	1
Dunajec	1
Great Morava	1
Hron	1
Maros	2
Morava	1
Prut	1
San	14
Siret	2
Tysa	4
Vah	1
Warta	3

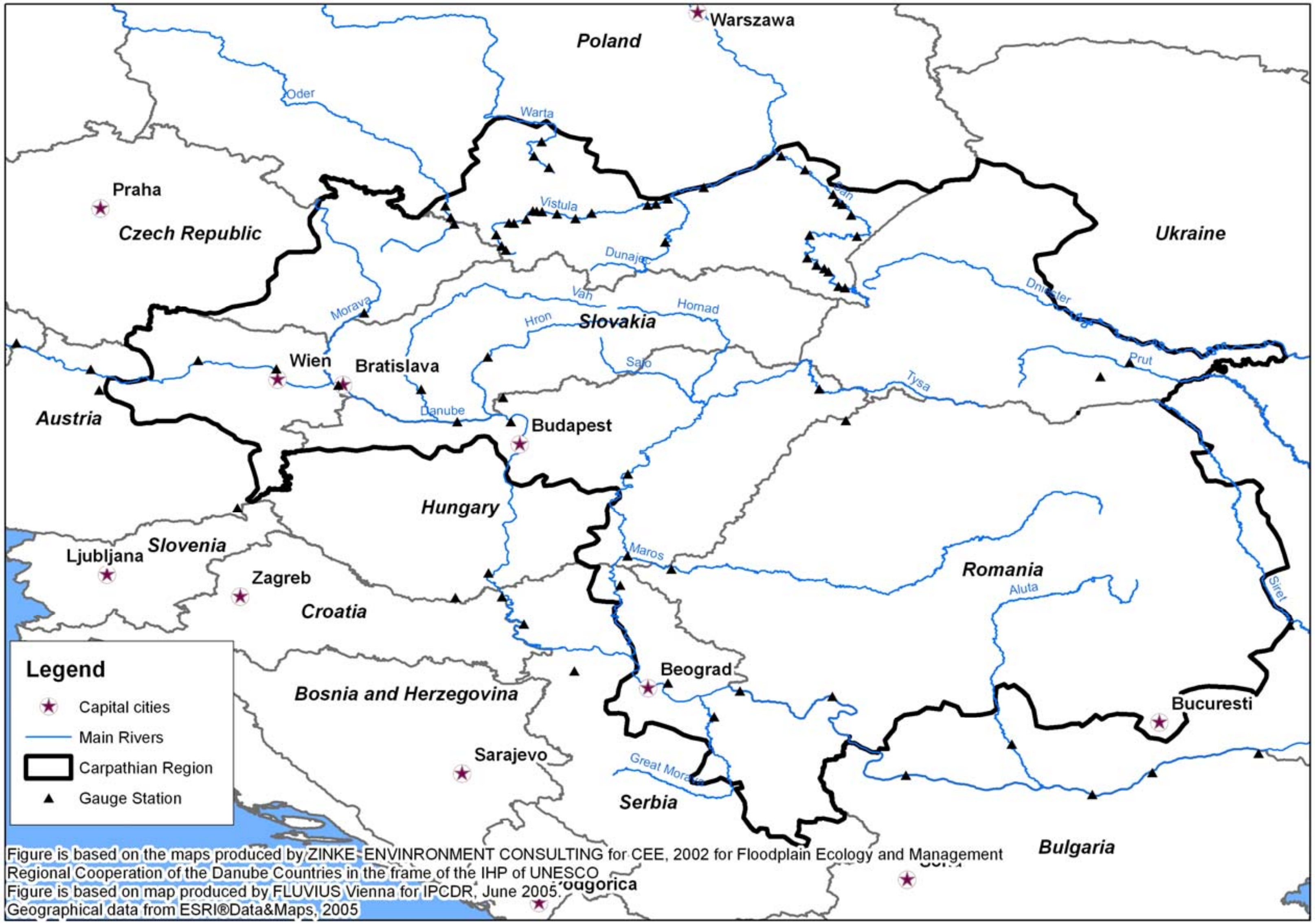


Figure 30: The gauging stations on the main Carpathian rivers

3.4. Management approaches to deal with flood, drought and water scarcity

3.4.1. Management solutions

The river basin management approach is the basis of all protection activities regarding floods, droughts and water scarcity in the Carpathian region.

The best solution to deal with flood, drought and water scarcity is implementation of the Integrated Water Resources Management principle. Integrated Water Resources Management (IWRM) is a participatory planning and implementation process, based on sound science, that brings stakeholders together to determine how to meet society’s long-term needs for water and coastal resources while maintaining essential ecological services and economic benefits. IWRM helps to protect the world’s environment, foster economic growth and sustainable agricultural development, promote democratic participation in governance, and improve human health. Worldwide, water policy and management are beginning to reflect the fundamentally interconnected nature of hydrological resources, and IWRM is emerging as an accepted alternative to the sector-by-sector, top-down management style that has dominated in the past.

Some of the principal components of IWRM:

- Managing water resources at the basin or watershed scale. This includes integrating land and water, upstream and downstream, groundwater, surface water, and coastal resources.
- Optimizing supply. This involves conducting assessments of surface and groundwater supplies, analyzing water balances, adopting wastewater reuse, and evaluating the environmental impacts of distribution and use options.
- Managing demand. This includes adopting cost recovery policies, utilizing water-efficient technologies, and establishing decentralized water management authorities.
- Providing equitable access to water resources through participatory and transparent governance and management. This may include support for

effective water users' associations, involvement of marginalized groups, and consideration of gender issues.

- Establishing improved and integrated policy, regulatory, and institutional frameworks. Examples are implementation of the polluter-pays principle, water quality norms and standards, and market-based regulatory mechanisms.
- Utilizing an intersectoral approach to decision-making, where authority for managing water resources is employed responsibly and stakeholders have a share in the process.

The idea of IWRM may be introduced by regional authorities, development corporations, planning executives and other bodies. Those bodies can therefore vary in their goals. It is noted that social participation is essential for better water management. However, it has not been easy to ensure active social participation in water management processes. Sometimes different interest groups have attempted to capture the water management processes to promote their own agenda's. In such case, legal frameworks related to river basin management (like Water Framework Directive in EU) should be congruent with the economic, social, political and institutional conditions of the different countries. The IWRM can be focused to improve its coordination and oversight role. A trans-disciplinary approach is needed. "Policing" by an independent body is very important to reduce poor implementation and management. A clear flexible management strategy should be elaborated.

The IWRM as a practical tool also have to assure:

- socio-economic and land projections,
- updating of the water demand/supply balance,
- proposal of priority programmes of medium and long term, including structural and non-structural measures.

Initiatives within the river basin require similar bases for various types of development:

- political as well as legal basis,
- economic and financial bases,
- social bases,
- organizational bases.

Floods, droughts and water scarcity are the main challenges on the way of implementation of the IWRM principle.

All activities should comprise:

- shaping the state policy,
- serving instruments including sufficient data management system and water quality monitoring,
- issuing regulations,
- planning instruments,
- water management information system,
- education of the society and scientific research.

In the context of climate change and of recent severe flood events, flood-risk as well as droughts management has raised as an important issue for human safety and the competitiveness and attractiveness of the different territories.

The proposed requirements which are also include in “flood directive” that shall undertake river basin authorities are :

- Preliminary flood risk assessment: to establish areas where potential significant flood risks exist or are reasonably foreseeable in the future.
- Flood risk maps: flood risks would be mapped for the river basins and sub-basins with significant potential risk of flooding, in order to increase public awareness; support the process of prioritising, justifying and targeting investments and developing sustainable policies and strategies; and to support flood risk management plans, spatial planning and emergency plans.
- Flood risk management plans: flood risk management plans would then need to be developed and implemented at river basin/sub-basin level to reduce and manage the flood risk. These plans would include the analysis and assessment of flood risk, the definition of the level of protection, and identification and implementation of sustainable measures applying the principle of solidarity: not passing on problems to upstream or downstream regions and preferably contributing to reduction of flood risks in upstream and downstream regions.

3.4.2. Technical solutions

Identification of water bodies under WFD develops a common understanding of the definition of water bodies and gives specific practical suggestions for the identification of water bodies under the WFD. The integrated approach set by the directive does not ignore socio-economical considerations. Human activities often result in several alterations. Physical modifications usually serve not only one but several uses, which are multipurpose alterations.

According to the European Commission communication it is important to underline, that there is a high risk of conflict between the implementation of different policies connected with water at all including:

- Water Framework Directive 2000/60 EC,
- flood protection including Directive on the assessment and management of flood risks,
- hydropower - Directive 2001/77/EC,
- navigation - The Commission's European Transport White Paper and Communication from the Commission of 17 January 2006 on the promotion of inland waterway transport "NAIADES": an Integrated European Action Programme for Inland Waterway Transport [COM(2006) 6 final - not published in the Official Journal].

There is a great need of flexibility to set objectives that reflect environmental, social and economic needs and priorities This flexibility means the needs and priorities of other policy areas can be taken into account in water management decisions, through the appropriate use of exemption mechanisms. On the other hand, the other policies must also take into account water management issues.

One of the major way to find compromise is the development of the “internalization” of the environmental costs and benefits. It is clear that to deal with floods, droughts and water scarcity the technical solutions are also required .

At a first glance, there is a high risk of conflict between the implementation of those different policies:

- The WFD puts a strong emphasis on the quality of hydro-morphological conditions as they support the type specific aquatic communities that constitutes good ecological status,
- The past developments of hydropower generation, navigation infrastructures and activities, and flood defence facilities have often required major hydro-morphological changes.

However:

- Whilst impacting on aquatic ecosystems, those activities are delivering important environmental benefits (e.g. climate change) or benefits to human safety,
- Many damaging consequences on aquatic ecosystems caused by those activities are due to insufficient precautions and sectoral approaches that did not take into account the multi-purpose uses of water bodies including the environmental protection.

In other words, there is no benefit and no fatality for conflicts between the different policies and there is room for important progresses by enhancing the recognition of the different interests, fostering the co-operation processes between the different competent authorities and stakeholders, and promoting more integrated development strategies.

This will require efforts and acceptance from all the parties:

- Water managers will have to accept environmental objectives for the waters affected by infrastructures justified by the environmental, social and economic needs and priorities.
- Infrastructures users and developers will have to invest to mitigate and compensate the impacts of existing equipments and activities; they will also have to develop alternatives to the traditional solutions in order to avoid deterioration and to progress on the justification and the environmental integration of future needed investments. In certain cases, they will have to accept modifications of the activities and the infrastructures to restore the ecological continuities and the aquatic ecosystems. Achieving a good balance between protection and uses will also require where possible modifications of the infrastructures for the restoration of the aquatic ecosystems. Indeed, single

mitigation measures at the scale of individual infrastructure might be insufficient in certain situations to maintain an overall ecological quality.

Where possible, technical solutions that do not cause deterioration of status should be promoted (e.g. setting flood embankments back from the edge of the river to make more space for the river to flood).

Three main hydromorphological driving forces have been determined as most relevant on the basin-wide scale in the Carpathian Region:

- hydropower generation,
- flood defense,
- navigation.

Most of the large rivers in the Region in densely populated areas are characterized by anthropogenic modifications for flood protection and to secure land for urban development. In many cases, hydro-structures have multiple purposes often resulting in changes of the river character. These changes affect not only the river itself but larger areas of the valley. Major systematic regulations for flood defense and navigation purposes began in Austria in the 19^{th} century. On the present territories of Hungary, Serbia, and Romania first dike systems for flood protection along the Danube were already built in the 16th century, but were intensified in the 19th and 20^{th} century. The former extensive floodplains with numerous side arms and backwaters were largely altered into canalised and straightened waterways with distinct river bank reinforcement. As a consequence, today only less than 19% of the former flood plains in the Danube basin, compared to the situation 150 years ago, remain. The area of floodplain affected by river regulation/flood defense is large – in Hungary for instance 2.12 million ha were diked. The Danube itself is regulated along over 80% of its length. The less danger situation is in that Carpathian part which belongs to the Baltic Sea basin.

To manage with flood, droughts and water scarcity in the Carpathian region there is a strong need of finding compromise between:

- urban development, land use planning ,
- restoration of the historical floodplains,
- inland waterway transport,

- construction of the new artificial reservoirs and compensation activities regarding new hydro-morphological changes,
- maintaining of the Environmentally Acceptable Flow.

The base for such compromise should be the Integrated Water Resources Management principle.

The good example is the new development in the Tysa river basin. River basin strategy is based on planning, implementation and supervision respecting the holistic approach, integrating land use and spatial planning. The measures are the combination of structural flood protection, natural retention, afforestation and partial floodplain reactivation.

4. Climate change-natural hazards

4.1. Predictable future pressures

Predictable future pressures relating to climate change (snow cover, distribution of precipitation in time and space, changes in water system and water-cycle and impacts on water management in Carpathians and the surrounding regions – especially concerning droughts and scarcity).

Natural phenomena of weather, climate and water are the basics for life, sustainable development and protection of natural resources and the environment. History of our planet is characterised by many changes in climate. On the other hand there is strong evidence that most of the observed recent warming are connected with human activities, in particular to emissions of greenhouse gases (GHGs).

On 29th of June 2007 The European Commission accepted GREEN PAPER FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS entitled Adapting to climate change in Europe – options for EU action (Green Paper). In this document adaptation is defined as a set of actions which are taken “to cope with a changing climate, e.g. increased rainfall, higher temperatures, scarcer water resources or more frequent storms, at present or anticipating such changes in future”. Overall Europe has warmed by 1°C in the last century.

Annual temperature deviation relative to average temperature from 1961-1990 in the Carpathian region fluctuates from 0.5 to 1.5°C. Generally this process in Europe is faster than global average. It is estimated that temperatures will increase by 2.0–6.3°C in Europe by the year 2100. In the Carpathian region temperature will increase till 2080 from to 2.0 to 2.6°C. This may have great consequences such as increasing drought stress, more frequent forest fires, increasing heat stress.

Mountain areas including Carpathians and surrounding floodplains are the most vulnerable zones in Europe. Climate change increases the frequency of extreme flood events in Europe, in particular the frequency of flash floods.

The changes in precipitation for the period 1900-2000 shows that average annual precipitation for the Carpathian region is lower from 0 up to 20%. For example winter droughts were most prevalent in the mountainous of southern Poland. Projected change in summer precipitation till 2080 for the Carpathian region fluctuates till less than 13% relative to average precipitation in the period 1961-1990. The change of frequency of summer days for decade (the days with temperature above 25°C between 1976-1999) reaches more than 6 days for Carpathians. The changes in frequency of very wet days (with precipitation above 20mm) fluctuates between 1976-1999 from -5% to +5%.

Southern and southeastern Europe have become drier. This will be continued in the future. Generally annual discharge of the rivers is expected to decline in southern and southeastern Europe. The changes in discharge the Baltic rivers (the Vistula and the Oder) are not important. On the contrary the large increase in discharge occurred in the Danube basin. The observed time periods on several the river gauging stations within the Carpathian Region indicates changes of the annual river discharges in the 20th century from -4% up to +26%. The annual river discharge is an indicator in a river basin and also a first estimate for low and high river flow events. If the annual river discharge increases the risk of danger floods rises. The change in annual river discharge in the Region till 2070 compared to 2000 fluctuates from -10% to +10% (small changes) using ECHAM4 climate model and from -25% to +10 using HadCM3 climate model. In such case the uncertainty of projected estimations is very high.

Influence of climate change in Europe will be perceptible on example of changing in precipitation (Figure 31). In Carpathian region in more than 60% of area precipitation changes will not be very distinct (between -5 and +5 percent in annual amount). But in northern and western parts of the region scientists predict higher precipitation, even 40% higher than actually annual level. Also in some high parts of Carpathian, annual precipitation could be higher. Drop in annual precipitation is forecasted rather in southern and eastern and central parts of the region. In Serbian parts of analyzing region in few areas this change could be between -40 and -20 % in annual amount.

Table 24: Temperature change areas

Change in annual amount [%]	Participation
between +20 and +40	0,1%
between +10 and +20	3,5%
between +5 and +10	19,0%
between -5 and +5	63,6%
between -10 and -5	9,1%
between -20 and -10	4,3%
between -40 and -20	0,4%

The real climate change will cause increase of the annual temperature in the Carpathian region between 3°C to 4,5°C. The figure shows distinct diversity of the changes depends on the localization of whole area. In the north – west part of his region the annual temperature will increase about 3 – 3,5 °C, in the middle – east part the growth will gain 3,5 - 4 °C. The highest temperature increasing is expected to be In south – east part of the Carpathian region and will reach about 4 – 4,5 °C.

The figure below (Figure 32) presents change in mean annual temperature by the end of this century.

In analysis of precipitation and temperature change data were used from Green Paper which is based on IPCC scenario A2. The projected climate impacts were estimated for 2071 – 2100 relative to 1961-1990.

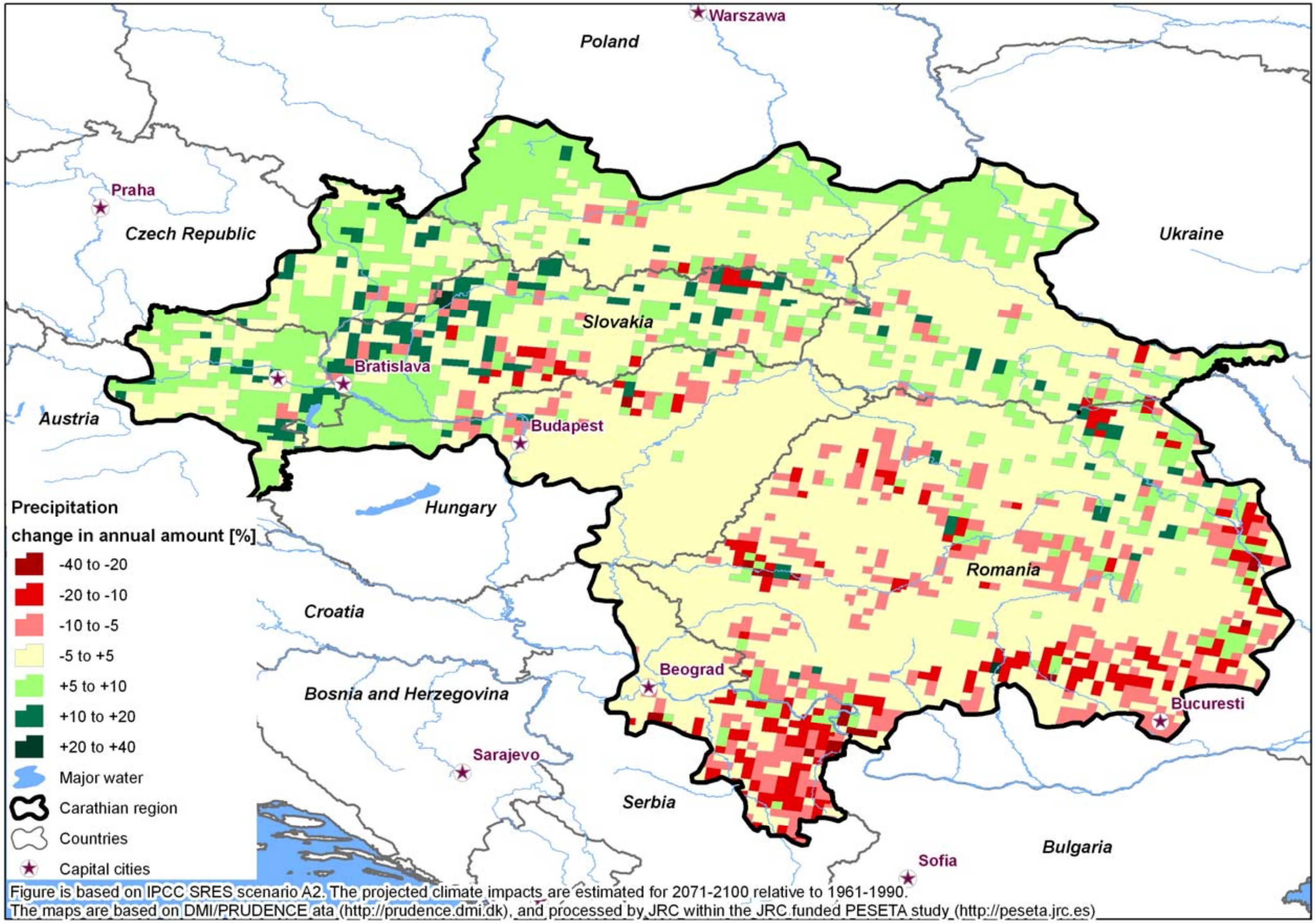


Figure 31: Change in mean annual precipitation by the end of this century in Carpathian region

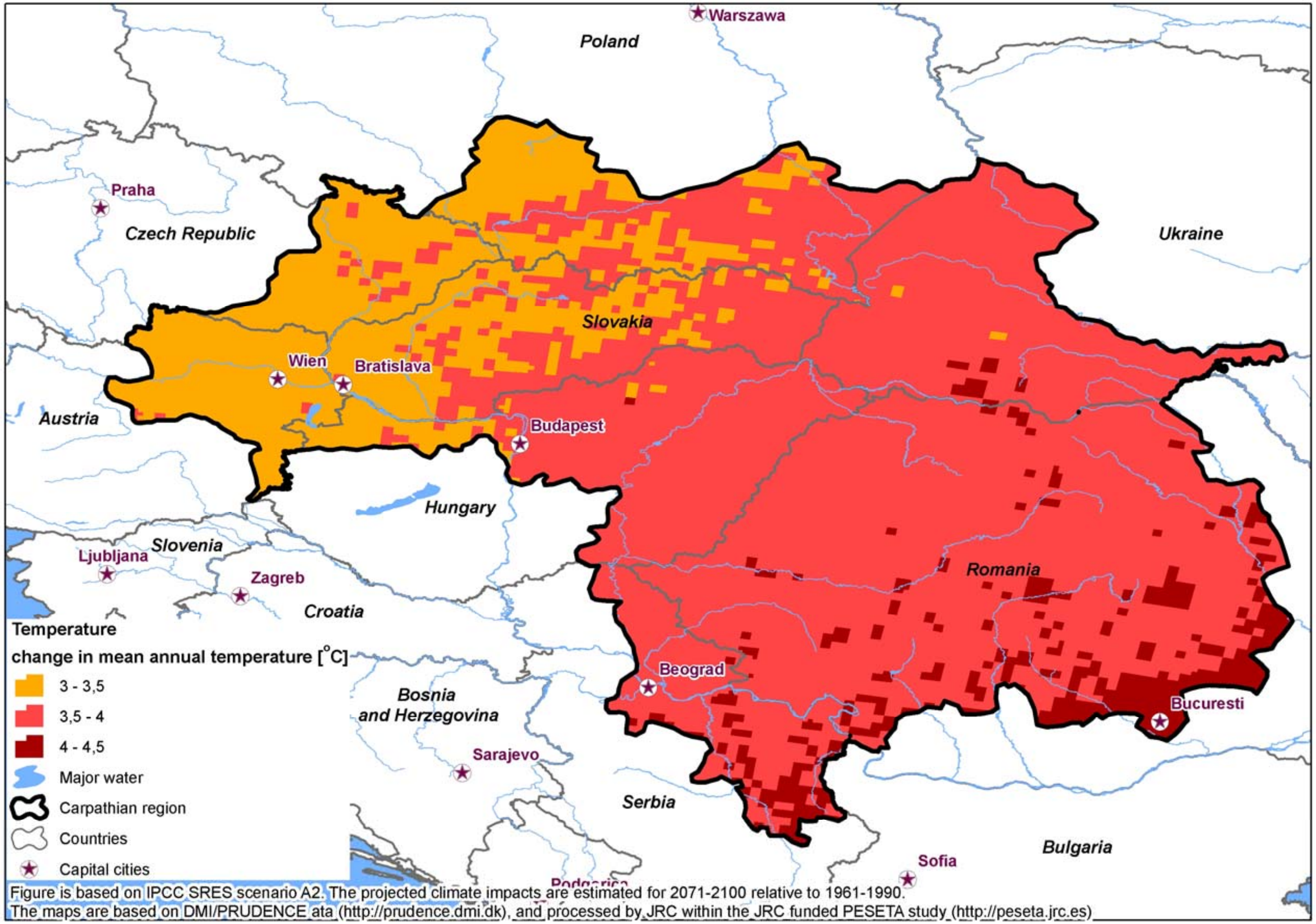


Figure 32: Change in mean annual temperature by the end of this century in Carpathian region

4.2. Floods and their growing impacts

Flooding and its impacts are often influenced by a combination of natural factors and anthropogenic interference. Floods are the most common natural disasters in Europe and, in terms of economic damage, the most costly ones.

In the table below flood related losses to life and property regarding flood events in the Carpathian region are presented.

Table 25: Major flood events in the Region

Flood event	Description
1838 March	Icy flood in Budapest,153 victims, 10 100 houses damaged along the river Danube,
1879 March	Flood in Szeged (HU) 158 victims,
1925 December	Flood in the Koros valley, 904 houses damaged, 21 100 flooded
1934 July	Great flood in the Vistula valley and Carpathian tributaries 126 000 ha flooded, 55 victims, 22 059 houses damaged, 167 km of roads devastated, 78 bridges destroyed,
1941 February	Icy flood in the Danube at Apostag
1947 December	Icy flood at the upper Tysa, 24 000 ha flooded
1954 July	Dyke bursting at Szigetkoz, 20 600 ha flooded
1956 March	Icy flood at the Danube , 58 dykes bursting downstream Budapest, 70 000 flooded,
1965 April-June	The biggest summer flood at the Danube until than, 11 dykes bursting at the Raba valley
1966 February-April	Icy flood at the Berretyo with dyke bursting , altogether 12 600 ha flooded
1970 July	Flood in the Upper Vistula, dykes bursting at the Raba and at the Dunajetz, 156 000 ha flooded, 11 victims, 980 bridges destroyed, a dozen thousands or so buildings destroyed,
1972 August	Flood in the Upper Vistula and the Oder, 8800 residents evacuated
1970 May July	The biggest Tysa valley flooding until than, 17 dykes bursting, 57 000 ha flooded, 5400 houses damaged, 96 000 residents evacuated,
1974 June	Flood in the Koros valley 7100 ha flooded, 407 houses damaged, 380 residents evacuated,
1974 October	Big flood in the valleys of Ipoly, Zagyva-Tarna, Sajo, Hornad and Bodrog
1975 July	Flood in Romania, 1000 000 people affected
1980 July	Flood in the Koros valley, two dykes bursting, 20 000 ha flooded, 4100 residents evacuated
1989 May	Extreme flood of Horand, 3 villages flooded
1991 August	Danube flood with record high level in Szigetkoz, dyke bursting
1997 July	The great flood in the Oder and the Vistula Valley, 55 victims, 7000 residents lost their homes, 680 000 flats destroyed, 4 000 bridges damaged, 613 km of dykes destroyed, 14 400 km of roads damaged and 500 000 ha of crops damaged.
1998 April	Flood in the Upper Vistula Valley from the mouth of the Dunajetz till the mouth of the San

Flood event	**Description**
1998 November	Floods in the Carpathian Mountains of Western Ukraine – 2 victims ***8000 people*** have been evacuated, heavy rain destroyed thirty villages.
2001 March	Floods on Hungarian-Ukrainian border, 6 victims 35,000 people have been evacuated and more than 21,300 houses were submerged in 216 towns
2001July-August	Flood in the Upper and the Middle Vistula, 11 623 flats destroyed, 883 schools damaged, 8975 km of roads destroyed, 1734 bridges destroyed, 510 km of dykes damaged, 136 200 ha of crops damaged
2002	Heavy floods (3) in Romania
2005 July	Heavy torrential floods in Romania, 27 victims, in total, 581 localities were affected, 13,856 houses have been flooded, 1905 houses damaged, 368 houses destroyed, 16,561 outbuildings affected, 10,231 wells and about 1,100 bridges of various sizes damaged and over 12,166 persons evacuated. A total area of over 88,000 ha of agricultural land has been flooded, as well. Roads (hundreds of kilometres) and railroads are also flooded.
2006 May and July-August	Floods in Romania 25 victims and thousands of homes inundated
2006 March –April and May	Floods in Austria -250 households affected, ,Czech Republic-5 victims, 4200 residents evacuated, Poland-, Romania-5000 households damaged,500km of roads 235 bridges 80 000 ha farmland flooded 15 000 residents evacuated, Slovakia and Hungary- the Tysa, reached a record level of 9.8 metres on 18 April threatening some 160,000 people and over 50,000 homes
2006 July	Flood in Ukrainie, the Dniester basin and the Prut basin. Two people were killed as a result of flash floods, while some 5,000 people were directly affected by flooding 956 of these are children up to 15 years of age. The total population living in areas severely affected by the disaster is 1,890,000. Most affected settlements were located in rural districts of Ivano-Frankovskaya and Chernovitskaya oblasts, more than 1,100 homes were submerged under water for several hours, some of them several days. Over 300 houses were severely damaged Over 30 dams and 171 bridges were damaged, more than 2,600 hectares of farmland destroyed and 20 km of riverbanks degraded, over 30 km of riverbeds were blocked by mud, stones and trees

Eastern Europe is the region for which the greatest number of flood disasters is reported (93 disastrous floods).

Generally the reported number of disasters caused by floods has dramatically increased in the UN European Macro-Region, from 31 in the period 1973 – 1982 to 179 during the last decade. Within the region of Eastern Europe (Belarus, Bulgaria, Czech Republic, Hungary, Poland, Moldova, Romania, Russian Federation, Slovakia and Ukraine); the number of flood disaster reported increased from about 8 in 1973-1982, 20 in 1983-1992 up to 70 in 1993-2002. Romania is on the top of rank for the number of disastrous floods, far before the other Eastern Europe countries. Fifteen floods are reported for the last 30 years but 13 occurred since 1996 and their number increased over the years. The highest annual number of flood was reported in 2002. In that year three floods occurred.

For the 1993-2002 decade the most deadly floods occurred in 2002 - Poland (55 deaths in 1997) and Slovakia (54 deaths in 1998). The remaining severe floods, with number of deaths between 10 to 30 occurred Romania (1997, 1998, twice in 1999, 2000, 2002), Czech Republic (1997 and 2002), Poland (2001) and Ukraine (1998). Within the decade 1993-2002 Romania was affected be severe floods, with more than ten deaths, virtually each year since 1997.

Total number of people affected by severe floods in Eastern Europe has raised from 1.000.000 in 1973-1982 to more than 5 000 000 in 1993-2002.

The total amount of damages reported for this region (Eastern Europe defined as above) is around 12.5 billion Euros (2002). Total amount of reported damages in Eastern Europe in 1983-1992 was more than 25 000 000 (2002 Euros X 1000) and in 1993-2002 near 10 000 000 (2002 Euros X 1000). It is important to underline that in the decade 1983-1992 the former Soviet Union and Russia (outside the Carpathian region) accounted for 52% (8 floods) of the reported damages, Poland for 26% (1 flood) and Romania for 21% (1 flood). During the decade 1993-2002 two floods in Poland accounted for 52% of the reported damages, two other floods in the Czech Republic for 22 %. For the three decades 1973-2002 the amount of damages is the highest for Poland (5.7 billion Euros) followed Czech Republic (2.1 billion) and Romania (1.2 billion).

The flood alert in Cracow - 08th of September 2007 - photograph by Tomasz Walczykiewicz

4.2. Trends in climate and their potential influence on water related natural hazards

Climate change is expected to further aggravate the situation, leading to an increased risk of flood events. Humans interference increase the risk of flooding through inappropriate land use in high-risk areas.

The map (Figure 33) is based on one emission scenario (IPCC SRES A2) and on climate model (HIRHAM, Danish Meteorological Institute) and it presents, for Carpathian region main rivers, changes in river discharge for a flood events that have probability to occur once during every one hundred years. The red – coloured river segments mean parts of rivers (change from -20 to -5) where the 100-year flood event will become less severe. The blue ones (change from 5 to 20) are rivers where 100-year flood event is expected to be more severe.

Table 26: Changes in river discharge for a flood events for main

Rivers	Change
Maros	from -20 to -5 (red rivers)
Aluta	
Siret	
Part of Vah	
Hornad	
Part of Danube	from 5 to 20 (blue rivers)
Oder	
Warta	
Vistula	
Dunajec	
San	
Dniester	
Tysa	
Morava	
Hron	

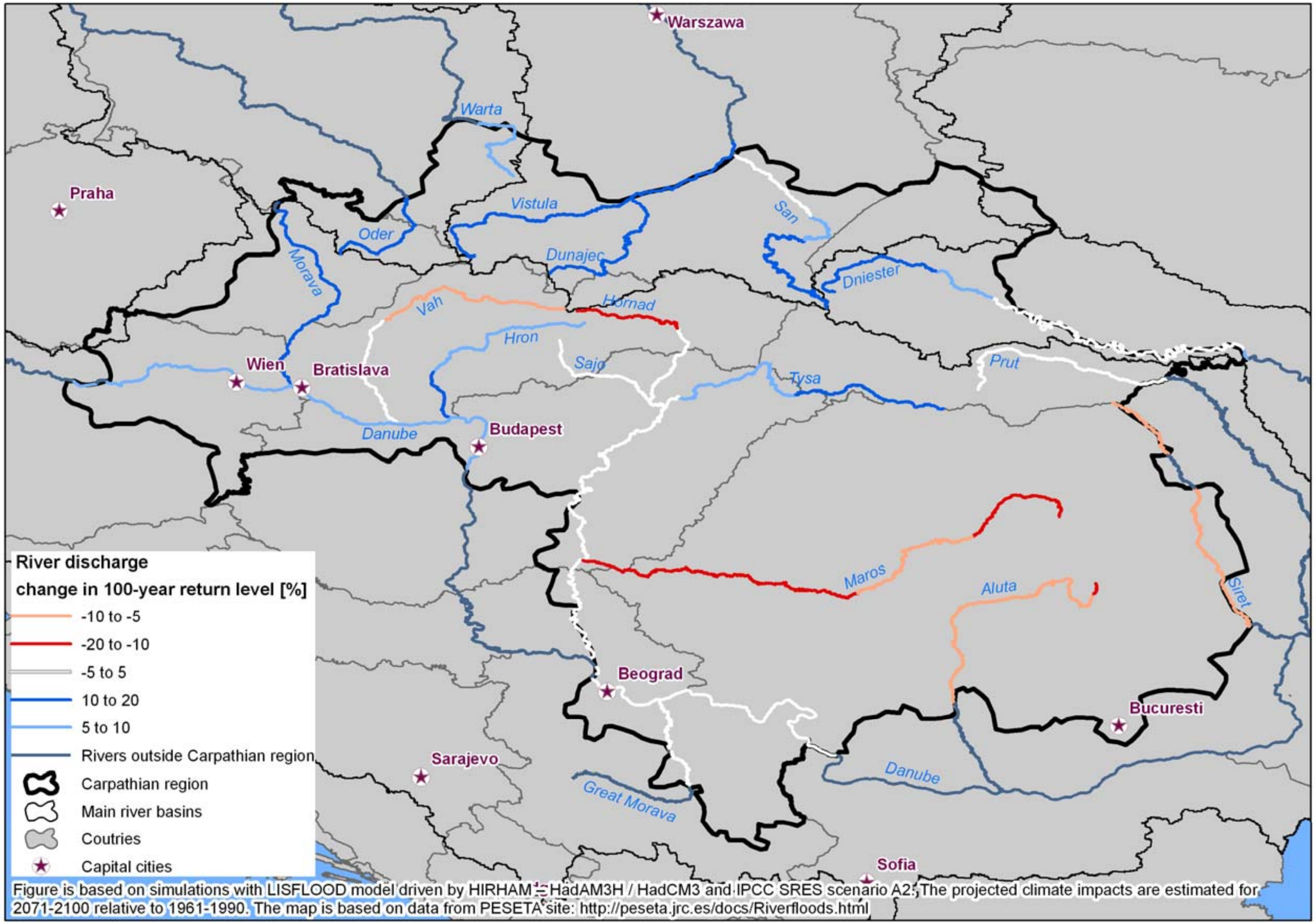


Figure 33: Changes in river discharge for a flood events for main rivers in the Carpathian Region

5. Significant water management issues

5.1. Water use

The activities of inhabitants in 8 countries have an impact on the natural environment of the Carpathian region and are also leading to serious problems with water quality and quantity, and significant reductions in biodiversity in certain parts of the region. The main problems are:

- Excessive nutrient loads (particularly nitrogen and phosphorous)
- Overexploitation of surface water and groundwater resources
- Changes in river flow patterns (hydromorphological alterations) and its effect on sediment transportation
- Contamination with hazardous substances (including heavy metals, oil, oxygen depleting substances and microbiological toxins)
- Accidental pollution
- Degradation and loss of wetlands

Adequate quantities of sufficient quality have to be available in the wilderness to sustain wildlife, plants and unique ecosystems. The most significant and widespread pressures are diffuse pollution, physical degradation of water ecosystems (physical modifications).

Too much inadequately treated waste water still ends up the main rivers within Carpathian region: the Danube, the Vistula ,the Oder, the Dniester putting at risk the drinking water supply for millions of people, and also leading to problems for irrigation, industry, fishing and tourism. The actual percentage of water bodies meeting all the Water Framework Directive objectives is rather low.

Diffuse pollution of agricultural origin is a major threat for water in this region. The main pollution problem is the excessive volumes of nutrients within this territory, mainly from agricultural fertilisers and unthreatened or not adequately threatened municipal sewage, including household products.

Toxic substances are also a major threat, made worse by occasional industrial accidents or floods when deadly toxins may be flushed directly into watercourses. It has happened for example during catastrophic flood in the Tysa river basin.

Preserving the natural habitats of the many species living in the basin is a constant struggle. For example the situation in the Danube basin has strong influence on the habitats of pelicans in the Danube Delta and sturgeon in the Lower Danube Regarding COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL- Towards sustainable water management in the European Union -First stage in the implementation of the Water Framework Directive 2000/60/EC COM 128 final situation regarding achievement of the WFD requirements is not good.

On the basis of the country reports the overall situation in Carpathian states was presented on the following figures.

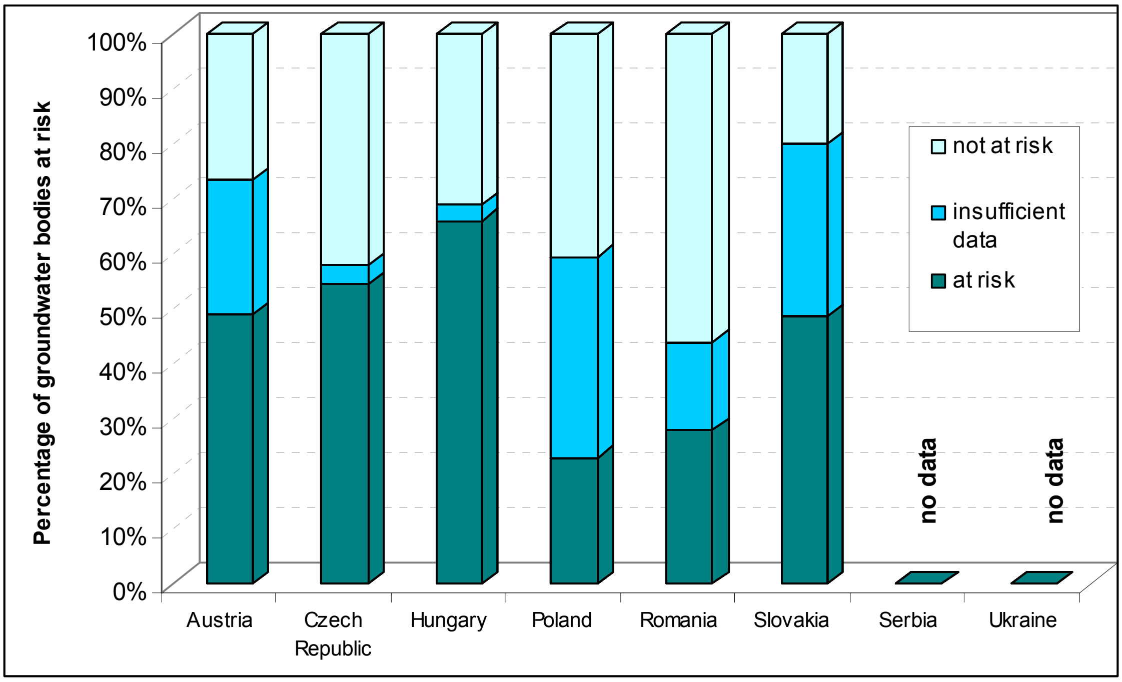


Figure 34: Percentage of surface water bodies at risk of failing WFD objectives per Member State of EU within the Carpathian

High "at risk" numbers are clearly linked with densely populated areas and regions of intensive, often unsustainable, water use.

Water quality in the Carpathian region is largely influenced by the inputs of pollutants - particularly excessive nutrients, organic material, and hazardous substances.

The main rivers of the Carpathian region flow towards the Black Sea and the Baltic Sea and conditions in their waters change considerably. From the upper to the lower reaches of the rivers is monitored significant overall increases in the following determinants:

- suspended solids
- organic pollution (expressed by COD)
- organochlorine pesticides (Lindane, DDT)
- concentrations of heavy metals (especially cadmium, and with the exception of manganese, for which the maxima were observed in the middle Danube)
- concentrations of nitrite and ammonium (however, the concentration of nitrate decreases)
- phosphorus (both total phosphorus, and phosphate)
- conductivity (caused by dissolved salts)
- alkalinity

Not proper agricultural activities are a major source of nutrients. Agricultural production is expected to increase in many parts of the Danube Basin as well as the Vistula and the Oder basin after the EU enlargement, which will probably lead to increased nutrient discharges from this sector.

Inputs of nutrients from urban areas, smaller municipalities and scattered settlements, as well as via atmospheric deposition must also be take into account.

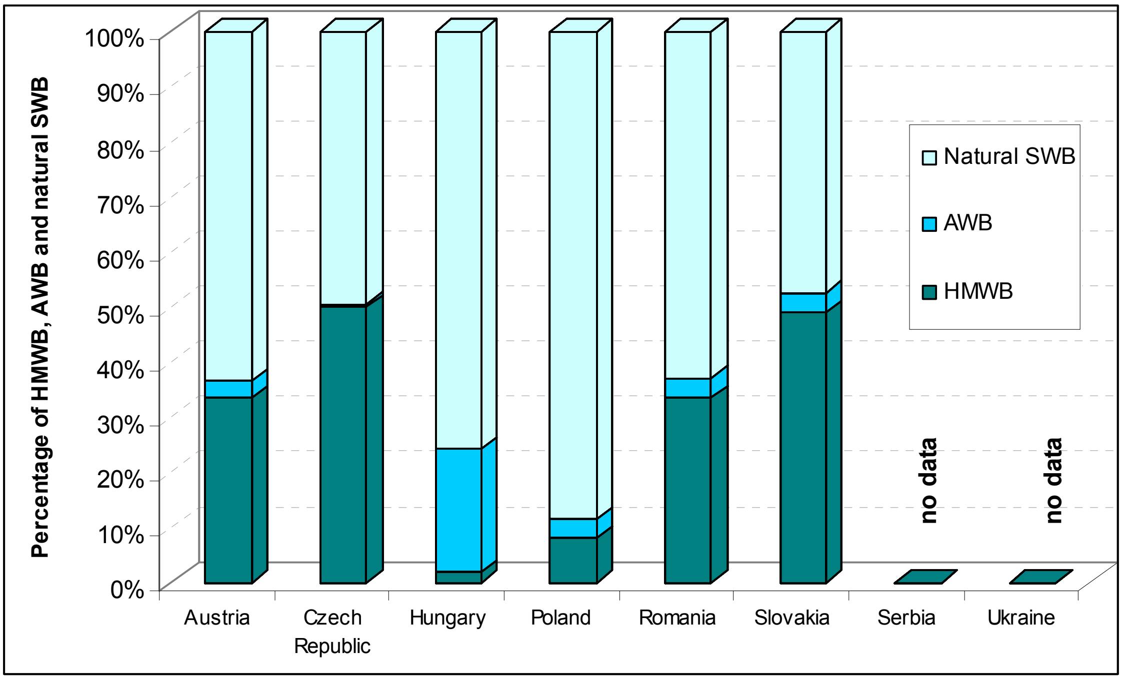


Figure 35: Percentage of provisionally identified Heavily Modified Water Bodies

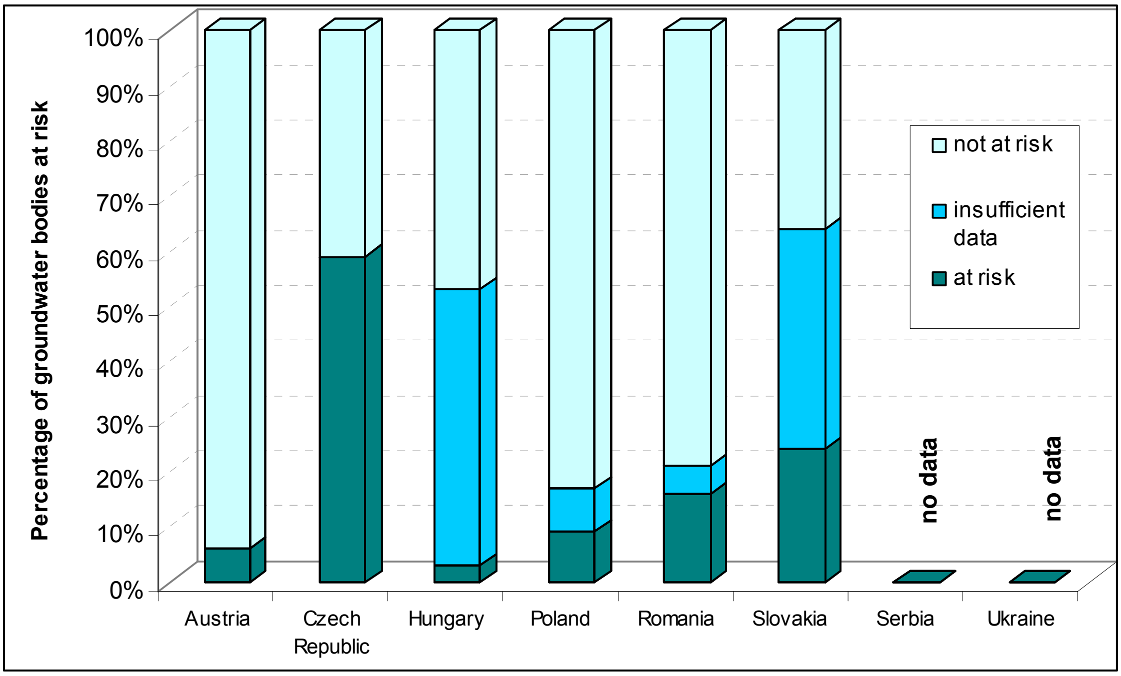


Figure 36: Percentage of groundwater bodies at risk of failing WFD objectives per Member

Water supply in the Dniester basin is heavily influenced by seasonal variations in precipitation and river flow. The most heavily cultivated agricultural areas, as well as the most water-intensive industries, are situated in the south-eastern, dry regions of Ukraine. The Dniester is mainly polluted with ammonia, oil products, chromium 6+, copper, zinc and magnesia. The chromium and ammonia content is increasing. The major problem in rural areas is that most waste water is discharged untreated. The urban problem, however, is the poor quality and inefficiency of waste-water and sludge treatment due to the technical state and capacity of existing installations. Insufficiently trained personnel is a more general problem: specific training in plant operation, process control and instrument operation would improve treatment performance.

Another country in Carpathian region - Serbia is well suited to intensive agricultural production. In Serbia portion of the Danube Basin, there are about 100 farms with an average of 1,000 cattle and 130 pig farms for a total of 1.2 million animals. Very few of these farms have any advanced form of waste collection and treatment; simple lagoons are common. The resulting runoff of nitrogen and phosphorus into the Danube and, eventually, into the Black Sea, contributes to the eutrophication of this international water body and a decline in fish production.

5.2. Droughts and floods

Too much water can cause loss of life and serious damage through flooding, as it happens in the European Union nearly every year. Too little water recognizing as a drought is equally devastating, like the droughts that are occurring more and more often. All these events are expected to become more frequent and extreme according to predictions on the impacts of climate change.

It is assumed that the effects of the floods that raged through Central Europe and the Danube basin in August 2002 were worsened due to deforestation, the destruction of natural floodplains and human-induced global warming.

Global warming means that everyone will be a loser. Droughts and floods will become more severe in many areas.

Climate-change projections do indicate that flooding is likely to become more frequent in Europe. Flood losses also are becoming higher due to growing number of extreme events. For example Swiss Re Report stated that the total loss in euro in observation period 1992-2006 reached near 80.000 million and within this 60.000 million uninsured. The total number of events within the same period reached near

70, in that number 12 events with losses greater than 1 billion. Flood hazard is intensifying due to:

- Land use changes
- Sea-level rise
- Changing rainfall regimes
- Land movement

Insured losses (source Benfield Grieg 2003, Munich Re 2002 , Swiss Re 2003) also are changing. The basic information is given in the table below.

Table 27: Insured losses connected with floods

Insured loss $US - 2002	Date of the event
982	April 1983
1071	Jan 1995
955	Jul 1997
2950	Aug 2002

Source - Richard Sanders, European Flood Modelling 6th March 2003

For example in Poland the flood in the summer of 1997 was one of the largest in the past century in Poland. During this flood, 54 people lost their lives; about 500.000 hectares of surface area were inundated, as well as over 12.000 businesses and institutions. About 47.500 buildings were destroyed or damaged; nearly 3.900 bridges collapsed. It is estimated that the flood of July 1997 caused losses on the order of 12 billion Polish złoty (about US$3.5 billion).

In some places, the probability of occurrence (or return period) of such a flood was about 0.1% (a so-called T1000 flood); it actually happened that culmination levels exceeded previous highest known maximums even by 2–3 meters.

Estimation of 2002 flood losses in Carpathian countries is presented in the table below.

Table 28: Flood losses in Carpathian countries in 2002

Country	Loss estimate (Euro)	Notes	Source
Czech Republic	2,6 billion	95% reinsured	Reuters
Austria	3,0 billion	200 million insured	---------
Slovakia	35 million		Guy Carpanter

Source - Richard Sanders, European Flood Modelling 6th March 2003

In Serbia The Great Morava represents a text book example of a meandering river. Its meandering ratio is 118:245, one of the highest in Europe. It was always the most populated part of Serbia, disastrous floodings prevented people to settle on the river banks itself. The only city actually urbanizing the river bank is Ćuprija, but it suffered for it more than once (including several times in the 1990s) being struck by floods. Others cities are built little bit away from river itself.

Floods in Serbia are caused by natural events and human activities. Large areas within territory of Serbia are potentially or actually endangered by flooding.

The actions undertaken indicate a slow but important change in the way of thinking about flood damage mitigation strategy. A fundamental element of this change is the use of non-structural means of catastrophe damage mitigation, as well as propagation of participation by various entities (administration, NGO’s, the private sector and ordinary people) in flood prevention and preparation.

European Commission estimates in COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT - Addressing the challenge of water scarcity and droughts in the European Union (SEC(2007) 993) that the direct economic impact of drought events in the past thirty years at a minimum of € 100 billion. The annual impact due to droughts is estimated to have doubled between 1976-1990 and 1991-2006. It reached an annual average of € 6.2 billion from 2001 to 2006. According to European Commission Communication The annual impact due to droughts is estimated to have doubled between 1976-1990 and 1991-2006. It reached an annual average of € 6.2 billion from 2001 to 2006.

5.3. Legal transposition of the EU policy

The objective of the WFD is to reach until 2015 a good status for all waters. This objective should be met with an integrated management at a river basin scale through the institution of basin authorities and management plans. The scale of the water body should be the water basin intended as the territory of a main river with all its tributaries, from the source to the sea. The given territory should be managed by a basin agency.

The river district corresponds generally to the river basin or watershed. The river basin is a territory where all running waters, including rainwater, that flow into the sea at the same estuary. An example of river basin is the Danube basin. The river district is an administrative territory. Sometimes its borders do not perfectly fit with the watershed.

Table 29: The list of the river basin of river basin districts within the Carpathian Region identified in accordance with Article 3 (1) of the Water Framework Directive

Member States	Name of the River Basin Districts	Size (km^2)	Part of an Int. RBD
Austria	Danube	80565	Y
Czech Republic	Danube	21688	Y
	Odra	7246	Y
Hungary	Danube	93030	Y
Poland	Odra	131207	Y
	Vistula	220008	Y
	Danube	Ni	Y
Romania	Danube	237391	Y
Slovak Republic	Danube	47084	Y

Table 30: The list of competent authorities identified in accordance with Article 3 (2) of the Water Framework Directive

Country	Name	Address	Webpage	RBD names
Austria	*Main competent authority:*			
	Bundesminister für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (Federal Ministry of Agriculture, Forestry, Environment and Water Management)	Stubenring 1 Wien (Vienna) Austria 1012	www.lebensministerium.at	Danube, Elbe Rhine
Czech Republic	The Ministry of Environment	Vršovická 65 101 00 Praha 10	http://www.env.cz/.	Danube, Elbe, Odra
	The Ministry of Agriculture	Těšnov 17 117 05 Praha 1	http://www.mze.cz/.	Danube, Elbe, Odra
Hungary	Környezetvédelmi és Vízügyi Minisztérium (Ministry of Environment and Water)	Fő utca 44-50. Budapest (Budapest) Hungary 1011	www.kvvm.hu	Danube
Poland	(Minister for water management (at present the Minister of Environment is carrying out the duties))	Ministerstwo Środowiska, ul. Wawelska 52/54, 00922 Warszawa Warszawa (Warsaw) Poland 00 922	www.mos.gov.pl	Odra, Vistula, Danube,
Romania	Ministry of Environment and Water Management	Ministry of Environment and Water Management 12 Libertatii Blvd., Sect. 5 04129 Bucharest	http://www.mmediu.ro/home/home.php	Danube
	National Administration ‘Apele Romane’	6 Edgar Quinet Str. Sector 1, 70106 BUCHAREST	http://www.rowater.ro/	Danube
	Interministerial Commission of Waters	-	-	Danube
Slovakia	*Main competent authority:*			
	Ministerstvo životného	Nám. Ľ. Štúra 1 Bratislava (Bratislava)	www.enviro.gov.sk	Danube and Vistula

Country	Name	Address	Webpage	RBD names
	prostredia Slovenskej republiky (The Ministry of the Environment of the Slovak Republic)	Slovakia 81235		

Water related legislation in Ukraine and EC are substantially different in their structures. Due to the market-oriented transformation of the economy, agricultural land ownership is undergoing many changes as land privatisation progresses. The previously dominant collective sector is shrinking, giving way to the development of the private sector. The area has problems typical of the transitional post - communist society, developed against the background of relatively low levels of industrialisation and urbanisation.

Basin planning is not required by watercode, instead this law declared necessity of:

- Sectoral programmes
- Water balances and schemes for water balances complex water use
- Principle of basin management stated is stated in Water Code but not full implemented.

All the rivers basins are really covered by basin organizations. The existing hydro-economics organizations are being transformed into the basin organizations. The Parliament of Ukraine is in process of examination of the proposal on the improvement examination of the proposal on the improvement of the Water code taking into account the basin principles as a priority; - Ukraine intensively cooperates with operates with international projects. A result of this is a basis international projects. A result of this is a basis for practical introduction of methodology of river basin management planning based on the best basin management planning experience of the EU countries.

Existing basin river authority in Ukraine which covers part of Carpathian region is the Dniester-Prut River Basin Authority. State Committee on Water Management of Ukraine plans to create Upper-Tysa River Basin Authority.

The Serbian Law on Waters covers protection of waters, utilization and management of waters, goods of general interest, conditions and methods for performing water-related activities, organization and financing of such activities, and supervision and monitoring for enforcement. The enforcement of the Law refers to surface and groundwater, including drinking water, thermal and mineral waters, border and trans-boundary water flows, and inter-Republic water bodies within the boundaries of Serbia.

Like the body of law, water management institutions exist at the federal and republic levels. In the 1990s the water management system in the pre-existing Federal Republic of Yugoslavia was revamped from one that was very decentralized and developed on the hydrographic units, to one that is more strictly centralized and built according to the model of a state-centralized system. The State Water Management Company "Srbijavode" is the key institutional body of water management in Serbia.

6. Reference material

River Basins Management Plans National Report 2004 Romania

River Basins Management Plans – National Report Poland

Danube River Basin DistrictPart B - Report 2003 *Serbia and Montenegro*

Danube Basin Analysis (WFD Roof Report 2004)-ICPDR 2005

OSCE/UNECE Project: Transboundary Co-operation and Sustainable Management of the Dniester River - 2005

EU Wasserrahmenrichtlinie 2000/60/EG Österreichischer Bericht über die Zuständigen Behörden 2004

Report of the Slovak Republic processed for European Commission in line with Water Framework Directive, Article 3 and Annex I Developed by: The Ministry of the Environment of the Slovak Republic, Water Research Institute, Slovak Hydrometeorological Institute, Slovak Environmental Agency June, 2004

Správa Slovenskej republiky o stave implementácie Rámcovej smernice o vode spracovaná pre Európsku komisiu v súlade s článkom 5, prílohy II a prílohy III a článkom 6, prílohy IV RSV

Water Management in Hungary- www.ovf.hu

The Tisza River Project Real-life scale integrated catchment models for supporting water- and environmental management decisions Contract No: EVK1-CT-2001-00099

First National Report of the Republic of Hungary on the implementation of the United Nations Convention to Combat Desertification-2002

Flood hazard in Europe in a changing climate JRC EC- emission scenario (IPCC SRES A2) and one climate model (HIRHAM, Danish Meteorological Institute).- 2007 EC JRC IPTS

GREEN PAPER FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Adapting to climate change in Europe – options for EU action Brussels, 29.6.2007 COM(2007) 354 final

Climate change and water adaptation issues- EEA Technical report No 2/2007

PESETA Projections of economic impacts of climate change in sectors of Europe based on bottom-up analysis Institute of Environment and Sustainability 2006

Impacts of Europe's changing climate - EEA Report No 2/2004

Three decades of floods in Europe : a preliminary analysis of EMDAT data. Philippe Hoyois, Debarati Guha-Sapir. WHO collaborating Centre for Research on the Epidemiology of Disasters (CRED), Catholique University of Louvain.

Sustainable water use in Europe Part 3: Extreme hydrological events: floods and droughts-Environmental issue report No 21 EEA, Copenhagen, 2001

2006 Floods in the Danube River Basin Working paper Vienna, July 2006

Bogdanovic, S. 2001. *Federal Republic of Yugoslavia: Prospective Change in the Water Management System.* Paper presented at the AWRA/WLRI-University of Dundee International Specialty Conference on Globalization and Water Resource Management. Novi Sad, Serbia

Government of Serbia and Montenegro. 2000. *Serbia Report on the State of Environment for 2000 and Priorities in 2001 for Serbia.* Ministry for Protection of Natural Resources and Environment. Belgrade, Serbia and Montenegro.

Government of Serbia and Montenegro. 2001. *Breaking with the Past: The Path to Stability and Growth.* Belgrade, Serbia and Montenegro.

United Nations Economic Commission for Europe. 2002. *Environmental Performance Review of Serbia and Montenegro*. UNECE. Geneva, Switzerland.