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International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

Analysis of the Tisza River Basin 2007

Initial step toward the Tisza River Basin Management Plan – 2009

Україна //// România //// Slovensko //// Magyarország //// Srbija

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List of Annexes

List of MAPS

Contents

1 Introduction

The Tisza[1] River Basin is one of the most picturesque territories of Europe. Mountain streams, meandering rivers, diverse floodplains are characteristic of this region – home to the unique mayfly species called the Tisza Flower (*Palingenia longicauda)*, which is only found in the rivers of the plains of the Carpathian Basin.

Ukraine, Romania, the Slovak Republic, Hungary and Serbia share not only the beauties of the Tisza River Basin but also the area's problems related to water supply, severe flooding, droughts, landslides and erosion, accidental pollution by industrial and mining activities as well as pollution from agricultural sources. These problems are influencing water quality and quantity, and the management of land and water. It is therefore essential that these issues are addressed in an *integrated* approach. This analysis presents the issues together with the facts from the Tisza River Basin that will enable an integrated river basin management plan to be developed which will meet the needs of the EU Water Framework Directive and the Flood Directive and which will enable the countries of the basin to manage their land and water to the benefit of the people and environment as well.

The Tisza River Basin is the largest sub-basin of the Danube River Basin and the countries of the basin have a long history of cooperation resulting among others in signing the Agreement on the protection of the Tisza and its tributaries in 1986 or in establishing the Tisza Forum to address flood issues in 2000. The Tisza cooperation has been given a new perspective in line with the development of the Danube River basin cooperation and the EU water policy.

In 1994, the Danube River Protection Convention (DRPC) was signed in Sofia. The DRPC forms the overall legislation instrument for cooperation on transboundary water management in the Danube River Basin. It aims to ensure that surface water and groundwater within the Danube River Basin are managed and used sustainably and equitably. To implement provisions and to achieve the goals of the DRPC, the International Commission for the Protection of the Danube River (ICPDR)[2] was established in 1998 following the entry into force of the Convention with a secretariat based in Vienna.

Under the EU Water Framework Directive (2000/60/EC)[3] the ICPDR is the platform for coordination amongst the Danube countries including EU Member States, accession countries and other Danube riparian states for the implementation of the provisions of the Directive at transboundary level. In addition to the Danube River Basin planning, the ICPDR is taking an active role in sub-basin planning as well. One of the key objectives of the EU Water Framework Directive (WFD) is to ensure that all water meets `good status` by 2015. A key step towards this objective is the development of a River Basin Management Plan by 2009.

At the first ministerial meeting of the ICPDR countries in December 2004, ministers and high-level representatives of the five Tisza countries signed the Memorandum of Understanding (*Towards a River Basin Management Plan for the Tisza River supporting sustainable development of the region* – **see Annex 1**). The ICPDR established the Tisza Group for coordination as well as implementation. The Tisza Group is the platform for strengthening coordination and information exchange related to international, regional and national activities in the Tisza River Basin and to ensure harmonisation and effectiveness of related efforts. The Tisza Group countries agreed on to prepare a sub-basin plan

[1] The spelling of the river name differs from country to country (UA: Tysa; RO: Tisa; SK: Tisa, HU: Tisza; RS: Tisa; UK: Tisza) In the context of this report, the English spelling **`TISZA`** will be used.
[2] http://www.icpdr.org
[3] http://ec.europa.eu/environment/water/

(the Tisza River Basin Management Plan) by 2009, which integrates issues on water quality and water quantity, land and water management, flood and drought.

The first step towards the objective is the preparation of the Tisza Analysis Report by 2007, which is the first milestone in implementing the Memorandum of Understanding (MoU – see Annex 1). It characterises the Tisza River and its basin, identifies the key environmental and water management problems, in relation to water quality and water quantity, and creates the basis for further steps. Following the identification of the key water management issues, the next milestone is to prepare an integrated Tisza River Basin Management Plan by 2009.

The Tisza Group under the ICPDR was responsible for this Analysis Report.

1.1 Aims of the Tisza River Basin analysis

This Analysis is an intermediate step between the WFD Article 5. report submitted in March 2005 (prepared at both the Danube River Basin level, 'Roof Report' and national reports) and the River Basin Management Plan to be submitted in 2009. This report is presented in four main sections:

- Part 1 presents the overall characteristics of the basin including, geography, climate, hydrology, land use, basic socio-economic information, etc.
- Part 2 presents the detailed characterisation of the water **quality** of the basin and expands the information collected for the WFD Article 5. report submitted in 2005 – Danube Roof Report
- Part 3 presents the detailed characterisation of the water **quantity** of the basin. This represents significant new information of the impacts of floods and droughts, use of water, etc.
- Part 4 *integrates* the issues in the basin, specifically on how water quantity impacts water quality.

The Tisza River Basin Analysis Report gives an overview of the following waters:

- the Tisza River and its tributaries with a catchment size of >1 000 km^2 ;
- natural lakes >10 km^2
- reservoirs
- main canals
- groundwater bodies >1,000km^2

1.2. The next steps towards an Integrated River Basin Management Plan

Plan of actions:

By the end of 2008, the plan calls for:

- Compilation of a list of future infrastructure plans and projects
- Validation of risk assessment using the WFD-compliant national monitoring data
- Preparation of a 'Programme of Measures' to address the priority issues
- Preparation of a draft Tisza River Basin Management Plan for public consultation

By the end of 2009, following public consultation, the plan calls for Tisza countries to complete the final Integrated River Basin Management Plan, including flood related aspects.

Long-term actions

It is critical to follow up on the work begun in this Tisza River Basin Analysis in order to protect the Tisza ecosystems from pollution as well as from floods and droughts. Success will depend on the dedicated cooperation from all countries and continuing work on long-term actions:

- Implementation of the measures of the Integrated River Basin Management Plan
- Developing strategies and implementing plans to adapt to climate change
- Improving flood risk management within the Tisza River Basin including the restoration of floodplains and wetlands
- Ensuring equitable balances of water resources between the needs of the countries and the environment

Part I – Characterisation

2 Tisza River Basin overview

The Tisza River Basin (see **MAP 1**) is the largest sub-basin in the Danube River Basin, covering 157,186 km² or 19.5% of the Danube Basin. Together with its tributaries, the Tisza River drains the largest catchment area in the Carpathian Mountains before flowing through the Great Hungarian Plain and joining the Danube River.

The Tisza River Basin is home to some 14 million people.

With a strongly meandering riverbed, the original length of the Tisza River was 1,400 km from its spring in the northeastern Carpathian Mountains in Ukraine to its mouth at the Danube. During the second half of the 19th century, extensive measures of river training and flood control were undertaken along the river. As a result of these works, the river's total length was shortened by approximately 30% and it is today 966 km. However, it is still the longest tributary of the Danube River with the second largest discharge after the Sava River.

The Tisza River Basin can be divided into two main parts:

- the mountainous Upper Tisza and the tributaries in Ukraine, Romania and the eastern part of the Slovak Republic and
- the lowland parts mainly in Hungary and in Serbia surrounded by the East-Slovak Plain, the Transcarpathian lowland (Ukraine), and the plains on the western fringes of Romania.

The Tisza itself can be divided into three parts:

- the Upper Tisza upstream from the confluence of the Somes/Szamos River,
- the Middle Tisza in Hungary which receives the largest right hand tributaries: the Bodrog and Slaná/Sajó Rivers together with the Hornád/Hernád River collect water from the Carpathian Mountains in the Slovak Republic and Ukraine, and the Zagyva River drains the Mátra and Bükk, as well as the largest left hand tributaries: the Szamos/Somes River, the Körös/Criş River System and Maros/Mures River draining Transylvania in Romania and
- the Lower Tisza (downstream from the mouth of the Maros/Mureş River where it receives the Bega /Begej River and other tributaries indirectly through the Danube – Tisza – Danube Canal System.

The Tisza River Basin has significant flood protection and land drainage systems.

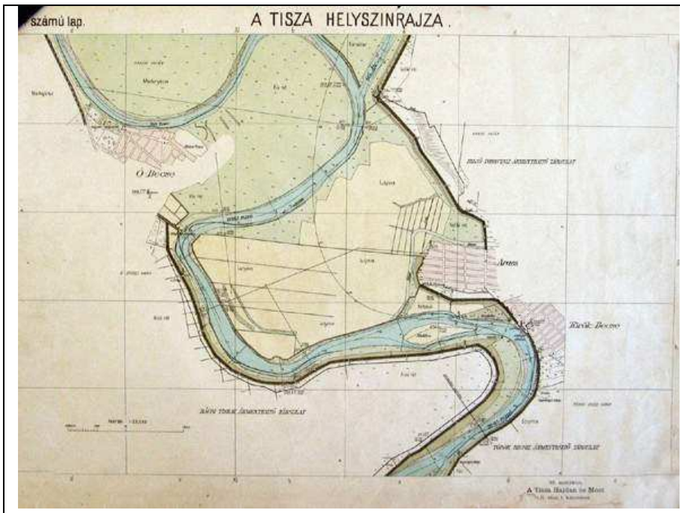
Problems facing water management in the Tisza River Basin include:

- severe floods (the most recent in the period of 1998 to 2006),
- drought problems in summer (particularly in Hungary and Serbia),
- landslides and erosion in the uplands (particularly in Ukraine),
- accidental pollution by industrial and mining activities, such as the cyanide spill occurring at Aurul Baia Mare in January 2000 and

- agricultural pollution, affecting the sensitivity of the Danube and Black Sea by nutrient pollution.

Accidental pollution and nutrient pollution can directly influence aquatic ecosystems and drinking water utilisation, while large-scale land reclamation can damage wetland ecosystems and intensified flooding problems in other areas.

History of Tisza River regulation



The Tisza River Regulation

Until the middle of 19th century, the Tisza River repeatedly inundated some 2 million hectares along its course.

The first survey of the river valley was done between 1833 and 1844, and Pal Vásárhelyi issued a plan for riverbed training with 121 short-cuts along the river in 1846. This plan was declined, and a new plan with 21 short-cuts was accepted in 1847. River training works began finally after a disastrous flood in 1855, and 112 short-cuts were made by 1875. The Tisza River length was shortened from ≈1,400km to today's 966km.

2.1. States in the Tisza River Basin

Five states share territories in the Tisza River Basin District: Ukraine, Romania, the Slovak Republic, Hungary and Serbia. The coverage of the states in the Tisza River Basin as well as the status of the countries in the EU is provided in **Table I.1.**

Table I.1: Coverage of the states in the Tisza River Basin as well as the status of the countries in the EU

Country	ISO-Code	Tisza River Basin area in the country (km^2)	Percentage of Tisza River Basin (%)	Percentage of Tisza River Basin area of the whole country area (%)	Status in the European Union
Ukraine	UA	12,732	8.1	2.1	-
Romania	RO	72,620	46.2	30.5	Member State
Slovak Republic	SK	15,247	9.7	31.1	Member State
Hungary	HU	46,213	29.4	49.7	Member State

Country	ISO-Code	Tisza River Basin area in the country (km^2)	Percentage of Tisza River Basin (%)	Percentage of Tisza River Basin area of the whole country area (%)	Status in the European Union
Serbia	RS	10,374	6.6	11.7	-[4]

Although Ukraine and Serbia are not EU Member States and non-EU States have no implementing and reporting obligations under the EU Water Framework Directive (WFD) they are cooperating in the frame of the ICPDR to implement the necessary WFD steps, including the development of a Tisza (and Danube) joint river basin management plans.

2.2. International coordination and cooperation

The 'Convention on Cooperation for the Protection and Sustainable Use of the Danube River' **(Danube River Protection Convention (DRPC)**, Sofia 1994) forms the overall legal instrument for cooperation and transboundary water management in the Danube River Basin. The main objective of the convention is the sustainable and equitable use of surface waters and groundwaters and includes the conservation and restoration of ecosystems. The Contracting Parties cooperate on fundamental water management issues and take all appropriate legal, administrative and technical measures to maintain and improve the quality of the Danube River and its environment. Austria, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Moldova, Romania, the Slovak Republic, Slovenia, Serbia, Ukraine and the European Community are Contracting Parties to the DRPC. Discussions about the ratification of the DRPC are under way with Montenegro.

The **International Commission for the Protection of the Danube River (ICPDR)** is the implementing body under the DRPC. Through the ICPDR, all Contracting Parties support the implementation of the WFD in their territories and cooperate in the framework of the ICPDR to achieve a single, basin-wide coordinated Danube River Basin Management Plan.

On the basis of the earlier activities and encouraged by a dialogue initiated by the EU Presidency of the ICPDR, the Tisza Countries signed the **Memorandum of Understanding**[5] and agreed to prepare a River Basin Management Plan for the Tisza River Basin by the end of 2009, aiming at the objectives set by the EU Water Framework Directive. The scope foreseen for this River Basin Management Plan is somewhat larger than that envisaged by the **WFD**, taking into account the requirements of the **ICPDR Flood Action Programme**, addressing pollution from point and non-point sources, wetland and floodplain restoration, priority substances, water quality standards, prevention of accidental pollution, flood and drought issues, river basin management and issues of sustainable development in the Tisza region as well.

The Tisza Group was created to prepare and coordinate the necessary activities for the preparation of Tisza River Basin Management Plan. All five Tisza countries are represented in the Tisza Group. The group jointly agrees on the necessary actions for the development of the Tisza River Basin Management Plan, such as the development of a strategy for establishing the River Basin Management Plan or identifying needs for harmonisation of methods and mechanisms.

The ICPDR serves as the *platform for coordination in the implementation of the WFD on issues of Danube Basin-wide importance* and coordinates the elaboration of a Tisza River Basin Management Plan through its Tisza Group. Transboundary *issues not covered by the ICPDR are solved at the appropriate level of cooperation* such as in the frame of *bilateral river committees/ international agreements* (**see Annex 2a and Annex 2b**). Bilateral transboundary water agreements are in place between almost all states in the Tisza River Basin but it is important to note that not all of these

[4] In October 2005, Serbia initiated a formal process to join the EU.
[5] (Towards a River Basin Management Plan for the Tisza river supporting sustainable development of the region)

agreements were "*established in order to ensure coordination*" as required by WFD Annex I, 6. These are generally *older treaties* that deal with specific issues of cooperation, except for the Hungarian-Romanian Agreement on the cooperation aimed at protection and sustainable use of transboundary waters, signed 19 September 2003, effective from 17 May 2004, which fully meets the provisions of the WFD.

Local issues remain a national task. Coordination efforts, conducted mainly through the respective *Ministries responsible for water and environment issues*, have been largely directed at inter-ministerial coordination.

The Tisza Group also serves as a platform to strengthen coordination and exchange information among the relevant international, regional and national activities in the Tisza River Basin to ensure harmonisation and effectiveness of efforts. List of frameworks and projects related to the Tisza River Basin - originated between 1996 and 2006 was prepared by the ICPDR Tisza Group (document can be downloaded from the following website: www.icpdr.org) .

The competent authorities for WFD implementation are designated by the states and are listed in **Annex 2c**.

2.3. Public participation in the Tisza River Basin

Various initiatives have been taken within the framework of the ICPDR to promote public participation as a core principle in sustainable water management. This principle was recognised when the Danube River Protection Convention was signed on 29 June 1994 in Sofia, Bulgaria and ever since then, has become a general practice in the activities of the ICPDR, including its meetings and expert groups.

Organisations representing civil society and private industry, as well as international organisations, are granted rights and opportunities to become observers and participate in the ICPDR and its Expert Group Meetings. Observers have the opportunity to participate in discussions, intervene or present their material and documents. To date, 15 organisations have taken this opportunity and become observers to the ICPDR. These organisations include NGOs, organisations representing private industry and intergovernmental organisations. Some of them also participate in the activities of the Tisza Group, and this cooperation has proven to be successful in ensuring that different concerns and approaches help influence current water management in the Danube River Basin.

This approach of involving the public has also been enhanced by the requirements of the WFD, the EU Directive on public access to information (2004/04/EC), the Directive on public participation in environmental procedures (2003/35/EC) and the Aarhus Convention. A more active and strategic approach has been taken since 2003 when the 'Danube River Basin Strategy for Public Participation in River Basin Management Planning 2003-2009' was drafted and approved as part of the 'ICPDR Operational Plan'. This plan and in particular the activities for 2004 were adopted for the first time in December 2003 and have since been updated every year. The Operational Plan provides a description of the activities at the roof level, including a timetable and a work plan. The Operational Plan is seen as a planning tool, regularly adjusted to the needs of the ICPDR. Recommendations were made to the Danube countries to implement the strategy also at national, sub-basin and local level.

The ICPDR has also established the Public Participation Expert Group, a network of national public participation focal points. This network was established to support communication and participation issues, to ensure that public participation activities are carried out in a concerted way throughout all Danube countries and that activities carried out on the ICPDR level complement national public participation efforts.

Information for stakeholders is provided through the ICPDR Information System (www.icpdr.org) with a special section on WFD implementation, providing access to all relevant documents. Links are available from the ICPDR Information System to the homepages of the respective Danube Basin Countries. This network of links provides easy access to information on different levels.

To raise awareness and reach out to the wider public, the ICPDR initiated the basin-wide celebration of Danube Day which provides a platform for local inhabitants to demonstrate their care for the river and their responsibility for its protection for future generations (http://www.danubeday.org). Celebrated for the first time on 29 June 2004 at the 10th Anniversary of the signing of the Danube River Protection Convention, Danube Day has become a fixture in the schedules of ministries, NGOs and other organisations caring and working for the Danube River Basin. In 2007 several Danube Day activities were also devoted specifically to the Tisza River Basin.

The information and public participation/stakeholder involvement activities in the Tisza River Basin are closely linked with the ICPDR activities and activities specific to the Tisza River Basin should be developed within the ICPDR framework and harmonized with the ICPDR activities. All of the tools and mechanisms for information and public participation established for the Danube River Basin can also be used for the Tisza River Basin. The network of Public Participation Focal Points can also be used, as the same experts are responsible both for the Danube and Tisza River Basins.

The `*Analysis of the Tisza River Basin - 2007*` has been uploaded to the public website of the ICPDR (www.icpdr.org) after official endorsement by the Heads of Delegations of the Tisza Countries (March 2008). The report available for the public for six months for comments.

More information on ICPDR Tisza Group and Tisza River Basin wide activities can be found on the following website: http://www.icpdr.org/icpdr-pages/tisza_basin.htm

The summary of comments will be made available together with the feedback on the comments provided by the ICPDR and endorsed by the Tisza Group through the website, in 2008.

The Tisza countries have already significant experience on handling access to environmental information request providing active provision of information and on public participation in environmental and water-related decision-making. Since the WFD came into force the active involvement of the stakeholders and public, information dissemination and preparations for consultaions have gained prominence.

In the EU Member States the draft timetable for RBMP and the draft work programme have been published on the web site as well as in hard copy. Comments have been collected electronically and consultations have been held.

Offices of public relations or water information centers have been established to support the WFD implementation. In Hungary, a stakeholder involvement strategy and methodology has been developed and adopted National and four sub-basin water management councils - including the sub-basin of Tisza - have been established, with the mandate to approve the important water management issues in 2008 and the RBMP in 2009. In Slovakia, the Council of Experts, a coordination body and working groups have been established to serve as consultation bodies. In Romania, public participation in the framework of WFD is implemented through the River Basin Committees (RBC) which are established as consultative mechanisms at regional and local levels. In addition to disseminating the national timetable and work programme for WFD implementation by e-mail and website, information was also collected through questionnaires on the involvement, in the different stages of RBM planning. In 2007, the consultations took place on the significant water management issues identified at river basin level in the elaboration process of the River Basin Development and Management Schemes within each Tisza River Basin Water Directorate.

Various international, bilateral and national projects have been carried out by the water authorities of Tisza countries or with their involvement, to implement the WFD requirements, and to test or support the public participation/stakeholder involvement process. (See list of project related to public participation **in Annex 2d)**

There have been active citizen initiatives in the Tisza River Basin, especially during the 2000 cyanide pollution accident. The Tisza platform was established and cooperation among NGOs in all Tisza River Basin countries was initiated. Several NGO projects have also been implemented as part of the

Danube Small Grants Programme funded by the GEF/UNDP Danube Regional Project as well as by other donors. The list of these NGOs and their project has been prepared by the REC and made available through the ICPDR website (See list of projects in **Annex 2d**). This open list will be updated regularly and can be used as a basis for identifying NGO stakeholders during the river basin planning at different levels. [6]

Several NGOs have also implemented WFD related projects in cooperation with water authorities, communities and different other stakeholders.

3 General characterisation of the Tisza River Basin

3.1. Geographic characterisation

The Tisza River Basin, the largest sub-basin of the Danube River, is shown in **MAP 1.**

The drainage basins of the tributaries of the Tisza River differ from each other in topography, soil composition, land use and hydrological characteristics. (**MAP 2** shows the topography and relief of the Tisza River Basin.) The 1800-2500 m high ridge of the Carpathian Mountains create in a semi-circle the northern, eastern and southeastern boundary of the Tisza catchment. The western – southwestern reach of the watershed is comparatively low in some places – on its Hungarian and Serbian parts it is almost flat.

The area is divided roughly along the centreline by the Carpathians Mountains, east of which lies the 400-600 m high plateau of the Transylvanian Basin, and the plains to the west. The highest summits of the river basin reach 1,948 m in the Low Tatras (Kráľova hoľa), 2061 m in the Chornogora Mountains (Hoverla), 2303 m in the Rodna Mountains (Pietrosul Rodnei) and even higher in the Retezat Mountains of the Southern Carpathians (Peleaga, 2509 m). Areas above elevations higher than 1600 m occupy only 1 % of the total; 46 % of the territory lies below 200 m.

The Tisza River rises in the Carpathian Mountains in northwestern Ukraine and is formed from the confluence of the Bila and Chorna Tisza Rivers. Further headwaters rise in the eastern mountains of the Slovak Republic, two of them in the Narodny (National) Park. The Uzh/Uh and Latorytsa/Latorica tributaries flow from Ukraine into the Slovak Republic where they, together with Ondava, Topľa and Laborec Rivers, form the Bodrog River before it enters Hungary. The Somes/Szamos and the Mures/Maros rise in the Romanian Carpathians, while the rivers forming the Cris/Körös system rise in the Apuseni Mountains.

The Tisza River Basin in the Slovak Republic is predominantly hilly area and the highest mountain peak in Kráľova hoľa - in the Low Tatras Mountain Range at 1,948 m. The lowland area lies in the south, forming the northern edge of the Hungarian Lowland. The lowest point in the Slovak Republic is the village of Streda nad Bodrogom in the eastern Slovak lowland (96 m) in the Bodrog River Basin.

The Hungarian part of the Tisza River Basin is a flat area bordered by small ranges of hills and mountains from the north and dominated by the Great Hungarian Plain.

[6] (Information about the results of the Small Grants Programme can be accessed at http://www.rec.org/REC/Programs/NGO_support/Grants/DanubeGrants/Default.html)

The Tisza River Basin in Romania is located in the northwest part of Romania, and is characterised by a high relief diversity: mountain areas (with elevations above 2000m), hilly areas (400-800m) and plain areas (200-300m).

A small, lowland part of the Tisza watershed area belongs to Serbia. There are various geomorphological elements in relief, with elevations of 74-143 m above sea level.

The obtained geographical database (**D**igital **E**levation **M**odel 1000x1000m) affords a simple spatial analysis. The results are presented in **Annex 13**.

3.2. Climate and hydrology

The Tisza River Basin is influenced by the Atlantic, Mediterranean and Continental climates, which impact regional precipitation. About 60% of the Upper Tisza River Basin gets more than 1000 mm of precipitation annually. Warm air masses from the Mediterranean Sea and the Atlantic Ocean cause cyclones with heavy rainfall on the southern and western slopes. In general, two-thirds of the precipitation occurs in the warm half of the year. Furthermore, land surface is subdivided into the Carpathian Mountains (70 % of catchment area) and the wide Tisza Lowlands.

The isotherms of the multi-annual mean air temperature vary from less than 3°C (in the Apuseni Mountains) to more than 11°C (along the middle and lower reach of the Tisza itself). The maximum temperatures are observed in July, the minimum in January (from –1 to –7°C). The annual mean potential evaporation (in RO and HU) is around 700 mm/a and the maximum monthly values (125-145. mm) occur in June and July.

The multi-annual mean values of annual precipitation vary within the Tisza River Basin from 500 to 1600 mm/a. The lowest values (500 mm/a and below) occur in the southwestern part of the basin, close to the Tisza River. The highest values (around 1 600 mm/a) occur in the northwestern Carpathians and in the Apuseni Mountains. Dry spells (with less then 10 mm/month) are frequent in most areas of the Tisza River Basin in February and March. (See **MAP 3 and Map 7** – Precipitation)

The highest maximum depth of snow, measured in various mountains of the Tisza River Basin (including the relatively low Mátra Mountains in Hungary) are above 100 cm, with water equivalents of 250-300 mm. Lower maximum values (40-60 cm with equivalents of 100-200 mm) were registered in the lowland parts of the basin.

The aridity factor (defined as the relation of annual potential evaporation to mean annual precipitation) at the eastern border of the Tisza River Basin (such as in the Carpathian Mountains) is below 0.2 and increases from the northeast to the southwest up to 1.4 in the middle of the Great Hungarian Plain (the mouth of the Körös Rivers).

In the mountainous regions, flash floods are common in the spring and summer. These are further intensified by the low infiltration capacity of the soils in the Carpathian Mountains. These floods cause enormous inundation in the lowland areas.

Flooding is a natural event necessary for riverine ecosystems, but it is also a significant threat to communities settled in the floodplain. Rainfall in the Carpathian Mountains can be substantial and sudden. Extensive runoff, floodplain deforestation and river canalisation reduce the ability of the catchment to attenuate the flood wave. When heavy rains occur, flooding threatens human lives as water levels rise quickly without sufficient retention capacity.

3.3 Surface geology

Concentration and drainage of the surface runoff depends fundamentally on the permeability of the soils close to the surface. Impervious soils induce flashy spates; pervious ones attenuate the runoff, store part of the rain and recharge the groundwater.

Volcanic rocks cover minor parts of the basin and sedimentary ones cover major parts of basin. Most of the volcanic and metamorphosed rocks tend to be impervious, though their weathered zones close to the surface and fissured faults convey often-appreciable flows, evidence of which has been found in mines.

Volcanic tuffs, unless weathered, are semi-pervious. Most of the sedimentary rocks are impervious, though cavities in karstified limestone and dolomite, loose sandstone, windblown sand, gravel and peat may convey large underground flows.

Predominant semi-pervious rocks in the upstream watersheds of the Tisza, the Somes/Szamos and the Bodrog rivers tend to attenuate flood waves and to store some water to augment autumn low flows. Large impervious areas in the Cris/Körös catchment lend a flashy character to the regime of these streams. Similar conditions also prevail over the major part of the Mures/Maros catchment, but adverse effects are offset by more pervious soils along the headwater reaches. The surface soils in the Tisza Basin have been grouped according to permeability in **MAP 4**.

Annex 13 shows territorial distribution, national distribution of mean elevations and surface gradients, amount of water transfer among Tisza countries.

3.4. The main water bodies in the Tisza River Basin

This section summarises the main tributaries, lakes, artificial water bodies and groundwaters in the Tisza River Basin. Information on their detailed characterisation in terms of quality and quantity are given in Part II (Water Quality) and Part III (Water Quantity) respectively.

The following subchapter describes the main 2nd order tributaries of the Tisza River:

3.4.1. The Tisza River and its main tributaries

The Tisza River rises in the southeastern part of the Carpathian Mountains and is a result of confluence of the Bila and Chorna Tisza Rivers. The Chorna Tisza River begins in foothill of the Svidovets Mountain at 1680 m. The Bila Tisza River begins in the Black Mountain (‘Chorna Hora’) at 1650m. Once the Chorna and Bila Tisza join near Rakhiv at 450 m above sea level, the river is called the Tisza. The riverhead of Chorna Tisza is taken as the riverhead of the Tisza River as it has the larger catchment area and the length to the confluence with the Bila Tisza River.

The united Tisza River maintains the roughly north-south direction of the Chorna Tisza as far as the Vişeu Stream on the left side, which is the first tributary of significant size. The Tisza turns west from here and after 26 km takes up the Iza River, which has its source in the Rodna Mountains. The Tisza follows the southeast - northwest direction of the Iza at the foot of the Oaşului Mountains (M. Avas), which makes the precursor of the Lapus (M. Ţibleşului) and Gutîiului (M. Gutin) Ranges. Between the Oaşului Mountains and the right bank of the Vinogradov (Nagyszőlősi) Mountains in the Huszt gate, the river suddenly widens, and before reaching the edge of the Great Plain it takes up the Terešva, Tereblya and Rika Rivers from the right bank. Between the Korolevo/Királyháza and the Somes/Szamos Rivers the Tisza follows an east-western direction. In this section it receives two larger tributaries; the Borzhava River from the right and the Tur/Túr River from the left in Hungary. The upper course of the river extends until the Szamos/Somes mouth. The Mures/Maros inflow serves as the border of the middle and lower course.

From a total length of 415 km, only 50 km of the Szamos/Someş River lies in Hungary. The river drains the northern part of the Transylvanian Basin. Its two main branches are the Someşul-Mare accompanying the Rodna Mountains to the south, and the Someşul-Mic originating from the union of the Someşul-Cald – rising in the Transsylvanian range, on the eastern slope of the Bihor Mountains (M. Bihorului) – and the Someşul-Rece rising in the Gilau (Gyalu) Mountains (M. Gilăului). The united Szamos has two larger tributaries: the Almás/Almaş and the Lápos/Lăpuş, which takes its source in the Lápos/Lapus and Gutin Mountains.

The Crasna/Kraszna River, feeding the former Ecsed Moor, flowed into the Somes until the 1890's. Its lower course has since been regulated so that it now flows directly into the Tisza about 3.5 km below the Szamos/Somes mouth. From the mouth of the Crasna/Kraszna, the Tisza turns north, going round the 170 m Nyírség sand ridge, until it reaches its northernmost point at Záhony. Here it makes its way west by southwest with a sharp bend, and takes up the Lónya Main Channel from the left, which collects the waters of the Nyírség, and in the foot of the Tokaj Kopasz hill it takes up the Bodrog River – its most important right tributary – at 544 km from its mouth.

The source of Bodrog River is the confluence of the Latorica and Ondava Rivers. Their significant tributaries are the Ondava, Topľa, Laborec and Uzh/Uh Rivers. From some 53.5% of the total catchment area of the Bodrog is located in the Slovak Republic, the rest in Ukraine and partly in Hungary. The maximum vertical dissection of the catchment area is 1,127 m.

The flow of the Tisza is directed southwest from the inflow of the Bodrog. It follows the Taktaköz sinking, and on the south edge of that it takes up the Sajó/Slaná River, increased by the Hernád/Hornád, also from the right. The waters of the Bükk Mountains drain into the Tisza through an old Tisza bed, the Small Tisza.

By damming up the section between the Kisköre and Tiszavalk Rivers (441.0-403.2 river kilometres) Lake Tisza was created within the foreshore of the Tisza River, which with its 127 km^2 extension has become the second largest stagnant water bodies of the Carpathian Basin. Putting the Kisköre barrage into operation in 1973 enabled damming and aimed at the complex eco-geographical reconstruction of the mid Tisza Valley, as well as the improvement of natural and social relationships.

The next tributary of the Tisza is the Zagyva River, also from the right bank, which drains the Mátra and Cserhát Mountains. After the mouth of the Zagyva River, the Tisza turns south and remains parallel to the Danube until the mouth. West of the Tisza River, between it and the Danube, lies the sand ridge, from which it does not get any significant inflow of water. However, the next left tributary, the Hármas-Körös River, is quite important and its is the second largest among the Tisza River's tributaries. Its network consists of five rivers which spread like a fan: the Crişul Alb/Fehér-Körös, Crişul Negru/Fekete-Körös, Crişul Repede/Sebes-Körös and Barcau/Berettyó and Hortobágy-Berettyó Rivers, the first four of which are fed by waters of the Transylvanian island range, while the last one drains waters from the plains beyond the Tisza River.

The last important water flowing into the Tisza in Hungary is the Mures/Maros River.

Along the Serbian section, the Tisza only receives two left tributaries flowing from Romania, the Aranca/Zlatica and Bega/Begej Rivers, with the mouth only 9.6 km upstream from the Danube confluence. The tributaries from the right are very small.

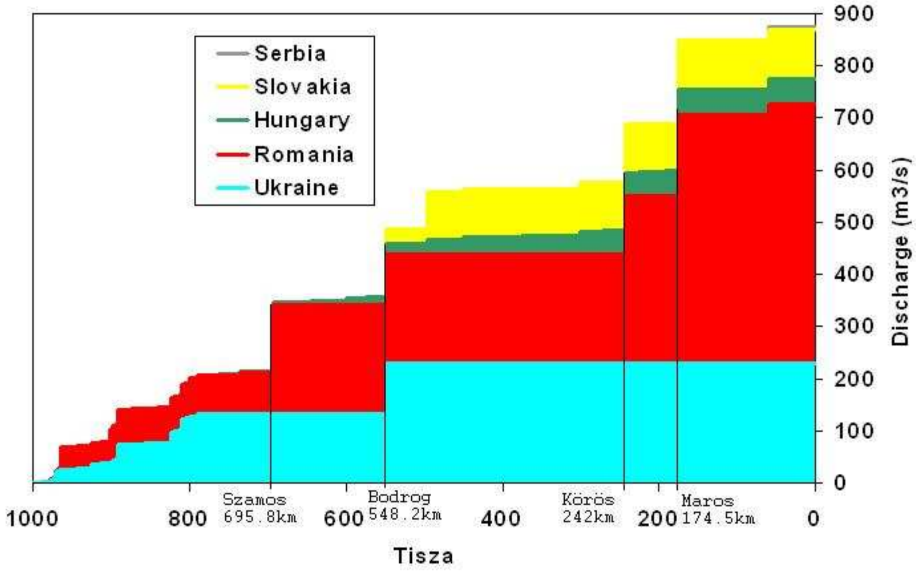


Figure I.1 : Longitudinal profile of the Tisza River and contribution of water from each country (in %) to the mean discharge of the Tisza (in m^3/s)[7]

Table I.2. indicates the main 2nd and 3rd order tributaries of the Tisza River specified by the ICPDR Tisza Group.

Map 1 (Overview Map) illustrate the tributaries of the Tisza River with surface area bigger than 1000 km^2.

[7] Information based on data of the JRC-IES dataset (1991-2002) and runs of theVITUKI NFHS flood routing module

Table I.2 – Tisza Tributaries

Main tributaries to the Tisza River - single indent, 2nd order tributaries - double indent, 3rd order tributaries - triple indent

	Name of river	Size of river basin [km²]	Countries (from mouth to source)
1	Tisa /Tisza/ Tysa	157,186	RS, HU, SK,RO, UA
2	Begej/Bega	4,458	RS, RO
3	Stari Begej/Bega Veche	2,943	RS, RO
4	Maros / Mureş	30,332	HU, RO
5	Târnava	6,253	RO
6	Kurca	1,266	HU
7	Dong – ér (main channel)	1,672	HU
8	Körös / Criş	27,537	HU, RO,
9	Hortobágy-Berettyó	5,771	HU
10	Kálló-ér	1,264	HU
11	Kettős-Körös (Fekete+Fehér)	9,600	HU
12	Fehér-Körös / Crişul Alb	4,275	HU, RO
13	Fekete-Körös / Crişul Negru	4,645	HU, RO
14	Sebes-Körös / Crişul Repede	9,119	HU, RO
15	Berettyó / Barcău	5,812	HU, RO
16	Ér / Ier	1,300 (RO)	HU, RO
17	Zagyva	5,578	HU
18	Tarna	1,810	HU
19	Sajó / Slaná	12,708	HU, SK
20	Hernád / Hornád	5,436	HU, SK
21	Torysa	1,349	SK
22	Bódva / Bodva	1,727	HU, SK
23	Rimava	1,378	SK
24	Bodrog	13,579	HU, SK, UA
25	Ondava	3,973	SK
26	Topla	1,544	SK
27	Latorica	7,680	SK, UA
28	Uzh/Uh	2,750	SK, UA
29	Laborec	4,523	SK
30	Kraszna / Crasna	1,931	HU, RO

	Name of river	Size of river basin [km²]	Countries (from mouth to source)
31	Szamos / Someş	18,146	HU, RO
32	Someşul Mic	3,773	RO
33	Túr / Tur	1,144	HU, RO, UA,
34	Borzhava	1,450	UA
35	Rika	1,145	UA
36	Teresva	1,220	UA
37	Iza	1,293	RO
38	Bila Tisza	485	UA
39	Vişeu	1,581	RO
40	Chorna Tisza	563	UA

3.4.2. Natural lakes larger than 10 km²

There are two natural lakes greater than 10 km^2 in the Tisza River Basin, the Szegedi Fehér Lake and the Füred-Kócsi Reservoir.

The Szegedi Fehér Lake is situated in Hungary in the Kiskunsági National Park (KNP) and is 13.1 km^2. The lake is a significant habitat for birds, and nearly 280 bird species have been recorded so far. The territory of the lake was inundated regularly in the past, but after the river regulation the inundation was blocked.

The Füred-Kócsi Reservoir is in the Hortobágy National Park. Its surface is around 600 ha, and the area regularly inundated is approximately 400 ha. Bulrush and reed are typical macrophyta in the reservoir. In addition to an ecological aquatic habitat, the reservoir aids emergency flood control functions.

3.4.3. Artificial water bodies and reservoirs

The main artificial water bodies in the Tisza River Basin are summarised below. Details of their characterisation are included in Part II (Water Quality) and Part III (Water Quantity).

The Danube-Tisza-Danube Canal System (DTD): is situated in the Vojvodina province of the Republic of Serbia. The DTD is divided into two independent parts; the Bačka and the Banat region. The DTD is a multi-purpose system with the following tasks: flood protection – adequate level achieved; draining excess interior waters and routing drainage waters through main channels towards the Danube and the Tisza Rivers; conveying water for the irrigation of agricultural land – presently very modest; water supply for industry and fisheries; navigation; receiving and conveying wastewaters; water quality protection; recreation, sports and tourism.

Annex 3 – History of the construction of the Danube-Tisza-Danube Canal System

The Eastern and Western Main Canals: are located in Hungary and are mainly used to assist water resource distribution.

Reservoirs: more than 60 reservoirs were built during the last century for various purposes including; drinking and industrial water supply, hydropower, flood protection, irrigation, fish farming and recreation, as well as seasonal flow regulation. The total reservoir capacity in the Tisza River Basin is estimated at about 2.7 billion m^3.

Reservoirs are listed in the **Annex 4**

3.4.4. Groundwater

Groundwater bodies are important sources for drinking water, industry and agriculture in the Tisza River Basin.

Detailed characteristics of these are included in Part II (Water Quality) and Part III (Water Quantity).

The countries in the region depend mainly on groundwater sources to meet their drinking water needs, with the exception of Romania and the Slovak Republic.

Shallow aquifers are at high risk of pollution as a result of the use of fertilisers and chemicals from agriculture, untreated sewage water and leaching from contaminated soils. In some cases, groundwater sources cannot be used without prior treatment. Therefore, countries need to ensure that the groundwater is not overexploited and that the quality of groundwater is preserved.

3.5. Main National parks, protected areas and Ramsar sites in the Tisza River Basin

The Tisza River Basin countries have a great number of protected areas and Ramsar designated sites. (see **Table I.3a,b and MAP5**)

Table I.3a: The main national parks, nature and biosphere reserves in the Tisza River Basin

Name	Surface (ha)	Location
Carpathians Biosphere Reserve	53,630	Ukraine: Zakkarpattia Oblast
Synevyr	40,400	Ukraine: Zakkarpattia Oblast
Uzhanskyi	39,158	Ukraine: Zakkarpattia Oblast
Cãlimani	24,041	Romania: Part of Bistrita-Nasaud, Harghita, Mures and Suceava Counties
Grãdistea Muncelului - Cioclovina	10,000	Romania: All in Hunedoara County
Muntii Apuseni	75,784	Romania: Part of Alba, Bihor and Cluj Counties
Retezat	38,047	Romania: All in Hunedoara County
Rodna	46,399	Romania: Part of Bistrita-Nasaud, Maramures and Suceava Counties
Maramures Mountains National Park	148,850	Romania; Maramures County
Slovak karst – National Park	34,611	Slovak – Hungarian border
Latorica - landscape protected area (LPA)	15,620	East of Slovakia – Bodrog River Basin
Slovak paradise – National Park	19,763	Upper part of Hornad and Slana River Basin
Muránska planina – National Park	34,611	Part of Slana River Basin

Name	Surface (ha)	Location
Hortobágyi – National Park	52,173	Hungary: Middle Tisza region
Kiskunsági – National Park	22,095	Hungary: Middle Tisza region
Aggteleki – National Park	19,247	Hungary: Middle Tisza region
Bükki – National Park	40,263	Hungary: North west - Middle Tisza region
Körös-Maros – National Park	800,000	Hungary: Middle - Lower Tisza region
Ludasko Lake	593	Serbia: Backa region
Slano Kopovo	976	Serbia: Banat region
Stari Begej (Old Bega) – Carska Bara	1,767	Serbia: Banat region

The main Ramsar sites

All five countries of the Tisza River Basin are Contracting Parties to the Convention on Wetlands. The main Ramsar sites in the Tisza River Basin are shown in **Table I.3b**. Main characteristics of the Ramsar sites are introduced below.

Table I.3b: The main Ramsar sites in the Tisza River Basin

Name	Surface (ha)	Location
Latorica - landscape protected area (LPA)	15,620	East of Slovakia: Bodrog River Basin
Domice	622	Slovakia: Kosice Region
Tisza River - Kosice	735	Slovakia: Kosice Region
Senné-rybníky (Senné fishponds	425	Slovakia
Hortobágy	52,173	Hungary: Middle Tisza region
Felső Tisza	22,311	Hungary: Szabolcs - Szatmár - Bereg County
Pusztaszer	5,000	Hungary: Csongrád County
Bodrogzug	3,782	Hungary: Borsod – Abaúj – Zemplén County
Mártély	2,232	Hungary: Csongrád County
Ludasko Lake	593	Serbia: Backa region
Slano Kopovo	976	Serbia: Banat region
Stari Begej (Old Bega) – Carka Bara	1,767	Serbia: Banat region

Hortobágy - Hajdú-Bihar, Szolnok, Heves Counties (23,121 ha) - Biosphere Reserve; National Park, Nature Protection Area. Four separate sectors of the extensive Hortobágy Steppe include a system of artificial fishponds; a reconstructed swamp system; a part of a dam, islands, woodland and mudflats; and extensive grassland, marshland and swamp areas. The area is important for breeding, wintering and staging important numbers of many species of migratory water birds. Human activities include intensive, large-scale fish production and reed harvesting. Public access is strictly controlled. A field research station and several observation hides are available.

Felső-Tisza (Upper Tisza) - Szabolcs-Szatmár-Bereg County (22,311 ha) - Nature Reserve, Landscape Protection Area. The site covers the entire active floodplain along a 215 km section of the Tisza River in northeastern Hungary, adjacent to the Bodrogzug Ramsar site; it meets the Ukrainian and Slovakian borders to the east and north, and the catchment is also shared with Romania. The natural and near-natural habitats consist of large patches of softwood (Salicetum albae-fragilis) and hardwood riverside forests (Querco-Ulmetum), oxbow lakes, filled-in meanders with rich natural flora and fauna, extensively managed or abandoned orchards and plough-lands. The site supports many vulnerable animal species such as Corn crake, Common otter, Danube salmon, Zingel, Sterlet, and Russian sturgeon and is an important migration route notably for the fish Nase (*Chondrostoma nasus*), Barbel (*Barbus barbus*), and Sterlet (*Acipenser ruthenus*). The oxbows perform important ecological functions such as spawning, rearing, feeding, resting and staging, aquifer recharge, aquatic species ‘banks’, and habitat connectivity. Dry periods in recent years have led to eutrophication and decreased habitat extent. Tourism, fishing and intensification of forestry are adversely affecting the ecological character. A special programme identifying the most important sites along the river has been implemented. It is designated in conjunction with ‘**Tisza River**’ in the Slovak Republic.

Pusztaszer – Csongrád County (5,000 ha) - Landscape Protection Area, Nature Conservation Area. The site is composed of artificial fishponds, marshlands, a seasonally flooded saline lake, flooded woodland and an oxbow lake. The area is important for staging numerous species of water birds and supports several species of notable or endemic plants. A research station and an information centre are available, and there are several observation hides.

Latorica – Trebisov (4,358 ha) - Landscape Protection Area, Nature Reserve. The widest part of the Latorica River, includes a well-developed network of oxbow lakes, tributaries, seasonal pools, reed beds, marshes, wet meadows, pasture and floodplain forest. The site borders Ukraine. The area supports a rich wetland fauna of dragonflies (*Odonata*), amphibians and nesting water birds. Human activities include fishing, hunting, forestry, livestock grazing and haymaking.

Bodrogzug - Borsod-Abadúj-Zemplén County (3,782 ha) - Landscape Protection Area. The floodplain area includes several lakes at the confluence of the Bodrog and the Tisza Rivers, with grassland, marshland, lakes, reed beds, willow scrub and areas of woodland on higher ground. The area is important for breeding and staging numerous species of water birds. Several notable plants are supported.

Mártély – Csongrád County (2,232 ha) - Landscape Protection Area, Nature Protection Area. A section of the Tisza River floodplain featuring oxbow lakes, wet meadows, arable land, scrub, and woodland. The site supports a large population of the otter *Lutra lutra* and is an important breeding area for various species of water birds. Human activities include recreation. The site supports commercial fisheries and a research centre.

Stari Begej/Carska Bara (1,767 ha) - Special Nature Reserve. The site, a remnant of the once flooded area in the Lower Begej River, is a mosaic of fishponds, swamp, marsh, forest, meadow and steppe intersected by rivers, canals and embankments. Vegetation consists of salt-tolerant communities, a rich aquatic flowering plant community and steppe vegetation. Of the 250 recorded bird species, 140 species nest at the site and 100 pass through on migration. Notably, all eight European heron species and *Anser anser* nest at the site. The diversity of biotopes gives rise to high species diversity at the site and includes various rare, endangered or vulnerable fish, birds, plants, amphibians, reptiles and mammals. Human activities include recreation, bird watching, sport fishing and some traditional agriculture. There is an important commercial fishery nearby.

Slano Kopovo – Vojvodina (976 ha) - Special Nature Reserve, IBA. The site, left over from the draining of an ancient meander of the Tisza River, is a rare and representative example of salt habitats but presents also, on its eastern side, a smaller freshwater depression. It is one of Serbia's most important bird habitats and regularly supports more than 20,000 water birds, breeding and migrating. It is especially suitable for cranes, ducks, geese and shorebirds and supports a significant number of vulnerable, threatened and critically endangered species such as *Numenius tenuirostris*, *Anser erythropus*, *Branta ruficollis*, *Oxyura leucocephala*, *Aquila heliaca*, *Falco naumanni*, *Otis tarda*, the rodent *Spermophilus citellus*, and plant communities such as the rare *Thero-Salicornietea* specific to salty grounds. The area is threatened by a decrease in water level, as the drying up of the depressions during summer and autumn is becoming more frequent, caused chiefly by the development of a channel web and dam construction on the Tisza, which has lowered the level of the groundwaters. Other negative factors are ploughing of pastures, use of chemicals and artificial fertilisers for agriculture. Human activities include regulated hunting, livestock husbandry, agriculture and the use of mud for curing ailments. There is a high potential of scientific research and conservation education. Church remnants from the 9^{th}-11^{th} centuries exist on site. Conservation priorities concern the sanitation and improvement of the water regime.

Tisza River – Košice (735 ha). In the southeastern part of the Slovak Republic, the site includes a 6 km section of the Tisza River and its floodplain contiguous with portions of the river in Hungary and Ukraine. The site includes floodplain forests and shrubs, an oxbow lake and grasslands. It is part of a larger wetland important for the recharge of aquifers in the Tisza River Basin, natural control of flooding and self-purification processes, as well as for maintaining biological diversity. It supports species vulnerable at the international level such as the Corn crake (*Crex crex*), Geoffroy's bat (*Myotis emarginatus*) and the Sterlet (*Acipenser ruthenus*). The upper part of the designated section has natural riverbed, but the lower part was changed by human interferences in the 1880s. Within the site, human activities include regulated recreation and tourism, hunting, pasture and extensive agriculture. There is high eutrophication in the oxbow as a result of pollution from nearby intensive agricultural practices. The site was also used for fishing before February 2000 when several heavy metals pollution spills originating in Romanian mines caused damage to river ecology. It designated in conjunction with ‘ Felső-Tisza (Upper Tisza)’ in Hungary.

Domica - Kosice Region (622 ha) - Protected Landscape Area, UNESCO Biosphere Reserve, World Heritage site. The sub-surface wetlands were discovered in 1926. It is part of the 25km-long Domica-Baradla Cave System, the largest subterranean hydrological system of the plateau karst, shared by the Slovak Republic and Hungary. It plays a substantial role in hydrological, biological, and ecological functions. The site has special value for a large number of endemic and rare plant and animal species, especially subterranean hydrobionts. The cave system has important tourism functions, with guided tours by boat and on foot, electric lighting and a visitors’ centre, and signposted trans-border nature trail surrounds the area on the surface. The cave also has very significant archaeological remains of Paleolithic and Neolithic occupancy. Associated with Hungary's Baradla Cave System Ramsar site.

Ludaško Lake – Vojvodina (593 ha) - Regional Park, Nature Reserve. It is one of the few remaining natural lakes of the Pannonian Plain. The shallow lake is fringed by extensive reed beds and surrounded by marshland. The area is important for numerous species of breeding water birds, and an ornithological research station is located at the site. Principal human activities include fishing, hunting, reed cutting and recreation.

Senné-rybníky (Senné fishponds). (425 ha). Nature Reserve. The site comprises three fishponds supporting aquatic vegetation and adjacent meadows. Water levels can be artificially regulated. The site is important for numerous species of breeding, wintering and staging waterbirds. Various species of notable plants occur at the site.

As a result of the intensive agricultural development of past decades, many natural ecosystems, particularly the Tisza floodplains, have been transformed into arable lands and pastures. In the Upper Tisza River Basin, notably in Ukraine and the Slovak Republic, deforestation in mountain areas is responsible for changes to typical habitats. For example, in the Kosice region the fragmentation of natural areas and the disappearance of wetlands have caused a decrease in biodiversity.

Biodiversity is also threatened by industrial pollution of rivers, particularly heavy metal pollution from the mining and metal processing industry. Mining and metal processing industry operations should be carefully managed to prevent negative impacts into natural ecosystems throughout the Tisza River Basin.

3.6. Summary of socio-economic aspects

Major historical and political changes took place in the Tisza River Basin during the last three decades. The riparian countries were members of the Council for Mutual Economic Assistance (COMECON) and the Warsaw Military Pact (except for Yugoslavia), and Ukraine was part of the Soviet Union until breaking away in 1991. With the rise in power of the socialist regimes, the natural resources of these countries such as wood and ores began to be forcibly exploited by Soviet-dominated enterprises. The collectivisation of agriculture, intense deforestation and implementation of centrally-based joint plans within the COMECON framework had profound negative effects on the environment.

All the Tisza River Basin countries, albeit at a different pace, have undergone a significant political, economic, social and environmental transformation in the past two decades. In most countries, radical political changes occurred in 1989 to 1991 that resulted in free elections in various forms and the establishment of pluralistic, multi-party democracies and separated branches of power.

In 1993, following a political decision, Czechoslovakia was split into two independent countries, the Czech Republic and the Slovak Republic. In 1991, Ukraine broke away from the Soviet Union. During the 1990s, the former Yugoslavia gradually lost its territorial integrity, and a series of civil wars took place. Since the early 1990s two countries (Hungary and the Slovak Republic) began their integration process with the European Union that culminated in membership on 1 May 2004; Romania joined the EU on 1 January 2007. Serbia is participating in the stabilisation and association process, while Ukraine is a part of the EU's recently developed 'Neighbourhood Policy'. Today, the five riparian states continue to experience various forms of the transition from centrally planned to free market economies. They are home to around 14 million people, with high population densities in lowlands and valley corridors and intensely utilised trans-Carpathian traffic routes.

Table I.4 presents the basic socio-economic data covering all five countries in the Tisza River Basin. The Gross Domestic Product (GDP) and population figures presented are normalised using the population equivalent. In this case, the considerable difference in the GDP per capita figures can shows a significant disparity in wealth. This big gap between the countries is reduced when GDP per capita figures are expressed in Purchase Power Parities (PPP).

Industrial production in the Tisza River Basin District has drastically dropped since the 1990s. Populations have preserved cultural and economic traditions, especially in the mountains. Migration has increased in recent years due to the scarcity of work opportunities in the poorest areas of the basin and offers in other parts that are more economically developed.

Table I.4.: General socio-economic indicators (data source: Competent authorities in the Tisza River Basin unless marked otherwise)

Country	Number of inhabitants in the Tisza River Basin***	GDP (in million EUR)	Total population (million)	GDP per capita (in EUR per capita)	GDP per capita (in PPP EUR per capita)
Ukraine *	1,240,000	70,381	47.1	1,494	Not available
Romania****	6,095,000	38,908	21.7	1,795	5,264
Slovak Republic**	1,670,000	33,1	5.4	6,15	14,35
Hungary	4,126,000	50,663	10.1	5,016	11,243
Serbia	810,000	8,628	9.0	959	not available

*1 date for year 2005
*** SK Source – Statistical Yearbook 2005. Data represent the year 2004 and are from preliminary quarterly accounts (at current prices).*
*****Romania – source of information is 2004*
***UNEP Rapid Assessment figures

3.6.1. Land use overview

Land in the Tisza River Basin is mainly used for agriculture, forestry, pastures (grassland), nature reserves, as well as urbanised areas. (See **MAP 6** on land uses)

The higher parts of the catchment, particularly in the Slovak Republic and Ukraine and the higher altitudes in Romania, are covered with (mainly deciduous) forest. The lower parts and floodplains are used for intensive agriculture, except where larger wetlands and traditional grazing areas exist.

The urban environment and related issues are gaining importance in the Tisza River Basin. Rapid urbanisation within the region is putting additional pressure on the surrounding rural and natural environment, including biodiversity and traditional landscapes. As a consequence, most countries today have large urban populations. For example, national statistics show that approximately 65% of the population in Hungary, and 60% in the Slovak Republic, currently live in an urban setting. In Romania the urban population was slightly lower at more than 50% of the total population.

The biggest cities in the Tisza River Basin are Timisoara (304 000), Cluj- Napoca (320 000) and Oradea (206 000) in Romania; Debrecen (205 000) and Miskolc (180 000) in Hungary; Kosice (234 000) in the Slovak Republic; Subotica (147 000) in Serbia and Uzhgorod (118 000) and Mukachevo (82 000) in Ukraine.

3.6.2. Main economic sectors in the Tisza River Basin

3.6.2.1. Agriculture

Intensive agriculture is still practiced in the Pannonian Plain, which includes both the middle and lower Tisza regions. This has been made possible after many rivers were canalised for irrigation purpose, and wetlands were drained, resulting in repeated severe flood damage in the Hungarian part of the Tisza Basin. This has also led to an increase in soil pollution and erosion, a loss of the absorptive capacity during floods, additional agricultural runoff and surface and groundwater pollution. Flora and fauna diversity are also affected by the disconnection and drainage of floodplains along the Tisza and its tributaries. The situation is exacerbated due to the use of agrochemicals, which run off into rivers and groundwater bodies.

The sharp decline in Hungarian crop production in the beginning of the 1990s was accompanied by a decrease in the use of pesticides and fertilisers. With the increase of production since 1994, fertiliser consumption was resumed, but the use of pesticides remained very low.

Although the Pannonian Plain is very suitable for cultivation, the average precipitation on this area is not enough for intensive cultivation, and evaporation consumes too much water. Due to this, natural water deficiency occurs regularly and resources have to be substituted by man-made means. In the southern part of the Slovak Republic, there are lowlands on the edge of the Pannonian Basin with intensive agriculture. Most streams have been canalised and the water quality and conservation value is considered poor. However, irrigated surfaces are decreasing as a result of significant costs involved in maintaining and extending existing irrigation systems. A similar situation is found in Serbia, where intensive agriculture is also practiced.

Past agricultural methods significantly altered the traditional agrarian structure of the region. In general, agricultural lands were transformed into vast large-scale arable fields covering hundreds of hectares in part of the Tisza River Basin. In the 1960s, this centralised method drained existing wetlands, destroyed forests, increased soil erosion and dramatically altered the landscape in the Tisza region. During the last 10-15 years, agricultural production, including plant production and animal husbandry, has decreased in the Tisza River Basin and huge areas became fallow land. Agricultural land does not have an optimal structure, with cereals occupying a much too important position, considering the soil and climatic conditions in the basin.

Also, there has been a general decline in the livestock, particularly in cattle and sheep stocks. In the Ukrainian part of the Tisza River Basin, agriculture has limited importance owing to unsuitable natural conditions, producing only small amounts of grain, meat and milk for domestic needs. Livestock breeding (based on seasonal pasturing of mountain meadows) is well preserved in the Carpathians, although the cattle and sheep stock decreased significantly during the past decade. In the southern part of the Slovak Republic, there is intense agriculture on the lowlands at the edge of the Hungarian Lowlands. Since 1990, livestock breeding has significantly decreased in the Slovak Republic (cattle by 41%, pigs – 43%, sheep – 20%, poultry – 4%). In Romania, big livestock farms closed down in the 1990s. In 2002, the Hungarian pig and poultry stock decreased by 63 and 60%, respectively, compared to the 1980 stock. In **Serbia**, fishponds and pig and cattle farming are still important for the local economy. (**Table I.5.**)

Table I.5. – Tisza River Basin agricultural area (ha) and livestock breeding

Country	Agricultural area				
	Arable land (ha)	Fruit trees, berries plantations (ha)	Grassland, Pasture (ha)	Vineyard (ha)	Heterogeneous Agricultural areas (ha)
Ukraine******	200,400 (16%)	14,100 (1%)	231,000 (18%)	4,800 (>1%)	8,300 (>1%)
Romania	1,475,848	102,718	126,232	50,598	1,452,310
Slovak Republic***	489,650	2,658	96,508	3,926	145,983
Hungary	2,614,400	38,901	527,905	47,987	250,129
Serbia	791,000	9,000	54,500	5,500	35

Country	Livestock	
	Livestock (thousands/year)	Livestock density (Livestock per hundred hectares of agricultural area)
Ukraine******	194,600 (3,755)	42,400 (819)
Romania	1740.4*	135.1**
Slovak Republic***	106*	14,35**
Hungary	1,675/30 724*	48/883
Serbia	865,5	96,70

* Cattle, pig, sheep/poultry
** All data from year 2002. Livestock in MEC (mature equivalent cow) units.
*** Livestock in MEC (mature equivalent cow) units
**** UA comments: All data for year 2004, Agricultural area: in brackets % from total territory in UA part of Tisza; Livestock: cows, pigs, sheep and goats (in brackets – poultry only)

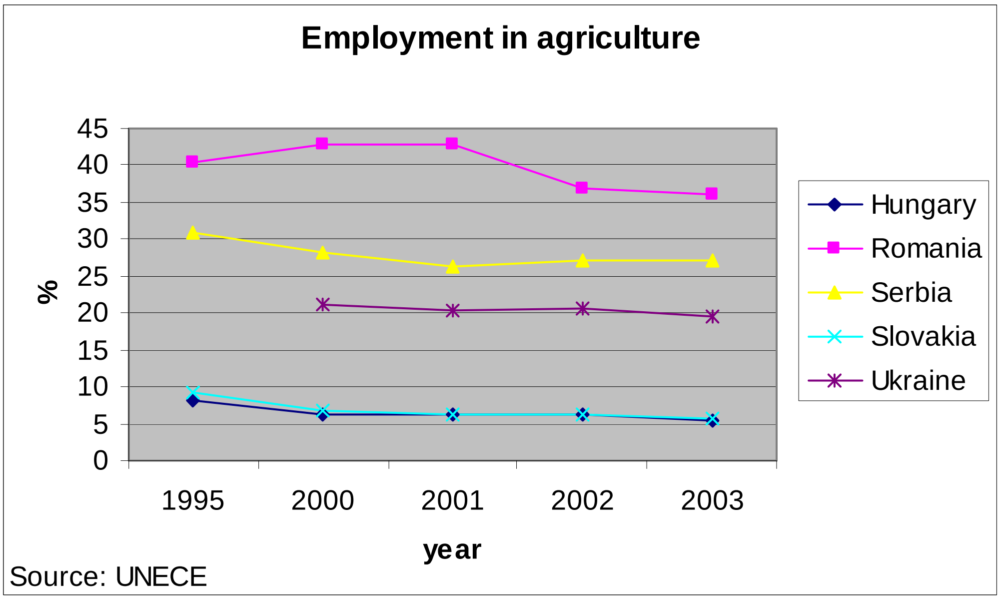


Figure I.2. Employment in Agriculture in the Tisza Countries

Employment in agriculture remains high in Romania (at 36%) and Serbia (at 27.2%), in Ukraine it reaches almost 20%, while the least agrarian countries in employment are Hungary (at 5.4%) and the Slovak Republic (at 5.8%) (see Figure I.2.).

3.6.2.2. Industry and mining

Industrial production has also dropped drastically since the 1990s. In the Tisza River Basin, the main industrial regions are located in Romania and Hungary, although there are also some important industrial facilities in Ukraine, the Slovak Republic and Serbia. Due to the economic decline and stagnation during the last decade, industrial sectors are now mainly oriented towards local resources. In the Upper Tisza River Basin in Ukraine, for example, timber processing, furniture and food production comprised 68% of the industrial output in 2000. Currently, the mining and metallurgical industries have an important share in the regional economy of the Tisza River Basin, as well as chemical, petrochemical, cellulose and paper, food, textile, and furniture industries.

The mining industry is well developed in the Tisza River Basin, notably in Romania. Non-ferrous metals are mined in the Somes and Mures Sub-basins, the major Romanian tributaries to the Tisza. Small-scale mining also occurs in the Ukrainian Tisza River Basin section, with the extraction of salt, kaolin, mercury, gold, complex ores, zeolites and rocks used as construction material. In the Slovak Republic there are two mining sites of polymetalic ore and its processing mining of salt and construction materials and the Hungarian mining industry produces hydrocarbons, coals, industrial minerals and construction materials.
However, the environmental risks involved in these activities continue to raise concerns throughout the region as many mining sites are significant sources of pollution and the development of additional mines is envisaged.

The manufacture of basic metals is an important sector in the Slovak Republic with a steel company in Kosice. **The chemical industry** operates mostly in the Upper and Middle Tisza in Hungary (Miskolc and Szolnok regions), in northern Romania (Cluj-Napoca) - only pharmaceutical industry - and in the southern part of the Slovak Republic (Presov region). In recent years, production has been reduced because of the lack of market demand in Eastern Europe. **The petrochemical industry**, including oil refinery, storage and transport (pipelines), is an important sector in the Hungarian and Ukrainian parts of the Tisza River Basin.

The cellulose and paper industry is present in the Upper Tisza River Basin in the Slovak Republic, Romania and Ukraine, and the cellulose industry in Romania and Ukraine. The **food industry** is mainly located in the Middle Tisza, although it is also a locally important sector in Ukraine and Serbia. Production has also been reduced in the last decade.

The textile industry has developed quickly in the Tisza River Basin due to the rapid transfer of technology and expertise. Since 1999, Romania has been the Central and Eastern European leader in textile exports to EU countries. The increasing demand for textile products represent an opportunity to augment the land surfaces cultivated with flax and hemp, crops that are well adapted to the climatic conditions of the Tisza River Basin. Use of modern technology reduces the textile industry's impact on the environment.

The furniture industry is one of the few economic sectors that maintained a positive trade balance after 1990 and shares an important part of the industrial output in the Romanian and Ukrainian parts of the Tisza River Basin. Important investments are needed in order to implement integrated production cycles to avoid the degradation of the environment due to subsidiary products, such as sawdust. A number of related industries are represented in the Tisza River Basin, such as leather goods, porcelain and pottery, which is a large energy consumer.

3.6.2.3. Navigation

The Tisza River is used as a waterway from the Ukrainian-Hungarian border to the confluence with the Danube – over 70% of the river's total length. Some Tisza tributaries are navigable on shorter sections: the Bodrog River (along Hungarian stretch and 15 km in the Slovak Republic), the Mures River (25 km, or less than 5% of its total length), the Körös River (115 km in Hungary) and the Bega/Begej River (presently 75 km in Serbia and 45 km in Romania before 1967).[8]

The regime of navigation on part of the Tisza River, from the Danube confluence to Tokaj, is set by bilateral agreement signed in 1955 by Yugoslavia and Hungary. The agreement enacted a commitment for common works on the waterway maintenance and upgrade, but waterway category and navigational conditions were not prescribed.

The adoption of the European Agreement on Main Inland Waterways of International Importance (AGN) in 1996 included the navigable waterway on the Tisza River up to Szeged in the European network as an international waterway. This requires the fulfilment of required criteria for class IV waterways, including required water way depths between 2.5 and 2.8 m and a minimal width of 75 m. These conditions can be achieved along the Serbian part (with the exception of some short stretches in sharp bends, accounting for less than 2% of the total length) at low of 95% duration, being approximately 175m^3/s.

3.6.2.4. Hydropower generation in the Tisza River Basin

There are about 35 hydropower stations within the Tisza River Basin with an output of greater than 10 MW. The total capacity of these stations is over 1.7 GW see **Table I.6**.

[8] Danube Basin Analysis (WFD Roof Report, 2004)

Table I.6. The Installed capacity and discharges of the hydropower stations

Country	Installed capacity (MW)	Installed discharge (m^3/s)	% of the total power generation in the country
UA	32	50	0.05
RO	1535.8	2020	34.01
SK*	96.4	193	15
HU	39.5	860	0.5
RS	0	0	0
Total	1703-	3123	N/A

* Comment : SK - % of the total power generation represents year 2005. Hydro Power generation decreased from 20% in 1995 up to 15% in 2005

3.6.2.5. Forestry

Forestry is an important economic sector in the uplands of the Tisza River Basin, particularly in the Slovak Republic, Romania and Ukraine (see **MAP 7.**). Forestry practices vary from country to country and are not generally addressed in conjunction with water management issues, despite the very close links to an integrated land use management framework. The usual method of forest exploitation is selective cutting. Clear-cutting is permitted only in some forest types and limited areas.

The average share of forest cover is 26%. It is concentrated in the northern and eastern part of the basin, while there are only sporadic forest covers the Great Plain and clusters forests in the Transylvanian Plateau.

Table I.7. gives an overview on the Tisza River Basin forested areas.

Zakarpattia is one of the five regions of Ukraine with the largest forest stock area – its timber reserves and forest coverage are the largest in the country and it is hence a region rich in timber resources. At one time, relic forests covered some 76% of the Zakarpattia territory. At present this index is 40.2% though the optimum coverage rate is acknowledged to be between 50 to 63%. Forestry management is one of the main branches of industries of the region. The area of the forest stock lands constitutes 53.8% to the total area of the region. At present there is some of 0,53 hectare of forests per capita in the Zakarpattia region while this index is 0,17 ha for Ukraine . On 1 January 2001, the total area of the forest stock of the region constituted 694,000 hectares, including the lands covered by forest vegetation.

Table I.7. Forested area of the Tisza River Basin

Country	Tisza River Basin area (ha) /country	Forested area in the Tisza River Basin (ha)/country	Deciduous forests (ha)	Coniferous forests (ha)	Country forested area share of country Tisza River Basin area (%)	Countries forested area share of total forested area of Tisza River Basin (%)
UA	1,273,200	694,000	467,200	180,800	54.5	16.1
RO	7,262,000	2,294,919	1,685,385	368,888	31.6	53.2
SK*	1,524,700	622,940	475,662	147,279	40.8	15.5
HU	4,621,300	683,025	No data	No data	14.8	15.8
RS	1,037,400	17,460	No data	No data	1.7	0.4
Total	15,718, 600	4,312,344	N/A	N/A	-	100

** - size of deciduous forest in SK comprises deciduous and mixed

Forest logging is one of the main economic activities in the uplands and along the lowlands of the Tisza River Basin. The increased economic reliance on forestry has been exacerbated by a decline in work opportunities in transitional economic systems. The conventional approach to forestry management, focused on trees rather than ecosystems, resulted in significant environmental impacts. Currently, the intensity of logging is having negative impacts on the retention capacity of the landscape, which in turn, may exacerbate the flooding problem. Deforestation also endangers the water quality of the Tisza River and its tributaries, and impacts biodiversity through the loss and change in habitats. In addition, there is a lack of sustainable techniques for forest logging, and inappropriate equipment used for logging as well as for afforestation endangers the future of forestry in the region. Unsustainable logging in mountainous areas also increases the propensity for landslides, endangering human settlements.

3.6.2.6. Tourism

The Tisza River Basin has a complex and valuable tourism potential, as well as diversified tourism facilities. The main limitation for this sector's development is poor infrastructure and, for the most part, very low development in terms of standards, skills and expertise. Transportation, lodging and accommodation facilities need to be developed in order to make use of the natural potential of the region.

The Carpathian Mountains, which occupy large areas in the Slovak Republic, Ukraine and Romania, have been identified as a possible region for tourism development. Geomorphologic landscapes with a great natural potential, such as the Apuseni and Retezat Mountains National Parks and the Pietrosul Rodnei Biosphere Reserve (all in Romania), have long attracted hikers and skiers to the mountains. Salt mines and lakes as well as thermal mineral water springs provide the basis for health tourism. In addition, efforts have been made in recent years to develop fishing (in the Middle Tisza) and rural tourism (in the Maramures), but their development has been slow.

In general, the urban tourist infrastructure in the Tisza River Basin region is dominated by hotels of various levels and capacities, concentrated in the main cities of the region. Small-scale tourist accommodation, like motels and camping sites, are situated along the major roads, and cabins are found in the mountains. In addition, there is a modest system of family-owned rural pensions, related to the rural habitat.

There are also several monuments in the Tisza River Basin region which are impressive architecturally and historically, such as the cultural-historical sites and treasures of medieval towns and museums and Dacian and Roman ruins in the Romanian area of the Tisza River Basin.

Tourism plays an important role in this part of Ukraine. The Carpathians and Crimea are the most popular tourist destinations for Ukrainians. Landscape diversity, close proximity to the border with Hungary, Romania, the Slovak Republic and Poland and the cancellation of visa requirements make it increasingly attractive for foreign tourists. The region is famous for many spa resorts, and ski tourism is well developed in the Carpathians. During recent years, many small hotels have been opened. Nevertheless, the tourism infrastructure, as well as roads and border check points, must be developed.

In the Slovak Republic the Zemplinska Sirava Reservoir benefits from international water tourism and the Palcmanska Masa, Ruzin and Domasa Reservoirs are nationally significance. Recreational fishing is popular on many smaller reservoirs and stretches of rivers. Caves also draw visitors, including the Ochtinská, Gombasecká, Domica, Jasovská, Dobšinská and Ľadová caves. Two significant spas are located in the Slovak Republic: the balneoterapeutic spa in Bardejov and the climatic spa in Štos. Mountains provide hiking and skiing opportunities, mainly in Upper and Middle Hornad and Hnilec.

The National Regional Development Plan of Hungary considers tourism to be one of the priority sectors in the country, including four distinguished parts of the Hungarian Tisza Valley, such as:

- recreational sub-region of high priority (Mátra-Bükk mountains, including 69 settlements),
- recreational sub-region (Budapest surroundings, Upper-Tisza section, Middle-Tisza section, Szolnok Tisza section, Tisza-Körös aea, Cserhát and surroundings, Zemplén, Aggtelek and surroundings, with 478 settlements),
- areas with recreational capacity,
- areas without recreational capacity.

Hunting is possible in several locations, and many animal species exist locally that are no longer found in other parts of Europe. Fishing is popular on natural rivers (such as the Tisza and Timis), canals, lakes and ponds (such as the Ecka, Ribar in Novi Knezevac and Orom).

In addition, ecotourism and spa tourism are rapidly developing.

Part II – Water Quality

4. Characterisation of surface water bodies

4.1. Identification of surface water categories

The first step in the analysis is the identification of the surface water categories.

The following surface waters have been selected for the basin-wide overview:

- all rivers, heavily modified waters with a catchment size grater than 1 000 km²
- all natural lakes with an area greater than 10 km²
- artificial water bodies, which are mainly canals

List of surface water bodies, which have been evaluated in these chapters are given in **ANNEX 5**.

4.2. Surface water types and reference conditions

4.2.1. Ecoregions in the Tisza River Basin

The Tisza River Basin covers two ecoregions (see **Table II.1).** Ukraine, Romania and the Slovak Republic have territories in both ecoregions. The Hungarian and Serbian parts of the Tisza River Basin belong to ecoregion 11 (Hungarian Lowland).

Table II.1 **Ecoregions in the Tisza River Basin**

Ecoregion	Countries with territories in the Tisza River Basin
10 – The Carpathians	Ukraine, Romania, the Slovak Republic
11 – Hungarian Lowlands	Ukraine, Romania, Hungary, the Slovak Republic, Serbia

In three countries – Hungary, Ukraine and Romania – ecoregions were divided into smaller geographical regions to address differences in river types based on diverse landscape features or variation in the natural vegetation or aquatic communities.

Hungary subdivided ecoregion 11 (Hungarian Lowland) into five sub-ecoregions based on the topography and the (hydro-)geochemical character of the region. Physical-geographical zoning commonly used in Ukraine based on landscape – genetic approach correspond to ecoregions. For the eastern part of the ecoregion 10 (The Carpathians) the sub-ecoregion `Ukrainian Carpathians physical-geographical province (including 4 physical-geographical regions)`was delineated. For the ecoregion 11 (Hungarian lowland) the sub-ecoregion `Zakarpattia lowlands physical-geographical region was delineated. Romania introduced a new sub-ecoregion within ecoregion 10, the Transylvania Plateau, an inner mountain area that shows differences in altitude, geomorphology and in the macroinvertebrate communities. For this reason two sub-ecoregions or bio-ecoregions were delineated for ecoregion 10 and six for ecoregion 11 (see **Table II.2**).

Table II.2 **Sub-ecoregions or bio-ecoregions in the Tisza River Basin**

Ecoregion	Country	Sub-ecoregions or bio-ecoregions
10	**Ukraine**	Ukrainian Carpathians physical-geographical province ; Vododilno-Verkhovynsky, Polonynsko- Chornogorsky, Rakhivsko-Chivchinsky and Volcanic Intermountain physical-geographical regions
	Romania	Carpathian Intramountain area
11	**Ukraine**	Ukrainian Carpathians physical-geographical province ;Zakkarpattia lowlands physical-geographical region
	Hungary	Mountainous regions with calcareous character
		Mountainous regions with siliceous character
		Hilly regions with calcareous covering layers
		Plains with calcareous covering layers
		Peaty areas

4.2.2. Rivers

4.2.2.1. Typology of the rivers in the Tisza River Basin

Typology Systems used in the Tisza River Basin

Most countries in the Tisza River Basin (Ukraine, Romania, Hungary and Serbia) applied System B according to Annex II of the Water Framework Directive (WFD). Only the Slovak Republic used System A.

The common factors used in all Tisza River Basin typologies are the obligatory factors of System A: ecoregion, altitude, catchment area and geology (see **Table II.3**). But most of the countries amended the classification according to their national requirements. Their use in the Tisza River Basin is described below.

Table II.3 **Obligatory factors used in river typologies**

Descriptor	Country	Class boundaries			
altitude	**WFD**	0-200 m	200-800 m		>800 m
	Ukraine	0-200 m	200-800 m		>800 m
	Romania	0-200 m	200-500 m	500-800 m	>800 m

Descriptor	Country	Class boundaries				
	Hungary	0-100 m	100-200 m	200-500 m	>500 m	
	Slovak Republic	0-200 m	200-500 m	500-800 m	>800 m	
	Serbia	0-200 m	200-500 m	500-800 m	>800 m	
catchment area	**WFD**	10-100 km^2	100-1,000 km^2	1,000-10,000 km^2	>10,000 km^2	
	Ukraine	10-100 km^2	100-1,000 km^2	1,000-10,000 km^2	>10,000 km^2	
	Romania	10-100 km^2	100-1,000 km^2	1,000-10,000 km^2	>10,000 km^2	
	Hungary	10-200 km^2	100-2,000 km^2	1000 -12,000 km^2	>10,000 km^2	
	Slovak Republic	10-100 km^2	100-1,000 km^2	>1,000 km^2		
	Serbia	10-100 km^2	100-1,000 km^2	1,000-4,000 km^2	4,000-10,000 km^2	>10,000 km^2
geology	**WFD**	siliceous	calcareous	organic		
	Ukraine	siliceous	calcareous	organic		
	Romania	siliceous	calcareous	organic		
	Hungary	siliceous	calcareous	organic		
	Slovak Republic	mixed				
	Serbia	siliceous	calcareous	organic		

Altitude

Ukraine applied the size-classes according to Annex II of the WFD. The other countries set an additional class boundary at 500 m. Since most of the Hungarian territory is located in the lowlands, class boundaries were adapted in this regard.

Catchment area

In general, the size classes of System A were applied. Hungary, the Slovak Republic and Serbia introduced other class boundaries than those suggested in the WFD. Hungary established overlapping class boundaries accounting for the continuous changes observed in natural systems. Large rivers were not differentiated into several size classes in the Slovak Republic. All rivers greater than 1,000 km^2 were pooled in one size-class. Serbia defined an additional catchment area boundary at 4,000 km^2.

Geology

The WFD delineates three main categories for geology: siliceous, calcareous and organic. These categories were refined by most of the countries. The Slovak Republic only used the category ‘mixed’ in their typology system.

Optional factors

Countries using System B used different optional factors to further describe the river types. With six descriptors Romania employed the highest number of optional factors (mean water slope, river discharge category, mean substratum composition, mean air temperature, precipitation and yearly minimum specific monthly flow with 95% probability). All other countries used mean substrate composition as the only optional factor within their System B typology (see **Table II.4**).

Channel substrate is defined differently by the countries. Both Ukraine and Romania specified the substrate diameter (d) to differentiate size classes, but boundaries were different: Romania defined blocks with d >200 mm, boulders with d = 70 to 200 mm, gravel with d = 2 to 70 mm, sand with d = 0.05 to 2 mm, silt with d = 0.05 to 0.005 mm and clay with d <0.005 mm. Ukraine delineated gravel and pebble with d < 70 mm, pebble and boulder with d = 70 to 150 mm and boulder with d > 150 mm. Hungary and Serbia differentiated the substrate size classes ‘fine’, ‘medium’ and ‘coarse’. For the Hungarian system fine substrates are ‘mud’, medium substrates are ‘sand’ and coarse substrates are ‘cobbles and pebbles’. In Serbia a mixture of clay, silt, sand and gravel is fine substrate, a mixture of sand, gravel and cobbles is medium substrate and gravel, cobbles and boulders constitute coarse substrates.

Table II.4 **Optional factors used in the river typologies by countries using System B**

<table>
<tr><th>Descriptor</th><th>Country</th><th colspan="6">Class boundaries</th></tr>
<tr><td>mean water slope</td><td>Romania</td><td colspan="2"><10 p.m.</td><td colspan="2">10-40 p.m.</td><td colspan="2">>40 p.m.</td></tr>
<tr><td>river discharge[9]</td><td>Romania</td><td colspan="2">high:
>30 l/s km^2</td><td colspan="2">average:
3-30 l/s km^2</td><td colspan="2">minimum:
<3 l/s km^2</td></tr>
<tr><td rowspan="4">mean substratum composition</td><td>Ukraine</td><td colspan="2">gravel-pebble</td><td colspan="2">pebble-boulder</td><td colspan="2">boulder</td></tr>
<tr><td>Romania</td><td>blocks</td><td>boulders</td><td>gravel</td><td>sand</td><td>silt</td><td>clay</td></tr>
<tr><td>Hungary</td><td colspan="2">coarse</td><td colspan="2">medium</td><td colspan="2">fine</td></tr>
<tr><td>Serbia</td><td colspan="2">coarse</td><td colspan="2">medium</td><td colspan="2">fine</td></tr>
<tr><td>mean air temperature</td><td>Romania</td><td colspan="2">high: >8 °C</td><td colspan="2">average: 0-8 °C</td><td colspan="2">low: <0 °C</td></tr>
<tr><td>precipitation</td><td>Romania</td><td colspan="2">abundant:
>800 mm</td><td colspan="2">average:
500-800 mm</td><td colspan="2">reduced:
<500 mm</td></tr>
<tr><td>yearly minimum specific monthly flow with 95% probability</td><td>Romania</td><td colspan="2">high:
>2 l/s km^2</td><td colspan="2">average:
0.3-2 l/s km^2</td><td colspan="2">minimum:
<1 l/s km^2</td></tr>
</table>

4.2.2.2. Typology of the Tisza River

The Tisza flows through or borders on the territories of five countries: Ukraine, Romania, Hungary, the Slovak Republic and Serbia. These countries divided the Tisza River into eight types (see **Table II.5**) and the typologies of the Tisza River were individually developed by the countries. Adjustment or harmonisation on the international level has not yet been completed. Therefore, five types were identified for the Upper Tisza: Ukraine delineated three types and both Romania and the Slovak Republic one type. For the Middle Tisza two types were delineated by Hungary, and for the Lower Tisza one type was delineated by Serbia.

As a future step, types must be further agreed upon between the border countries.

[9] In case of Romania - the multiannual mean specific flow

Table II.5 **Stream types defined for the Tisza River**

Country	Name of the types
Ukraine	UA_2C: Large rivers, low mountains, calcareous
	UA_1C: Large rivers, lowland
	UA_1D: Very large river, lowland
Romania	RO_06: Stream sector with wetlands in hilly or plateau area
Hungary	HU_14: Very large calcareous lowland stream
	HU_20: Very large calcareous lowland river
Slovak Republic	P1V_B1Large streams in Hungarian lowland
Serbia	RS_Typ1.1: Very large rivers, lowland, siliceous, fine sediments

4.2.2.3. Typology of the relevant tributaries in the Tisza River Basin

In total, 40 stream types have been defined at relevant rivers of the Tisza River Basin with catchment greater than1,000 km² (see **Table II.6**). All stream types at relevant rivers are listed in **ANNEX 6** . This includes the eight types for the Tisza River itself.

Table II.6 **Number of stream types defined in the Tisza River Basin**

Country	Number of stream types defined for the relevant rivers in the Tisza River Basin
Ukraine	7
Romania	12
Hungary	11
Republic Slovak	7
Serbia	3
Total number of types	40

The types of the Tisza River Basin are evenly distributed on both ecoregions (see **Table II.7**). Only three types were delineated for the altitude class of greater than 800 m. The other types were described for the low and medium altitude range. For each small, medium and large river the same approximate number of types was defined, considering that small and medium-sized rivers are merged in the Romanian typology. For very large rivers only four types were differentiated. The ratio siliceous to calcareous stream types is approximately 1:1, only a few types were described as being of mixed geology.

Table II.7 **Number of types per ecoregion, altitude, catchment size and geology class**

<table>
<tr><th rowspan="2"></th><th colspan="5">Countries</th><th rowspan="2">Total number</th></tr>
<tr><th>Ukraine</th><th>Romania</th><th>Hungary</th><th>Slovak Republic</th><th>Serbia</th></tr>
<tr><td colspan="7">Ecoregion</td></tr>
<tr><td>Ecoregion 10</td><td>5</td><td>7</td><td>-</td><td>6</td><td>-</td><td>18</td></tr>
<tr><td>Ecoregion 11</td><td>2</td><td>5</td><td>11</td><td>1</td><td>3</td><td>22</td></tr>
<tr><td colspan="7">Altitude</td></tr>
<tr><td><200 m</td><td>2</td><td>5</td><td>8</td><td>1</td><td>3</td><td>19</td></tr>
<tr><td>200-800 m</td><td>3</td><td>6</td><td>3</td><td>6</td><td>-</td><td>18</td></tr>
<tr><td>>800 m</td><td>2</td><td>1</td><td>-</td><td>-</td><td>-</td><td>3</td></tr>
<tr><td colspan="7">Catchment size</td></tr>
<tr><td>small rivers</td><td>2</td><td rowspan="2">5</td><td>3</td><td>2</td><td>-</td><td rowspan="2">20</td></tr>
<tr><td>medium-sized rivers</td><td>2</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>large rivers</td><td>2</td><td>7</td><td>3</td><td>3</td><td>1</td><td>16</td></tr>
<tr><td>very large rivers</td><td>1</td><td>-</td><td>2</td><td>-</td><td>1</td><td>4</td></tr>
<tr><td colspan="7">Geology</td></tr>
<tr><td>siliceous</td><td>-</td><td>12</td><td>-</td><td>-</td><td>3</td><td>15</td></tr>
<tr><td>calcareous</td><td>7</td><td>-</td><td>11</td><td>-</td><td>-</td><td>18</td></tr>
<tr><td>organic</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0</td></tr>
<tr><td>mixed</td><td>-</td><td>-</td><td>-</td><td>7</td><td>-</td><td>7</td></tr>
</table>

4.2.2.4. Reference conditions

Annex II 1.3 (i) of the WFD prescribes that for each surface water type, type-specific hydromorphological and physico-chemical conditions shall be established representing the values of the hydromorphological and physico-chemical quality elements specified for that surface water type at high ecological status. Type-specific biological reference conditions shall be established, representing the values of the biological quality elements for that surface water type at high ecological status.

The Danube River Basin countries agreed on general criteria as a common base for the definition of reference conditions (see **Annex 7**). These have then been further developed by the countries of the Tisza River Basin on the national level into type-specific reference conditions.

The definition of reference conditions was based on the following approaches:

- spatially based approach using data from monitoring sites,
- approach based on predictive modelling,
- definition of temporally based reference conditions using either historical data or palaeo-reconstruction, or
- use of expert judgement (where none of the above methods were possible).

Spatially based reference conditions and expert judgement were the two methods predominantly used in the Tisza River Basin. Methods were also combined to derive reference conditions.

Use of spatially based data from monitoring sites

The method is based on the use of existing sites of high ecological status. In the Tisza River Basin (as in other European river basins) only a few reference sites are available which fulfil all the criteria mentioned in **ANNEX 7.** Especially in the lowland, and for large rivers, undisturbed reference sites no longer exist. Therefore, the description of reference conditions was based on best available sites for these types. This method was used by all countries to describe the reference conditions for benthic invertebrates, phytoplankton and the fish fauna.

Use of expert judgement

In addition to spatially based reference sites, most countries applied expert judgement for deriving reference conditions for respective biological quality elements and the physico-chemical and hydromorphological elements.

Historical reconstruction

Historical data were frequently applied to define reference conditions for benthic invertebrate communities, the fish fauna and hydromorphology.

Predictive modelling

Predictive modelling was used to define macrozoobenthos and phytobenthos reference conditions in the Slovak Republic. Ukraine and Serbia applied this approach for defining the physico-chemical aspect of the references.

Biological quality elements

The Tisza River Basin countries defined reference conditions for all relevant biological quality elements, however ‘macrophytes and phytobenthos’ were not described by Ukraine (**Table II.8**).

The Tisza River Basin countries used different indicative parameters to describe the reference conditions for **phytoplankton**: Taxonomic composition was applied by all countries. Abundance is considered by all countries except Ukraine. The Slovak Republic additionally used phytoplankton biomass. The Saprobic Index applied to phytoplankton taxa is used by Romania for reference definition.

For the biological element ‘**macrophytes and phytobenthos**’ all countries, except Ukraine, defined the reference conditions for taxonomic composition and abundance. Romania defines reference conditions for phytobenthos; the description of macrophytic references is under development. Hungary used abundance only for macrophytes, while Serbia defined this parameter only for phytobenthos. Furthermore, Serbia added the parameter diversity to the description of reference state.

The variables of taxonomic composition, abundance, diversity and the ratio sensitive to insensitive taxa were used by all countries to define reference conditions for **benthic invertebrates**. Romania defines type-specific reference values for the Saprobic Index and for various other metrics, such as the total number of taxa, percent of Plecoptera taxa and the Mayfly Average Score.

Reference values for the **fish fauna** were used by all countries, but different indicative parameters were applied: Taxonomic composition was defined by all countries. Age structure was considered by Romania, Hungary and Serbia. In addition Serbia described fish diversity in reference state. The ratio ‘sensitive to insensitive fish taxa’ was applied by Ukraine and Romania. In the Slovak Republic the definition of fish fauna references is in preparation.

The **hydromorphological** and **physico-chemical** reference conditions for rivers were defined by Ukraine, Hungary and Serbia. For both the Slovak Republic and Romania the definition is still under development.

Table II.8 **Definition of reference conditions for different indicative parameters of biological quality elements (x – parameter applies to quality element)**

		taxonomic composition	abundance	diversity	sensitive to insensitive taxa	age structure	biomass
Ukraine	Phytoplankton	x			x		
	Macrophytes and Phytobenthos						
	Benthic Invertebrates	x	x	x	x		
	Fish Fauna	x			x		
Romania	Phytoplankton	x	x				
	Macrophytes and Phytobenthos	x	x				
	Benthic Invertebrates	x	x	x	x		
	Fish Fauna	x	x		x	x	
Hungary	Phytoplankton	x	x				
	Macrophytes and Phytobenthos	x	x[1]				
	Benthic Invertebrates	x	x	x			
	Fish Fauna	x	x			x	
Slovak Republic	Phytoplankton	x	x	x	x		x
	Macrophytes and Phytobenthos	x	x	x	x		
	Benthic Invertebrates	x	x	x	x		
	Fish Fauna	x	x				
Serbia	Phytoplankton	x	x	x			
	Macrophytes and Phytobenthos	x	x[1]	x			
	Benthic Invertebrates	x	x	x			
	Fish Fauna	x	x	x		x	

[1] only Macrophytes

4.2.3. Lake typology

The elaboration of lake typology is in progress.

4.3. Identification of surface water bodies

4.3.1. Water bodies in rivers

According to Annex II 1.1 WFD “*Member States shall identify the location and boundaries of bodies of surface water…*”. “*A body of surface water means a discrete and significant element of surface* *water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water"* (Art. 2. 10. WFD).

Water bodies must be clearly identified, and certain rules apply for their delineation. For this initial characterisation water bodies may also be aggregated to form groups of water bodies of similar character. The surface water categories have been identified in **Chapter 4.1.** The water bodies described here refer to the Tisza River Basin overview map (see **Map 1**), such as to those relevant on the basin-wide level. All other water bodies are dealt with in detail in the National Reports (Part B). Ukraine has not finalised the identification of water bodies.

Some 16 water bodies were identified on the Tisza River. The number of water bodies on the Tisza varied per country – seven delineated on the Hungarian part of the Tisza and only one on the Romanian and Slovakian part. This means that the size of the water bodies also varies significantly. The smallest water body on the Tisza is only 5 km long (Slovak Republic) and the longest is 159 km (Hungary). **Table II.9** and **II.10** give an overview of the number of water bodies identified on rivers. So far, 203 water bodies have been identified on the tributaries on the overview scale. Romania has the largest number of water bodies but also the largest part of the basin. The mean length of water bodies is 37 km on the tributaries and 62 km on the Tisza.

Table II.9 **Number and lengths of water bodies at the Tisza River**

country	number	mean length [km]	min [km]	max [km]
Ukraine	5	35.5	13	75
Romania	1	61	-	-
Hungary	7	83.5	21	159
Slovak Republic	1	5	-	-
Serbia	2	80.5	63	98
	Σ 16			

Table II.10 **Number and lengths of water bodies at tributaries of the Tisza River Basin**

country	number	mean length [km]	min [km]	max [km]
Ukraine	17	34	6	65
Romania	100	38.5	1	142
Hungary	43	39.5	7	94
Slovak Republic	30	34	5	91
Serbia	13	39.5	13	81
	Σ 203			

4.3.2. Water bodies in lakes

Two natural lakes greater than 10 km^2 were identified on Tisza Basin wide level: the Szegedi Fehér Lake and the Füred-Kócsi Reservoir.

MAP 8 shows the surface water bodies identified in the Tisza River Basin.

4.4. Identification of significant pressures

4.4.1. Overview of significant point and diffuse source pollution

ICPDR Emission Inventories

The necessity to analyze pressures and impacts is stated in Article 5 of the WFD and requires, for each river basin district, an analysis of its characteristics, review of the impact of human activity on the status of surface waters and groundwater, and an economic analysis of water use.

Through the ICPDR emission inventories many input parameters have to be collected at a specific investigation area based on reporting requirements covering all potential sources of pollution to water and types of sectors (municipal, industrial and agro-industrial).

The ICPDR uses a systematic approach in line with EU regulations to collect and calculate emission data for the whole Danube River Basin to create a system which is able to compile emission inventories basin-wide and deliver results in easily accessible and user-friendly forms.

Point sources of pollution

The same approach used for the Roof Report for Danube Analysis 2004 has also been used for Tisza River Basin – the Tisza countries contributed data to the emission inventories for their part of the basin. The reference year of the data in the emission inventories is 2005.

The values in the emission inventories were determined as loads for individual plants, based on continuous or periodic measurements. All municipal sources with more than 10,000 PE (population equivalents) have been included in the emission inventory. The inventory of industrial discharges takes into consideration the most relevant types of industry: food, chemical, pulp and paper, fertiliser, mining, iron and steel, metal surface treatment, textile, leather industry and large agricultural plants. All direct industrial discharges, which are bigger than 2 ton/a COD or 1 ton/a BOD has been reported according to EPER[10]. All agricultural emissions from agricultural sources (farms) with more than 2,000 pigs, more than 30,000 chicken, more than 2,000 dairy cows and more than 1,000 sheep have been considered. For agricultural sources, the main parameters are: COD, BOD, NH_4-N, total P, suspended solids, total N, total dissolved solids, sulphides, detergents, phenols.

Additionally, reporting to the ICPDR List of priority substances is included.

Diffuse sources of pollution

The MONERIS (MOdelling Nutrient Emissions in RIver Systems) model allows for the estimation of nutrient emissions to the surface water on a very large geographical scale and provides quantification of nutrient emissions to the surface water at the catchments level, in order to optimally support the river basin approach. Whereas point emissions from wastewater treatment plants and industrial sources are directly discharged into the rivers, diffuse emissions into the surface waters reflect the sum of different pathways. Seven pathways are taken into consideration: point sources; atmospheric deposition; erosion; surface runoff; groundwater; tile drainage and urban surface water runoff. Estimates of diffuse sources of pollution in the Tisza River Basin would be available once the MONERIS update for 2005 is finalised.

[10] European Pollutant Emission Register (EPER), European Pollutant Release and Transfer Register (E-PRTR)

4.4.1.1. Significant point sources of pollution

The assessment of significant pressures in the Tisza River Basin is based on the ICPDR Emission Inventory for Tisza River Basin and the same criteria to define what is significant at the basin level for the Danube River Basin Roof Report 2004 have been used.

The identification criteria for the significant point sources for the basin-wide overview are given in **Table II.11**. These criteria, (refined for the Danube Roof Report 2004) refer especially to substances mentioned in Annex VIII of the WFD, to the Urban Wastewater Treatment Directive (91/271/EEC), to the Integrated Pollution Prevention and Control Directive (96/61/EC) and to the Dangerous Substances Directive (206/11/EC former 76/464/EEC).

The thresholds used for defining significant point source pollution should be further discussed and agreed upon for the Tisza River Basin.

Table II.11.: Definition of significant point source pollution on the basin-wide level[11]

Discharge of	Assessment of significance
Municipal wastewater	
Any municipal wastewater from Agglomerations with < 10,000 PE WWTPs with < 10,000 PE	Not significant
Untreated municipal wastewater from Agglomerations with > 10,000 PE	Significant
Only mechanically treated municipal wastewater from WWTPs with > 10,000 PE	Significant
Mechanically and biologically treated municipal wastewater without tertiary treatment from WWTPs with > 100,000 PE	Significant if at least one parameter is exceeded: – BOD^1 > 25 mg/l O_2 – COD^1 > 125 mg/l O_2 – N_{total}^2 > 10 mg/l N** – P_{total}^2 > 1 mg/l P
Industrial wastewater	Significant if at least one parameter is exceeded: – COD^3 > 2 t/d – $Pesticides^4$ > 1 kg/a – Heavy metals and $compounds^5$: As_{total} > 5 kg/a Cd_{total} > 5 kg/a Cr_{total} > 50 kg/a Cu_{total} > 50 kg/a Hg_{total} > 1 kg/a Ni_{total} > 20 kg/a

[11] Discussion on further criterias to define significant point source pollution in Tisza Basin wide level is under development (e.g. mechanically and biologically treated municipal wastewater without tertiary treatment from WWTPs with 10,000 PE – 100,000 PE will be also considered during further assessments)

Discharge of	Assessment of significance
	Pb_{total} > 20 kg/a Zn_{total} > 100 kg/a
Wastewater from agricultural point sources (animal farms)	Significant if at least one parameter is exceeded: N_{total}[5] > 50,000 kg/a P_{total}[5] > 5,000 kg/a

WWTP = wastewater treatment plant
[1] According to Table 1 of the EU Urban Wastewater Treatment Directive, 91/271/EEC
[2] according to Table 2 of the EU Urban Wastewater Treatment Directive, 91/271/EEC
**) Equivalent to 13 mg/l N in Germany, due to 2h-composite sample monitoring
[3] Threshold as in the EMIS inventory for industrial discharges 2000
[4] Thresholds water in kg/year as in the EPER
[5] Threshold as in the EPER (EMIS inventory for point agricultural sources 2002)

Within this report the focus of the analysis is on the significant point sources of pollution. **Table II.12** gives an overview of the significant point sources identified in the Tisza River Basin.

Table II.12: Significant pressures(point sources) in the Tisza River Basin (based on the agreed ICPDR criteria)

Countries	Municipal	Industrial	Agricultural
Ukraine	1	0	0
Romania	22	25	2
Slovak Republic	1	1	0
Hungary	11	7	0
Serbia*	16	6	0
Total	**51**	**39**	**2**

* Municipal and industrial point sources discharges for Tisza River Basin in Serbia are only estimated

Significant point source pollution from organic substances and nutrients

Table II.13. shows the results of the point source inventory for the Tisza River Basin for the year 2005 indicating the loads of COD, BOD, N and P for individual municipal wastewater treatment plants.

Table II.13: Municipal point source discharges of COD, BOD, total nitrogen and phosphorus in the TRB (based on ICPDR Emission Inventory data of 2005)

Point Source discharges from Municipal sources

Country	BOD(t/a)	COD(t/a)	N(t/a)	P(t/a)
Ukraine	558	820	145	117
Romania	12275	30092	5094	685

Point Source discharges from Municipal sources				
Slovakia	230	667	401	64
Hungary	6896	13507	2501	311
Serbia*	660	1198	15	5
Totals	**21,285**	**48,234**	**8,821**	**1,264**

* Municipal and industrial point sources discharges for Tisza River Basin in Serbia are only estimated

4.4.1.2. Significant sources of nutrients (point and diffuse) including land use patterns

Present state of the nutrient emissions from point discharges

The specific P point discharges reflect, not only the state of the P elimination in wastewater treatment plants, but also the existing use of phosphorus in detergents, and discharges from direct industrial sources, as well as the amount of the population connected to wastewater treatment plants.

According to the MONERIS modelling results of based on data representing the period from 2002 to 2004, the nutrient inputs by point sources into the surface waters of Tisza Sub-basin are:

Emissions of Phosphorus	2636 t/a P
Specific Emissions of Phosphorus	0.50 g/(inh.d) P
Emissions of Nitrogen	14044 t/a N
Specific Emissions of Nitrogen	2.67 g/(inh.d) N

Table II.14.: National average nutrient inputs by countries in the period 2002-2004

Country	P specific emissions from point sources	P – point sources	Tot P	N specific emission from point sources	N - point sources	Tot N
	g/(inh.d) P	t/y	t/y	g/(inh.d) N	t/y	t/y
Ukraine	0.26	121	684	1.06	499	14467
Romania	0.63	1171	3222	4.82	8995	46647
SlovakRepublic	0.27	142	698	1.86	969	12058
Hungary	0.59	1194	3147	1.74	3520	22738
Serbia	0.02	8	463	0.17	63	2689

These specific discharges are calculated based on the total population living within the Tisza Basin and reflect two effects: the level of nutrient elimination in the municipal and industrial wastewater treatment plants and the level of population connected to wastewater treatment plants.

Land use patterns and agricultural indicators

The Tisza River Basin is characterised by large gradients of anthropogenic and natural indicators, which are important for affecting nutrient inputs into the river system. One indicator for the level of the diffuse emissions of substances can be the land use within the basin and its regional distribution. Sources of information are results of the MONERIS application and the available CORINE land cover map.

Besides being influenced by the land use itself, the level of the emissions into the surface waters of a river system is also dependent on the intensity of the land use. Because agricultural activities are a main source for the diffuse nutrient emissions into the river system, it is important to show differences in intensity of use on a unique statistical database.

According to the FAO agricultural statistics for the individual countries for the years 1998 to 2000, the use of mineral fertilisers in agriculture in the Slovak Republic and Hungary is low to moderate, between 25 and 50 kg/ha/a N. In all other countries the level of mineral fertiliser consumption is significantly below 25 kg/ha/a N.

Total Nutrient emissions

An overview on the total emissions (point and diffuse sources) into the river system of the Tisza is given below:

Emissions of Phosphorus	8213 t/a P
Specific Emissions of Phosphorus	526 g/ha a P
Emissions of Nitrogen	98599 t/a N
Specific Emissions of Nitrogen	6.31 kg/ha a N

After MONERIS recalculations in 2007, the estimation for the origins of nutrient pollution can be summarised based on the reference year 2004 as shown in **Figure II.1**:

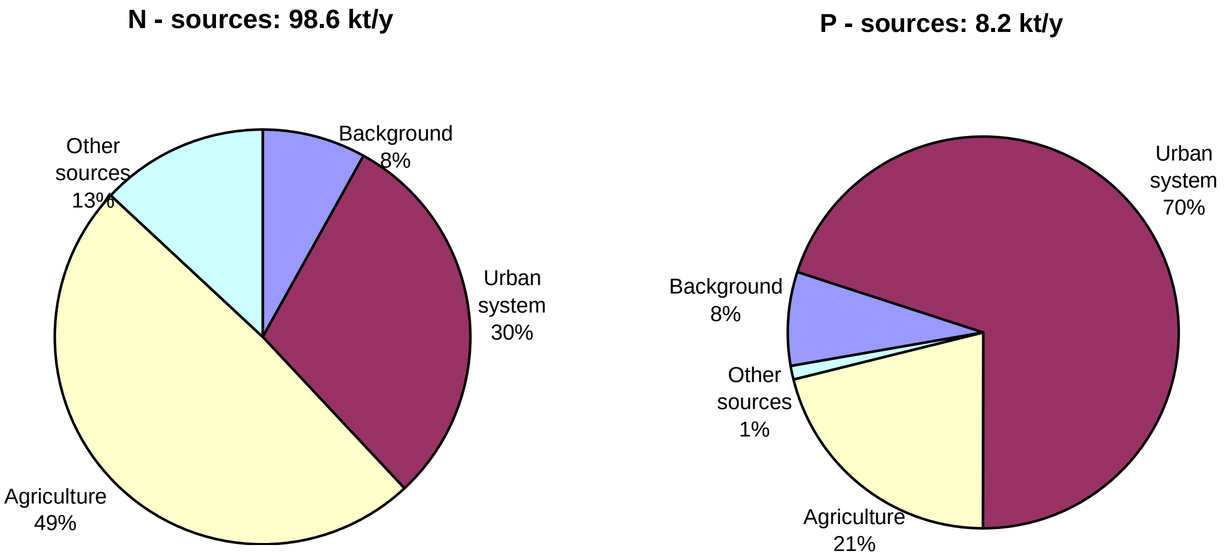


Figure II.1. Estimation of the origins of nutrient pollution after recalculations from MONERIS (2007) based on reference year 2004

Table II.15: Sum of total specific nutrient emissions into country parts of the Tisza River Basin in the period 2002-2004 from MONERIS (2007)

Country	sum specific emission	sum specific emission
	kg/ha a P	kg/ha a N
Ukraine	536	11.33
Romania	451	6.53
Slovak Republic	441	7.63
Hungary	694	5.01
Serbia	426	2.47

4.4.2. Other significant anthropogenic pressures in the Tisza River Basin

4.4.2.1. Accidental pollution

4.4.2.1.1. Analysis of Accidental Risk Spots (ARS)

Regional inventory of potential accidental risk spots in the Tisza River Basin

As a follow-up to the Baia Mare cyanide spills in year 2000, the Tisza River Basin government representatives from Romania, Hungary, Ukraine and the Slovak Republic – at a Tetra-lateral Commission meeting held in Cluj, Romania, on 23-24 May 2000 – agreed to prepare national inventories of potential accidental risk spots, including their mapping, for the Tisza Basin. The model adopted for the inventory was based on the previous classification of installations posing a danger of accidental water pollution in the Elbe catchment area. The map of potentially high-risk spots, industrial hot spots and tailing ponds in the Tisza River Basin was made in August 2000. The Accidental Risk Spots inventory was finalised in 2001 for most Danube countries and updated in 2003 with contributions from Austria and Bosnia and Herzegovina. An update of the Accidental Risk Spots inventory based on data from 2005 in now under development.

4.4.2.1.2. Accident Emergency Warning System of the Danube River Basin

The general objective of the Accident Emergency Warning System (AEWS) is to increase public safety and protect the environment in the event of accidental pollution by providing early information for affected riparian countries. Participating countries established Principal International Alert Centres (PIACs) to distribute the warning message at the international level.

The procedures for the AEWS operation are described in the International Operation Manual, which is translated into the national languages of the Danube countries. The Danube AEWS is activated in the event of transboundary water pollution danger or if warning threshold levels are exceeded. The AEWS operation has been tested many times during various Danube alerts.

4.4.2.2. Mining activities in the Tisza River Basin[12]

The subchapter gives an overview of mining activities and their related environmental impacts in the Tisza River Basin.

The mining industry is well developed in the Tisza River Basin. Mining for non-ferrous metals generates much needed income along the Somes and Mures Sub-basins, the major Romanian tributaries to the Tisza River. The mining industry has been developed in some mountainous areas like the Maramures, Gutai and Apuseni Mountains. This industry offers employment for ten thousand local inhabitants, but also constitutes a serious potential for soil and water pollution.

In Romania at present, mining activity is severely reduced as several mines are closed and other mining sites will be closed in the future. Also, according to the Romanian – EU Adhesion Memorandum/Ro-EU Common Position and to Romanian legislation, the mine waste rock storage in non ecological dumps/piles has ceased, except for a few which have obtained a transition period.

Among the riparian countries, Romania has the most developed mining and ore processing industry due to its significant deposits of copper, lead, zinc, gold, silver, bauxite, manganese and iron ore. Copper is mined in two districts in the Tisza River Basin, both in Romania. Lead and zinc are produced at underground mines in Baia Mare, Baia Borsa, Certeze - Socea and Rodna districts. The regional production of alumina was performed by the Oradea refinery (since 2006, this company has temporarily ceased its activity). Gold resources in the Tisza River Basin region are mainly concentrated around the cities of Baia de Aries, Brad, Sacarimb and Zlatna. Uranium deposits are also found in the Romanian part of the Tisza River Basin, located in the Western Carpathians (Apuseni Mountains).

Small-scale mining also occurs in the Ukrainian section of the basin, with the extraction of salt, kaolin, mercury, gold, complex ores, zeolites and rocks used as construction material. There are three types of mines in Ukraine:

- There are many mines for building materials, such as rocks, clay and sand, and they cover the entire Tisza River Basin. Their impact on water quality is not significant. The volumes of broken brick were 897,000 m^3, gravel – 20,000 m^3 and sand – 30,000 m^3 (data - 2003).
- Salt mines are located in Solotvyno in the Tisza floodplain (at the Ukrainian-Romanian reach of Tisza). The salt extraction was 132,000 tons (2003). Mining wastewaters are pumped into the Tisza River, but concentration of chlorides in the river does not exceed fishery MAC (maximum allowable concentration).
- Golden and polymetallic mine is located in Muzhievo village in the Verke River Sub basin (river Verke flows into Tisza and Latorica through the network of canals). The mine became operational in 1998 and beneficiating factory – in 1999 in 12 km from the mine. The mine is of gallery type. Only gold is extracted at the mine using gravitation method. Since opening, tailing deposit of 150,000 tons was established as well as sludge pond. Deposits and sludge have high concentrations of Pb, Cd, Zn and Mn, and their drainage into groundwater creates a problem with drinking water in weirs of nearby villages and river Verke. In 2007 activities on the mine were stopped due to low economic value (from 2000 till 2005, only 632 kg of gold have been extracted). Although the sludge pond became dry, the remaining deposits caused significant environmental threat and additional researches are needed.
- In the Borzhava Basin there were several coal mines, but they closed in the 1960s.

Mining of polymetalic ore and its processing was active in the Slovak Republic in the middle part of the Hornad River Basin - watershed – above the Ružín Reservoir (Smolník, Rudňany, Slovinky) and the upper part of the Slaná River Basin. In the beginning of 1990s these activities were terminated, and only two remain active at the present time:

[12] Information based on countries contribution as well as information from the UNEP – Rapid Environmental Assessment of the Tisza River Basin, 2004

- Rudňany (Markusovce) - production of barytes, copper and siderite extract and
- Nižná Slaná – extraction and treatment of siderite ore to final product – blast furnace pellets (the single location for such production in Middle Europe).

The mine in Rudňany is operated only one month in a year. There exist one tailing deposit – the leakage water is of quality - pH=7,7 – 8,1, Cu=0,005 mg/l, Fe=0,2 mg/l (year 2007).

In the mine Nižná Slaná project „Protection of the Environment“ was realized. In the frame of this project a changes in technology were realized – with positive effect on waste water pH. The changes enabled decreasing of discharged waste water volume and re use the waste water again in technological process. Nizna Slana is provided by two settlings reservoirs – one is used for treatment of waste waters from ore treatment (sedimentation – wish high efficiency on suspended solids), the second is an emergency settlings reservoirs, which is used for accumulation of water during time when the mine is not operated. The mine obtained an integrated permit.

In addition to the ore mines, salt mines exist in eastern part of the Slovak Republic, in Presov, and also mines for building materials.

Mining activities in the Hungarian part of the TRB dates back to medieval times when copper was mined in the Mátra hills. Ores of non-ferrous metals were extracted in this region until the 1980s.

Coal mining was typical in the Northern central range of hills (Északi-középhegység) in the 19th and 20th centuries. At present only lignite is mined in an opencast mine at Bükkábrány.

Crude oil and natural gas exploitation started in the Great Hungarian Plain in the 1960s. The yield of the oil and gas fields is declining.

Sand and gravel have been exploited from alluvial layers and pits especially in the river basins of some tributaries of the Tisza river (river Sajó and Hernád).

Raw material for lime-burning and cement industry has been quarried in the Bükk hills.

At present, the Hungarian mining industry in the Tisza River Basin produces hydrocarbons, coals, industrial minerals and construction materials. Locations of mining activities are quite evenly distributed in the territory. The Tisza alluvial provides an opportunity for a great number of permitted and illegal gravel pits.

There are no significant mining activities in the Serbian part of the Tisza River Basin, except the extraction of clay and sand for construction. There are, however, many oil and gas wells – more than 100 gas wells and 8 oil fields in Vojvodine.

There is considerable diversity among sites in the types of problems they present. Sites may have a variety of physical, environmental and public safety concerns. In countries with a long mining history the magnitude of these impacts is often considerable and the cost of ‘cleaning up’ these sites are daunting.

The largest environmental impact of mining activities is mine waters, a lasting remnant of historical and past mine activities. Mine waters are waters which flow out from an impaired environment, such as slag heaps, settling basin or liquidated mine shafts. The amount of water and its chemical composition, particularly with a content of heavy metals and low pH, can vary in dependence from hydrogeological and hydrogeochemical situation of concrete region and system of drainage. In many cases it is not possible to measure its quantity and quality, or diffuse outflow.

The environmental impact of abandoned mines may cause significant pressures on the environment, which can dramatically increase after the mine closes. Often, the impact of the mines starts immediately after the closure of the mine and cessation of the mining activities. The impacts can be extremely difficult to control, often because they are a function of depositing very large amounts of waste in ways that may not meet modern best practices. Mining produces a large volume of waste than any other industry; there are individual waste sites involving deposits of hundreds of millions or even billions of tons of material.

The environmental impact of abandoned mines in Slovak part of Tisza river basin Slovakia: **T**he most negative influence of past mine activities in Slovak part of Tisza river basin is registered in Smolník creak (the second tributary of Hornad River – above Ruzin reservoir). After closing down the mine SMOLNIK in 1990 and its flooding (it lasted around 3,5 years), the mine water flow out through one concentrated outflow from flooded shafts Pech and through several diffuse discharges directly to the Smolník creak. Amount of water depends on precipitations and general climatic conditions – it varies from 8 to 25 l/s). Mine water contains free sulphate from intensive oxidation of sulphides; it has high mineralization and extremely high content of heavy metals. According to data from 1998 – the quality was as follows: pH= 2,7 – 3, Zn = 60 mg/l, Ag= 0,01 mg/l, As = 0,04 mg/l, Sb = 0,001 mg/l, V= 0,026 mg/l, Cd = 0,03 mg/l, Cr= 0,01 mg/l, Cu = 9,8 mg/l, Al = 553 mg/l, Fe= 1483 mg/l, Mn= 140 mg/l).
Other type of waste water in this locality is drainage water from recultivated tailing deposit. This water is of different quality - pH 6,6, Cu = 0,005 mg/l, Fe = 0,3 mg/l.
In Smolnik area were realized several measures for reduction of unfavourable impact of mining water on surface water. One of them was filling the shafts with limestone and dolomite crashed stone. The measures are in responsibility of Rudné bane a.s. Banská Bystrica.

Tailings Deposits[13]: Currently, there are many old tailings dams and mine waste rock piles in the Tisza River Basin which are potential sources of heavy metal contamination by acid mine drainage. Major non-ferrous metals deposits of the Tisza River Basin contain copper, lead and zinc ores in the form of sulphides. Under aerobic conditions, sulphuric acid is formed by the oxidation of sulphides. This process results in the formation of acid mine drainage, which is a major source of chronic environmental pollution from tailings and mine wastes in the Upper Tisza River Basin. Due to the low pH of these waters (between pH 1.5 to 3.0), heavy metals such as copper, zinc, cadmium, arsenic and lead, can be leached from the rock and mobilised, causing severe contamination of surface and groundwater, soil and vegetation. Consequently, heavy metals can enter and bioaccumulate in the natural and human food chain. As the sulphide oxidation only takes place under aerobic conditions and the reaction is rather slow, acid mine drainage is mainly a long-term problem of poorly managed or abandoned mining sites (including waste rock piles and tailings ponds). In Maramures County, where the total area occupied by tailing dams is about 450 ha, the problem of acid water generation is aggravated by the high amounts of pyrite and marcasite observed in the sulphide ore, which are not separated by milling and flotation processes, and are deposited with the tailings.

A serious environmental problem occurs in old mine sites where all operational activities have ceased, but the mine has not been adequately closed. Management of abandoned sites present a problem where no owner exists, the owner cannot be identified or where the owner is not capable of meeting the costs of proper closure and decommissioning.

In Romania, by law, a company has taken over the mines closing activity and developing wastewater treatment plants, at national level.

There are cases where contaminated mine waters from old mine sites have been collected and treated. Ilba-Nistru, Campurele-Tyuzosa, Asecare and Toroioaga mines have modern wastewater treatment plants which collect about 60% of wastewaters from closed sites, with the rest discharged to nearby streams.

The main financial problems are not linked to the operation of existing wastewater treatment plants, but mainly to investments for increasing the capacity to collect the all mine water discharges.

In Romania project on '*Hazard Risk Mitigation and Emergency Preparedness project* - component D - *Risk Reduction of Mining Accidents in Tisza Basin*' is now undergoing. Component (co-financed by

[13] Information presented only for RO and HU; no information provided by UA about the tailings deposits, mine wastewater, radioactive wastes and hazardous chemicals from mining activities. In UA no separated impact assessment is available in connection to mining activities.

"Global Environment Facility" and supported by World Bank).D of the project will assist in the implementation of mitigation and hazard preventions activities to reduce the risk of water and soil contamination and loss of human and aquatic life from catastrophic mining accidental spills of pollution.

In Hungary the deposits of „drilling-lubricating sludge" originating from discovering hydrocarbons can consider as risk factors, the majority of them containing the more hazardous substances locates in the Southern part of the Great Plain, and the ones posing slighter risk on the middle and Eastern parts of the Great Plain.

The most significant water quality impact of mining was caused by extraction of non-ferrous ores.

Due to highly saline mine drainage water, it was difficult to fulfil the requirements of irrigation water in the recipients of the mine drainage water in the period of mining until the closure of the mines.

From tailing dumps acidic water has been leached contaminating soil, ground water and surface water. The deposits of flotation slurry polluted water resources with heavy metals. Remediation measures focussed on preventing precipitation from finding access to the tailings. Current problem is the polluted sediment (mainly copper, zinc and lead pollution) in the recipient water courses.

At present there are neither metal mine nor processing of tailings containing metals in operation in the catchment area of the Tisza river.

There are no storage of either sludge or materials coming from either metal processing or treatment of water from mines posing direct or real risk to the river Tisza or its side watercourses. The sludge with metal content stored in Gyöngyösoroszi, Recsk and Rudabánya may pose only indirect risk to the river Tisza in case of emergency with a low potential.

Mine Wastewater: In addition to the problem of acid mine drainage typical at old mine sites and tailings deposits, wastewater discharges from current mining and ore processing activities are also of concern in the Tisza River Basin. Several relatively new wastewater treatment plants built in 2000 and 2001 are appropriate in terms of construction and equipment endowment. In good exploitation conditions, these plants are efficient in reducing the quantities of discharged heavy metals.

Radioactive Wastes and Hazardous Chemicals from mining activities:

In the Hungarian part of the TRB, there is a radioactive landfill at Puspokszilagy, upstream the Zagyva River in the middle Tisza region. This site is considered as a pollution "hot spot" by the Regional Inventory of Potential Accident Risk Spots in the Tisza Catchment Area conducted by the ICPDR (2000).

In the Romanian part of the TRB, there are several radioactive waste deposits from uranium mining and milling. At the present the activities of radioactive mining exploitation have ceased owing mainly to the complete exploitation of the ore, works for closure, conservation and ecologisation of these areas, being underway.

Some of these mines were used for geological exploitation purposes and some were used for exploitation purposes.

The storage of hazardous chemicals, particularly obsolete pesticides, is of regional concern in the whole TRB Currently, there are no inventories available about these sites covering the TRB area as a whole.

4.5. Overview of significant hydromorphological alterations

The three categories of hydrological and morphological alterations – according to Annex II,1.4 WFD - *(1) estimation and identification of significant water abstraction for urban, industrial, agricultural* *and other uses, (21) estimation and identification of the impact of significant flow regulation, including water transfer and diversion, on overall flow characteristics and water balances, and (3) iIdentification of significant morphological alterations to water bodies* - are strongly interrelated and have therefore been summarised as "hydromorphological alterations" in the context of this report.

The hydromorphological drivers relevant on the Tisza basin-wide scale are: hydropower generation, flood defence, navigation as well as water transfer, diversion and water abstraction and are discussed in separated chapters of this report. The present chapter gives an overall picture about hydromorphological alteration relevant to the Tisza River Basin.

Hydropower generation

In the Tisza River Basin all together 37 hydropower plants are located. 35 hyropower stations of these 37 are with installed capacity > 10MW, and two additional situated in Ukraine with installed capacity < 10MW. 28 hydropower plants were built in Romania, three in Slovakia, three in Hungary and four in Ukraine. (See **Annex 14** – list of Hydropower plants in the Tisza River Basin)

Hydropower plants are mainly situated in the tributaries, only two hydropower plants were built in the Tisza River in Hungary at Tiszalök and Kisköre. Table I. 6. (**Chapter 3.6.2.4**.) gives an overview on the installed capacity and discharges of the hydropower stations.

Flood Defence Measures

Most of the larger rivers in densely populated areas are characterised by anthropogenic modifications for flood protection to secure safety for the protected areas as well as land for urban development. In many cases, hydro-engineering structures have multiple purposes often resulting in changes of the river character, e.g. straightening of a meandering or anabranching river. These changes affect not only the river itself but larger areas of the valley floor.[14]

Major systematic regulations for flood defence and navigation purposes began in the second half of the 19th century, when extensive measures of river training and flood control were taken along the river. As a results of this work approximately 30% of the total river length was shortened. In Hungary the draining of the Tisza wetlands begun in the 19th century and today some of 500,000 people (5% of the Hungarian population) live on land reclaimed from the Tisza.

Chapter 7.2. (Flood protection and drainage systems in the Tisza countries) give an overview on the river engineering works done in the Tisza Countries. Table III.3. list the dikes (flood portection structures) of the Tisza River Basin area.

Navigation

The Tisza River is used as a waterway from the Ukrainian-Hungarian border (downstream from the border towns of Chop and Záhony) to the confluence with the Danube, which over 70% of the total river length. (see also **Chapter 3.6.2.3.)**[15] Some Tisza tributaries are navigable on shorter sections: Bodrog (Hungarian stretch and 15 km in the Slovak Republic), Mures (25 km, which corresponds to less than 5% of its total length), Körös (115 km in Hungary) and the Bega/Begej River (presently 75 km in Serbia and 45 km in Romania before 1967).

Water transfer, diversion and water abstraction

In the Tisza River Basin three main canals can be found - located in Serbia and Hungary - which are playing an important role in water supply. The Danube-Tisza-Danube Canal System is situated in the Vojvodina province of the Republic of Serbia and has multi-purpose system. The Eastern and Western Main Canals are located in Hungary and are mainly used to assist with water resource distribution.

[14] Danube Basin Analysis (WFD Roof Report, 2004)

[15] Danube Basin Analysis (WFD Roof Report, 2004)

In the frame of the ICPDR Tisza Group the analysis focuses on present water uses of public water supply, agriculture (irrigation, other agricultural use), industrial purposes where the average value for three years (2002-2004) was analysed. The distribution of total water use and estimation of consumptive use between water users is given in **Figure III.1a and III.1b (Chapter 6.1. – Water uses).**

Based on a scenario analysis for the year 2015 it was estimated, that (data about planned water uses were collected and water demand in the Tisza River Basin was analysed for the year 2015) it is likely that the total annual water demand in the TRB will be about 1.5 billion m^3 in 2015, being 5.5-6% of the total annual runoff. Deeper aquifers are planned as a supply source for approximately 20% of expected water demand.

However, at this moment it is very hard to estimate water quantities which will be used for preservation of the good ecological status in rivers and canals, the increase of water use in Tisza River Basin set in national water management plans, will be an additional pressure on already endangered aquatic ecosystems. This stands in particular for irrigation, because this consumptive use takes place in low water period of the year.

4.6. Artificial and heavily modified water bodies (provisional identification)

4.6.1. Artificial water bodies

The identification of artificial water bodies (AWBs) is part of the characterisation of the River Basin District as defined in Annex II of the WFD. This section describes the AWBs identified in the Tisza River Basin, based on data collected from the Tisza countries in the form of templates (HMWB/AWB Templates). In total, 21 AWBs were identified on tributaries of the Tisza River Basin in Romania, Hungary and Serbia. No AWBs were identified in Ukraine and the Slovak Republic. The identified AWBs amount to 10% of the total identified tributary water bodies in the Tisza Basin and have a total length of around 772 km. Serbia identified the majority of its tributary water bodies as AWBs (≈85%), due to the significant presence of canals in this lower part of the Tisza River Basin (see also information on canals in section 3.4.3 of this report). The Serbian AWBs mainly used for navigation and flood protection. In other parts of the basin, such as Romania, AWBs are also used for hydropower.

4.6.2. Provisional heavily modified surface waters

“Heavily modified water body means a body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accordance with the provisions of Annex II.” Art. 2(9) WFD.

This section provides an overview of provisionally identified heavily modified waters in the five countries of the Tisza River Basin.

4.6.3. Approach for the provisional identification of heavily modified waters

4.6.3.1. Tisza Basin-wide criteria

In the process of the provisional identification of heavily modified water bodies (HMWBs), the relevant provisions of Annex II of the WFD include the description of significant changes in hydromorphology and the assessment of whether the water body is likely to fail the good ecological status due to changes in hydromorphology. In this context, it was agreed to identify provisional HMWBs of Tisza Basin relevance that fulfil the following criteria:

1. The size of heavily modified water sections, which can include one or more heavily modified water bodies should be more than 10 km, whereby a minimum of 70% of the section should

show significant physical alterations and hydromorphological impacts, i.e. it should be heavily modified. Such a section may also include more than one physical alteration with a significant impact on hydromorphology such as a chain of successive hydropower plants or weirs over a section of more than 10 km.

2. One or more of the following main uses/measures which affect the Tisza River Basin via hydromorphological alterations should be present: hydropower, navigation, flood protection, urbanisation.
3. One or more of the following significant physical alterations (pressures) should be present: dams/weirs, channelisation/straightening, bank reinforcement/fixation. These physical alterations were selected as the main significant physical alterations linked to the uses of the above criterion. It was up to the individual Tisza countries to assess the significance of these physical alterations, based on their national approaches.
4. By expert judgement, it must be concluded that the water body is ‘at risk’ of failing to achieve good ecological status due to changes in hydromorphology. According to the WFD, this risk assessment should be based on the assessment of significant physical alterations and the assessment of the ecological status. Due to the current unavailability of appropriate biological data, indirect criteria based on physical parameters (expert judgement) were selected to conclude on the risk. The expert judgement criteria based on the impacts of the main hydromorphological pressures in the Tisza River Basin are the following:
   - obstacles not passable for migratory species (weirs/dams),
   - change of water category (e.g. change of river to dammed reservoir),
   - impoundment with significant reduction of water flow,
   - disruption of lateral connectivity, and
   - other criteria which need to be specified.

These judgement criteria allowed experts to choose the most obvious provisional HMWBs in the Tisza River Basin.

4.6.3.2. National methods and criteria

Additionally, some Tisza countries used nationally developed methods and criteria for the provisional identification of HMWBs. Relevant information on the methods of Hungary, the Slovak Republic and Romania is presented in the HMWB **ANNEX 9**. Serbia and Ukraine had no specific national criteria for provisional HMWBs at the time of writing this report. Serbia mainly used the criteria presented above. Ukraine also used this criteria combined with elements from the Slovakian and the Romanian methodology.

In general, according to the information available so far, the Tisza countries have identified provisional HMWBs using mainly physical parameters (indirect criteria), while the validation based on biological data is still pending.

4.6.4. Provisional identification of heavily modified waters on rivers

Overview of provisional HMWBs

The data summarised here were collected from the Tisza countries in the form of templates (HMWB/AWB Templates) on the basis of their national assessments. Some of the heavily modified sections meeting the agreed basin-wide criteria consisted of chains of successive HMWBs. In such cases, some of the individual HMWBs were shorter than the 10 km size threshold (see the first criterion above).
Hungary reported provisional HMWBs as either ‘modified’ or ‘possibly modified’. For the purpose of this Tisza Analysis Report, these two aspects were combined into one provisional HMWB status in the report. Slovakia reported on HMWBs and candidate HMWBs which are combined into one provisional HMWB status in the report.

All in all, a considerable part of the Tisza River and of numerous Tisza tributaries were assessed as significantly affected by hydromorphological alterations and were identified as provisional HMWBs. (**MAP 9** shows HMWBs of the Tisza River Basin - candidate HMWBs are not shown in the Map)

Main Tisza River

Eight provisional HMWBs were identified on the main Tisza River of 540 km length. The provisional HMWBs identified are equivalent to 56% of the total length of the Tisza River (of 966 km) and to 50% of the total Tisza water bodies. The provisional HMWBs on the Tisza River are concentrated in Hungary and Serbia (the middle and lower part of Tisza). (see **Table II.16.**).

It must also be mentioned that preliminary designation of the HMWBs is higher in the Tisza River than the European average. Further approach of the methodology on final designation of HMWB is under development.

Table II.16 Length and number of provisional HMWBs (pHMWBs) on the Tisza River

Country	pHMWBs [km]	% of total Tisza length	No. pHMWBs	% of total Tisza WBs	% of national Tisza WBs
UA	61	6	1	6	23
RO	61	6	1[16]	6	100
SK	5	1	1	6	100
HU	252	26	3	19	43
RS	161	17	2	12	100

Note: The numbers of pHMWBs are based on the information provided in the completed HMWB/AWB Templates.

[16] This is a ‘candidate’ HMWB. According to its national methodological approach, Romania uses three classes of HMWB (non-HMWB, candidate HMWB and provisional HMWB) based on the hydromorphological pressures and data availability.

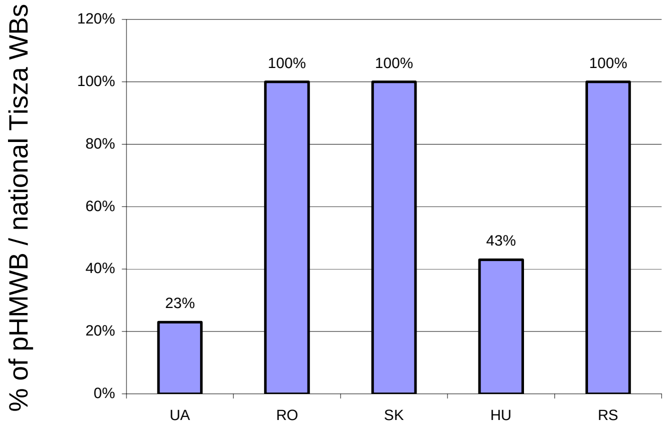


Figure II.2 Percentage of provisional HMWBs on the national Tisza water bodies in the Tisza Countries

Tisza tributaries

The 77 provisional HMWBs identified on the tributaries of the Tisza River are 2,431.77 km long. Most of the tributary provisional HMWBs lie in Romania, the Slovak Republic and Hungary (see **Table II.17**). The provisional HMWBs identified are equivalent to ≈38% of the total tributary water bodies of the basin (see also **Table II.17.)**.

From a cross-country perspective, it is interesting to note that the Slovak Republic identified up to ≈83% of its total tributary water bodies as provisional HMWBs. The high percentage of provisional HMWBs within the Slovak Republic can be explained by the fact that the main Slovakian rivers were regulated after World War II. Regulation served to provide enough water for economic development (as reservoirs for industry and hydropower generation) and for flood protection of inhabited areas. On the other hand, Ukraine identified only ≈6% of its tributary water bodies as provisional HMWBs (see **Figure II.3**). The low percentage of provisional HMWBs on the Ukrainian tributaries of the Tisza is due to the fact that rivers in Ukraine have not been very developed and are thus not significantly modified yet in their hydromorphology.

Table II.17 Length and number of provisional HMWBs on the Tisza tributaries

Country	pHMWBs [km]	No. HMWBs	% of total Tisza River Basin tributary WBs	% of national tributary WBs
UA	10.00	1	1	6
RO	746.85	33	16	33
SK	922.85	25	12	83
HU	682.07	17	8	40
RS	70.00	2	1	15
Total	2431.77	77	38	-

Note: The numbers of pHMWBs are based on the information provided in the completed HMWB/AWB Templates.

Figure II. 3. illustrates the percentage of provisional HMWBs on the water bodies of the Tisza tributaries.

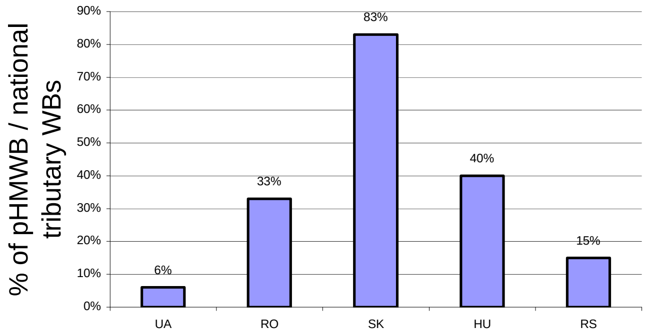
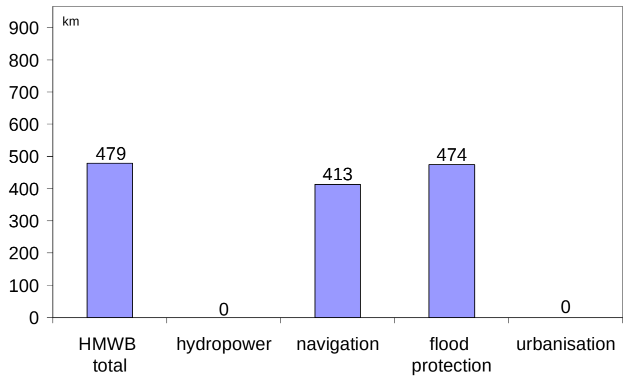


Figure II.3. Percentage of provisional HMWBs related to national tributary water bodies of the Tisza River in the Tisza countries

Uses affecting provisional HMWBs

According to Figure II.4., flood protection and navigation appear to affect almost the entire length of provisional HMWBs on the Tisza River, while hydropower and urbanisation are not linked to any of the provisional HMWBs. In Serbia and Hungary, the entire length of the Tisza provisional HMWBs are used for navigation and flood protection and, in Romania, flood protection.

On the tributaries, the main use affecting the greatest length of provisional HMWBs (see **Figure II.5.)** is flood protection, followed by urbanisation, hydropower and navigation. In Ukraine, the only provisional HMWB tributary identified is used for flood protection. In Romania and in the Slovak Republic, the greatest length of tributary pHMWBs serves flood protection, hydropower and urbanisation. In Hungary, all tributary provisional HMWBs are used for flood protection. Finally in Serbia, tributary provisional HMWBs are used mainly for flood protection and navigation and urbanisation to a lesser extent.



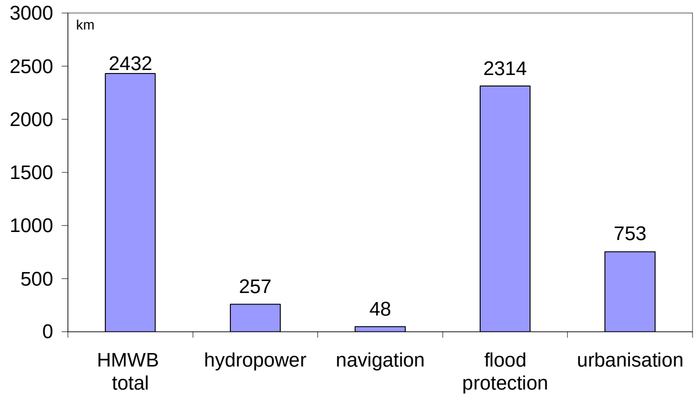


Figure II.4 Main uses/measures of provisional HMWBs on the **Tisza** River

Figure II.5 Main uses/measures of provisional HMWBs on the **tributaries** of the Tisza River

Significant physical alterations affecting provisional HMWBs

The main significant physical alterations affecting provisional HMWBs on the Tisza River are bank reinforcement/fixation and dams/weirs (see **Figure II.6.)**. In the case of the tributaries, dams/weirs are the main significant physical alterations affecting the greatest length of provisional HMWB, followed by bank reinforcement/fixation and by channelisation/straightening (see **Figure II.7.**). Ukraine's single tributary provisional HMWB is affected by channelisation/straightening. In Romania, tributary provisional HMWBs are affected to their greatest length by channelisation/straightening, followed by bank reinforcement/fixation and last by dams/weirs. In the Slovak Republic, the greatest length of tributary pHMWBs is affected by bank reinforcement/fixation, dams/weirs and finally by channelisation. Hungary's tributary pHMWBs are mainly affected by dams/weirs. Finally, Serbia's tributary pHMWBs are affected mainly by channelisation/straightening and bank reinforcement/fixation.

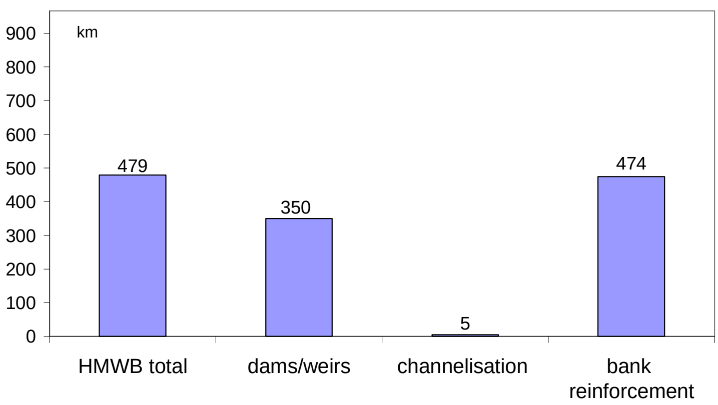


Figure II.6 Physical alterations of pHMWBs on the **Tisza** River

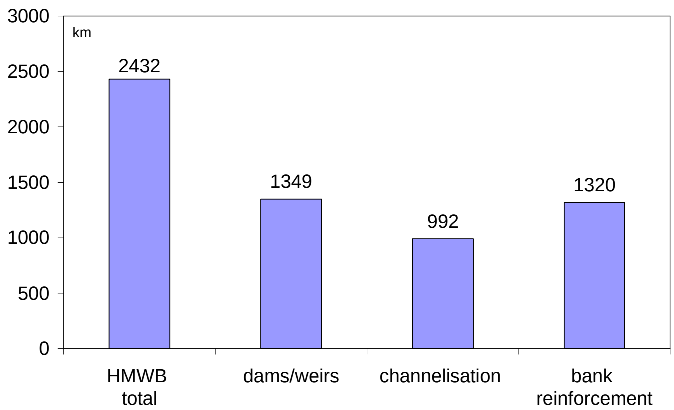


Figure II.7 Physical alterations of pHMWBs on **tributaries** of the Tisza River

Expert judgement for assessing risk of failing good ecological status

The greatest length of pHMWBs on the main Tisza River was assessed ‘at risk’ due to the disruption of lateral connectivity, followed by the presence of impoundment with significant flow reduction, the presence of obstacles not passable for migratory species, the change of water category and dredging (see the fourth pHMWB basin-wide criterion in section 4.6.3).

For the Tisza tributaries, the disruption of lateral connectivity was also the ‘risk’ expert judgement most commonly used to provisionally identify HMWBs. This was followed by the presence of obstacles not passable for migratory species, the presence of impoundment with significant flow reduction, changed discharge caused by hydropeaking or residual water discharge and the change of water category (listed in order of importance).

4.6.5. Provisional HMWBs on lakes

No data on pHMWBs related to lakes of the Tisza River Basin were collected for the purposes of this report.

4.7. Monitoring

Information on national monitoring stations in this chapter are based on data from 2005. Regarding the Transnational Monitoring Network (TNMN) chapter describes development in progress in Danube basin wide level according to the Article 8 of the EU Water Framework Directive (WFD).

4.7.1. Water quality monitoring in surface waters

According to the Article 8 of the EU Water Framework Directive (WFD) the Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin district. These programmes shall be operational at the latest six years after the date of entry into force of WFD (i.e., by December 2006). Such monitoring shall be in accordance with the requirements of Annex V of WFD.

Article 8 of the Directive establishes the requirements for the monitoring of surface water status, groundwater status and protected areas.

For surface water bodies, the Directive requires that sufficient surface water bodies are monitored in **surveillance programmes** to provide an assessment of the overall surface water status within each catchment and sub-catchment within the river basin district. For surveillance monitoring, parameters indicative of all the biological, hydromorphological and all general and specific physico-chemical quality elements are required to be monitored.

Operational monitoring is to establish the status of those water bodies identified as being at risk of failing their environmental objectives, and to assess any changes in their status resulting from specific measures. Operational monitoring programmes must use parameters indicative of the quality element or elements most sensitive to the pressure or pressures to which the body or group of bodies is subject. This means that fewer quality element values may be used in status classification.[17]

MAP 10 a of this report includes the surveillance monitoring I (SM 1), surveillance monitoring II (SM 2) and operational monitoring stations of surface waters, which are operating in the Tisza River Basin since January 2007. The design of surveillance monitoring I (SM 1) is based on WFD Annex V,

[17] Summary Report to EU on monitoring programmes in the Danube River Basin District designed under Article 8 – Part I. WFD Roof report on Monitoring - Part I: Development of WFD compliant monitoring programmes for the Danube River Basin District, 2007

1.3.1. The monitoring network is based on the national surveillance monitoring networks and the operating conditions are harmonised between the national and basin levels to minimise the efforts and maximise the benefits. Surveillance Monitoring II (SM 2) is supplementary to Surveillance Monitoring I and aims at the long-term monitoring of specific pressures of basin-wide importance. The design of operational monitoring is based on Annex V, 1.3.2. of the WFD and will be carried out at the national level. Operational monitoring will be undertaken in order to establish the status of those bodies identified as being at risk of failing to meet their environmental objectives, and assess any changes in the status of such bodies resulting from the programmes of measures. [18]

In 2005 five Transnational Monitoring Network (TNMN) stations were operating in the Tisza River Basin in Sajópüspök, Tiszasziget, Martonos, Novi Becej and Titel.

Regarding national monitoring stations in 2005 there were a total of 204 water quality monitoring stations on rivers larger than 1000 km^2 catchment area in the Tisza River Basin. **Figure I.3** indicates the distribution of the water quality monitoring stations in the Tisza River Basin countries and shows also the number of stations operated through bilateral agreements.

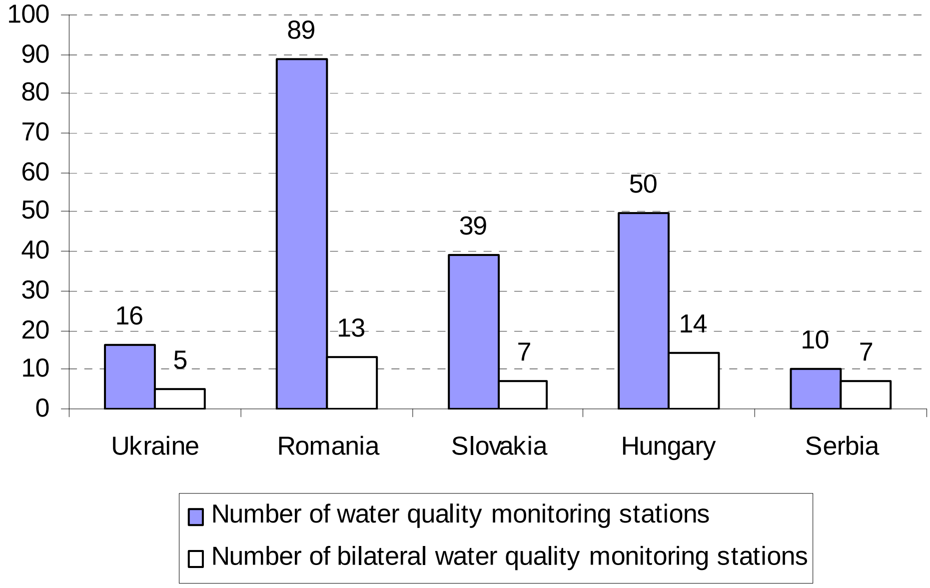


Figure II.8 Water quality monitoring stations for rivers larger than 1000 km^2 in the Tisza River Basin

4.7.2. Water quantity monitoring

There were a total of 255 water quantity monitoring stations on the surface waters of the Tisza River Basin in 2005. **Figure II.9** shows the distribution of the water quantity monitoring stations among the Tisza River Basin countries. All the stations measure water level (gauging stations). Additionally some other parameters, such as discharge or water temperature, are regularly measured at some of the water quantity monitoring stations.

[18] Summary Report to EU on monitoring programmes in the Danube River Basin District designed under Article 8 – Part I. WFD Roof report on Monitoring - Part I: Development of WFD compliant monitoring programmes for the Danube River Basin District, 2007

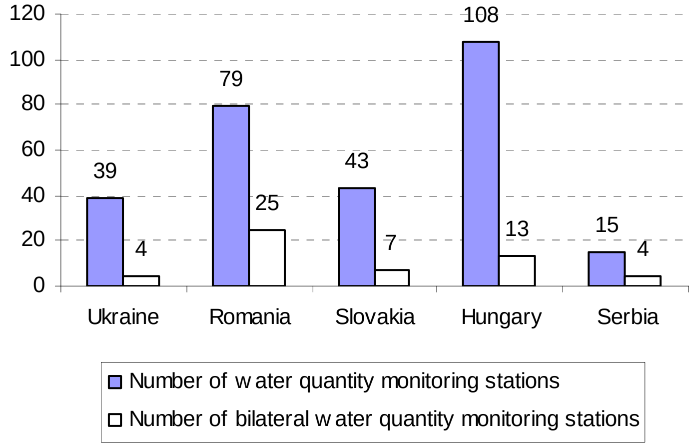


Figure II.9. Distribution of the water quantity monitoring stations among the Tisza River Basin countries

4.7.3. Groundwater monitoring

The development of the "Transnational Monitoring Network" (TNMN) of the ICPDR within the last 15 years was exclusively focussing on surface waters. Hence, this network as well as the monitoring and reporting procedures are already well established.

The transnational monitoring activities focussed on groundwater in the Danube River Basin District started in February 2002, and were triggered by the Water Framework Directive.

11 transboundary GW-bodies were identified as being of basin-wide importance and they were characterised in the "WFD Roof Report 2004". Monitoring of these selected GW-bodies is now an integral part of the TNMN.

According to WFD Art 8 Member States shall ensure the establishment of programmes for the monitoring of water status […] for groundwaters such programmes shall cover monitoring of the chemical and quantitative status.[21]

Chemical groundwater monitoring programmes are required to provide a coherent and comprehensive overview of water status within each river basin, to detect the presence of long-term anthropogenically induced trends in pollutant concentrations and ensure compliance with Protected Area objectives.

A quantitative monitoring network is required to assist in characterisation, to determine the quantitative status of groundwater bodies, to support the chemical status assessment and trend analysis and to support the design and evaluation of the programme of measures.[19]

MAP 10 b introduces the chemical and quantity groundwater monitoring stations in the Tisza River Basin. The groundwater network design is based on existing national monitoring programmes which were adapted to the requirements of Article 8 of the WFD in EU Countries. [19]

[19] Summary Report to EU on monitoring programmes in the Danube River Basin District designed under Article 8 – WFD Roof report on Monitoring - Part II: Status report: Towards the development of groundwater monitoring in the Danube River Basin, 2007

Figure II.10. indicates the number of groundwater monitoring stations in national level based on data from 2005.

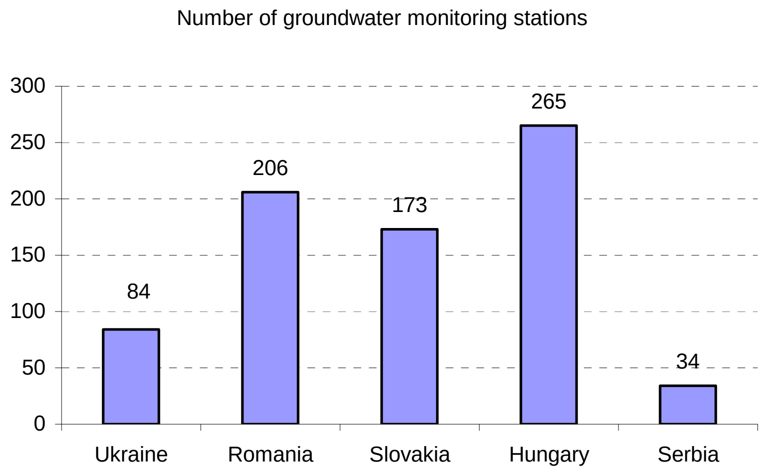


Figure II.10. Number of groundwater monitoring stations

4.8. Assessment of impacts

For the purposes of this report water quality was assessed by Romanian experts based on *National Romanian Norm for surface water classification (1146/2002)*, which represents the transposition of the TNMN assessment system into Romanian legislation.

The *target objectives* are represented by the values of the second class of the *Norm 1146/2002*, the analysis of the water status is based on the mean annual concentrations.

Data are based on the period of 2001 to 2003 and in case of Tiszasziget,Martonos, Novi Becej, Titel period of 2004 – 2005.

The chapter includes assessment of the Tisza River and main tributaries, which are originated in Romania. Tisza Group highlighted that development of common methodology on impact assessment in transboundary level as future step still has to be further considered and based on the agreed methodology further assessment would be necessary also taking into account all tributaries with surface area greater than 1000 km^2.

Water quality status assessment

For the water quality assessment the following data were used:

- data provided by the TNMN
- data provided by the Romanian National Monitoring Network
- data provided by the Joint Danube Survey-Investigation of the Tisza River 2001 (JDS-ITR)

For the spatial-temporal evolution, chemical water quality was assessed using data from the period of 2001 to 2003 from the following monitoring sites:

- Four monitoring sections/sites on the Tisza River part of the TNMN (one on the Hungarian territory (Tiszasziget) and three on the Serbian territory (Martonos, Novi Becej and Titel) – chemical water quality was also assessed using data from period of 2004-2005.
- Two monitoring sections/sites from the expeditionary campaigns on the Tisza (Novi Becej and Titel)
- Two monitoring sites on the Tisza River part of the Romanian National Monitoring Network (Valea Viseului, at the entrance of the Tisza River in Romania from Ukraine and Teceu at the exit of the Tisza from Romania).

The contribution of the Tisza tributaries has also been taken into account as follows:

- Eight transboundary monitoring sites were considered on the main Tisza tributaries (the Somes, Barcau, Crisul Repede, Crisul Negru, Crisul Alb, Bega and Mures Rivers) as part of the Romanian National Monitoring Network
- One monitoring site on the Tisza tributary Sajo (Hungary) which is part of the TNMN.

For the characterisation of the water status evaluation of organic substances, nutrients, heavy metals and organic toxic substances were taken into consideration.

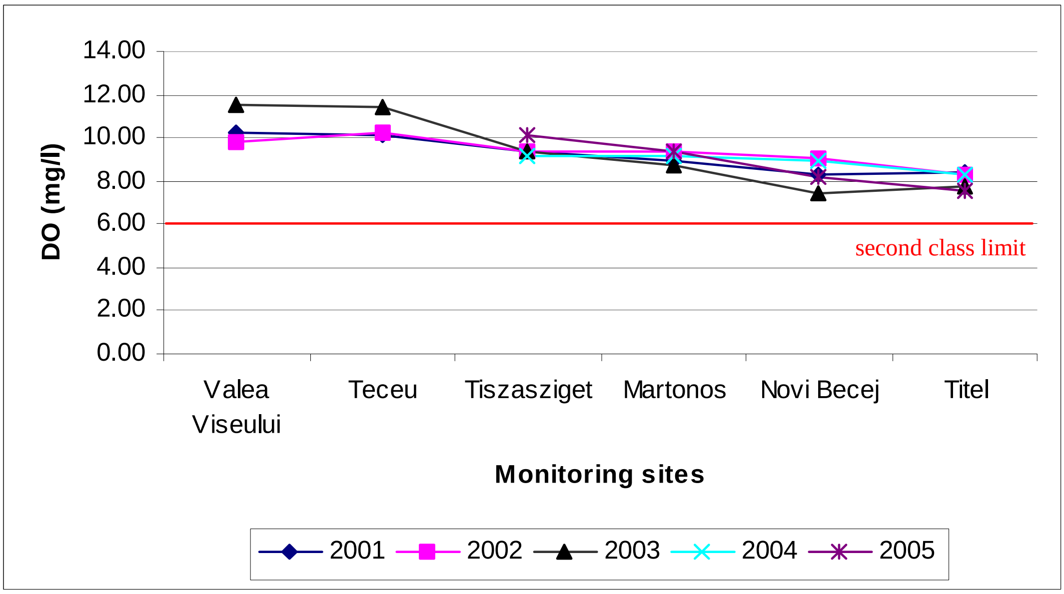
4.8.1. Organic substances

The representative parameters of water status characterisation for organic substance are: dissolved oxygen, BOD_5 and COD-Mn.

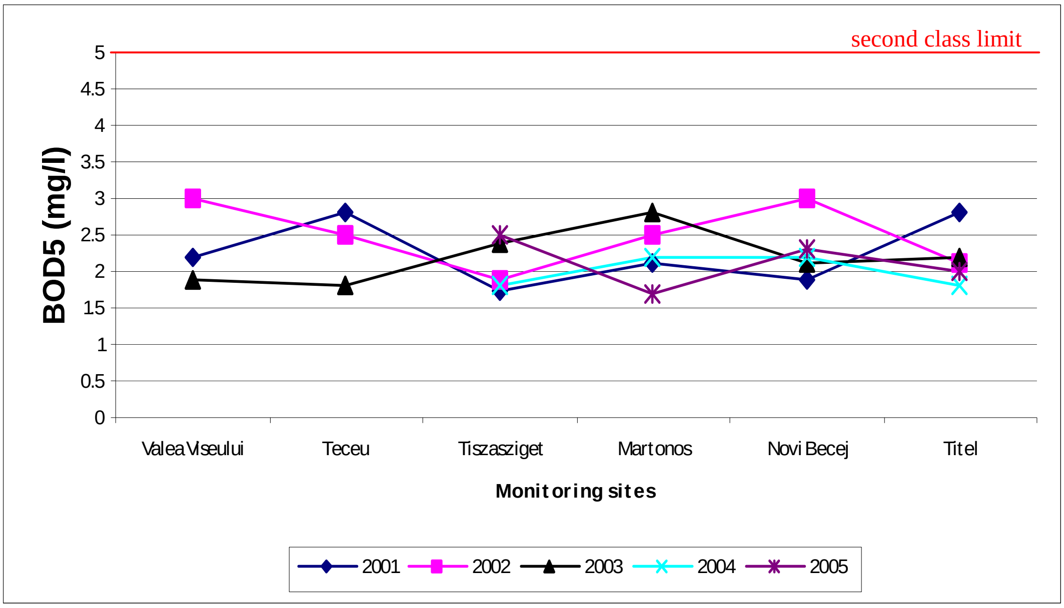
The results for the period of 2001 to 2003 (**Figure II.11**) show:

- the values of the dissolved oxygen concentrations (7,40 – 11,50 mg/l) have classified the **Tisza River** in the first class for the all monitoring sites;
- the values of BOD_5 concentrations (1,73 – 2,8 mg/l) have classified the **Tisza River** in the first class for the all monitoring sites;
- the values of COD-Mn (2,10 – 5,10 mg/l) have classified the **Tisza River mainly** in the first class for all the monitoring sites between 2001 and 2003 and in the second class in 2004 and 2005.

Similar results have been also recorded for the **Tisza tributaries**, values which belong to the first and second class, the only exception being the Dara monitoring site (on the Somes River) for which the value of the COD-Mn concentration belongs to the third quality class.



DO (mg/l)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
second class limit
Valea Viseului
Teceu
Tiszasziget
Martonos
Novi Becej
Titel
Monitoring sites
2001
2002
2003
2004
2005



BOD5 (mg/l)
5
4.5
4
3.5
3
2.5
2
15
1
0.5
0
second class limit
Valea Viseului
Teceu
Tiszasziget
Martonos
Novi Becej
Titel
Monitoring sites
2001
2002
2003
2004
2005

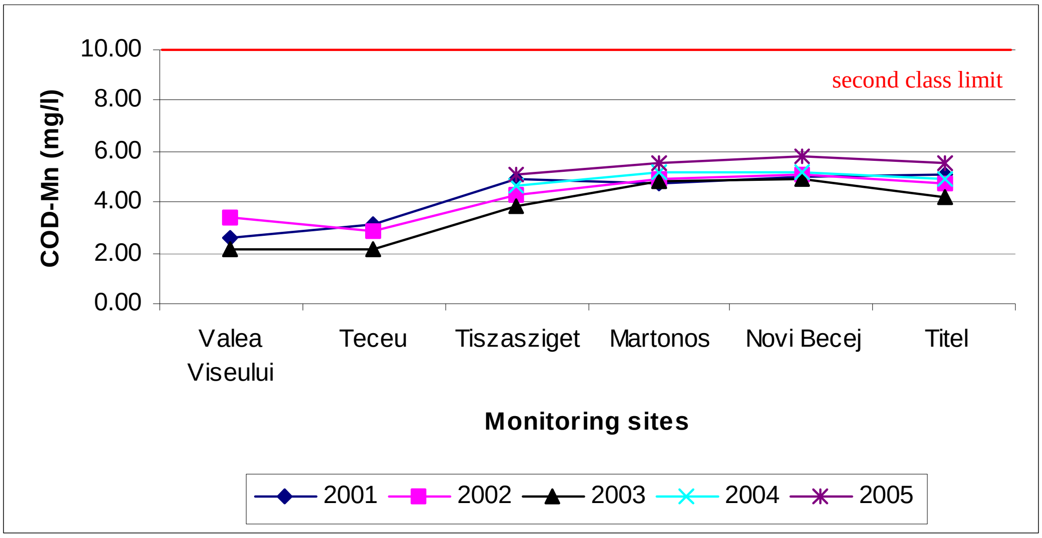


Figure II.11 The spatial-temporal evolution of the values of the organic substances concentrations on the Tisza River from 2001 to 2003 (and also from 2004 to 2005 in the TNMN stations)

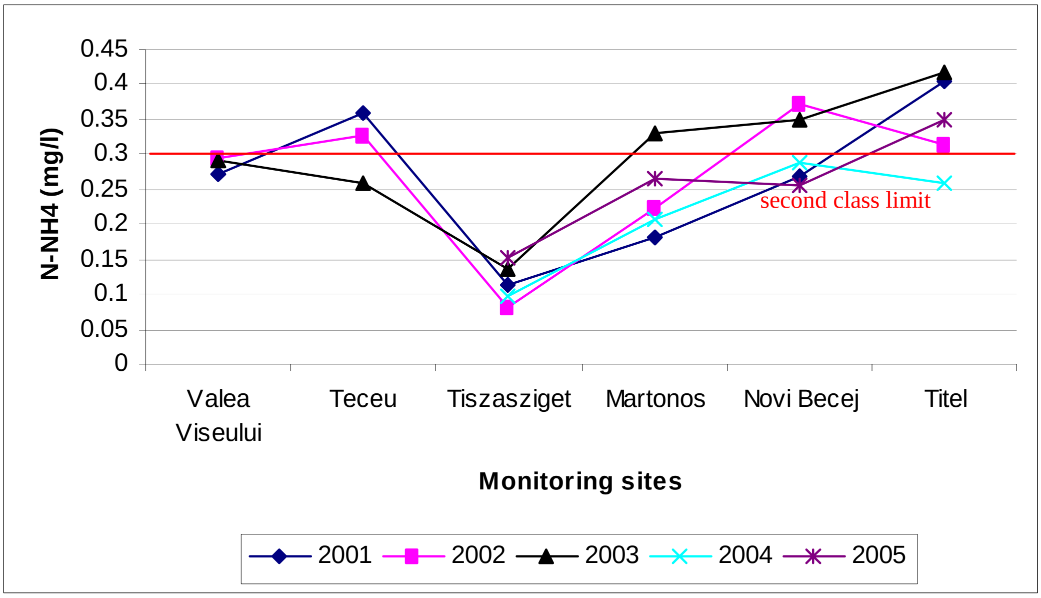
4.8.2. Nutrients

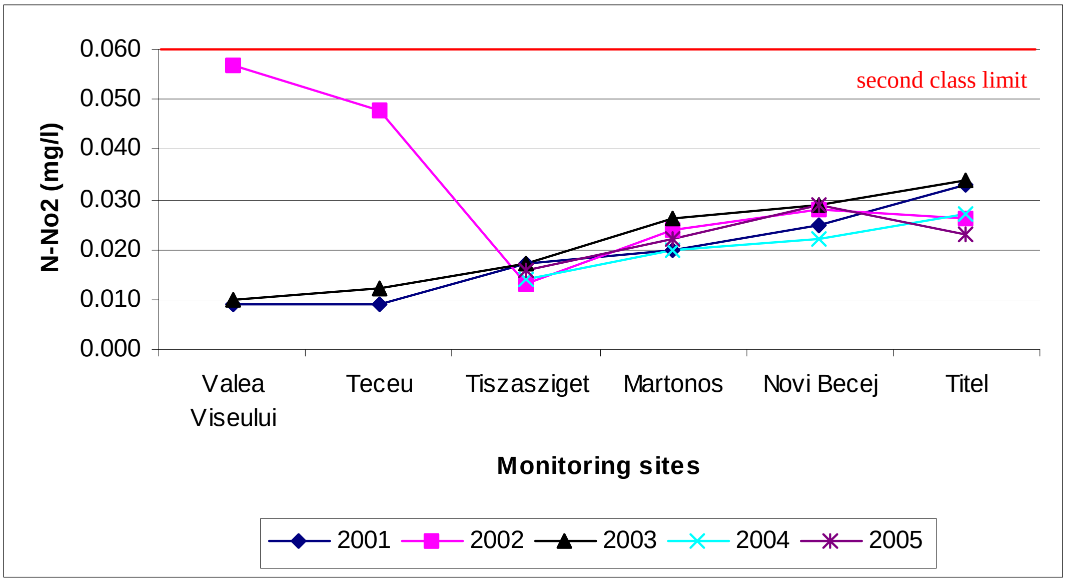
The representative parameters for water quality characterisation are: N-NH_4^+, N-NO_2^-, N-NO_3, P-PO_4^{3-} and Ptot.

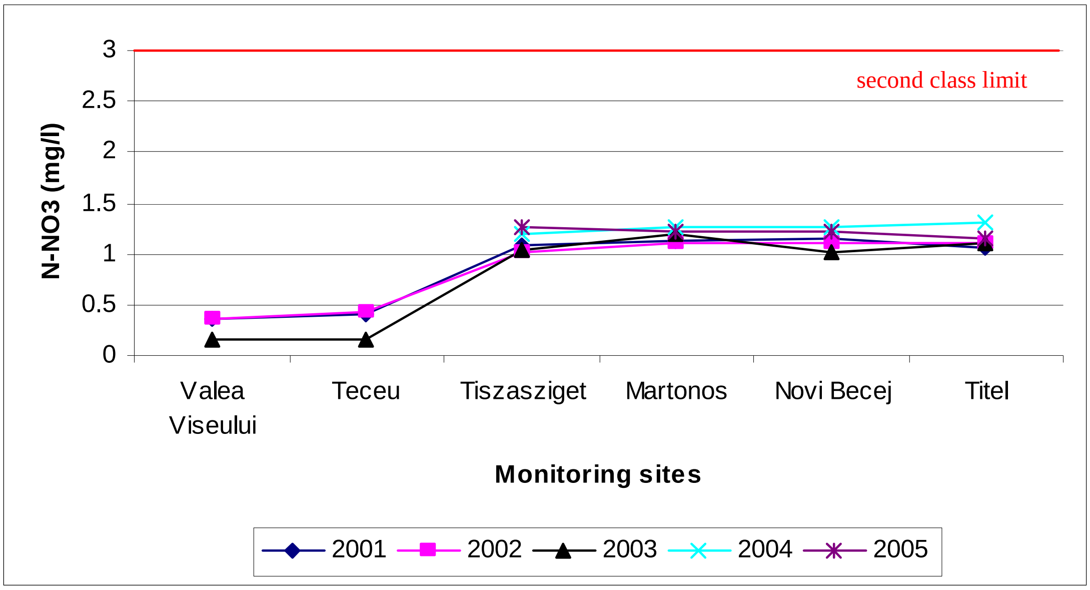
The nutrient concentrations for 2001 to 2003 (**Figure II.12**.) have been characterised through the following values:

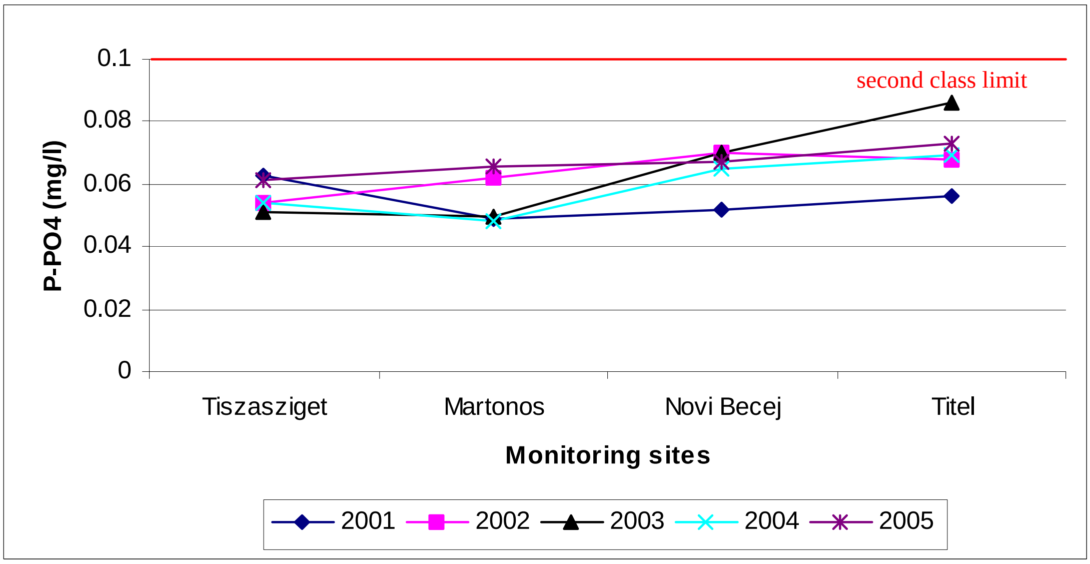
- 0,081 – 0,405 mg/l for N-NH_4^+. The monitoring sites Teceu (2001, 2002), Martonos (2003), Novi Becej (2002, 2003) and Titel (2001 – 2003) recorded that the target objectives were exceeded, with the indicator N-NH_4^+ belonging to the third class. According to the data from JDS-ITR, there were no exceedings recorded to the first class in the Novi Becej and Titel monitoring sections.
- 0,009 – 0,057 mg/l for N-NO_2^-. All the monitoring sites of the Tisza River recorded that the values for indicator N-NO_2^- were in the second class in most cases, with the remaining sites belonging to the first class. Similar results were also recorded in the JDS-ITR.
- 0,15 – 1,19 mg/l for N-NO_3^-. For this indicator, the Tisza River is classified in the first class for Valea Viseu and Teceu (2001-2003), and in the second class for the remaining monitoring sites. For the two sections of JDS - ITR (Novi Becej and Titel) the values of N-NO_3^- concentrations belonged to the first class.
- 0,027 – 0,086 mg/l for P-PO_4^{3-} For this indicator the Tisza has been classified in the second class in general, with the remaining monitoring sites belonging to the first class. Similar results have also been recorded in the JDS-ITR.
- 0.011 – 0.23 mg/l for P total. For this indicator the Tisza belonged to the second class in general, with the exception of the Tiszasziget monitoring site (2001, 2002) which belonged to the third class.

Regarding the **Tisza tributaries**, the values of the nutrient concentrations belonged to the first and second class, with the exception of the Dara (Somes) monitoring site for which the value of N – NH_4^+ belonged to the fourth class for the entire period of time and sections Sajopuspoki (Sajo) and Cheresig (Crisul Repede) belonged to the third class for the indicator P–PO_4^{3-} for 2003.


0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
N-NH4 (mg/l)
second class limit
Valea Viseului
Teceu
Tiszasziget
Martonos
Novi Becej
Titel
Monitoring sites
2001
2002
2003
2004
2005


0.060
0.050
0.040
0.030
0.020
0.010
0.000
N-No2 (mg/l)
second class limit
Valea Viseului
Teceu
Tiszasziget
Martonos
Novi Becej
Titel
Monitoring sites
2001
2002
2003
2004
2005


N-NO3 (mg/l)
3
2.5
2
1.5
1
0.5
0
second class limit
Valea Viseului
Teceu
Tiszasziget
Martonos
Novi Becej
Titel
Monitoring sites
2001
2002
2003
2004
2005


P-PO4 (mg/l)
0.1
0.08
0.06
0.04
0.02
0
second class limit
Tiszasziget
Martonos
Novi Becej
Titel
Monitoring sites
2001
2002
2003
2004
2005

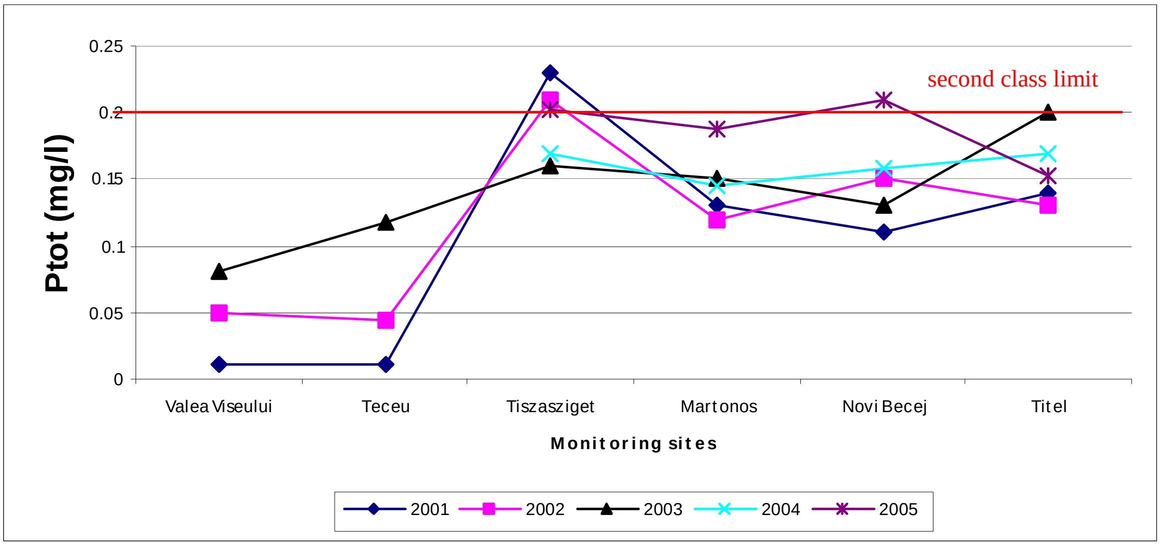


Figure II.12 The spatial-temporal evolution of the nutrient concentrations values on the Tisza River from 2001 to 2003 (and also from 2004 to 2005 in the TNMN stations)

As a general trend for the period of 2001 to 2003, the values of nutrient concentrations on the Tisza River were not high, ranging within the 'target objectives' class, with the exception of the indicator N – NH_4^+ which had a random variation: high values in the Upper Tisza monitoring sites and a rapid decrease in the Tiszasziget monitoring site (very high dilution), followed by a similar increase to that of Upper Tisza for the Lower Tisza.

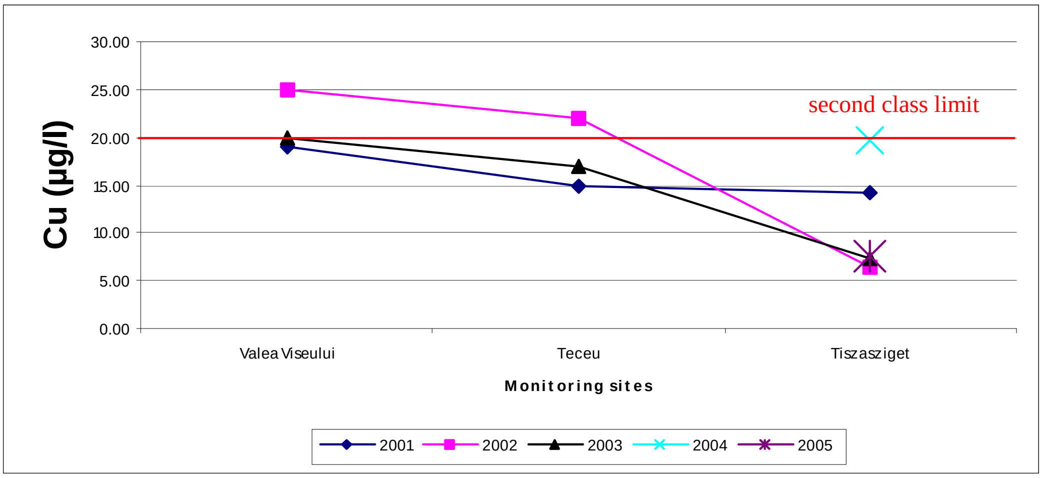
4.8.3. Heavy metals

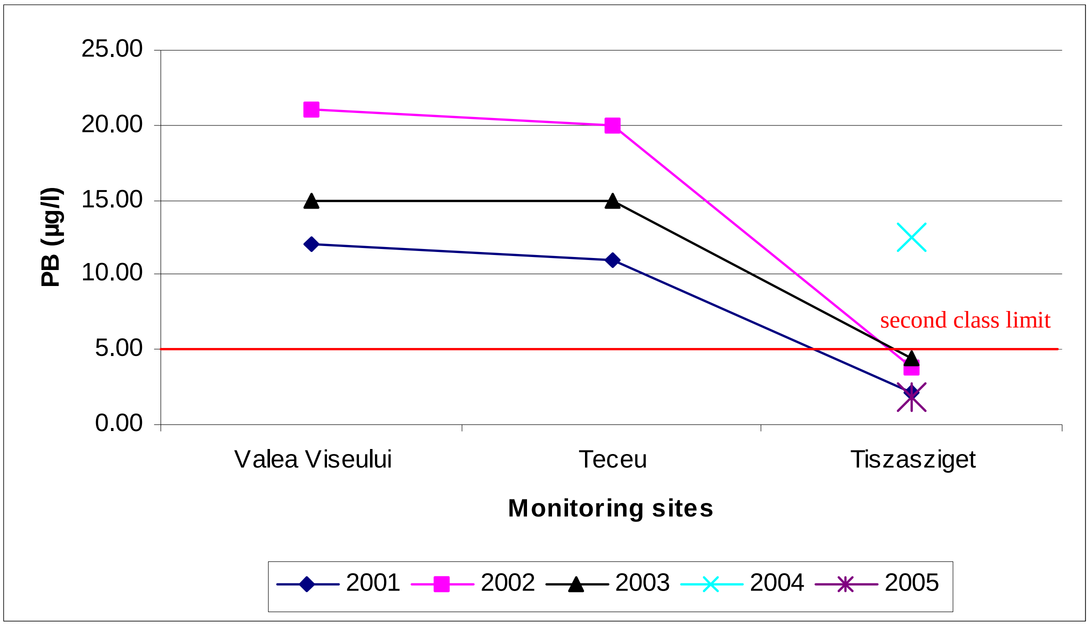
The evolution of heavy metals from 2001 to 2003 was the following (**Figure II.13**.):

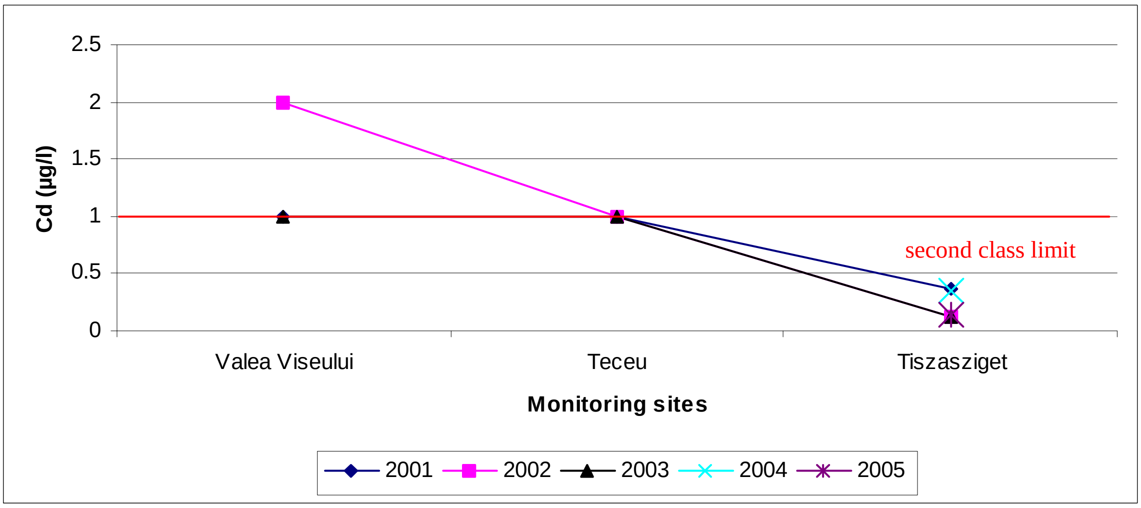
- Cu concentration has been between 6.34 – 25 µg/l which classified most of the Tisza River monitoring sites in the first and second class, with the exception of Valea Viseului (2002) and Teceu (2002) which belonged to the third class.
- Cr concentration values (1 – 7.32 µg/l) corresponded to first class for the entire period of time and for all the monitoring sites.
- Pb concentration values (2.1 – 21 µg/l) classified the Tisza River in the fourth class in general, with the exception of the Tiszasziget site for which the values corresponded to the first and second class except in 2004.
- Cd concentration values (0.13 – 2 µg/l) classified the Tisza River in the first and second classes in general, with the exception of the Valea Viseu (2002) site which corresponded to the third class.
- Ni concentration values (3.66 – 27 µg/l) corresponded to the first class, with few exceptions (Valea Viseului, 2002, 2004 – second class).

Referring to the **Tisza tributaries**, the values of the heavy metal concentrations belonged to the first and second classes with few exceptions: the monitoring site Dara (Somes) for which the value of Zn concentration for 2001 belonged to the third class, the value of Pb concentration for 2002 and 2003 belonged to the third and fifth classes and the value of Cd for 2002 and 2003 belonged to the fourth class.

According to the results of the heavy metals from JDS-ITR, the values for both monitoring sites (Novi Becej si Titel) were under '*target values*'.







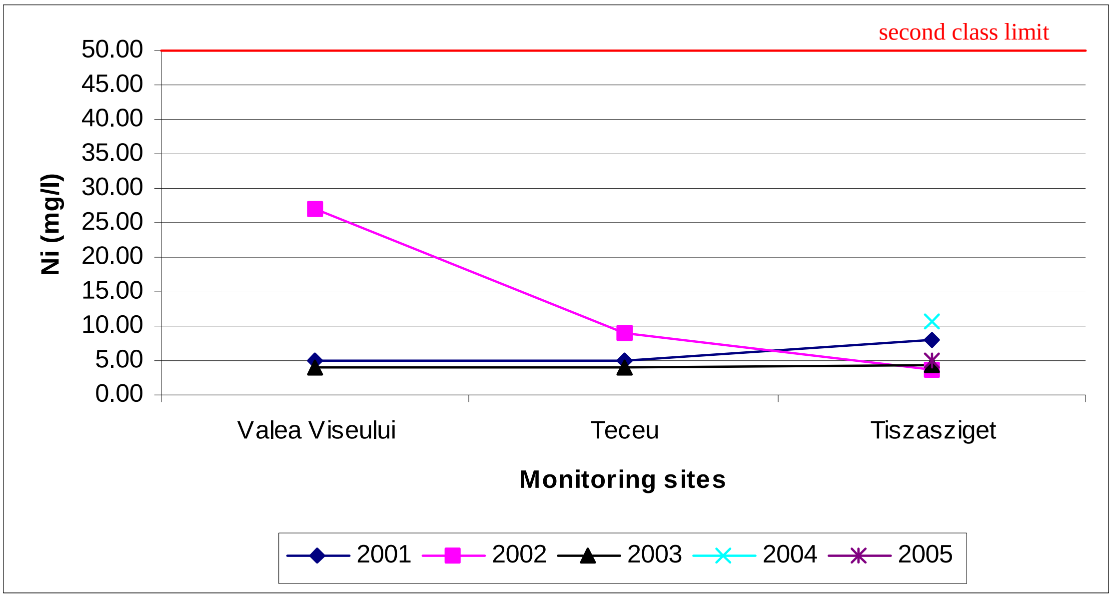


Figure II.13. The spatial-temporal evolution of the heavy metals concentrations on the Tisza River from 2001 to 2003 (and also from 2004 to 2005 in the TNMN stations)

Regarding **heavy metals** Cu, Pb and Cd exceed the II-nd class and are considered toxic substances, Pb and Cd being very toxic for water resources, especially for the biota.

High heavy metals concentrations show the pollution of the area with heavy metals (mining area) only in the monitoring sites of the Upper Tisza.

The Tisza River flowing from Ukraine at entrance in Romania has altered chemical characteristics through constantly exceeding the second class quality (Target Values) of the TNMN Water Quality Classification System for Pb, Cd and Cu.

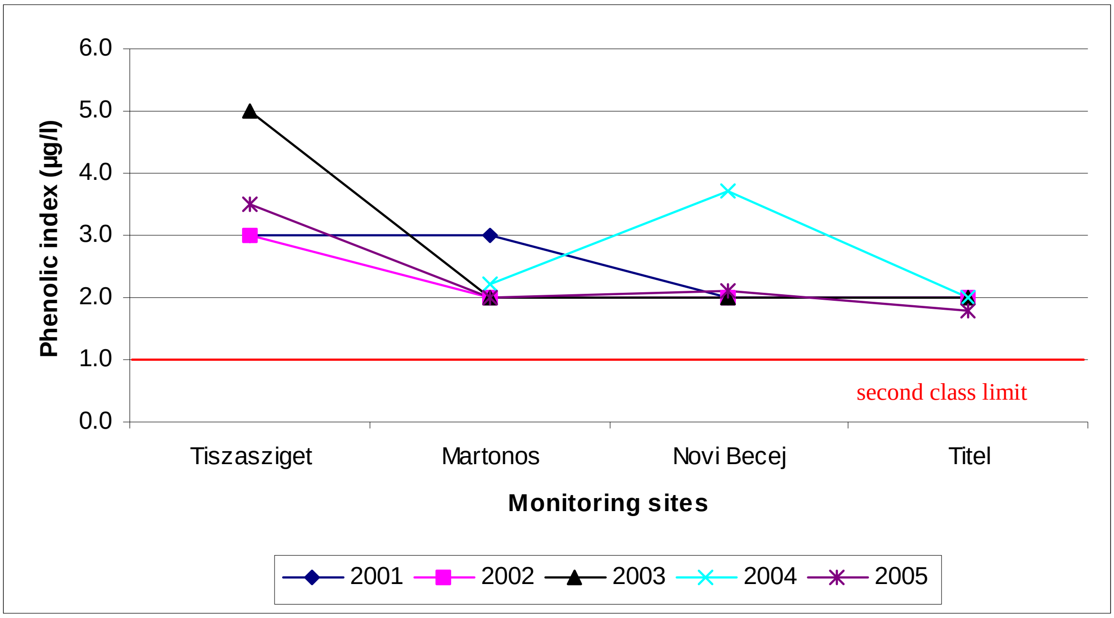
4.8.4. Organic toxic substances

Of the organic toxic substances, only phenolic index and detergents were analysed. There is not enough data for the remaining substances (AOX, oil products, lindane, DDT, atrazine, chloroform, carbon tetrachloride, trichloroethan, tetrachlorethan).

The evolution of the toxic substances concentrations values on the Tisza River from 2001 to 2003 has been the following (**Figure II.14**):

- the values of the phenolic index concentrations ranged between 1.0 – 5.0 µg/l which determined the classification of the Tisza River in the third class, with the exception of Valea Viseului (2003) which belonged to the second class.
- the values of the anionic detergent concentrations were between 11.0 – 42.0 µg/l, the Tisza River classified accordingly to the first class.

For the Tisza tributaries the values of the phenolic index concentrations belonged to the third class for all the monitoring sites.



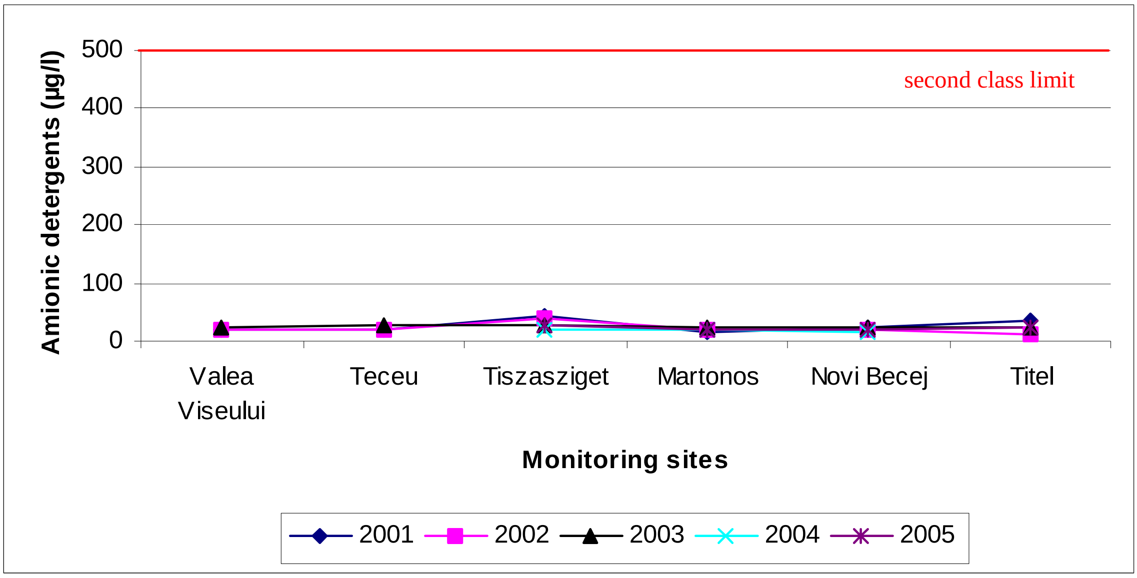


Figure II.14 The spatial-temporal evolution of the toxic substances concentrations on the Tisza River from 2001 to 2003 (as well as from 2004 to 2005 in the TNMN stations)

Of the two classes of analysed pollutants, it was noticed that the detergents do not pose pollution problems as they are all well under the target objectives, but the same is not true for the phenolic index. Phenols are known as substances with toxic effects on aquatic organisms. They can appear in water through accidental pollution, and in general their trend is decreasing however values are enough high in comparison to target objectives.

Based on the work of ICPDR River Basin Management Expert Group (RBM EG - issues papers on organic, nutrient and hazardous substances pollution) possible impacts related to organic, nutrient and hazardous substance pollution are listed in **ANNEX 8.**

4.9. Risk of failure to reach environmental objectives

4.9.1. Risk of failure to reach the environmental objectives (overview) – methodology

The WFD requires Member States to carry out an assessment of the risk of failing to meet its environmental quality objectives by 2015. The objectives include both the overall objective to achieve a good status by 2015, and possibly additional specific objectives that apply to protected areas as defined by other legislation. The objectives may also depend on the current status of the water body, since Member States must generally prevent any deterioration in the status.

Failure to achieve the objectives on surface waters may be the result of a very wide range of pressures, including point source discharges, diffuse source discharges, water abstractions, water flow regulation and morphological alterations. These and any other pressures that could affect the status of aquatic ecosystems must be considered in the analysis. The risk assessment is therefore based on information collected in the pressure and impact analysis.

This chapter summarises data on the risk assessment of surface water bodies in the Tisza River Basin. The data were collected from the five Tisza countries in the form of templates (Risk Assessment Templates) and are based on national assessments.

4.9.1.1. Methods and criteria for risk assessment

The risk assessment is based on a combined evaluation approach considering both significant pressures and in-stream quality data. The risk analysis is a stepwise approach from disaggregated information to the aggregated analysis of risk. The pressures and their relating impacts are disaggregated into the following risk categories:

- Organic pollution,
- Hazardous substances,
- Nutrient pollution and
- Hydromorphological alterations.

Other kinds of risks were not identified on the transboundary Tisza Basin level, but may be relevant in the individual National Reports. In many cases, water bodies in the Tisza Basin are affected by multiple risks.

Regarding the risk assessment methodology, some Tisza countries applied their own national methods and criteria. Details on national methods and criteria used by Hungary , Romania and Slovak Republic are given in **ANNEX 10,** based on information currently available. In general, however, the Tisza countries used the ICPDR risk assessment criteria applied in the Danube Roof Report 2004, to allow comparability of results on the basin level (ICPDR criteria are listed in detail in the following section). Where relevant, noteworthy additions and/or modifications made by the Tisza countries, such as national thresholds, are mentioned here and in **ANNEX 10.**

Risk assessment for organic pollution

If a water body is subject to significant pressure from municipal, industrial or agricultural point sources, then the water body is classified as being ‘at risk’. The discharge of partially treated or untreated wastewater from urban areas is especially significant and does not meet the requirements of relevant EU legislation, in particular the EU Urban Wastewater Treatment Directive and the Directive for Integrated Pollution Prevention and Control. Therefore, such water bodies should be classified as being ‘at risk’. For impacts from organic pollution, the Saprobic Index (SI) utilising benthic invertebrates was used, and Serbia, for instance, derived the SI from plankton. Hungary did not use the SI, but the parameters of biochemical oxygen demand (BOD_5) and dichromate chemical oxygen demand (COD_d). Due to missing equivalent saprobic index-based criteria, most of the water bodies in Hungary were assessed as ‘possibly at risk’ for organic pollution in this case, which is not in harmony with the Art. 5. National Report. The methodology used will be adapted to the ICPDR criteria as soon as possible.

Risk assessment for hazardous substances

Generally, there are substantial data gaps in both the pressure and the impact data. It was agreed that if a water body is subject to a significant pressure which exceeds the limit values for hazardous substances, the water body would be classified as being ‘at risk’. For the risk assessment of impacts, the presence of hazardous substances from the ICPDR List of Priority Substances (i.e. EU List for Priority Substances plus Arsenic, Chromium, Copper and Zinc) in the water or sediments was used. Substances on the ICPDR List were screened by applying national quality standards.

For the risk assessment, Serbia used, among others, the following three substances and threshold values: mercury (Hg) > 0.1 µg/l, phenols > 1 µg/l and chlorides > 40 mg/l. In Ukraine, heavy metals, mercury, cyanides and chlorides were used in the risk assessment. In Romania the risk assessment for hazardous substances was based on the heavy metals determination in water resources. A screening of hazardous substances in water resources was carried out in 2006.

Risk assessment for nutrient pollution

It was not possible to define common risk assessment criteria for nutrient pollution at the basin level due to the heterogeneity of surface water types. Therefore, the Tisza countries applied national criteria and threshold values (most commonly total N, total P, PO_4, NH_4, NO_2).

Risk assessment for hydromorphological alterations

No common risk criteria were defined for pressures from hydromorphological alterations. The Tisza countries applied nationally developed hydromorphological risk criteria (for Hungary, the relevant criteria are presented in the Risk Assessment (**ANNEX 10**). Relevant information can also be found in the chapter on Heavily Modified Water Bodies.

Final risk classification

The final risk classification into one of the risk classes ‘at risk’, ‘possibly at risk’, or ‘not at risk’ was based on the individual results of the applied pressure and impact risk criteria described above. A water body was classified as being ‘at risk’ if at least one of the four risk categories had been identified. In cases of insufficient data, water bodies were classified as being ‘possibly at risk’ until more detailed information becomes available.

4.9.2. Risk of failure analysis on rivers

The information presented in this section concerns risk assessment on rivers in the Tisza River Basin and refers firstly to the Tisza River and secondly to the basin tributaries. The risk analysis results are based on the national assessments included in the completed Risk Assessment Templates. Results are presented in an aggregated form as well as according to the four distinct risk categories.

4.9.2.1. Results on the Tisza River

On the Tisza River, 11 water bodies (668 km long) were assessed as ‘at risk’. This is equivalent to 69% of the total Tisza water bodies (see **Figure II.15**.) and of the total length of the Tisza River. The main part of water bodies ‘at risk’ lies in Hungary and Serbia. Tisza water bodies possibly at risk (25% of the total) were reported only by Ukraine and Hungary, while the only Tisza section not at risk (6% of the total) lies in Ukraine (see **Table II.18.** for details).[20]

Figure II. 16 reflect national ‘risk assessment’ differences between the five Tisza countries. Three Tisza countries (the Slovak Republic, Romania and Serbia) classified up to 100% of their national share of Tisza WBs as at risk. In Ukraine, only 20% of its national Tisza water bodies were classified as at risk but 60% were classified as possibly at risk (**see Table II.18.** for details).

[20] Ukraine classified one stretch of its Tisza as ‘not at risk’, although it considered this stretch as ‘possibly at risk’ for hydromorphology.

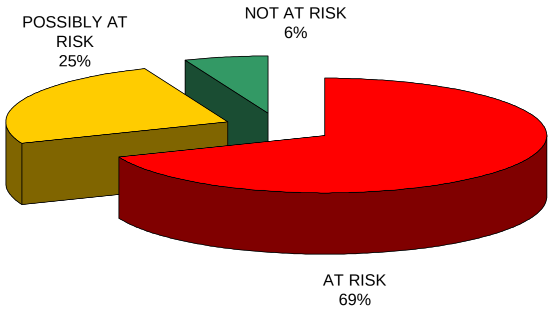


Figure II.15 Surface Water Bodies at risk/possibly at risk/not at risk on the Tisza River

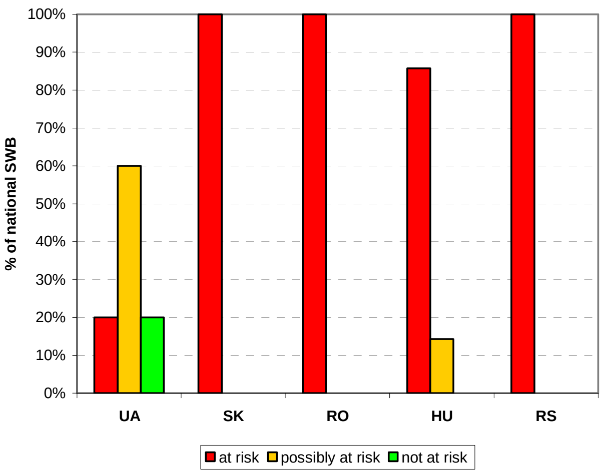


Figure II.16 Surface Water Bodies at risk/possibly at risk/not at risk in the 5 countries sharing the Tisza River

Table II.18 Main Tisza – Length and SWBs at risk/possibly at risk/not at risk

Country		[km]	[% of total Tisza length]	[% of national Tisza length]	No	[% of total Tisza SWBs]	[% of national Tisza SWBs]
UA	**at risk**	13	1%	5%	1	6%	20%
	possibly at risk	149	15%	63%	3	19%	60%
	not at risk	76	8%	32%	1	6%	20%
RO	**at risk**	61	6%	100%	1	6%	100%
	possibly at risk	0	0%	0%	0	0%	0%
	not at risk	0	0%	0%	0	0%	0%
SK	**at risk**	5	1%	100%	1	6%	100%
	possibly at risk	0	0%	0%	0	0%	0%
	not at risk	0	0%	0%	0	0%	0%
HU	**at risk**	428	44%	73%	6	38%	86%
	possibly at risk	157	16%	27%	1	6%	14%
	not at risk	0	0%	0%	0	0%	0%
RS	**at risk**	161	17%	100%	2	13%	100%
	possibly at risk	0	0%	0%	0	0%	0%
	not at risk	0	0%	0%	0	0%	0%

Source: All data are based on the completed Risk Assessment Templates. The length of the Tisza River in each country was based on the sum of kilometres in the Risk Assessment Templates.

Data on risk assessment were available for most of the Tisza River. The few data gaps and uncertainties could be overcome through future harmonisation of river kilometres and risk assessment results for transboundary Tisza sections shared by Ukraine/Romania, Ukraine/Hungary and the Slovak Republic/Hungary**. Figure II.17.** illustrates the reasons for which water bodies are at risk (nutrient pollution, hazardous substances, organic pollution or hydromorphological alterations).

Figure II.17. is based on the information provided in the completed Risk Assessment Templates. To correctly interpret the information, it should be considered that in three transboundary Tisza sections, shared by Ukraine/Romania, Ukraine/Hungary and the Slovak Republic/Hungary, non-harmonised risk assessment results and river kilometres were reported by the riparian countries. In these cases, only the data of one riparian country could be illustrated in the Figure. In the case of the Ukraine/Romania section, the figure illustrates only the Romanian data. The corresponding Ukrainian data, not shown in the figure, classified part of this section as ‘at possible risk’ due to hydromorphology, as ‘possibly at risk’ due to hazardous substances, as ‘not at risk’ for nutrients and ‘possibly at risk’ due to organic pollution. In the case of the Ukraine/Hungary section, the figure illustrates the Hungarian data. The corresponding Ukrainian data, not shown in the figure, classified this section as ‘possibly at risk’ instead of ‘at risk’ due to hazardous substances. In the Slovakia/Hungary section, the figure again illustrates the Hungarian data. The corresponding Slovakian data, not shown in the figure, classified this section as ‘at risk’ due to organic pollution, as ‘at risk’ due to nutrients, as ‘possibly at risk’ due to hazardous substances and as ‘at risk’ due to hydromorphology.

Based on the data shown in the Figure, 69 % of the Tisza was calculated as ‘at risk’ or ‘possibly at risk’ due to organic pollution, 65 % due to nutrient pollution, 92 % due to hazardous substances and 100% due to hydromorphological alterations.

The Upper Tisza in the mountainous area of Ukraine is classified as ‘possibly at risk’ due to hydromorphological alterations. In Romania, the Tisza is classified ‘at risk’ due to hazardous substances and possibly at risk for hydromorphological alterations, nutrient pollution and organic pollution. The Middle Tisza is partly classified as ‘at risk’ and partly as ‘possibly at risk’ due to hydromorphological alterations, hazardous substances and organic pollution. In this middle part, nutrient pollution is also as a reason for the possible risk of a significant part of the Tisza River. The Lower Tisza is ‘at risk’ due to hydromorphological alterations, hazardous substances and nutrient pollution.

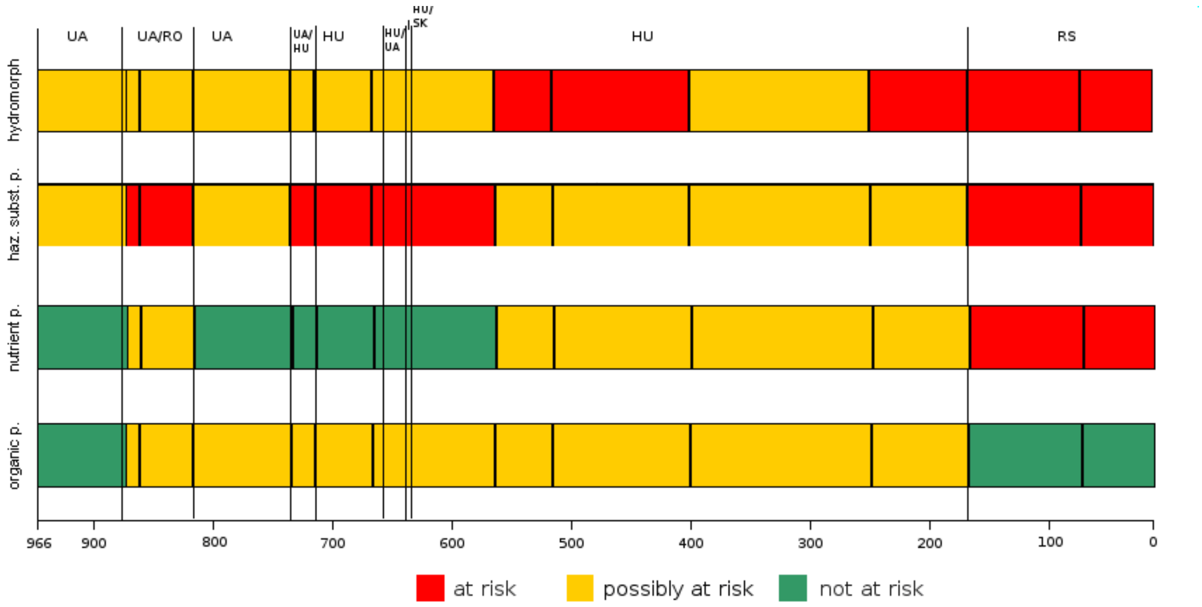


Figure II.17[21] Risk classification of the Tisza, disaggregated into risk categories. Each full band represents the assessment for one risk category (hydromorphological alterations, hazardous substances, nutrient pollution, organic pollution). Colours indicate the risk classes

The high risk or possible risk due to hydromorphological alterations is related to the presence of physical pressures such as weirs, bank reinforcement, channelisation and river regulation, especially in the middle and lower parts of the Tisza. Hydromorphological risk is also linked to the identification of approximately 50% of the length of the Tisza as provisionally heavily modified in its middle and lower part.

The Tisza has also been classified to a substantial extent as 'at risk' or 'possibly at risk' due to the presence of hazardous substances. A major problem in assessing the results on hazardous substances is the limited data availability in the Tisza River Basin. In Ukraine, risk and possible risk were related mainly to heavy metals and cyanides from Romanian mines, chlorides from Ukrainian mines as well as mercury.

Romanian sections of the Tisza were also assessed as 'at risk' from hazardous substances coming from upstream in Ukraine. Specifically, the waters of the Romanian Tisza constantly exceeded second class limits (Target Values of the TNMN Water Quality Classification System) for heavy metals Pb, Cd and Cu at Valea Viseului, the entry of Tisza in Romania. At the exit of the Romanian/Ukrainan Tisza at Teceu/Tyacchiv, concentrations of heavy metals were lower in 2001 - 2003 than those for the entry and as the same as for the entry in 2005-2006.

In Hungary, heavy metals mainly of transboundary origin were reported as responsible hazardous substances for classifying water bodies on the Tisza River as 'at risk'. In Serbia, parameters such as mercury (Hg) and phenols exceeded the set thresholds of 0.1 µg/l and 1 µg/l respectively.

[21] Organic pollution is based on saprobic-index which is not used in Hungary

Tisza water bodies at risk due to nutrient pollution were classified mainly in Hungary and Serbia. The main reason for failing the WFD objectives for nutrient pollution is the incomplete implementation of the urban wastewater treatment directive and diffuse nutrient pollution from agriculture.

4.9.2.2. Results on the Tisza tributaries

On the Tisza tributaries, 144 water bodies were assessed as 'at risk'. This is equivalent to 71% of the total tributary water bodies in the Tisza River Basin (see Figure). The main water bodies 'at risk' lie in Romania, the Slovak Republic, Hungary and Serbia. Tributary water bodies possibly at risk (15% of the total) were reported by all Tisza countries except for Serbia. Tributary water bodies not at risk (14% of the total) are found in Ukraine, the Slovak Republic and Romania.

Figure II.19 reflects national 'risk assessment' differences between the five Tisza countries for their share of the Tisza tributaries. On one hand, Serbia, Hungary, Romania and the Slovak Republic classified the largest part of their tributary water bodies as 'at risk'. On the other hand, Ukraine classified 41% of its national share of Tisza tributary water bodies as 'possibly at risk' and 47% as 'not at risk'.

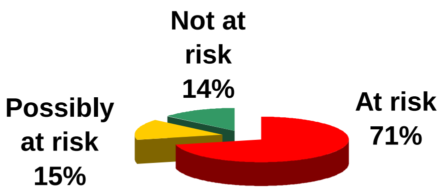


Figure II.18 SWBs at risk/possibly at risk/not at risk on the Tisza tributaries

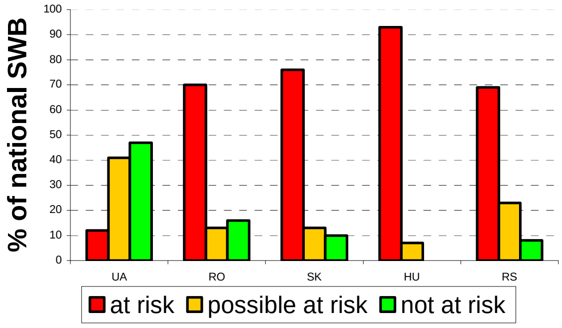


Figure II.19 SWBs at risk/possibly at risk/not at risk in the five countries sharing the Tisza tributaries

Figures II.20 and II.21 and **Table II.19** illustrate the reasons tributary water bodies are at risk and possibly at risk in the Tisza Basin and in each country. The Tisza tributaries are at risk mainly due to hydromorphological alterations and nutrient pollution followed by organic pollution and hazardous substances. Hazardous substances, however, were the main reason for the classification of tributary water bodies as 'possibly at risk' (especially in Romania, Hungary and the Slovak Republic).

The high risk of tributary water bodies due to hydromorphological alterations is related to the frequent presence of bank reinforcements, channelisation and transverse river structures for flood protection and urbanisation (see also related information on the identification of pHMWBs on the Tisza tributaries).

The high risk from nutrient pollution in Romania is caused by diffuse pollution sources from human settlements, especially in rural areas where a small part of the population is connected to sewage systems and wastewater treatment plants. In Hungary and the Slovak Republic, the high risk from nutrient pollution can be explained by the incomplete implementation of the urban wastewater treatment directive and diffuse nutrient pollution from agriculture.

For the extended classification of water bodies as 'possibly at risk' and 'at risk' due to hazardous substances, several tributaries in Romania exceeded second class limits for heavy metals. These rivers were thus classified as at risk due to natural background and discharges (direct or by tributaries) from mining pollution sources. In Hungary, the presence of heavy metals is mainly responsible for the classification of water bodies as at risk or possibly at risk due to hazardous substances. In the Slovak Republic, hazardous substances such as mercury (HG), zinc (Zn), trichlormethane, trichlorethane-1,1,2 and Polychlorinated Biphenyls (PCBs) are responsible for the water bodies being at risk. Serbia reported mercury (Hg) and phenols as reasons for the risk of water bodies due to hazardous substances.

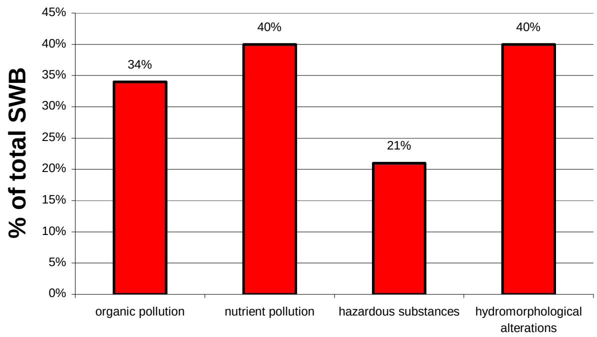


Figure II.20 SWBs **at risk** from different pressures on the Tisza tributaries

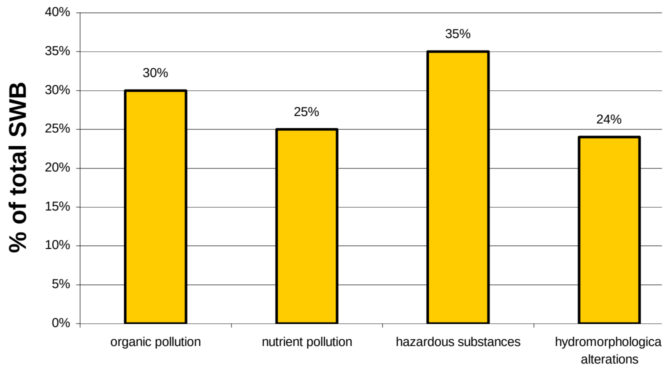


Figure II.21 SWBs **possibly at risk** from different pressures on the Tisza tributaries

Table II.19 Tisza tributaries – SWBs at risk/ possibly at risk from different pressures

At risk from...	**organic pollution**		**nutrient pollution**		**hazardous substances**		**hydromorphological alterations**	
	SWBs	% of total Tisza SWBs	SWBs	% of total Tisza SWBs	SWBs	% of total Tisza SWBs	SWBs	% of total Tisza SWBs
UA	0	0%	2	1%	0	0%	1	1%
RO	39	19%	34	17%	17	8%	34	17%
SK	12	6%	12	6%	2	1%	23	11%
HU	10	5%	24	12%	13	6%	21	10%
RS	8	4%	10	5%	10	5%	2	1%

Possibly at risk from...	**organic pollution**		**nutrient pollution**		**hazardous substances**		**hydromorphological alterations**	
	SWBs	% of total Tisza SWBs	SWBs	% of total Tisza SWBs	SWBs	% of total Tisza SWBs	SWBs	% of total Tisza SWBs
UA	13	6%	4	2%	4	2%	4	2%
RO	9	4%	27	13%	23	11%	30	15%

Possibly at risk from...	organic pollution		nutrient pollution		hazardous substances		hydromorphological alterations	
SK	31	1%	2	1%	19	9%	2	1%
HU	33	16%	14	7%	22	11%	13	6%
RS	3	1%	3	1%	3	2%	0	0%

MAP 11 – 14 includes information on risk assessment related to hydromorphological alteration, nutrient, organic pollution and hazardous substances.

4.9.3. Risk of failure analysis on lakes

No risk data related to lakes of the Tisza River Basin were collected for the purposes of this report.

4.10. Data gaps and uncertainties

4.10.1. Data gaps and uncertainties related to HMWB/AWBs

Methodological issues: The basin-wide criteria and national criteria for the identification of pHMWB were used in a complementary manner for the purposes of this report. Some differences between the basin-wide and certain national criteria may deserve further clarification to ensure a correct interpretation of the Tisza data set on pHMWB. As an example, the national criteria in Hungary defines a water body as pHMWB when certain significant hydromorphological changes affect more than 50% of the water body. This national threshold could lead to pHMWB results which are different from those following the application of the basin-wide criteria. Namely, the basin-wide criteria define that a minimum 70% of a water section should show significant physical alterations and hydromorphological impacts to qualify as pHMWB. In the future, it is worth clarifying how this difference in thresholds is reflected in the reported pHMWB data in Hungary.

Furthermore, according to the information available so far, the Tisza countries have identified pHMWBs using mainly physical parameters (indirect criteria). The validation of pHMWBs on the basis of biological data is still pending.

Upon completion of this report, only a few data gaps and uncertainties remained with regard to the identification of pHMWBs in the Tisza River Basin.

There is still need for cross-border harmonisation on certain transboundary pHMWBs, and the main uncertainties are:

- A water body on the common Tisza River border of the Slovak Republic/Hungary was identified as a pHMWB by the Slovak Republic but not by Hungary.
- A water body on the common Mures River border of Romania/Hungary was identified as a pHMWB by Romania but not by Hungary.

4.10.2. Identification of data gaps and uncertainties – related to risk assessment

Generally, the risk assessment results for the Tisza Basin indicate satisfactory progress of the national risk assessments and of efforts towards cross-border harmonisation.

However, follow-up risk assessment activities are needed to fill in data gaps, especially concerning the numerous water bodies which were classified as ‘possibly at risk’ due to the current lack of data.

Additionally, there is need for further bilateral exchange concerning risk assessment. Several uncertainties in the data evaluation were related to the lack of harmonisation of river kilometres and of risk assessment results for common transboundary water bodies on the main Tisza (especially for sections shared by Ukraine/Romania, Ukraine/Hungary and the Slovak Republic/Hungary) and some of its tributaries. In several cases, the same river sections were included in the Risk Assessment Templates of neighbouring countries indicating non-matching river kilometres and risk classification results.

4.11. Conclusion on surface water bodies

Artificial Water Bodies and pHMWB assessments

(Tisza River Basin Analysis Report vs. Danube Basin Analysis)

A more detailed reporting approach was followed concerning artificial water bodies (AWBs) for this Tisza River Basin Analysis than for the Danube Basin Analysis 2004 (Roof Report). On the Danube reporting level, only three large AWBs were selected to be described in advance (canals of basin-wide importance). On the finer level of the present Tisza Basin assessment, all AWBs identified in the basin were reported and no size threshold was set in advance. Thus, a more complete picture of the existing AWBs basin-wide could be achieved at the Tisza level.

The reported pHMWBs on the Tisza River were almost identical to those reported in the Roof Report, with some slight length variations in the Hungarian Tisza pHMWBs. It is important to note that the Tisza River was identified as a pHMWB to a smaller extent (50% of its length) than the Danube River (75% of its length), but the number of pHMWBs are still higher than the European average. This may reflect fewer substantial changes in character of the Tisza River and less widespread hydromorphological alterations.

Concerning the Tisza tributaries, pHMWBs were reported in a more detailed manner in this report than in the Roof Report, as more tributaries of the Tisza were considered for the assessments in this report.

Also the information presented in this report on pHMWBs in Ukraine enhances the information presented in the Roof Report, where no data could be included from Ukraine.

The basin-wide criteria agreed upon for the Roof Report were used in a slightly modified way in the Tisza assessment, and the size threshold for reporting heavily modified water sections was reduced from 50km (at the Danube level) to 10km (for the Tisza level).

Finally, the Tisza River Basin Analysis Report is more transparent in terms of the national methods and criteria used for the identification of pHMWBs. Unlike the Roof Report, this report offers explicit information on national methods and criteria used in addition to the agreed upon basin-wide criteria. This way any inconsistencies between the basin-wide criteria and national criteria could be more easily recognised, pointing to the need for further criteria harmonisation in the context of the international Tisza Basin.

The risk assessment results in this report have provided new risk data on two Tisza countries (Ukraine and Serbia) which could not deliver risk assessment results for the Roof Report in March 2005. This report also provides risk assessment data on more tributaries of the Tisza Basin than those covered on the Danube level.

For the methodology and criteria used, the risk assessment for the Tisza Basin was carried out largely on the basis of the ICPDR criteria used in the Roof Report for the Danube. To increase cross-border transparency, this report highlights national modifications to the ICPDR criteria and, where available, provides detailed information on national risk methods applied by Tisza countries.

5 Characterisation of groundwater quality

According to Article 2 of the WFD (2000/60/EC), ‘groundwater’ means all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. An ‘aquifer’ means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater. Finally, a ‘body of groundwater’ means a distinct volume of groundwater within an aquifer or aquifers. Groundwater bodies are subject to analyses and reviews as required under Article 5 and Annex II of the WFD. According to Annex II:

“*Member States shall carry out an initial characterisation of all groundwater bodies to assess their uses and the degree to which they are at risk of failing to meet the objectives for each groundwater body under Article 4. Member States may group groundwater bodies together for the purposes of this initial characterisation. This analysis may employ existing hydrological, geological, pedological, land use, discharge, abstraction and other data but shall identify:*

- *the location and boundaries of the groundwater body or bodies,*
- *the pressures to which the groundwater body or bodies are liable to be subject (…)*
- *the general character of the overlying strata in the catchment area from which the groundwater body receives its recharge,*
- *those groundwater bodies for which there are directly dependent surface water ecosystems or terrestrial ecosystems.”*

According to paragraph 2.3 under Annex II, for those bodies of groundwater which cross the boundary between two or more Member States, further information on the impact of human activity on groundwaters shall be collected and maintained where relevant.

This chapter provides an overview characterisation of important transboundary groundwater bodies (GWBs) in the Tisza River Basin. A size threshold of more than 1,000 km² was defined to select important transboundary GWBs to be included in this Tisza Analysis Report. Transboundary GWBs were additionally selected on the basis of several other criteria used by the Tisza countries: use of the GWB as a source of drinking water, water for agriculture and industry, the GWBs’ contamination threat, the GWBs’ link to important ecosystems, such as protected areas or national parks, and the presence of transboundary impacts.

Despite its focus on important transboundary GWBs, this chapter also summarises information on important national GWBs of the Tisza Basin larger than 1,000 km².

MAP 10b shows the Groundwater bodies in the Tisza River Basin.

5.1. Location, boundaries and characterisation of groundwater bodies

5.1.1. Important transboundary groundwater bodies in the Tisza River Basin

Data on the characterisation of important transboundary GWBs were reported by all five Tisza countries in templates (Groundwater Characterisation Templates).

In total, 33 important transboundary GWBs were identified. **Figures II.22 and II.23** indicate the national breakdown of these transboundary GWBs with regard to the size and the number of GWBs.

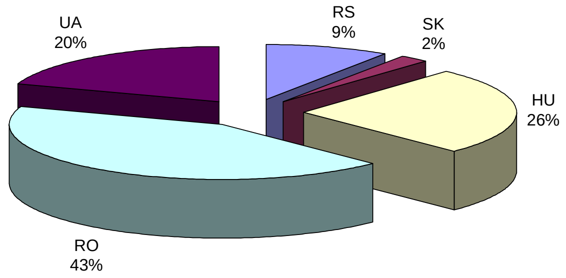


Figure II.22 Country repartition of transboundary GWBs (related to size/Km²)

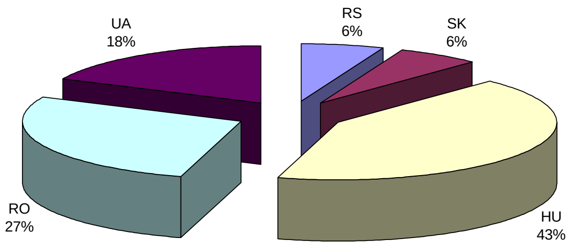


Figure II.23 Country repartition of transboundary GWBs (related to numbers of GWBs)

Table II.20. gives an overview of the common borders between countries in the Tisza River Basin (white cells). Numbers in the cells indicate the number of transboundary GWBs reported as bilaterally agreed upon. The numbers in brackets indicate GWBs where bilateral (or trilateral) agreements are still missing or need to be renewed or need to be further clarified.

Table II.20: Matrix of transboundary groundwater bodies

	RS	HU	RO	SK	UA
RS		(5) / (1)	(1) / (1)		
HU	(1) / (5)		8 / 6	2 / 3	(5) / 0
RO	(1) / (1)	6 / 4(4)			(5) / 0
SK		3 / 2			(6) / 0
UA		0 / (5)	0 / (5)	0 / (6)	

	B
A	2 (1) / 2

Country A reported 2 transboundary GWB bilaterally agreed with country B

Country B reported 2 transboundary GWB bilaterally agreed with country A and 1 transboundary GWB where bilateral agreement is pending, needs to be further clarified or renewed with country A

Data source: Groundwater Templates submitted by the Tisza countries.

Note 1: The matrix should be considered as preliminary until further harmonisation of transboundary GWB data between the Tisza countries.

Note 2: The matrix indications on the 'not bilaterally agreed' status of Ukraine's transboundary GWBs with reference to specific neighbouring countries is based solely on Ukraine's submitted groundwater maps and was not provided as such in Ukraine's Groundwater Template.

Some countries reported the presence of 'transboundary GWB groups' or aquifer systems, which contain several GWBs located in two or three countries. Altogether, 6 transboundary GWB groups were reported by Hungary, Romania and the Slovak Republic including a total of 24 individual transboundary GWBs. It is possible that more individual GWBs are part of larger groups, but this could not be concluded on the basis of the current information available. To this aim, further data clarification and cross-border harmonisation is needed by the Tisza countries.

5.1.2. Summary description of important transboundary groundwater bodies

The following gives a summary of the information provided by the countries on their transboundary GWBs concerning their delineation criteria, their uses, main pressures and impacts.

Criteria for delineation: The GWBs were generally delineated according to a combination of criteria including the geological type and the borders of the surface catchment areas. Thermal water bodies were sometimes additionally separated on the basis of their temperature.

Geological overview: Sand, gravel, silt, clay and boulder are the main components of the aquifers of the important transboundary GWBs. Hydraulic conductivity varies.

Groundwater use: Groundwater in the Tisza River Basin is used mostly for drinking water purposes (91% of the transboundary GWBs). It also supplies water for industry (58% of the GWBs) and agriculture (mainly irrigation, in 48% of the GWBs). In some cases, groundwater is also used in balneology, for industrial bottling and geothermal purposes.

The chemical pressures on groundwaters most often named were from agriculture (use of fertilisers) and settlements (absence of wastewater services). Overabstraction of groundwater in some parts of the Tisza River Basin is recognised as a possible cause for the unbalance between abstraction and recharge of groundwater.

5.1.3. Important national groundwater bodies in the Tisza River Basin

Ukraine, the Slovak Republic and Hungary provided information on their important national GWBs – 43 in total – to be included in this report. Some of the important national GWBs may be part of larger transboundary GWBs. More data and future bilateral exchange are required in the future to verify this.

Although not explicitly reported, it is assumed that the GWB delineation criteria mentioned above were also used for the delineation of national GWBs. Most national GWBs reported are used for drinking water, agriculture and in industry.[22] No information was provided on the geological overview and the main pressures and impacts affecting national GWBs.

5.2. Risk of failure to reach the environmental objectives

5.2.1. Approaches for groundwater risk assessment

The groundwater risk assessment was performed on the basis of national criteria for both the quantity and the (quality) chemical status. The following provides an overview of the methodologies and criteria used by the Tisza countries, based on information currently available.

Romania:

The criterion for risk assessment of **quantity** status is based on the evolution trend assessment of the groundwater piezometric levels. The criteria for (quality) **chemical assessment** included the overlying strata for litho–protection, actual groundwater quality, pressures and their possible impact, as well as on the nitrogen compounds which exceed the admissible limit.

Slovak Republic:

A groundwater body is at risk of failing to achieve good **quantity** status if the annual groundwater withdrawals over the last 5 years for the whole GWB exceed 50% of the documented available groundwater resources, or if there are localities inside the GWB with groundwater abstraction superior to 85% of documented groundwater sources (ecological aspect of abstraction). A groundwater body is also at risk of failing to achieve good quantitative status if the linear trend

[22] Hungary provided no information on the uses of its national groundwater bodies.

evaluation of long-term monitoring data of groundwater regime shows an important decreasing trend while at the same time there is documented influence on the dependent ecosystems.

The present (quality) **chemical** status of groundwater in the Slovak Republic was evaluated according to the chemical composition of groundwater consisting of 16,359 analyses (statistical density of sampling was 3 samples/km²) divided into the delineated groundwater bodies. A 'contamination index' was used as quality criterion, which was calculated for each analysed component that exceeds limit values of the National Drinking Water Standards. For the calculation of the contamination index of each sample, the following input indicators of groundwater were used: total dissolved solids (TDS), NO3, Cl, SO_4, As, F, Cd, Cu, Cr, Pb, Hg, Se, NH_4, Al, Mn, Zn, Fe, Na and Sb.

Hungary:

A groundwater body is at risk of failing to achieve good **quantity** status, if (i) the area identified as affected by decreasing tendency of groundwater levels is larger than 20% of the area of the groundwater body; or (ii) the actual abstraction is more than 80% of the estimated available groundwater resources of the water body, or (iii) important groundwater dependent ecosystem is significantly damaged by anthropogenic alterations.

Evaluation of the (quality) **chemical** status is based on the analysis of N-load from different diffuse sources (fertilisers and manure in agricultural area and in settlements as well as infiltrated communal wastewater from settlements that are not connected to the sewer system) and on the assessment of hazard from point sources of pollution. A water body is at risk due to diffuse sources of pollution if in 12 years the weighted concentration of the upper 50 m is greater than 37.5 mg/l in more than 20% of the water body's area.

Serbia:

The criteria used for **quantity** risk assessment were based on the history of alterations of piezometric levels from 1960 observed at a limited number of monitoring stations, on the data collected from operators of groundwater sources on level alterations and quantities of abstracted water as well as on a developed regional hydrodynamical groundwater model used for the estimation of future trends of piezometric levels for several scenarios of future groundwater abstraction.

The criteria used for (quality) **chemical** risk assessment were based on the thickness, hydraulic conductivity of overlying layers as natural protection of groundwater body, the results of quality analysis of chemical monitoring and identification of possible upward trends as well as on the presence of anthropogenic pressures on chemical status.

Ukraine:

There are no standard criteria for groundwater risk assessment in Ukraine. The groundwater risk assessment in Ukraine was based on expert judgement.

5.2.2. Results of the risk assessment on groundwater

The risk classification distinguished between three classes: GWBs 'at risk', GWBs 'possibly at risk' and GWBs 'not at risk'. A GWB is classified as being 'at risk', if the nationally applied risk criteria are fulfilled. In cases of insufficient data, GWBs were classified as being 'possibly at risk' until more detailed information becomes available.

(Quality) chemical status

The majority (88%) of the transboundary GWBs was reported as not at risk in terms of (quality) **chemical status** (see **Figure II.24**). Transboundary GWBs at qualitative risk (12%) were reported by the Slovak Republic, Romania and Ukraine.

Concerning the important national GWBs, 12% was reported as being at risk in terms of (quality) **chemical status** and another 16% as possibly at risk.

Quantity status

Of the nominated transboundary GWBs, 85% were assessed as 'not at risk' in terms of quantity status (see **Figure II.25**). Transboundary GWBs at quantitative risk were reported by Hungary (3%) and GWBs possibly at risk were reported by Serbia and Ukraine(12%).

As concerns the nominated important national GWBs, 7% were assessed as 'at risk' in terms of quantity and another 5% as 'possibly at risk'.

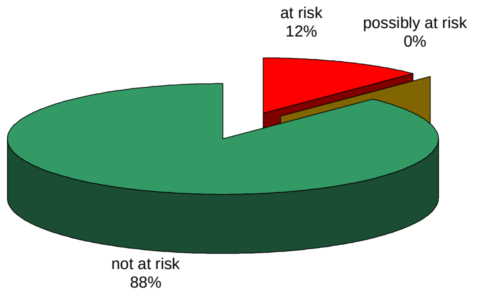


Figure II.24 Transboundary GWBs at risk/ possibly at risk/ not at risk in terms of **quality – chemical status**

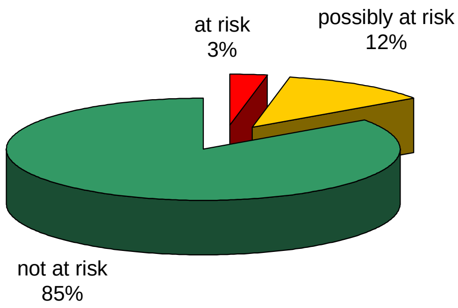


Figure II.25 Transboundary GWBs at risk/ possibly at risk/ not at risk in terms of **quantity**

5.3. Identification of data gaps and uncertainties

The characterisation of important transboundary and national GWBs carried out for the purposes of this report was a valuable exercise, which can serve as the basis for future bilateral (and if necessary trilateral) exchange and harmonisation of GWB information in the Tisza Basin. The evaluation of the GWB data submitted by the Tisza countries has indicated several remaining gaps and uncertainties.

No bilateral agreements or pending bilateral agreements were explicitly reported for the transboundary GWBs of Ukraine. All indications made in this chapter concerning bilateral agreements needed between Ukraine and its neighbours are based on the authors' assumptions using the GWB maps provided by Ukraine. Further transboundary GWB data clarification and harmonisation is needed between Ukraine and its neighbours.

Bilateral agreements also still need to be completed between Serbia and Hungary as well as between Serbia and Romania.

A satisfactory level of bilateral agreement has been reached on transboundary GWBs shared between Hungary and the Slovak Republic as well as between Hungary and Romania.

Several of the important national GWBs are smaller than 1,000 km². In fact, some of the important national GWBs may be part of larger transboundary GWBs. In order to verify this, more data and future bilateral exchange are required in the future.

Finally, the GWB risk assessment results based on national assessment criteria were not always harmonised across borders with regard to the same GWB or GWB group. In this respect, further cross-border harmonisation of the groundwater risk analysis results is needed.

Due to the needs for further data improvement and cross-border harmonisation of transboundary GWBs in the Tisza River Basin, only a few preliminary comparative remarks are provided below.

Five of the six GWB groups reported for this report are related to GWB groups already reported in the Roof Report (Danube Roof Report GWBs with ID numbers 5,6,7,9 and 10). The reported information on the GWB groups Bodrog, Slovensky kras/Aggtelek-hgs., Mures/Maros and Somes/Szamos is similar to the respective data presented in the Roof Report (see Roof Report GWBs with ID numbers 5,6,9 and 10), with only slight revisions regarding the size of individual GWBs. A new aspect reported on the GWB group Bodrog (ID 9 in the Roof Report) is the indication that part of this GWB group may also lie in Ukraine. One of the transboundary GWB groups nominated for this report (shared by Hungary-Serbia) seems to be related to the larger transboundary GWB group ID 7 of the Roof Report (the Upper Pannonian-Lower Pleistocene GWB from Backa and Banat/Dunav/Duna Tisza köze déli r.).

In general, the Tisza transboundary GWBs identified in this report are greater in number than those reported for the Tisza Basin in the Roof Report. This is mainly due to the finer level of analysis in this report, considering that a lower size threshold was used for selecting important transboundary GWBs (a size threshold of 1,000km² compared to the size threshold of 4,000km² used on the Danube level).

Additionally, any information given on transboundary GWBs from Ukraine is new in this report, as no relevant information for Ukraine was made available in the Roof Report.

Finally, in the context of this Tisza River Basin Analysis Report, important national GWBs (larger than 1,000 km²) were also identified, while the Roof Report focused only on transboundary GWBs.

Part III – Water Quantity

6 Water resources and uses

6.1. Water resources

The Tisza River ranks as the longest tributary (966 km) and the second largest tributary of the Danube River by flow volume, with an average discharge of about 830 m^3/sec. The basin drains an area of 157,186 km^2 and is the main water source for Hungary, a significant source for Serbia and an important source for western Romania and southeastern part of the Slovak Republic.

The multi-annual area mean values of the main balance elements of the Tisza River Basin[23] are:

- precipitation 744 mm/a,
- evapotranspiration 560 mm/a,
- runoff 177 mm/a (= 830 m^3/s).

The isoline map of runoff (**MAP 15**) shows the variation of runoff within the Tisza River Basin between 10-20 mm/a (along the middle reach of the Tisza River) and more than 1,000 mm/a (in the northeastern Carpathians and the Apuseni Mountains).

6.1.1. Monthly flow analysis

Statistical analysis of monthly flows in the Tisza River Basin was carried out for the main gauging stations, on the Tisza River and its main tributaries. The analysis was based on monthly mean river discharges data recorded between 1955 and 2000. The **Annex 15** presents the interannual distribution of monthly discharges at eight stations on the Tisza River where significant changes of river discharge are present due to input from tributaries: Rahiv (Ukraine), Tiszabecs (Hungary), Vásárosnamény (Hungary), Záhony (Hungary), Tiszalök (Hungary), Kisköre (Hungary), Szeged (Hungary), and Senta (Serbia). Similar data for six stations at the main tributaries: Chop (Ukraine, the Latorica River), Satu Mare (Romania, the Somes River), Streda nad Bodrogom (Slovakia, the Bodrog River), Felsözsolca (Hungary, the Sajo River), Gyoma (Hungary, the Harmas-Körös River), and Mako (Hungary, Maros River).

6.1.2. Low water flows

Analyses of low water flows on the Tisza River and its main tributaries were also completed for 1955-2000 on the basis of a series of minimum annual discharges, where data existed. Statistical values (mean annual minimum, standard deviation and skewness) and theoretical values for selected return periods are given in **Table III.1.**

[23] Detailed information about the main components of the multi-annual water balance in the Tisza River Basin, based on measurements from 1931 to 1970, is given in the monograph ‘Hydrology of the River Danube’, published in 1986 in Munich.

Table III.1 Minimum annual flow-$Q_{min,T}$ (m^3/s)

River	Station	Statistic parameters: Mean	Standard	Skewness	Return period T (years): 100	50	10	2
Tisza	Vilok	48.84	15.45	-0.290	10.65	13.54	24.18	46.87
	Senta	200.4	82.7	0.463	60.28	69.74	103.4	187.4
Latorica	Chop	6.05	2.32	0.892	2.19	2.47	3.43	5.72
Bodrog	Streda nad Bodrogom	26.7	8.09	-0.495	5.0	8.03	16.01	27.38

6.1.3. Surface water storage

Chapter 3.4.3. of this report gives an overview of the reservoirs in the Tisza River Basin. The total reservoir capacity is about 2.7 billion m^3 and this amount represents about 10% of the average annual flow for the Tisza. There are 7 reservoirs larger than 100 million m^3 which were built for a variety of purposes (**See Table III.2).**

Table III.2: Reservoirs in the Tisza River Basin larger than 100 million m^3

Category (capacity range)	Location: Country	River Basin	River	Reservoir: Name	Catchment upstream of reservoir	Volume	Surface	Purpose
Mm^3					km^2	Mm^3	ha	
100-200	**RO**	Crisuri	Dragan	Dragan	159	112	292	multipurpose
		Mures	Sebes	Oasa	187	136	401	multipurpose
	SK	Bodrog	Ondava	VD Veľká Domaša and Malá Domaša	827	178.28	1,510	electricity production, recreation, fishing, flood protection, industry water supply, irrigation
	RS	Tisza	Tisza	Tisza	na	160	na	irrigation, flood protection
200-500	**RO**	Somes	Somes Cald	Fantanele	325	225	826	hydropower, flood protection
	RO	Mures	Raul Mare	Gura Apelor	235	210	411	hydropower
	HU	Tisza	Tisza	Kisköre	65,670	253	12,700	Multipurpose

Category (capacity range)	Location			Reservoir				
	Country	River Basin	River	Name	Catchment upstream of reservoir	Volume	Surface	Purpose
Mm^3					km^2	Mm^3	ha	
	SK	Bodrog	Laborec-bočná nádrž	VN Zemplínska Šírava	1,567	297	3,280	recreation, fishing, irrigation, industry water supply, flood production

6.1.4. Groundwater

Groundwater in the Tisza River Basin is of major importance and is subject to a variety of uses with the main focus on drinking water, industry and agriculture. Chapter 5 gives detailed information on the GWBs of the Tisza River Basin and indicates the risks related to the quantitative status of the GWBs. In summary it should be noted that no GWBs were indicated as ‘at risk’ for quantitative status in the Slovak Republic or Romania. In Hungary two GWBs were identified as ‘at risk’, and four GWBs in Ukraine and two in Serbia were identified as ‘possibly at risk’ for quantitative status.

6.2. Water uses

The water resources of the Tisza River Basin are mainly used for public water supply, irrigation and industrial purposes, but also for other agricultural uses, such as fishery, and recreation.

Analyses were made in the framework of the ICPDR Tisza Group on the present water uses of the public water supply for agriculture irrigation or other agricultural use, as well as for industrial purposes where the average value for three years (2002-2004) was analysed. **Annex 11** includes detailed background information on the water quantity used by various users as well as figures on the sources of water related to water uses based on the collected data.

Based the `*average total water quantities annually used by the given users*` and the `*percentage of the estimated consumptive use*[24]` (see Annex 11), calculations were done, which gave the estimated consumptive uses by the various water users (million m^3).

The overall estimation of consumptive use between water users is given in **Figure III.1a.**

[24] **Consumptive use :** Water abstracted which is no longer available for use because it has evaporated, transpired, been incorporated into products and crops, or consumed by man or livestock. Water losses due to leakages during the transport of water between the point or points of abstraction and the point or points of use are excluded. Definition source Joint OECD/Eurostat questionnaire 2002 on the state of the environment, section on inland waters.

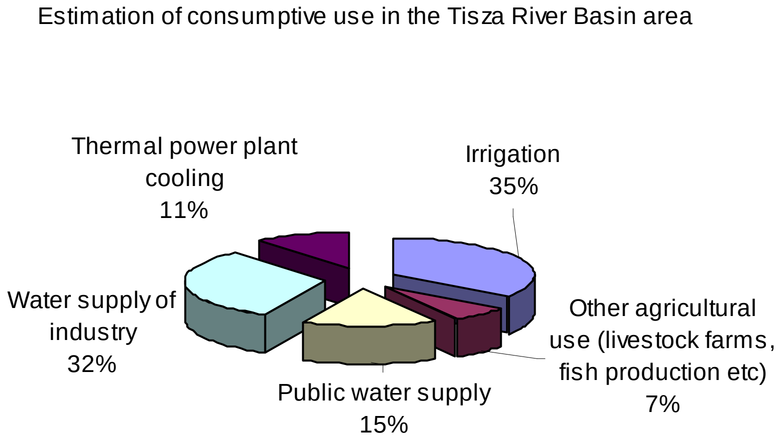


Figure III.1a Estimation of consumptive use between water users in the Tisza River Basin

The total annual water consumption in the Tisza River Basin is estimated at about 700 million m^3, or about 2-3% of the total annual flow. About 20% of this consumption comes from deeper aquifers.

As further analysis of the ICPDR Tisza Group, detailed information was collected on the average total water quantities used annually for various water uses in the last three years which also illustrates the major sources of water for the water users.

I**rrigation** represents the major consumptive use of water in the Tisza River Basin. Many older irrigation systems are temporarily out of operation due to reasons that may include the economic situation in countries or change of ownership, among others. The total annual consumptive use of water for irrigation is about 250 million m^3, or about 8 m^3 per second, representing about 1% of the annual flow.

The use of water for other **agricultural uses** (livestock farms, fish production or other uses) is relatively low due to the reduced number of livestock lately also resulting from the economic situation in countries or change of ownership. The use of water for livestock is highest in Serbia and Hungary, and the use of water for fish production is significant in most of the countries, especially in Serbia, Romania and Hungary. The total annual consumptive use is relatively small - about 50 million m^3.

Total annual consumptive use of water for **public water supply** is about 110 million m^3, while for **industrial water supply** the total annual consumptive use of water is about 230 million m^3. There are no thermal power plants in Ukraine and Serbia and the total annual consumptive use of water for **cooling of the thermal power plants** is about 80 million m^3, required by Romania, Hungary and the Slovak Republic.

Part I of Chapter 3 gives an overview on the **hydroelectric power plants** with an installed capacity of over 10 MW in the Tisza River Basin. Altogether 38 hydropower plants were identified by the countries, and out of these, 28 with the highest installed capacity are in Romania. The installed capacity and discharges of hydropower station in the Tisza Countries are illustrated in **Annex 14**.

As the Tisza River is established as a class IV international waterway by an AGN agreement, the required navigation conditions should be available at low flow of 95% duration, or approximately 175 m^3/s. The minimum discharge in the Tisza River required for safe navigation on the selected profiles in Hungary is 120 m^3/s between Kisköre and Szolnok.

Other water uses that have been considered significant to determine the existing water use are tourism and recreation. No environmental water demands are calculated for the volumes of water needed for preserving ecosystems.

6.3. Scenario for 2015 – water demand

Based on the `*average total water quantities annually used by the given users*` and the `*percentage of the estimated consumptive use*` (see Annex 11), a scenario for 2015 was created giving the estimated consumptive uses by various water users (million m^3).

This overall estimation of consumptive use between water users for 2015 is given in **Figure III.1b.**

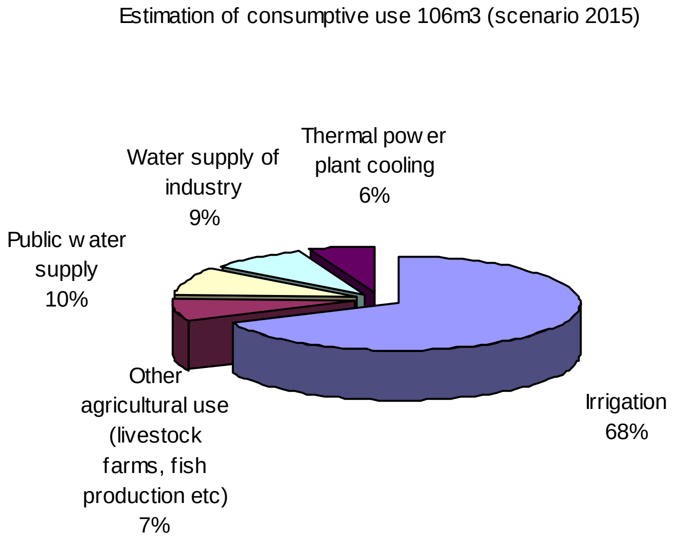


Figure III.1b Estimation of consumptive use between water users for 2015 in the Tisza River Basin

Data on planned water uses were collected and water demand in the Tisza River Basin was analysed for the year 2015. The total water demand is given for: irrigation, other agricultural uses (such as livestock farms or fish production), municipal and industrial water supply, hydropower, navigation, preservation of water regimes and ecological requirements.

It is likely that the total annual water demand in the Tisza River Basin will be about 1.5 billion m^3 in 2015, or 5.5-6% of the total annual runoff. Deeper aquifers are planned as a supply source for approximately 20% of the expected water demand.

A significant increase in water use for **irrigation** is planned for 2015. All countries plan to upgrade their existing irrigation systems or build new ones. Irrigated areas will increase from about 500,000 ha to about 625,000 ha. Areas and water quantities needed for irrigation in 2015 are given in **Annex 14**. The total annual consumptive use of water for irrigation is predicted to be about 950 million m^3 or about 35 m^3 per second, representing about 4,2% of the mean annual flow. Future augmentation of water use for irrigation, where consumptive use is a major component, will be an additional pressure in the Tisza River Basin. Aquatic ecosystems already vulnerable will be particularly endangered in the summer, when planned irrigation can go beyond available water quantities.

For other **agricultural uses** it is estimated that the total consumptive use will be around 100 million m^3.

Estimations related to the water quantities planned for **public water supply** by 2015 indicate a 25% increase by 2015. The total consumptive use will be relatively low – about 140 million m^3 – and will not be a key pressure if adequate treatment of municipal wastewater can be provided.

On the other hand, a significant portion of water for municipal water supply originates from slowly renewable deep aquifers, and the sustainability of the water supply from these aquifers must be ensured.

An increase in water use for **industrial water supply** is not planned. However it is important to note that some industries require large water quantities, while untreated wastewater may be polluted in some cases.

No new hydropower plants are planned in the Slovak Republic, Hungary, Serbia or Ukraine, but one on the border between Romania and Ukraine. The future increase of **hydropower** capacities in the Tisza River Basin should be through the reconstruction and upgrade of the existing infrastructure to minimise the need for development of new structures. New developments or reconstruction/upgrade of existing facilities should be in line with EU environment protection standards (i.e. new hydropower plants should have fish passages and respect requirements for minimum environmental flow) to lessen the impact on water quality.

Low water flows needed for **navigation** will remain the same in 2015.

Due to the lack of methodology and data in most countries, it is currently difficult to estimate water quantities which will be used for the **preservation of good ecological status** in rivers and canals.

New tourist and recreational facilities are planned in Ukraine by 2015, but water quantities planned for tourism and recreation will not grow significantly.

The quantity of cooling water for **thermal power plants** will remain the same in 2015.

The increase of water use in the Tisza River Basin as set in national water management plans will be an additional pressure on already endangered aquatic ecosystems. This is particularly true for irrigation, as this consumptive use takes place in low water period of the year.

7 Floods

7.1. Floods in the Tisza River Basin

Floods in the Tisza River Basin can form at any season as a result of rainstorm, snowmelt or the combination of the two. Snowmelt without rainfall rarely occurs in the Tisza Basin and floods resulting from this account for no more than 10-12% of the total amount. The rise in temperature is almost always accompanied or introduced by some rain. Thus large flood waves are generated more frequently in late winter and early spring.

The warm period from May to October accounts for nearly 65% of total floods, and the cold period from November to April accounts for only 35%. However maximum discharges and the volume of restricted flow of floods in the cold period generally exceed those observed in warm period.

The floods generated in Ukraine, Romania and the Slovak Republic are mainly rapid floods and last from 2-20 days. Large floods on the Tisza in Hungary and in Serbia, in contrast, can last for as long as 100 days or more (the 1970 flood lasted for 180 days). This is due to the very flat characteristic of the river in this region and multi-peak waves which may catch up on the Middle Tisza causing long flood situations. Also characteristic of the Middle Tisza region is that the Tisza floods often coincide with floods on the tributaries, which is especially dangerous in the case of the Somes/Szamos, Crasna/Kraszna Bodrog, Cris/Körös and Mures/Maros Rivers.

Recent severe floods have highlighted the problem of the inundation of landfills, dump sites and storage facilities where harmful substances are deposited and toxic substances can be transferred into the water posing a clear threat to the environment. Such potential threats were recognised by the ICPDR (Potential Accident Risk Sites in the Danube River Basin, 2002), and an inventory of old contaminated sites in potentially flooded areas in the Danube River Basin was compiled in 2002-2003.

Long-observations of level regime and maximum flow provide evidence of the distribution of extremely high severe floods in the Tisza River Basin along the Upper, Middle and Lower Tisza and its tributaries. However, not all high upstream floods cause severe floods along the Middle or Lower Tisza due to attenuation.

Following a relatively dry decade, a succession of abnormal floods has annually set new record water levels on several gauges over the last four years. Over 28 months between November 1998 and March 2001, four extreme floods travelled down the Tisza River. Large areas were simultaneously inundated by runoff and rapid floods of abnormal height on several minor streams. The extreme Tisza flood in April 2006 was preceded by several floods in February and March generated by melting snow and precipitation.

In the 19th century, river floodplains traditionally supported flood-tolerant land uses, such as forests, meadows and fishponds. Since then, land development interests have changed to modern agricultural production demanding low and tightly-regulated water levels and protection from seasonal inundation. This trend has been facilitated by the availability of arable land, crop intervention payments and grant aid for drainage, including pumped drainage within floodplains. This has led to the development of arable agriculture that demands low water levels in associated rivers. Industrial and urban building has also increased within drained floodplains lasting recent decades. In Hungary, work to drain the Tisza wetlands began in the 19th century and today some 500,000 people – 5% of Hungary's population – live on land reclaimed from the Tisza. Efforts to reduce flood impacts by building higher dikes and continued river bed regulation have resulted in a deposit of silt within the main bed which has inadvertently increased flood risks.

In addition to the altered nature of floodplains, the reduction in upper and mid-catchment water retention leads to more flood events downstream where river channels and small floodplains no longer contain peak water levels, even for minor flood events. The lack of coordinated mechanisms to mitigate floods in the upper catchment may lead to compounded impacts downstream. When flooding occurs, industrial sites, mining areas, agricultural fields and municipal waste facilities can become inundated and pollute the waters of the Tisza Basin.

The Danube River Protection Convention emphasises the need for transboundary level cooperation in forecasting and monitoring flood events if their impacts are to be minimised. In response to this, the Danube countries have decided to establish joint emergency plans. The *'Action Programme for Sustainable Flood Protection in the Danube Basin'* was endorsed at a Ministerial Conference in December 2004.

Another type of inundation in the lowland areas of the Tisza River Basin originate from unfavourable meteorological, hydrological and morphological conditions on saturated or frozen surface layers as a result of sudden melting snow or heavy precipitation, or as a result of groundwater flooding. This undrained runoff or excess water cannot be evacuated from the affected area by gravity and may cause significant damages to agriculture or even to traffic infrastructure and settlements.

The appearance of the inundation caused by *excess water* (undrained runoff) is determined together by natural and artificial circumstances. Natural circumstances can be the meteorological conditions (temperature, precipitation), morphological conditions (altitude, geographic structure), soil properties (permeability, physical structure, reservoir ability, type of soil), hydrogeological conditions (groundwater level state), geological conditions (soil, rock, impermeable layer). Artificial conditions include drainage networks (the capacity of the network during the excess water's period, its construction, backwater effect), agricultural practice (irrigation, used agricultural technologies, type of cultivated plant) and the increase in urbanised areas.

There are more than 50 definitions for this phenomenon in Hungarian alone. The large number of definitions shows that this phenomenon has an effect on several parts of the catchment and several elements of the economy.

Lowland drainage systems are characteristic attributes of the Tisza Valley. These networks determine surface water accumulation and effect runoff in the whole lowland area along the Tisza River. These networks have been always connected to the everyday life of the population living in the lowland. Small local depressions and small valleys were the first elements of these networks, and were later modified for a higher capacity.

Experience with the formation of the undrained runoff phenomena shows that the most critical period is the springtime. The most serious inundations are registered at this period when the natural conditions are unfavourable for natural runoff. In spring rapidly melting snow combined with rains may cause inundations over significant areas.

Undrained runoff has also been observed in the summer, when heavy rainstorms trigger inundations. This type of inundation causes extensive damage in settlements and in plough-lands, as plants can't tolerate the inundations in that period of their growth.

In autumn undrained runoff have been registered on only a few occasions in connection with heavy rainfalls.

Man-made facilities have a strong effect on runoff, as they can modify the flow conditions such as the backwater effect (at the mouth of canals) or the effect of pumping stations (where there isn't conformity between the concentration time and the capacity of pumping station).

Historical floods in the Tisza River Basin (I)

The following list contains remarkable floods in the Tisza River Basin.

- March 1879: devastation of Szeged claiming 151 victims, 94% of houses destroyed;
- March 1888: extreme floods with new peaks in the Tisza River Basin extending to the Tisza, Szamos, Túr, Kraszna, Bodrog, Körös/Berettyó Rivers, resulting in more than 210 dike breaches across the basin, claiming 2 victims and inundating more than 100 communities including 9 towns;
- 1919 and 1932: the two most significant floods between World War I and II – the 1919 flood resulted in two dike breaches, in 1932 there were no failures in the territory of Hungary but failures occurred in Transcarpathia and in the Crisuri Valley in Romania;
- December 31, 1947: flash flood on the Upper-Tisza resulting in dike breaches at Tivadar, inundating 300 km^2 including 9 communities;
- Spring 1966: disastrous flooding along Timis/Tamiš river after a breach of the Romanian left-bank levee upstream of the Serbian-Romanian border. In Serbia water from flooded area has been evaquated troughout cuts on levees on the Bega/Begej and the Timis/Tamiš.
- February-March 1966: record floods and dike breaches in the Körösök/Berettyó system;
- May 1970: extreme floods in the entire Tisza River Basin, dike breaches, victims and substantial damages in the Somes and Mures Basins, record flood stages along the Middle and Lower Tisza;
- March 1974: record floods along the Black and White Körös Rivers and to protect the city of Gyula the interfluvial of the two rivers were inundated by blasting the dikes;
- October 1974: record floods along the Bodrog, Hernád, Sajó and Zagyva-Tarna Rivers, several dike breaches along the Tarna River;
- July 1975: record floods along the Mures River;
- March-April 1979: new flood peaks along the Bodrog and Middle-Tisza between Tokaj and Tiszafüred;
- July 1980: dike breaches at the confluence of the Berettyó and Sebes-Körös Rivers, later the right bank of Kettős-Körös at Hosszúfok, opening of Mályvád and Mérges detention basins, 200 km^2 inundated, 4,100 people evacuated, dike breach closed by sheet piling at 0,48 m head;
- March 1981: new flood peaks along the Black-Körös River, opening the Mályvád detention basin;
- Christmas 1995: record floods along the White-Körös River, dike breach at the Gyula pumping station with successful localisation, opening of Mályvád and Mérges detention basins;
- January 1996: record floods along the Mures River at Nadlac;
- Between November 1998 and March 2001, four extreme flood waves travelled down the Tisza River;
  - November 1998: The Upper Tisza Basin in Transcarpathia, Ukraine experienced catastrophic losses due to floods, landslides and mudflows with 17 victims claimed; successful emergency operation in Hungary against new peaks exceeding those on record by 20-93 cm;
  - March 1999: extreme flood along the Bodrog and Middle Tisza, exceeding previous maximum on the Bodrog River at Sárospatak by 52 cm, on the Tisza River at Szolnok by 65 cm;
  - April 2000: extreme floods along the Middle Tisza, previous maximum water stages were exceeded along river section of 471 km (at Szolnok +67 cm above the record of 1999); extraordinary alert along 1342 km flood embankments of the River Tisza and tributaries; total length of flood embankments in emergency: 2980 km; days in emergency/extraordinary emergency: 114/32
  - March 2001: extreme floods along the Upper Tisza, several dike breaches and 9 victims in Ukraine, in Hungary previous peaks were exceeded between Tiszabecs and Záhony in a magnitude of 1-56 cm; dike breach on the right bank of Tisza River near Tarpa, 26,000 ha flooded in Hungary and another 6,000 ha in Ukraine, 8 1/2 communities were flooded and evacuated, another 9 communities were successfully defended by confinement activities);

Historical floods in the Tisza River Basin (II)

- April 2005: In the Bega River Basin in April and May 2005 large quantities of precipitation fell, at certain meteorological stations the historic maximum being exceeded. The maximum values of precipitation concentrated on an area between the sources of the Bega River, the middle course of the Timiş River, until the upper basin of the Bârzava River and practically included the entire catchment of the Caraş River. These precipitations superposed in certain areas with the snow melting period, fact which led to the formation of floods with important discharges. As a result of the floods occurred in 2005 in the Bega River Basin, there were affected 34 localities, 127 economic objectives, 617 bridges and foot bridges, 55 km of national roads, 200 km of county and communal roads, 9 km of railway and 93000 hectares of agricultural lands. The total value of the recorded damage was evaluated at 80 million EURO.
- April 2006: the extreme floods on the Tisza were preceded by several floods in February and March generated by melting snow and precipitation that fell from high humidity air masses arriving from the Mediterranean Sea; new record flood stages along the Middle and Lower Tisza between Tiszaug and Titel at a length of 270 km, magnitude of exceeding 14-62 cm; along the Hármas-Körös River at a length of 70 km, exceeding up to 32-54 cm. The flood lasted almost two months, within which the duration of water stages over the previous maximum records lasted two weeks at *Szeged* and *Mindszent* stations.

7.2. Flood protection and drainage systems in the Tisza countries

7.2.1. Flood protection systems and the status of flood protection structures

In the Tisza Valley, organised, systematic flood protection started in the mid 19th century. The backbones of these works are the flood protection dikes along the main river, but also include river training works, bank protections, flood retention reservoirs and polders. At this time drainage systems with pumping stations were also built. As the hydrological regime of the Tisza River became better understood and some dikes breached or failed to meet the design criteria, the dikes had to be reconstructed, upgraded and strengthened.

Generally, the main dikes are designed for the ‘one in hundred year’ return period floods. Although this is a general design criterion, there is still a major difference between the approach used in Ukraine, Romania and the Slovak Republic as compared to the method used in Hungary. In upstream countries where reliable discharge intervals are available, the ‘$Q_{1\%}$’ is used for the design of the structures. On the flat region of the Tisza the rating curves are not single-valued, and the discharge statistics are not reliable and water level statistics are used to provide the ‘$h_{1\%}$’ design level. This leads to a different degree of protection at border sections, but in the frame of the existing bilateral agreements, this problem is relaxed during negotiations.

To provide security against wave actions and to compensate for the uncertainty in the calculation of design flood level and in the dimensioning of dikes, a freeboard of 1 m is generally applied with positive and negative deviances in justified cases.

Reservoirs are mainly multi-purpose in mountainous area and are used for water management, fish farming, electricity production, providing ecological flow and some are also used for flood retention. The polders (flood detention basins) on the lowland regions are used for emergency flood detention only.

Flood protection structures

Table III. 3 summarises the length of the dikes (km) and the amount of reservoirs (and polders) in the Tisza River Basin.

Table III. 3 Flood protection structures in the Tisza River Basin

Country	Length of the dike km	Reservoir and/or polders[25] $10^6 m^3$
Ukraine		
Tisza River Basin	726 (embankments) + 276 (bank protecting and training structures)	65.8 in 9 reservoirs an 59 ponds
Romania		
Tisza	5.56	-
Viseu	7.85	-
Iza	13.53	-
Tur	77.12	28.09 in 4 reservoirs
Somes	1198.00	557.0 in 35 reservoirs
Crasna	163.39	28.79 in 1 reservoir and 1 polder
Barcau	336.00	
Crisul Alb	210.19	
Crisul Negru	378.10	45.50 in 2 polders
Crisul Repede	55.40	117.25 in 3 reservoirs
Mures	825.00	524 in 31 reservoirs and polders
Bega-Veche	104.30	46.94 in 9 reservoirs and polders
Bega	115.40	65.43 in 15 reservoirs and polders
Slovak Republic[26]		
Tisza	6	-
Slana	5.7	-
Tributaries of Slana	107.8	14.1 in 4 reservoirs
Bodva	28.6	
Tributary of Bodva	41.0	25.6 in 2 reservoirs
Hornad	34.2	62.7 in 2 reservoirs
Tributaries of Hornad		11.5 in 1 reservoir
Bodrog	22.12	-
Tributaries of Bodrog	230.87	631.9 in 3 reservoirs and 1 polder

[25] Total storage

[26] Note: Total reservoir volumes in the text and table taken from Abaffy, D., Lukáč, M., Liška, M.: Dams in Slovakia. T.R.T. Medium, Bratislava 1995. The actual volumes are changed due to sedimentation, wind wave

Country	Length of the dike km	Reservoir and/or polders[27] $10^6 m^3$
Hungary		
Tisza	1 064.1	-
Túr	75.7	-
Szamos	93.0	-
Kraszna	62.3	-
Lónyay Main Canal	102.8	-
Bodrog	57.9	-
Sajó (incl. Takta)	119.6	-
Hernád	62.0	-
Zagyva-Tarna	389.0	46.0 in 3 reservoirs and 2 flood detention basins
Körösök (incl. Berettyó, Hortobágy-Berettyó)	747.9	295.0 in 6 flood detention basins
Maros	95.1	-
Tisza River Basin in Hungary	2 869.3 (primary defences) and 407.6 (confinement structures)	326.0 in 3 reservoirs and 8 flood detention basins
Serbia		
Tisza	314.8	-
Old Bega	71.5	-
Bega	62	-

In **Ukraine** the flood protection complex in Zakkarpattia District was created to protect the area against water during frequent floods that can take place at any season and includes: protection embankments, bank strengthening, regulated reaches of river, main and incoming canals with structures, pumping stations on reclamation systems, reservoirs and ponds.

Protection embankments were constructed beginning in 1863 with the use of various technologies, for various probabilities, and according to present norms they no longer constitute a reliable flood protection complex.

The extent of the embankment accounts for 726 km and bank protecting and training structures on 276 km are constructed as rubble concrete bulkheads, rock paving, gabions and bank heads. Severe floods, especially those in 1998 and 2001, damaged bank protection at many places and the complex now requires reconstruction and strengthening.

There are 9 reservoirs within the district of a total volume over 41.8 $10^6 m^3$ and 59 ponds. The volume of all reservoirs totals up to 65.8 $10^6 m^3$, and their surface area is 1,563 thousand ha.

abrasion of reservoir banks and revisions (sediment removal). Updated reservoir volumes for selected reservoirs are available, but from different time moments.

[27] Total storage

In **Romani**a the main objectives of the water management works in Tisza River Basin are to:

- Satisfy the water needs for population, industry and other water usages;
- Protect water quality;
- Mitigate the destructive effects of water;
- Capitalise on the hydropower potential of main watercourses;
- Assure the ecologic and health needs of people.

Flood protection is achieved through regulation works, bank protections, embankments and reservoirs with high flows attenuation role.

Levees along both-side of the Bega Veche River were built at the end of the 19th century in the scope of overall river training. After a disastrous flood in 1932, levees were reconstructed and the riverbed deepened to enable safe flood conveyance.

The Bega River is fully canalised. The Topolovac weir, the furthest upstream, holds inflow into the channel lower than 83.5 m^3/s. Excess waters are routed into the Timis River through an outflow channel.

In **the Slovak Republic** flood protection is provided by dikes. In general the dikes are dimensioned to $Q_{1\%}$, – but at certain location (Bodva for example) $Q_{5\%}$ is used – valid before the floods in 1972-1976. Values of high waters for 1% exceedance were reconsidered and increased by 25-40%. Flood retention reservoirs are used to reduce peak discharges, and where this possibility is available the design discharge has been reduced.

Several dams and reservoirs have been built to store water for economic use and to protect against flood.

In **Hungary** approximately half of the territory of the country is situated in the Tisza Basin, and the present level of flood protection development has been attained by almost two centuries of planned water management efforts. In the early years of the 19^{th} century, parts of the 20,000 km^2 floodplain (20 % of the Hungarian plains) were inundated permanently or for periods of differing lengths of the year. Flood control development in the Tisza Valley was introduced by training isolated sections of some of the tributaries and building embankments along them. The ambitious comprehensive project was launched in 1846 and 4,500 km of embankments were built over 150 years (according to the data of 1980), offering flood safety for an area of 27,000 km^2. The present shares of Hungary are 2,869 km of embankment and 15,354 km^2 protected area. **MAP 16** shows the flood defences in the Tisza River Basin in Hungary.

Flood control has been extended to 97 % of the flood plains along the Hungarian section of the Tisza. These flood plains are subdivided into 96 flood plain basins (flood areas). The ratio of the flood plains in the Danube and the Tisza catchments is approximately 1:3, clearly demonstrating the importance of flood control in the latter. The 96 flood areas in the Tisza Valley cover an area of 15,354 km^2 with a total population of 1 448 702 and 418communities is 418 including 60 towns. These communities rely on 2,869 km of embankments (levees) for their flood safety.

Flood waves rushing down mountain catchments enter the lowlands before the national boundary. River and levee sections of common interest have been designated with the neighbouring countries, where streams form or cross borders. The total length of levees covered by international agreements amounts to 1,055 km (one-fourth of the defences).

Embankments of 1,704 km (59% of the total) comply with the dimensional specifications. The rest of the levees (1,194 km) offer safety against floods of 60-80 years return period, though at the price of considerable emergency efforts. It should be noted that even the improved, strengthened levee sections include local weak spots, with properties poorer than those of the connecting parts, which fail to meet the safety criteria. Regular levee surveillance reveals several hundred sections where the level of safety is dangerously low (such as the crossing of ancient meanders, streams, cracked embankments). The total length of these sections is approximately 560 km.

There are 1,800 structures (sluices and culverts) which cross the levees. Some of these were built 80-100 years ago and are in a very poor state and in need of repair. These and other crossing structures represent potential safety risks and are monitored with special care.

In **Serbia** flood protection for the Tisza River is based on 314.8 km of levee lines along both riverbanks. Levees were built in the 18th century and heightened and improved after each large flood (in 1919, 1924, 1932, 1940, 1944, 1947, 1965 and 1970). After a long-lasting and costly flood defence in 1970, a systematic reconstruction of existing levees was carried out and new levees were built. The conditions of floodwater conveyance were also considerably improved by engineering works in the riverbed (enlargement and shortcutting) and on the floodplain (correction of levee lines). In some parts, floodplain areas are protected and cultivated with 'summer dikes' for floods of 10% probability.

7.2.2. Drainage systems

Characteristics of lowland drainage

The total area covered by lowland drainage networks in the Tisza Valley is 56,789.37 km^2. The area and the numbers of the sub-drainage systems can be seen in the **Table III.4.**

Table III.4. The area and the numbers of the sub-drainage systems

Country	**Number of sub-drainage systems**	**Total areas [km2]**
Ukraine	5	109.70
Romania	273	10 964.37
Slovakia	12	1 205.30
Hungary	64	33 765.00
Serbia	10	10 745.00
Sum	*364*	*56 789. 37*

The length of the canals in these areas is 63,937 km in the following distribution (**Table III.5.**):

Table III.5. Length of the drainage channels

Country	**Lengths of canals [km]**
Ukraine	1 296
Romania	16 409
Slovakia	633
Hungary	37 083
Serbia	8 515

The average discharge of these systems per total area is 145 l/s/km^2, which is detailed in the **Table III.6.**:

Table III.6. Average discharges from drainage channels

Country	Average discharges [l/s/km2]
Ukraine	384
Romania	138
Slovakia	115
Hungary	31
Serbia	59

In connection with these systems, 860 pumping stations operate with 2,050.73 [m^3/s] total flow at the mouth of the canals in the following distribution (**Table III.7.**):

Table III.7. Number of the pumping stations

Country	Number of pumping stations	Total flow [m^3/s]
Ukraine	35	lack of data
Romania	860	1524.00
Slovakia	16	115.20
Hungary	609	266.00
Serbia	70	145.53

According to geomorphological conditions, the longitudinal slope of the canals is very small (0,1-0,2 m/km). Consequently grass and water-receptive vegetation decrease the conveyance capacity of the canals, and the backwater effect (at the mouths) can cause similar difficulties in the systems.

Reservoirs are used in several locations to reduce damage caused by undrained runoff. Most of them are former wetlands or other low value areas where the morphological conditions are advantageous for the storage. The utilisation of these areas is complex – outside of the inundation period they function as fishponds, wet meadows or wetlands and they provide free storage capacity at inundation times for excess water. This may cause conflicts between operational and storage functions. The reservoirs play a key role in the lowland drainage in Hungary, with a total volume of 227 million m^3.

The biggest inundated areas were observed in 1942 when 9,000 km^2 along the Tisza Valley were underwater due to undrained runoff. At the end of 1999 the inundated areas were about 8,000 km^2, which represented the second largest inundation in the region. The database doesn't have precise or homogeneous inundation data because the registration of the inundated areas was made with different procedures and with different precision. Some 20% of the total Tisza lowland catchment was inundated by undrained runoff. These inundations are meaningful from the point of view of surface water resources: every 1 km^2 represent 100,000 m^3 of water which can possibly mitigate the negative consequences of water scarcity.

Excess water prevention and mitigation, present practice and future possibilities

For the effective prevention and mitigation of the consequences of inundations, the capacity of the lowland drainage networks are very important. For this reason continuous maintenance activities have to be carried out. These activities should include mowing the grass and water-receptive vegetation in canals; dredging canals; stabilising canal beds and banks; depositing and treating dredged material and maintenance and repairing pumping stations, weirs and bridges. Unfortunately, the lack of financial resources has caused difficulties in maintenance activities, and inundations have occurred in some cases as a consequence.

In many lowland drainage systems the original capacity of the system has been reduced due to the lack of continuous maintenance causing lot of problems during periods of inundation. Mowing the grass and removing sludge are very expensive and not as efficient as prevention.

Using the mobile pumping stations increase the surface slope along the canal can be useful in those areas where conditions are provided for continuous operation. However there have been some negative experiences of using of them in the Slovak Republic.

With the transition to a more market-based agriculture after 1989, state subsidies for agriculture declined and state funding for large-scale drainage operations was reduced as well. These factors, along with low productivity of ‘converted wetlands’, have resulted in a decline in agricultural activity.

In most Eastern European countries, the policy is changing. New policies call for approaches that rely on ecological means to control flood and on defining water management priorities more broadly, but also focus on preserving natural habitat for biodiversity conservation, on water quality and other more broadly defined benefits. Governments have made great efforts to comply with the EU legislation and seek ways of improving water management and encouraging appropriate agricultural practices in the region. The transition from conventional water and agricultural management techniques to an integrated ecosystem management should lead to an effective utilization of the Tisza Valley.

The inner area of settlements represent a key question in connection with the lowland drainage networks.

The increasing areas of the settlements is accompanied with an increase in the paved impervious areas and the increase in urban runoff in terms of volume and peak discharge as well. To reduce urban flood risk, storm water reservoirs should be constructed (wet ponds and dry ponds).

7.2.3. National long-term flood plans (Action Plans)

Ukraine

In 1998 and 2001, catastrophic floods occurred in Zakarpattia and led to significant material and social damage in the region. To avoid such damage in the future, the State Committee for Water Management developed the **‘Scheme on Complex Flood Protection in the Tisza River Basin in Zakarpattia’.** Leading academic and research institutes and organisations in Ukraine were involved in its elaboration: the Hydrometeorological Institute of the State Hydrometeorlogical Service of Ukraine, Ukrainian Shevchenko National University, Ukrainian Research Institute on Mountain Forestry (Ivano-Frankivs’k), Institute of Carpathian MTs Ecology National Academy of Sciences of Ukraine (Lviv), Institute of Geology, National Academy of Sciences of Ukraine, Uzhgorod National University and others. It also developed the corresponding **‘Programme for integrated flood protection in the Tisza River Basin in Zakarpattia oblast on 2002-2006 and forecast until 2015’** to realise flood protection measures provided by the Scheme. It was approved on 24 October 2001 by the Cabinet of Ministers of Ukraine № 1388.

The Programme realisation was set up in **three stages**: The first stage from 2002 to 2006 envisaged implementation of urgent measures with a total budget of 441 million UAH, the second stage for the period of 2007 to 2011 with a total budget of 423 million UAH, and the third for the period of 2012 to 2015 with a total budget of 569 million UAH.

The Scheme 2001 recommends a comprehensive approach to:

- control flood runoff through the construction of 42 unregulated, flow-through flood retention reservoirs and additional polders with regulated outflow in the flatland to reduce the flood discharge from Q1% to Q10%
- erection of regulating hydrotechnical constructions (weirs and semi-weirs)
- strengthening of the system of flood protection dikes
- forest protection, antierosive and mudflow protection measures in the mountainous area
- local versions of the protection of certain settlements or for their proposals.

Table III.8. Distribution of the planned reservoirs and polders in Transcarpathia, Ukraine

River	Number			Capacity, Mm^3		
	of flood retention reservoirs					
	Total	**till 2005**	**till 2010**	**Total**	**till 2005**	**till 2010**
Uzh	5		3	50		29
Latorytsa	8		2	62		14
Borzhava	7	1	3	25	7	16
Rika	6	1	2	29	15	19
Tereblya	1	1	1	20	20	20
Teresva	4	1	3	37	19	32
Tisza	11	4	6	65	30	42
Total reservoirs	**42**	**8**	**20**	**288**	**91**	**172**
	Polders					
Tisza	16	12		142	4	
Borzhava	6			92	6	92
Total polders	**22**			**234**		
Total retention	**64**			**522**		

Additional Scheme provisions:

- reconstruction of the operating flood protection dikes to withstand the flood of 1% probability and the construction of some new dikes, especially those related to the creation of polders and some ring dikes for the protection of communities, for a total length of 957 km (191 km by 2005; 478 km by 2010);
- bank protection for a total length of 55 km to be finished by 2010 (11 km by 2005);
- river training for a length of 155 km (32 km by 2005, 78 km by 2010).

The analysis of the programme implementation from its realisation in 2002 showed that on 1 October 2006 only 17 % of the budget was financed. Out of a total budget of 400.5 million UAH, only 66.8 million UAH was provided.

During this period 40.2 km of protection dikes were constructed (only 26% of planned works under the Programme), 20.4 km of bank protections were reconstructed, 5.57 km of river courses were cleaned off and 7 hydrotechnical structures were built.

Having analysed the programme implementation in detail and considering the urgent necessity of flood protection measures, theZakkarpattia State regional administration, State Committee for Water Management, Government and Verhovna Rada of Ukraine developed the new version of the *Programme of integrated flood protection in the Tisza River Basin in Zakarpattia oblast on 2006-2015***.** It was approved on 13 February 2006 by the Cabinet of Ministers of Ukraine №130.

MAP 17 introduces the national flood defence improvement scheme in Transcarpathia in Ukraine.

In Slovakia Long-term flood protection plan is oriented predominantly at water retention measures (mainly construction of polders (dry reservoirs) with the aim to decrease surface runoff and maximum discharges.

In the field of new river engineering works or reconstruction of existing regulations the following criteria are taken into account:

- inside residential area - the water management purpose of measures on rivers is balanced with ecological requirements. Attention is paid mainly to shaping of cross section and the longitudinal slope.
- outside residential area – aim is to retain existing course of the river and stabilize part of cross sections as much as possible. The water courses are shortened in exceptional cases only and cut meanders are let opened - not filled up.

By means of previously built flood protection measures the adequate land protection against high floods was provided. However at present, from capacity point of view many of the river regulation works do not secure adequate flood protection. This situation is caused by the following factors:

- natural decrease of rivers discharge capacity due to growing of vegetations and silt sedimentation.
- change of hydrological conditions (increase in maximum discharge values)
- water management measures realized in neighbouring countries (e.g. at Bodrog river in Hungary – with the backwater effect in Slovak territory).

In the Slovak part of Tisza river basin many water management measures for limitation of floods are planned. These measures are contained in Development and Investment Program of River Basin Administrators. The most urgent measures are contained in **table III.9**. However the realisation of these measures depends on existing finances, which were very limited. In case of Slovakia flood protection measures are financed from state budget, but mainly from EU funds.

Table III.9 – List of most urgent planned measures at Slovak part of Tisza River Basin

Name of measure
Hornád – protection of Košice residential area
Prešov – protection of residential area
Sekčov – runoff condition in watershed of Sekčov
Sobrance – flood protection measures in Záchytný kanál watershed
Reconstruction of Ondava left side dike in stretch 8,500 – 14,100 rkm
Reconstruction of Ondava left side dike in stretch 12,500 – 17,800 rkm
Tisza River - Veľké Trakany – Reconstruction of right side dike

Name of measure
Torysa regulation in stretch of Sady nad Torysou – Seniakovce
Torysa regulation in stretch of Bretejovce – Haniska
Lúčky – reconstruction of bottom discharge device of Zemplínska Šírava reservoir
Lúčky, Jovsa – reconstruction of Zemplínska Šírava reservoir dikes
Zálužice – reconstruction of safety spillway device of Zemplínska Šírava reservoir
Uh River – increase capacity in stretch between confluence and Vysoká nad Uhom
Obišovce - polder – runoff condition in Veľká Svinka watershed
Moldavská lowland – run off condition reconstruction

In **Hungary** the national policy objectives are twofold:

As a *general aim* the Government of the Hungarian Republic in its *Government Resolution 2005/2000. (I. 18.) on the revised development plan of flood defence* confirms that the issue and the tasks of flood protection are considered part of the security policy of the country in the field of disaster management and the maintenance and development of those structural flood defences which are the property of the state has to be done accordingly.

Regarding *quantitative targets*, the followings can be summarised :
Lessons learnt from the series of extraordinary floods from 1998 to 2001 revealed that the former strategy to prevent floods by heightening and strengthening dikes should be reconsidered. As a result of studies, a new strategy called `*Update of the Vásárhelyi*[28] *Plan*` (Hungarian abbreviation: *VTT*) was developed aiming to reduce flood hazards by decreasing flood crests. This goal will be achieved by a 'room for rivers'-type project, the VTT, in the frame of which there are three main elements concerning flood hazard reduction:

- development (heightening and strengthening) of the existing dikes where they do not comply with the 1 in 100 year floods;
- improvement of the flood conveyance capacity of the river by setting back the dikes at bottlenecks, creating a hydraulic corridor in the floodway with low resistance by minimising obstacles of flow (opening sand bars, reducing the height or even demolishing summer dikes and rehabilitating pastures and mosaic-type forests instead of the existing unmaintained forests of invasive species with dense undergrowth in the hydraulic corridor) (**MAP 18** shows the improvement of flood conveyance capacity of the Tisza River in Hungary);
- reactivation of protected floodplains with controlled inundation by creating flood detention basins to cut the flood peaks (**MAP 19** shows the planned flood detention basins along the Tisza River in Hungary)

Examination of possible detention basins was extended to around 30 sites, and 10-12 detention basins were selected, covering a total area of 75,000 ha with a storage capacity of around 1,500 million m^3. Compared to the similar parameters of the IRMA programme[29], the reactivated floodplain is 3.5 times the size, the detention capacity is 7 times higher in the Tisza Valley. According to preliminary calculations, this capacity is enough to decrease the peak levels of extreme (1/1000 year) floods with 1m all along the Hungarian section of the Tisza River.

[28] Pál Vásárhelyi was a hydraulic engineer who developed the conceptual flood alleviation and river training plan of the Tisza River Basin in the middle of the 19th century.

[29] Interreg Rhein-Meuse Activities

Prompted by the results of extensive and careful preparatory studies, the government adopted a decision in 2003 on the first Stage of the VTT and following this Parliament created the corresponding act as well. (Act 2004: LXVII.)

During the first phase of VTT, between 2004 and 2007, improvement was planned for the discharge capacity of the flood bed in the vicinity of the Tivadar Bridge on the Upper Tisza and along the Middle and Lower Tisza, as well as construction of six detention basins (Cigánd- Tiszakarád, Szamos-Kraszna-közi, Nagykunsági, Hanyi-Tiszasülyi, Tiszaroffi and partly the Nagykörüi detention basin).

Although the main objective of the VTT is to increase flood safety along the Tisza River in Hungary, it also aims to establish and apply new landscape management in the territory of the reservoirs as well as regional, rural and infrastructure development, which may result in a healthier social and natural system in the Tisza River Basin.

During 2000-2006 the following results were achieved in Hungary:

- upgrading flood defence infrastructure:
    - reinforcement of existing flood embankments: 126 km in the Tisza Valley;
    - new flood embankments: 10.9 km in the Tisza Valley;
    - repair and reconstruction of flood defences damaged during the extreme floods: 83.5 km in the Tisza Valley;
- implementation of the VTT (Tisza) project:
    - improvement of the flood conveyance capacity in the vicinity of the Tivadar Bridge on the Upper Tisza;
    - improvement of the flood conveyance capacity along the Middle and Lower Tisza has been started at different spots;
    - construction of two flood detention basins (Cigánd-Tiszakarádi and Tiszaroffi) and the related works are going on;
    - construction of a flood gate at the mouth of the Lónyai principal canal is going on (substituting the reinforcement of the dikes of the Lónyai principal for a total length of 100 km);
    - dike relocation at the Bivalytó bottleneck upstream from the Vezseny bend is going on;
    - construction of flood defence for Tószeg (downstream from Szolnok along the right bank of Tisza River)
- main obstacles encountered in the implementation of the development programmes:
    - series of extreme floods and the subsequent recovery and repair works hindered the programme both in terms of time (9 months fell out in 2005-2006) and financial resources lost;
    - conditions of the state budget weakened, restrictions applied to implement the convergence programme significantly reduced the VTT budget, only 38% of the planned resources were available;
    - preparatory works of the VTT project implementation (to reach agreement with the stakeholders, land acquisition and appropriation, archaeological survey, etc.) needed much more time and were much more costly than planned.

Development plans in Hungary from 2007 onward

Based on the experiences of the extraordinary flood emergency in 2006 as well as due to changes in the financial conditions the VTT programme will be modified and the implementation will be adjusted to the financial cycles of the EU.

From the six detention basins planned to be built in Phase I, the construction of the Cigánd-Tiszakarád and Tiszaroff basins is significant and they will be finished in 2007. The licensing procedure of the Nagykunsági and Hanyi-Tiszasülyi detention basins is finished, and is in progress for the Szamos-Kraszna Basin. (**Table 10** gives an overview about the planned detention basins.)

The proposed sequence of implementation of the detention basins is as follows:

- first the six detention basins planned in Phase I are to be finished (Cigánd-Tiszakarádi, Tiszaroffi, Szamos-Kraszna közi, Hanyi-Tiszasülyi, Nagykunsági, Nagykörüi), no changes in the planned sequence are needed;
- the Szeged detention Basin is proposed as the seventh, because the flood crest depression effect of the first six basins is minimal for the Tisza River downstream from Csongrád, while the coincidence of significant floods on the Tisza and Maros Rivers may create extraordinary flood hazards;
- either the Bereg or the Szamosköz are proposed as the eighth detention basin, as the Upper Tisza reach in the vicinity of Tivadar remains vulnerable, despite the dike reinforcements and the positive effect of the Szamos-Krasznaközi detention basin,;
- the further sequence is determined by the relative lack of detention capacity along the Tokaj-Kisköre reach, therefore the ninth detention basin can be selected from among the Dél-Borsodi, the Hortobágy central or the Körös-zugi;
- the rest of the sequence including the Hanyi-Jászsági, the Csanyteleki and the Tiszakarádi, further the Csongrád Nagyréti are to be determined according to their hydraulic efficiency and specific costs.

Table 10 List of the planned detention basin

	Detention basin				
No	**name**	**surface (km^2)**	**volume (M m^3)**	**storage level (mBf)**	**Remark**
1.	Cigánd-Tiszakarádi	24,7	94,0	99,00	under construction
2.	Tiszaroffi	22,8	97,0	89,74	under construction
3.	Szamos-Kraszna közi	51,1	126,0	112,65	selected project
4.	Hanyi-Tiszasülyi	55,7	247,0	90,05	selected project
5.	Nagykunsági	40 0	99,0	88,10	selected project
6.	Nagykörüi	2,3	1,5	84,00	landscape mgmt
7.	Szegedi	61,0	306,0	83,40	
8.	Beregi	33,0	109,0	112,00	
9.	Szamosközi	47,0	130,0	112,74	
10.	Dél-borsodi	29,8	72,8	92,50	
11.	Hortobágy central	65,8	178,5	91,36	
12.	Hanyi-Jászsági	37,0	145,0	90,13	
13.	Csanyteleki	12,4	74,6	85,15	
14.	Tiszakarádi	36,8	110,0	99,00	
15.	Körös-zugi	**n.a.**	**n.a.**	**n.a.**	to be investigated
	Total :	**519,4**	**1790,4**		

The necessary 1.5 billion m^3 detention capacity can be implemented within 15-20 years (by 2025) at a cost of implementation around 0.48-0.6 billion Euro.

Financial resources planned in the EEOP of the National Development Plan for the implementation of the VTT in the period of 2007-2013 cover roughly one-third of the entire programme and make possible the implementation of the first six detention basins, further development of existing flood defences, improvement of flood conveyance conditions (one third of the full programme) as well as development of the non-structural measures such as monitoring, forecasting and IT background of the operation of the system of detention basins.

In Romania the National Institute of Hydrology and Water Management is in charge with the elaboration of the River Basin Development and Management Schemes , which are the instruments for planning at basin level and are composed of two parts: the River Basin Development Plan and the River Basin Management Plan.

Romania signed an agreement in 2004 with the International Bank for Reconstruction and Development to finance a project on ‘Risk mitigation in case of natural calamities and preparation for emergency situations’. The project covers rehabilitation and safety improvement of the flood defence infrastructure for rivers (Tarna Mare, Tarnava Mica, Cibin and Bega), for large dams (Berdu, Varsolt and Lesu) and for small dams (Sanmihaiul Roman and Taria).

One of the beneficiaries is the Ministry of Environment and Sustainable Development which is also responsible for the implementation of the project.

In Serbia levees along the Serbian section of the Tisza River enable the protection from the flood with return period once in 100 years (4 100 m^3/s), with one meter additional freeboard above the design flood level. Presently, protection lines on 90% of their total length meet this standard. The quality of executed works was in general justified in 2000 and 2006, when large flood waves occurred.

Only two levee sections remained, which has to be reconstructed in the same manner: one at the right bank and one at the left bank, both at the most downstream section of the Tisza River. During spring time in 2006, the necessity and urgency of these works was proven, because these levees were seriously endangered due to concurrent extreme floods on the Danube and the Tisza rivers.

The reconstruction of Tisza levees on the most downstream sector is an urgent task in Serbia. The main design for reconstruction works is ready, and financing will probably ensured from the Investment plan for Vojvodina. It is expected that reconstruction works will start in 2008.

Annex 16 includes `*Flood Risk assessment and management strategy for the development of flood action plans in the Tisza River Basin*` (version January 2008).

7.2.4. Potential damage to the economy from flooding

Table III. 11 presents estimates made in 2002 during the preparation of a report for the Tisza Forum. Although efforts were made to use a uniform approach figures should be considered with caution. In spite of the uncertainty in the estimates, the figures show a relationship between potentially flooded areas and the value of the assets on these territories.

Table III.11. Estimation of potential damages caused by flood events (2002)

Country	Potential damages 10^6 USD*	Potential damages 10^6 EUR
Ukraine	13.57	9.4
Romania	2860	1984.84
Slovak Republic	1 376.0	954.9
Hungary	2 579.0	1789.8
Serbia[30]	-	-

*I USD = 0.6940

Related to potential flood damages in Serbia, the Tisza River floods endanger surrounding lowland areas in the Banat and Backa regions. Potentially flooded areas are only defined approximately, because the risk analyses defining potential damages due to 1% probability flood were never performed. Also, no data on real damages exist because no flooding occurred in the 20th century. However, levees in the Tisza River valley are of the greatest importance, protecting more than 20 settlements, 150,000 hectares of agricultural land, 100 km of railroads and 320 km of roads and numerous industrial facilities.

Levees of the Old Bega and the Bega Channel protect around 50,000 hectares of arable lowlands and many settlements, with approximately 50,000 inhabitants.

An example is given in the **Table III.12 of** the comparative characteristics of damage caused to the national economy of Zakarpattia oblast as a result of the floods in 1998 and 2001.

Table III.12. – Sample - Consequences of catastrophic floods in 1998 and 2001 (Ukraine)

Indexes	Unit	1998	2001
Settlements flooded	number	269	255
Houses flooded	number	40793	33509
Houses destroyed	number	2984	1937
People evacuated	persons	24340	13769
Human lives lost	persons	17	9
Damaged or destroyed dikes	km	6,67	8,003
Damaged or destroyed bridges	number	48/12	6/17
Damaged or destroyed roads	km	96,2	52,7
Settlements with disrupted electricity supplies	number	162	107
Damaged connection with settlements	number	169	65
Telephone lines cut off	number	187	76

[30] No figures are given, because the risk analyses defining potential damages due to 1% probability flood were never performed. Also, no data on real damages exist, because no flooding occurred in the 20th century.

Indexes	Unit	1998	2001
Settlements cut off from gas supplies	number	42	10
Damaged and destroyed railway	number	2	5
Damaged and destroyed railway lines	km	0,65	0,58
Damaged and destroyed railway bridges	number	0	1
Estimated costs	**mill EURO**	**180.4**	**59.2**

7.2.5. Assessment of risks - flood risk mapping

Common approach and methodology in assessment of flood prone areas and evaluation of flood risk[31]

The ICPDR Flood Protection Expert Group conducted a *survey on the state-of-the-art of flood hazard and risk assessment and mapping* in the Danube River Basin countries. The survey revealed a wide diversity concerning the availability of different products, methodologies and even in the projection system and reference levels used in the different countries (even within the Tisza River Basin).

The only comprehensive flood map covering the entire Tisza River Basin and showing the extension of the floodplains is the one compiled in 1938 in Hungary on the scale of 1:5.000.000, and summarising historic inundations before river training and flood alleviation works started (see **MAP 20** – Historic flood map of permanently and temporarily inundated areas before the flood alleviation and drainage works). Romania compiled historic flood maps of the Someş and Crisuri floodplains in 1996 (1:25.000), but no historic flood maps have been reported for the territory of the Tisza Basin in the Slovak Republic and Serbia.

A map of flooded areas in the Tisza River Basin during 1998 – 2006 was created by the Dartmouth Flood Observatory (USA) by merging satellite images, showing the inundations of 1998 and 2006 in the Upper Tisza and the 2005 flood in the Banat region (see **MAP 21**)[32].

General inundation maps are available for floodplains in Hungary, compiled in 1977 in scales of 1:100,000; 1:50,000, indicating the flood extent of 1% and 0,1% probability (see **MAP 19**). General inundation maps have also been created covering the Tisza Basin in Serbia. The maps compiled in 2002 are in scales 1:20,000. The maps are available in both countries in paper format for restricted use. No such maps have been reported for the territory of the Tisza Basin in Romania, the Slovak Republic and Ukraine.

A flood hazard map was developed in 2005 in the Slovak Republic for the 56 km long stretch of Topľa River, between Prešov and the Topľa River mouth to the Hornád River. Initial efforts in the recent past to develop digitised flood hazard maps resulted in 5% coverage of the Tisza River Basin floodplains in Hungary. In the frame of TACIS and other projects, initial steps to provide flood hazard maps were made in Ukraine in recent years, however flood risk maps are not yet available in any of the Tisza River Basin countries.

***A common approach** and methodology in assessment of flood prone areas and evaluation of flood risk* is under development and will be based on the EXCIMAP[33] 'Guide of Good Practices of flood mapping` which should be finalised before the end of September 2007, as well as on the outputs of

[31] Proposal was taken by Sandor Toth, chairperson of Flood Protection Expert Group of the ICPDR

[32] This satellite image does not give information on the extension of floodplains in the Tisza River Basin, only the actual flooding of the referred years. Furthermore, the inundations can be seen between the dikes and on the land due to undrained runoff (excess water).

[33] European exchange circle on flood mapping (established in the frames of the EU Action Programme on Flood Risk management Planning)

the ICPDR Flood Protection Expert Group Flood Risk Mapping Workshop (Budapest, 12-13 September 2007).

*Realistic **timetable** for producing flood maps (and flood action plans):*

- development of a common approach on flood hazard and risk assessment and mapping in the Danube River Basin with regard to Flood Directive requirements –Deadline: March 2008[34]
- preliminary flood risk assessment (EU Flood Directive Article 4-5) – Deadline: end of 2009
- flood hazard maps (EU Flood Directive Article 6) – Deadline: end of 2011
- flood risk maps (EU Flood Directive Article 6) – Deadline: June 2012
- flood risk management plans (flood action plans) (EU Flood Directive Article 7-8) – Deadline: end of 2013

8 Drought

The Tisza River Basin runoff is highly variable – there are alternate periods of drought and flooding that are difficult to forecast and manage effectively. The droughts of recent years, such as the drought of August 2003, had severe effects in the region, particularly on the Hungarian Plain where agriculture was extremely affected. The lack of water reduces not only agricultural activity, but also the development of industry and urbanisation. Cities and other communities demand more water than the quantity available from rainfall, and it has always been difficult to get enough water for settlements far away from rivers.

There is no general definition of drought, but it is commonly understood to be a less than usual natural water supply. According to the Working Group on Water Scarcity and Drought at the Water Directors, water scarcity refers to long-term water imbalances, combining an arid or semi-arid climate (low water availability) with a level of water demand exceeding the supply capacity of the natural system. The box below gives an overview on the ongoing processes in the European Commission.

Water scarcity and drought - process in the European Commission

Considering the drought events and water scarcity situations which arose in EU Member States, a working group was set up by the Water Directors to prepare a technical document on drought events and water scarcity situations. The water directors approved its main conclusions and recommendations in a policy summary in June 2006. The Commission, with the help of the working group leaders (France, Italy, Spain), created a questionnaire, aimed at getting national information on water scarcity situations as well as drought events. Following the presentation of a first interim report at the meeting of the Water Directors in November 2006, the Commission committed itself to addressing the remaining data gaps on the scope and impacts of the issues with the cooperation of Member States. A new questionnaire was disseminated to the Water Directors in early 2007. The second interim in-depth assessment, published in June 2007, attempts to present an updated overview of drought events and water scarcity situations at the EU level whenever quantitative data are available at national and European levels.

[34] As a result of a six month delay in the delivery of the EXCIMAP Guide

Aridity and droughts are natural aspects of the Earth's climate, but aridity is a long-term average feature while droughts are a deviation from an average situation for limited period of time. Aridity is defined by long-term low precipitation rates, often together with high evaporation rates, and results in a limited availability of water resources.

Droughts, on the contrary, are a temporary decrease of the average water availability.

The first stage in this paper investigated only the issue of drought issue.

The mostly commonly used indices

1. Palfai index (PAI) (Serbia, Romania, Hungary)
2. SPI (Serbia, Hungary)
3. PDSI (Serbia, Hungary)
4. aridity index (Serbia, Romania) – MAP – Tisza Flood Forum – Distribution of the aridity factor in the Tisza River Basin
5. water balance (Serbia)
6. parameters of soil drought: values of hydrolimits: point of plant withering, point of lowered water availability, field water capacity (Slovakia)
7. agronomical classification (Slovakia)
8. relative evapotranspiration (Hungary)
9. Amount of precipitation for vegetation period (%N)
10. hydrothermic parameter (Slovakia)
11. relative soil humidity (Hungary)

8.1. Drought and drought management in the Tisza River Basin countries (time and space varying droughts in theTisza Valley)

In **Ukraine** the term 'Drought management' has never been applied to the Ukrainian part of the Upper Tisza River Basin due to the fact that in Transcarpathia the annual surface water resources potential per capita (3130 m³) is three times as much as the same index for the whole country (1000 m³). In this case the only terms which fit are 'Water scarcity' or 'Water deficit'. In the set of observations available there were examples of dry years (1961, 1963) but which didn't result in water shortage.

The most comprehensive studies in this field were carried out in the 'Scheme of multi-purpose use and protection of water and land resources of the Soviet part of the Tisza River Basin' dated 1974. This document compared the design annual runoff for a dry year of 95% probability and design aggregated water consumption for defined future periods. The calculations were done based on the prognosis of population growth and industry and agriculture development. The balance is given in the table below.

	Years				
Indexes	**1975**	**1980**	**1985**	**1990**	**2000**
Annual water consumption, Mm³	57	126	192	243	292
Sanitary discharges in the rivers, Mm³	768	768	768	768	768

Indexes	Years				
	1975	1980	1985	1990	2000
Design annual runoff (95% prob.), Mm^3	4160	4160	4160	4160	4160
Balance (+/-),Mm^3	+3335	+3267	+3200	+3149	+3100

In reality the situation appeared to be quite the opposite. According to official statistics (State Water Counting) the actual water extraction out of different water bodies since 1990 has been decreasing (see the table), and this trend will continue.

Index	Years			
	1990	1995	2000	2005
Annual water extraction, Mm^3	158	112	80	59

In any scenario of water sector development for 2015, a water deficit can hardly be considered for the Ukrainian part of the Upper Tisza River Basin.

In **Serbia** drought has been the object of much research and investigation by a number of Serbian authors. This research and investigation encompasses all aspects of drought: from global and regional problems, environmental impacts, morphological, physiological and biochemical aspects of plant resistance to drought, to irrigation problems. Some of the drought indices or indicators (such as the deviation from average precipitation levels, seasonal fluctuations of precipitation, relationship between precipitation and potential evapotranspiration, water balance, occurrence of dry periods or development of semi-arid areas in Serbia) are being used in regional drought assessments from the hydro-meteorological perspective.

Drought is a recurrent feature of the **Hungarian** climate and can cause substantial damage to the nation's agriculture. Dunay and Czakó (1987) note that 36% of the overall agricultural loss originates from drought, followed by hail, floods and frosts, in order of importance. Each year from 1983 to 1995, with the exception of 1987, 1988 and 1991, were drought years. This long period of drought was unprecedented in the 20th century in the region and comparable in length only to the ten-year period from 1943 to 1952 or in severity to the 1779-1794 drought event (Gunst, 1993). Since eight of the twelve years were disastrous drought years, this series of dry years has increased the scientific and political interest in climate variability and climate change and the importance of drought as an extreme meteorological event. After a couple of normally wet years, Hungary experienced very dry years again in 2000 and 2003. (Szalai, S., Szinell, Cs., Zoboki, J. (2000)

In **Romania** the identification of high drought risk areas in the Tisza River Basin was made on the basis of the correlation of the aridity index calculated through the reporting of precipitations to the potential evapotranspiration with the one of the aridity index Palfay (PAI) which takes into consideration the frequency of the dry years. It was considered that the affected areas comprise the territories in which the aridity index has values under 0.65 and the ones with sensitivity to drought for which the Palfay index is between 4 and 8 **(see Annex 12).** For the basins afferent to the Tisza River tributaries, the areas with PAI index values between 4 and 6 (moderate sensibility) and 6 and 8 (high sensibility) are only encountered in the Salaj Hills and in the Western Plain, at the border with Hungary and Serbia (**see Annex 12).** The respective areas are fragmented and comprise a relatively small surface.

The obvious conclusion is that in the Romanian part of the Tisza River Basin, the intensity of the drought expressed through a high frequency of the dry years isn't a characteristic phenomenon, as the areas with high values of the Palfay index are small and discontinuous **(see Annex 12).** This area is, to a great extent, classified as a dry/sub/humid area. In this region there are still dry years and even dry periods, the most important being the 1961 – 1973 period, but interrupted by excessively rainy years. Analyses emphasise that the driest season is autumn, especially in September and October.

For the **Slovak part** of the Tisza River Basin, the PAI index was used during the evaluation of drought**, and showed that** the most unfavourable year was 2003. Most of the Slovak part of the Tisza River Basin was classified as having 'moderate draught', with the exception of the Somotor station (in the vicinity of the Bodrog River), with value of 10.4 meaning 'severe draught', and the Michalovce station (Laborec Valley) with value of 8.41 as 'medium draught'. Return periods were not calculated.

The aridity factor – defined as the relation of annual potential evaporation to a mean annual precipitation – is below 0.2 at the eastern border of the Tisza Basin (in the Carpathian Mountains) and increases from northeast to southwest up to 1.4 in the middle of the Hungarian Plain (at the mouth of the Körös Rivers), as displayed in the **MAP 22.**

8.2. Signs of groundwater depletion

In Romania there was not a quantitative risk for groundwater bodies with important catchments such as the Somes alluvial fan having the two groundwater bodies, as well as the Mures alluvial fan there was not emphasized a quantitative risk. For the Somes alluvial fan no permanent significant decreases of the piezometric levels in the catchment area for the water supply of Satu Mare were observed. Thus, in the case of the Mures alluvial fan, the low discharge in the Mures River and the water intake for the water supply of Arad resulted in a decrease in the piezometric levels in monitoring wells situated in the catchments area – southwest of the Santana well (the northern part of catchments), Arad F1 (the southern part of catchments) and F1 Sofronea until the 1992-1995 interval when the piezometric levels were stabilised.

Based on existing data **In Serbia** (a maximum 10 years' long-term series), there are no signs of groundwater depletion (continuous lowering of groundwater levels in longer period) in the shallow aquifer, since it is under influence of climate parameters (precipitation, temperature)

In the **Slovak part of the Tisza River Basin** no groundwater bodies (transboundary or larger than 1000 km2) are at risk in respect to quantitative status.

MAP 23 shows an example of deviation in Hungary between the annual depth of the groundwater table in 2003 and the annual mean for 1956-1960.

Part IV Cross Cutting Water Management Issues

9. Economy

9.1. The Water Framework Directive and economics of water use

The need to conserve adequate supplies of water resources for which demand continuously increases is also behind what is arguably one of the WFD's most important innovations – the introduction of pricing. Adequate water pricing acts as an incentive for the sustainable use of water resources and thus helps to achieve the environmental objectives of the WFD. According to Article 9 of the WFD Member States shall take into account the principle of cost recovery of water services, including environmental and resource costs, with regard to the economic analysis conducted according to Annex III, and in accordance with the 'polluter pays' principle.

The WFD stipulates that by 2010 Member States shall also ensure:

- water pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of the WFD,
- an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis conducted according to Annex III of the Directive and taking into account the 'polluter pays' principle. In doing so, Member States may regard the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of the region or regions affected.

ANNEX III of the WFD explicitly explains that the economic analysis shall contain enough information in sufficient detail (taking account of the costs associated with collection of the relevant data) in order to:

(a) make the relevant calculations necessary for taking into account the principle of recovery of the costs of water services under Article 9, taking account of long-term forecasts of supply and demand for water in the river basin district and, where necessary:

- estimates of the volume, prices and costs associated with water services, and
- estimates of relevant investment including forecasts of such investments;

(b) make judgements about the most cost-effective combination of measures in respect to water uses to be included in the programme of measures under Article 11 based on estimates of the potential costs of such measures.

9.2. Water pricing in Tisza River Basin countries

This section gives a short overview on water pricing in the Tisza River Basin based on country expert contributions.

9.2.1. Water tariffs and charges in Hungary

The system of water resource fees to be paid in proportion to water uses, has been introduced in order to regulate the utilisation of water resources based on the aim of the water use and the type of water used. Water resource fees account for a relatively small part of the total costs of abstraction, in the industrial, agricultural and the public utility sector.

The obligation of paying a water load fee was introduced on 1 January 2004 for all polluters – including companies that operate water public utilities – who discharge their pollution into surface water, in proportion to the quantity of pollutants discharged. The obligation to pay a soil load fee was introduced on 1 July 2004 for all those who do not connect their facilities into the public sewage system (where such a system exists) and thereby pollute groundwater.

In Hungary there are two types of water price systems (price structures) for the basic services: a one-factor system based on unit price, block tariffs, fixed price and a two-factor system based on the basic price and service fee (variable part).

9.2.2. Water tariffs and charges in Romania

Water abstraction charges are the same all over Romania, but differ according to the source of water (inland rivers, the Danube and groundwater) and the category of user (industry, household, power plant, agriculture, fisheries). Prices of drinking water are set up at the municipality level taking into account the local conditions and costs associated with providing drinking water.

The effluent charges are levied on a set of pollutants and aimed at reducing their content in the rivers to within the limits set by the law. If limits are exceeded, fines or penalties are levied. Penalties are levied for non-compliance for both water intakes and discharges of wastewater. The penalties are used as income for the Water Fund, and the income from all water charges is used to cover operating costs.

The drinking water and sewage and wastewater treatment tariffs are based on the production and exploitation costs, maintenance costs, depreciation costs, loan rates according to the obligations of the loan contracts and credit reimbursement.

The income from all water charges is used to cover operating costs. The penalty revenues according to the Law 310/2005 are source of income for National Administration Apele Romane , and not funding the “Water Fund.

9.2.3. Water tariffs and charges in Serbia

The funding of water management at the national level is defined in the Water Law. The major sources are: the budget (including fees for the use and protection of water and charges for extraction of material) and revenues from fees assessed by public water companies (drainage fees, irrigation fees and fees for the use of the infrastructure). Additionally, local governments and utilities invest in the water sector through local activities (primarily municipal water supply and wastewater disposal), as do other legal entities and individuals to meet their needs or protect their property.

The basic problem associated with water sector funding arises from the fact that there is a large gap between needed funding and secured funding. Namely, 'user pays' and 'polluter pays' principles are not fully applied in water and service pricing, resulting in an extremely low level of self-funding and a major reliance on the budget. Further, fees for the use and protection of resources are far below required levels, and the management of accounting, invoicing and collection does not ensure full collection.

Current drinking water tariffs and removal of wastewater charges are well below economic levels.

9.2.4. Water tariffs and charges in the Slovak Republic

According to the 2004 Water Act, two categories of payments for water using exist in the Slovak Republic:

- (1) payment for water abstraction from water courses, utilisation of hydropower potential of water courses with install capacity, water abstraction from water courses for energy production, utilisation of hydropower potential of water coursers of water constructions according to the international agreement utilisation for navigation other services in the public interest
- (2) charges for groundwater abstraction, wastewater discharge

Most of the revenue from payments are income of the Slovak Water Management Enterprise (SWME) and are used to operate water courses and river basins. Charges are collected by SWME and they are a funding source of the Slovak Environmental Fund since 2004.

The household drinking water bill is calculated on a volumetric consumption of water (price multiplied by volume of delivered water). According to the 2004 Water Act, the polluter is obliged to treat wastewater according to the state-of-art technologies (that is secondary treatment at the minimum). The Water Act also requires treating wastewater to meet the emission limits. Therefore, there are cases where the polluter must add a tertiary step in order to meet the standards. According to the Regulation on Pollution Charges from 1979, each polluter must pay a water effluent charge.

9.2.5. Water tariffs and charges in Ukraine

Ukraine has several laws and other secondary laws regulating the issues of drinking water, water supply and sewage water. According to the 2002 Law of Ukraine 'On Drinking Water and Drinking Water use' communal enterprises of territorial communities (vodocanals) are those enterprises which provide central water supply services. These enterprises have their own property and are financially independent. Vodocanals make tariffs for water supply and sewage water by themselves and approve them in local village or city councils.

The tariffs do not take into account the source from which the water in-take is made (surface or groundwater).

Tariffs differ for various consumer groups: population, governmental organisations and industry. All water, supplied by Vodocanal is drinking (there is no technical water for industry). Tariffs increase from year to year for all groups of consumers, and they are the highest for industry.

According to the current legislation, all water users have to clean wastewaters. If a water user does not make direct discharge, it should discharge wastewaters to wastewater treatment facilities of Vodocanal. A separate agreement for subscriber service provision is made in this case.

The discharge of pollutants into surface waters by Vodocanal and by the water user with direct discharge is regulated by the 1999 Decree of Cabinet of Ministers of Ukraine 'About Approval of Order of Establishment of Charges for Pollution of Environment and Getting the Charges'.

10. Interaction between water quality and water quantity aspects

This chapter introduces the main questions discussed by the ICPDR Tisza Group Experts and will give proposals for the future steps to be taken by the Tisza Countries.

10.1. Relevance of integration of water quality and water quantity aspects in the Tisza River Basin area

The Tisza River Basin is one of the areas where the importance of the integration of water quality and water quantity management activities is apparent.

Nearly the entire Tisza River is 'at risk' or 'possibly at risk' due to hazardous substances, more than half of the river is 'at risk' or 'possibly at risk' due to nutrient pollution and a significant section of the Tisza River is 'at risk' or 'possibly at risk' due to organic pollution. In the Tisza tributaries, related risks from nutrient and organic pollution are even higher than in the main river and pressure from hazardous substances play a significant role as well.

In addition to hazardous substances, nutrients and organic pollution problems, the Tisza River Basin also faces other problems due to extreme events of floods and drought. During the last century, Tisza countries made significant efforts against floods. During the second half of the 19th century, extensive river training and flood control measures (including more than one hundred cut-offs) were taken along the river. As a result of these works, the river's total length (1,420 km) was shortened by approximately 30% and is today 966 km. Most of the Tisza River is at risk or possible at risk due to hydromorphological alterations`.

Both floods and drought are natural phenomenon, yet results of the present fluctuating climatic conditions these events could cause increasingly dramatic problems in the Tisza River Basin. Drought and flood events follow each other in many cases in alternating periods of the same year, creating serious problems in the Tisza River Basin.

Part II (Water Quality) of this report introduced the main pressures in the Tisza River Basin as well as the main risks related to the water bodies. The subchapter on significant pressures introduced the main point and diffuse source pollutions and highlighted the important role of agriculture as a significant source of diffuse source pollution.

Part III gave an overview of the pressures related to floods and droughts, and introduced the historical floods and potential damage by flood events as well as facts related to drought events (including an assessment of low water flow and the signs of groundwater depletion).

Important issues are how the mentioned pressures impact the water ecosystems, and how the interactions between the related impacts should be analysed, as well as how the risks of floods and droughts to human health and life, environment and economy can be prevented and managed by integrated water and land use management.

During its expert work, the ICPDR Tisza Group highlighted the importance of the interaction between floods/drought and risks from pollution (nutrient, organic pollution and pollution from hazardous substances). The Tisza Group's work draws attention to water quantity management (water flow regulation) as a key issue in the Tisza River Basin and its influence on water quality aspects.

In the `*Flood Risk assessment and management strategy for the development of flood action plans in the Tisza River Basin (version January 2008* - **see Annex 16) -** importance of measures related to pollution prevention and mitigation with respect to floods are highlighted.

An important discussion point in the frame of the Tisza Group work process was that `hydromorphological pressures can be reduced inter alia by appropriate use of the active, and where feasible, by partial reactivation of former floodplains`. Protecting nature and restoring wetlands will be significant future tasks in the Tisza River Basin; however, the ecologically important water needs of wetlands are not yet determined for the transboundary level. Ecologically important water needs are different for different parts of the Tisza River Basin and transboundary harmonization of water needs must be taken into account.

An inventory of water resources and uses is not currently available for the transboundary level, but inventories would be essential for further analysis as well as for planning future infrastructure projects, which have potential effects on the transboundary level.

It is important to note that wetlands play an important role in river basin functions. They are central components of the hydrological cycle, performing economically and environmentally valuable functions to regulate water quality and quantity and therefore contribute to reaching and maintaining 'good status'[35]. It was stressed during the Tisza Group Workshop (19-20 February 2007) that the water needs of wetland ecosystems are often forgotten as a classical water use.

Tisza Countries called the attention to the importance of the water needs of wetlands and floodplain ecosystems in the Tisza River Basin, highlighting that these water ecosystems have to be considered as an important water user of the area as well.

Finally, there are important actual or potential links between the purposes and methods of flood management and the achievement of water quality objectives. In particular, flood management has the potential to positively affect the risk of runoff and associated diffuse pollution from agricultural and rural areas. Flood management involves interventions to modify the conveyance and storage of surface waters, thereby affecting the hydromorphological characteristics of rivers and in turn their ecological status.

As a discussion point, the present extreme climate conditions can strongly influence the water quantity aspect of the Tisza River Basin and can have a secondary effect on the quality of water ecosystems. The following subchapter gives an overview of the possible impacts related to climate changes and highlights the possible effects on the Tisza River Basin.

[35] Elements of Good Practice in Integrated River Basin Management, key issues, lessons learned and 'good practice' examples from the WWF/EC `Water Seminar Series` 2000/2001. pp. 35-36

10.2. Anticipated impacts due to climate changes

Climate variability and change in Europe over the next 50 years could severely impact the quality and quantity of aquatic resources for human consumption as drinking water and the availability of water in agriculture, increase the frequency of extreme events such as floods and droughts and make policy adaptation very challenging.

hotter	colder	weather
less	more	water
dry	humid	ambient air evaporation
seasonal	uniform	precipitation
drought	flood	disaster
river basin	sea / ocean	drainage / storage

Figure IV.1 **Uncertainties of Climate change**

The Ministry for European and International Affairs in cooperation with the Ministry of Agriculture, Forestry, Environment and Water Management and the International Commission for the Protection of the Danube River (ICPDR) were organising a conference (*Conference on Adaptation of Water Management to Effects of Climate Change in the Danube River Basin*) on December 3, 2007 in Vienna to address the effects of climate change in the Danube region, especially focussing on the needs for adaptation from a water management point of view.

One of the main conclusions of the conference is that climate change is an issues of Danube Basin wide significance and will be addressed by a stepwise approach taking into account the issues of flood protection, low water discharge and land use.

Possible impacts from climate change:

Aspects related to Water Quantity:

- A further increase in the risk of flooding, further decrease in water availability and an increase in water stress - impact on water quality and biodiversity

Aspects of the WFD in connection to climate changes (climate-induced changes):

- River Basin Management Plan - related aspects: climate-induced changes in land use and land cover, agriculture
- Typology of water bodies - related aspects (climate-induced changes): typology criteria, type specific reference conditions
- Ecological quality assessment - related aspects (climate-induced changes): classification borders and intercalibration, emission limits and quality standards
- Economic analysis related aspects

Table IV.1. introduces climate sensitive type parameters.

Table IV.1. Climate sensitive type parameters (highlighted in red in the table)

	Rivers	Lakes
Obligatory factors	latitude longitude geology size	altitude latitude longitude depth geology size
Optional factors	distance from river source energy of flow mean water width mean water depth mean water slope form and shape of main river bed river flow category valley shape transport of solids acid neutralising capacity mean substratum composition chloride air temperature range mean air temperature precipitation	mean water depth lake shape residence time mean air temperature air temperature range mixing characteristics acid neutralising capacity background nutrient status mean substratum composition water level fluctuation

Relevant projects and ongoing work related to climate change

Projects and events

- PESETA – Flood risk in Europe in a changing climate – JRC (ies.jrc.cec.eu.int)
- KLIWA – Climate change and Water Resource Management – Cooperation project in Southern Germany (www.kliwa.de)
- ESPACE – European Spatial Planning – Adapting to climate events – INTERREG project (www.klimaproject-espace.bayern.de)

Research projects

- CLAVIER (Climate Change and Variability: Impact on Central and Eastern Europe) – Bulgaria, Hungary, Romania (www.clavier-eu.org)
- PRUDENCE
- CECILIA

Conclusions related to the Tisza River Basin

Significant impacts on the Tisza and Danube water systems are expected, in particular:

- Reduced average water flow
- Increase in extreme events
- Significant regional and local variations
- Impacts on water uses not known
- Changes is water quality and ecological status likely but not investigated

Practical research needs to prepare a River Basin Management Plan (scenarios):

- Quantify the impacts of climate change on water quality/classification of surface and groundwater
- Quantify the impacts of climate change on water quantity, its spatial-temporal distribution including extreme events such as floods and droughts
- Assess the availability of surface and groundwaters under different scenarios and for different uses
- Evaluate the associated costs of adaptation and the effectiveness of different protection/adaptation measures in transnational river basins
- Evaluate the impacts of climate change on the re-mobilisation and re-distribution of contaminants as a result of extreme events

Climate change is a new key challenge, but not the only one existing in water management. The EU Policy Frame with IWRM and ICZM is a sound basis for coordination across sectors, but further developments must involve all concerned to avoid conflicts among different users - prioritisation of uses, sharing of costs.

Ongoing work in the Tisza Countries

Hungary

The project 'Impacts and responses concerning Global climate change in Hungary' (abbreviated VAHAVA) provides scientific support for the establishment of a national climate policy focusing on adaptation. The project ended in 2006, and its final report summarised:

- Experiences related to the Hungarian climate and weather and the expected impacts of climate change,
- Major elements of atmospheric protection and of the national strategy of adaptation to climate change and
- Recommendations for future measures aiming to prepare, prevent and mitigate.

Slovak Republic

- climate change scenarios (three climate change scenarios were applied CCCM1997, CCCM2000, GISSS1998)
- Increase in extreme events is predicted

Romania (see separate box)

- Increase in extreme events predicted
- one consequence: give rivers more space

Options / Measures for Adaptation Strategies

Wide range of options to counteract impacts:

- Technically-oriented measures
- Economic instruments (steer consumer behaviour)
- Land use related measures
- Information measures
- Regulatory measures – legal and institutional frame to solve conflicts among water users; prioritisation of uses

Adaptation options (technological and management options)

Short-term adjustments:

- Improving irrigation efficiency:
    - Land management techniques (e.g. conservation tillage)
    - Irrigation management (e.g. adjusting timing and volumes of water application)
- Crop substitution to reduce dependence on irrigation or to increase water availability
- Changing or improving harvest insurance mechanisms to protect farmers from the economic impacts of flood or drought damage

Long-term adaptations

- Changes in farming systems to make them more flexible and adapt to higher variability in climatic conditions (e.g. mixed farms; organic farming)
- Changes in land use and landscape management:
    - To conserve water and reduce the sensitivity of farming systems to flood damage, e.g. replacing arable land by grassland and even by wetlands, where feasible
- Crop breeding and development of more resistant varieties:
    - Developing crops that are more resistant to water stress

Conclusions of the Berlin Conference

- It is time to adapt now! Scientific evidence urges action
- EU water and marine policy provides a solid basis for integrated water resource management – it should be used to factor in adaptation to climate change
- A successful adaptation strategy needs a common and integrated approach
    - Adaptation starts with using water more efficiently in all sectors
    - Measures to reduce demand should clearly be favoured in comparison to increasing supply. This applies to all sectors.
    - Moreover, supply side management needs to become for efficient, e.g. by reducing leakages.
    - Water dependent sectors need to be involved
- All EU policy areas need to undergo an adaptation check
- Actions in all sectors need to be taken and integrated into the wider water management
- In addition, the following specific conclusions were drawn:
    - Agriculture can make a stronger contribution to adaptation
    - Energy and electricity production play an important role in mitigation and adaptation
    - Navigation management and planning needs to become climate-proof
    - Truly sustainable tourism needs to be promoted
- More intense cooperation and common action at the EU level
- The ‘user pays principle’ needs to be fully implemented
- Further research activities are necessary to tackle adaptation issues more effectively – the science policy dialogue needs to be continued and strengthened
- Don’t forget the world outside the EU! Adaptation and the integrated water resource management should be a key element of development cooperation including cooperation with States in the European Neighbourhood

The impact of climatic changes (Sample from Romania)

In view of the assessment of the climate changes on hydrological resources in a river basin, the doubling of the CO^2 in the atmosphere hypothesis was considered, using a monthly water balance model.

The mathematical model was applied in two cases: the current regime (scenario 1), which consists of the simulation of runoff on the calculation period considering measured inputs, and the modified regime (scenario 2), in which the runoff it is simulated with the same model and during the same period considering the modified inputs, determined in the hypothesis of the doubling of the CO^2 in the atmosphere.

The climatic scenario adopted in the hypothesis of the doubling of the CO^2 in the atmosphere was determined with the support of the Global Circulation Model of the Canadian Climatic Center – CCCM, considered to be the most appropriate for the climatic and orographic condition in Romania.

The methodology presented was applied in the Tarnave River Basin, situated in the centre of the country inside the Carpathian Arch, which has a surface of 6,253 km2, or 22.5% of the Mures River Basin to which it belongs.

Though the comparison of the mean monthly discharges resulted in the two scenarios, the impact of climatic changes on water resources could be evaluated.

In the hypothesis of the occurrence of the climatic scenario 1, the discharge regime of rivers will be modified due to the changes in precipitations and increase in real evapotranspiration. The most significant changes are the following:

- Mean annual runoff will increase by 0.9%
- The variation of runoff during the year will increase up to 71.7% during October – February, July and August and decrease up to 30.2% during March – June and September. Usually, mean multiannual runoff, in the hypothesis of climatic changes, will be less variable than it is at present
- The variation of the mean runoff during the year has recorded an increase of up to 71.7% in October – February, July an August and a decrease of up to 30.2% in March – June and September
- The minimum runoff will increase during December - February by 156.9% and will decrease during spring, summer and autumn by up to 19.4%
- Flash floods from snowmelt will occur earlier, usually during January, and will be larger by up to 21.4% with a de-synchronization with the pluvial flash floods
- Soil humidity, in the hypothesis of scenario 2, decreases with an average of 6.8% due to the increase in real evapotranspiration. During the year an increase in soil humidity can be noticed during winter of up to 76.4% and a decrease during summer of up to 20.7%

11. Summary & Conclusions

The Tisza River Basin is one of the areas where the importance of the integration of water quality and water quantity management activities is apparent. The Tisza River Basin Management Plan will integrate issues of both water quality and water quantity in a combined approach for land and water management.

Action must be taken collectively to maintain and protect the ecosystem with an integrated river basin management approach combining land and water management, as well as balancing water quality and water quantity.

The threats to the Tisza River Basin must be addressed and managed through enhanced international planning and measures. The Tisza River Basin Analysis provides vital information to successfully develop the Integrated River Basin Management Plan.

The Tisza River Basin countries have collaboratively prepared this report which will be converted into a plan of action with support from the EU and other financing institutions. The Tisza countries will then implement the plan under their EU and ICPDR commitments.

Identifying the next steps

While the Tisza countries have undertaken much work, there are still many areas that need to be addressed to successfully develop a River Basin Management Plan for the Tisza Basin. The report has helped to identify the gaps in data and information that need to be delivered.

Based on the outputs of the analysis the following can be assessed:

Water quality evaluation must be improved by:

- Unifying the approaches of risk assessment between countries, as well as providing data (such as results from water quality monitoring) for impact assessment to validate risk estimation
- Refining the assessment of the risk of failing to meet Good Ecological Status
- Improving the monitoring of all parameters required by the WFD

Water quantity evaluation must be improved by:

- Improving data on water uses
- Developing flood maps including flood hazard and risk maps

Management of water quality and quantity must be better integrated by:

- Improving flood risk maps
- Improving inventories of pollution hot spots
- Collecting and organising information on planned infrastructure projects
- Improving assessments regarding excessive river engineering projects
- Defining minimum flows for ecological quality and pressure criteria

The Tisza River Basin Analysis, as a step towards the fulfilment of the WFD, is the analysis of the Tisza Basin environment and the impacts on it. As such, it is a major step by the Tisza countries to protect and maintain important resources in the river basin. This report characterises the Tisza River Basin by identifying key environmental and water management problems in relation to water quality and water quantity, and creates the basis for the development of the integrated Tisza River Basin Management Plan by 2009.

The Tisza River Basin Analysis, supported by an EU grant, has undergone the same process taken by the Danube countries to produce the Danube River Basin Analysis 2004 (Roof Report) at the Danube River Basin level. However, the analysis for the Tisza went beyond the work of the Roof Report in several significant ways:

- The Tisza River Basin Analysis addresses issues specific to the sub-basin level, such as mining pollution.
- The analysis includes new data from Ukraine and Serbia, which was previously unavailable for the Roof Report.
- The analysis integrates management issues of both water quantity and water quality to manage jointly.

Integration of water quality and quantity in land and water planning will be essential. To achieve this success in the Tisza River Basin, countries must work together and with all other partners.

The results of the analysis will be used to develop the Tisza River Basin Management Plan and Programme of Measures for implementation by 2015. Although the analysis shows that there are still many areas where additional work is needed, the Tisza Group and the countries of the Tisza River Basin have achieved significant progress and serve as an outstanding example of cooperation.

Plan of Action recommended by The Tisza Group:

By the end of 2008, the plan calls for:

- Preparation of a draft Tisza River Basin Management Plan for public consultation
- Preparation of a ‘Programme of Measures’ to address the priority issues of organic, nutrient and hazardous substance pollution as well as the impacts of extensive river engineering
- Validation of risk assessment using the new WFD-compliant national monitoring data
- Compilation of a list of future infrastructure plans and projects

By the end of 2009, following the public consultation, the plan calls for Tisza countries to complete the final Integrated River Basin Management Plan, including flood-related aspects.

Long-term actions

It is critical to follow up on the work begun in the Tisza River Basin Analysis in order to protect the Tisza ecosystems from pollution as well as from floods and droughts. Success will depend on the dedicated cooperation from all countries and continuing work on long-term actions:

- Implementation of the measures of the Integrated River Basin Management Plan
- Developing strategies and implementing plans to adapt to climate change
- Improving flood risk management within the Tisza River Basin including the restoration of floodplains and wetlands
- Ensuring equitable balances of water resources between the needs of the countries and the environment

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