

**ICPDR** IKSD

International Commission  
for the Protection  
of the Danube River

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zum Schutz der Donau

# The 2015 Droughts in the Danube River Basin

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# 1. Introduction

In 2015 significant parts of the Danube River Basin were affected by droughts which negatively impacted different water-dependent economic sectors, vegetation and the aquatic environment. This is the latest of a series of events which occurred in Europe during the last decade.

The widespread droughts in 2003 have affected over 100 million people, a third of the EU territory<sup>1</sup>. They were followed by events that have affected portions of Northern, Southern, and Western Europe in 2007, 2011, and 2012<sup>2</sup>. These recent trends highlight the significance of the issue in some regions of Europe, specifically in the context of climate change.

Closely following these developments, the International Commission for the Protection of the Danube River (ICPDR) is increasingly paying attention to the issue of water scarcity and droughts in the Danube River Basin. The ICPDR Strategy on Adaptation to Climate Change<sup>3</sup> from 2012 indicated that “drought and low flow events, as well as water scarcity situations, are likely to become more intense, longer and more frequent”, already pointing out the necessity to become more active on this issue.

Following, the Danube River Basin Management Plan – Update 2015<sup>4</sup> for the first time responds to the issue of water scarcity and drought, which was previously not systematically addressed on the basin-wide scale. This is also in line with the target of the EU Strategy for the Danube Region (EUSDR) “To address the challenges of water scarcity and droughts in line with the Danube River Basin Management Plan – Update 2015, the report on the impacts of droughts in the Danube Basin in 2015 (due in 2016) and the ongoing work in the field of climate adaptation”. A number of Danube countries reported that specific measures are planned or under implementation through their national River Basin Management Plans.

In line with these developments, and following the 2015 droughts event, the ICPDR decided at the 18th Ordinary Meeting in December 2015 “to elaborate a report on the impacts of droughts in the Danube Basin in 2015, the measures taken and lessons learned”. The report in hand is also a direct follow-up to the Danube Ministerial Meeting 2016<sup>5</sup>, where Ministers asked the ICPDR “to maintain its activities expanding the knowledge and facilitating the exchange of information on best practice examples and progress in research” on water scarcity and droughts.

<sup>1</sup> Communication from the Commission to the Council and the European Parliament – Addressing the challenge of water scarcity and droughts, COM(2007) 414, 18 July 2007.

<sup>2</sup> Communication from the Commission to the Council and the European Parliament – Report on the Review of the European Water Scarcity and Droughts Policy, COM(2012) 672 final, 14 November 2012.

<sup>3</sup> ICPDR Strategy on Adaptation to Climate Change:  
[www.icpdr.org/main/sites/default/files/nodes/documents/icpdr\\_climate-adaptation-strategy.pdf](http://www.icpdr.org/main/sites/default/files/nodes/documents/icpdr_climate-adaptation-strategy.pdf).

<sup>4</sup> DRBM Plan – Update 2015:  
[www.icpdr.org/main/activities-projects/river-basin-management-plan-update-2015](http://www.icpdr.org/main/activities-projects/river-basin-management-plan-update-2015).

<sup>5</sup> Danube Declaration 2016:  
[www.icpdr.org/main/sites/default/files/nodes/documents/danube-declaration2016.pdf](http://www.icpdr.org/main/sites/default/files/nodes/documents/danube-declaration2016.pdf).

## 2. Approach and scope

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This report was elaborated and discussed with input from relevant ICPDR Expert Groups. Building on existing data and additional information provided by the Danube countries, it has the scope of a brief policy report. An overview on the main characteristics of the meteorological and hydrological situation during 2015 is provided, leading to the droughts which were witnessed in parts of the Danube River Basin. The main impacts on water-related sectors are summarized and an overview on measures which were taken by the individual countries is provided. Based on the analysis and discussions, conclusions were agreed which are summarised in the final chapter.

Following the definition as outlined in the Danube River Basin Management Plan – Update 2015, drought is considered as a natural stress phenomenon. It is defined by a temporary, negative, and severe deviation or trend along a significant time period and over a large region from average precipitation values (deficit in rainfall), which might lead to meteorological, agricultural, hydrological, and socioeconomic drought, based on its severity and duration.

Building on already existing initiatives dealing with droughts in the region of the Danube River Basin, the information provided in this report is based on centrally available data sources as far as possible. Clear references are provided for the sources which were used.

The discharge information for selected monitoring sites of the Danube Transnational Monitoring Network (TNMN) was provided by the relevant Danube countries. In addition, data was provided by thirteen Danube countries (AT, BA, BG, CZ, DE, HR, HU, MD, RO, RS, SI, SK and UA) via a specific “Questionnaire on the 2015 Droughts in the Danube River Basin” – the information which was collected is summarised here: [www.icpdr.org/main/resources/annex-report-2015-droughts-danube-river-basin](http://www.icpdr.org/main/resources/annex-report-2015-droughts-danube-river-basin).

This report was adopted by the ICPDR at the 19<sup>th</sup> Ordinary Meeting in December 2016.

# 3. Meteorological and hydrological situation

## 3.1 Overall situation

Similarly to the summer of 2003, a large part of continental Europe was affected by a severe drought in summer 2015, as a consequence of the combination of rain shortages and very high temperatures which resulted in high plant water requirement (evapotranspiration) levels. Significant drought

phenomena were experienced in Austria, Bosnia and Herzegovina, Croatia, the Czech Republic, Germany, Hungary, Moldova, Serbia, the Slovak Republic, Slovenia and Ukraine. Bulgaria and Romania did not report significant droughts phenomena in 2015.

### Summer of 2015 in Germany\*

Summer of 2015 in Unterfranken (left), Wellenbach bei Emsgaden / Manching, 13.08.2015 (right)

FIGURE 1



\* source: Bavarian State Ministry of the Environment and Consumer Protection.

The distribution of high air pressure formations and, in particular, the extensive and renewing anticyclones contributed to the fact that Central Europe was not supplied by sufficient moist air from the surrounding seas and ocean. Consequently, the frontal systems were not humid enough for the development of thunderstorms.

The relatively low air humidity and few clouds at the peak of summer also contributed to increased overall evaporation, thus further enhancing water shortage<sup>1)</sup>.

<sup>1)</sup> Czech Hydrometeorological Institute (CHMI), Drought in the Czech Republic in 2015.

In almost all regions of Austria and in Bavaria, deficits in precipitation were observed between February and August 2015 compared to the long term average. As for the Czech Republic, the summer of 2015 ranked among its most serious historical drought episodes. In Hungary in particular the Southern and Eastern part of the country were affected by the drought; for the Slovak Republic the significant drought phenomena did not occur on the whole territory of the country but only in some regions.

The largest precipitation deficit noticed in the Ukraine referred to areas in the north-west part of the country with traditionally sufficient rainfall.

In summer, countries of the Balkan Peninsula also faced a heat wave. The majority of the Peninsula faced extreme high air temperatures. In some places absolute maximum air temperature records were observed, together with water balance deficits<sup>1</sup>. This was in particular the case for Slovenia (from June to August 2015), the northern and eastern part of Bosnia and Herzegovina, the lower central and southern part of Moldova, Croatia and Serbia.

### 3.2 Temperature

For the Balkan Peninsula, the first three months of 2015 were in general wet and cold. In the north-western and part of the central Balkan Peninsula, the temperatures were warmer than normally in January, while other parts had normal or colder than the average values. April was colder than normal in the whole region. Warm air temperatures were recorded in the first two weeks in May. In the third week of May it got colder and air temperatures dropped below the long-term average in the western Balkan Peninsula.

In June the Balkan Peninsula was divided into two parts, warmer than normal in the northern part and colder in the southern part<sup>2</sup>.

Since the beginning of June 2015, almost the entire European continent experienced temperatures that were significantly above the seasonal norm. Conditions turned out even worse in July, with absolute maximum daily values above 34–35°C in almost the entire EU and absolute maximum temperatures that were well above 40°C in many areas (e.g. 46.2°C in southern Bulgaria and southern Romania). As for the Ukraine, the annual air temperature was 1.8–2.8° above the norm across the country in 2015; long heat waves and dry weather conditions with air temperatures of 34–39° were noticed across the country for a duration of 10 to 20 days. Moreover, several areas in Germany, Austria and the Czech Republic recorded their highest maximum daily temperatures for July since 1975<sup>3</sup>.

The Balkan Peninsula experienced another hot period in the first two weeks of August. Despite a cool third week, August was warmer than normally in the majority of the Peninsula. In eastern and northern Hungary and north-western Romania it was extremely hot, with anomalies up to 4° C above the long-term average. Air temperature anomalies in a major part of the Balkan Peninsula were up to 2° C, in the north and part of central Peninsula were up to 3° C above the long-term average.

The last hot spell in 2015, with air temperatures above 30° C, happened at the turn of August to September. September was warmer than normal in the whole Balkan Peninsula, with the exception of its north-western part and very warm Moldova, where average air temperatures were classified in the warmest 5% of years in the record<sup>4</sup>. More than 45 days with temperatures above 30° C were recorded over summer 2015 in Moldova.

<sup>1</sup>) Drought Management Centre for Southeastern Europe (DMCSEE), Drought Monitoring Bulletin.

<sup>2</sup>) Drought Management Centre for Southeastern Europe (DMCSEE), Drought Monitoring Bulletin.

<sup>3</sup>) European Drought Observatory (EDO), European Commission – Joint Research Centre, Drought News August 2015.

<sup>4</sup>) Drought Management Centre for Southeastern Europe (DMCSEE), Drought Monitoring Bulletin.

### 3.3 Precipitation

In Austria the mean annual precipitation 2015 was 80% of the long-term average (1981–2010), which was comparable to the situation in 2003 when the last significant drought was experienced. Almost all regions (except some regions in the south) suffered from monthly precipitation deficits in June, July and August with regional variations up to 70%.

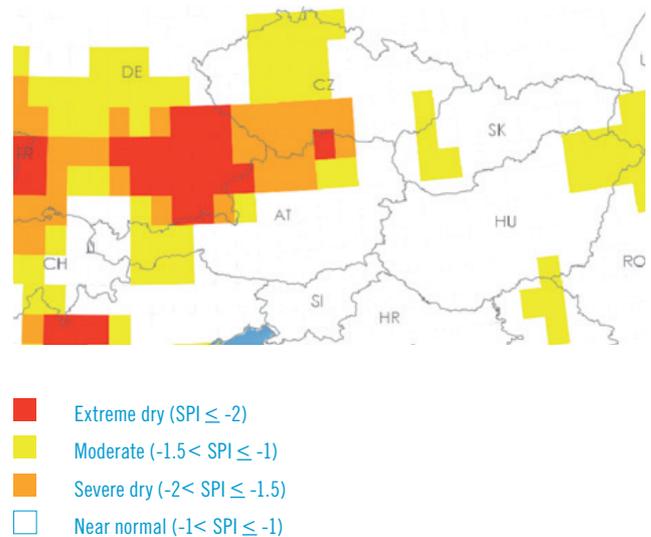
The average deviation of the annual precipitation in Bavaria, in relation to the average of the last 35 years, was about 21%. Concerning the groundwater, the relative deviation of the groundwater recharge rate in 2015 in relation to the average of the decade 1970 until 2000 was close to 50%, the average in Bavaria was about 30%. In the Czech Republic, the precipitation deficit already began to develop itself as early as in 2014, and from February 2015, it slowly continued during the spring months and increased to 150 mm by the end of August.

In the beginning of the year 2015, slightly wetter than normal months occurred on the Balkan Peninsula. April was relatively dry, with exception of some parts in central and southern Peninsula and eastern Romania, which had even excess of precipitation. July was in general the driest month of this year. The driest conditions on the Balkan Peninsula occurred in the central part, in parts of Croatia, Serbia, Bosnia and Herzegovina, Romania, Hungary and Bulgaria, where water balance anomalies reached 100 mm below the long-term average. Dry conditions persisted in the 60-days period from 10 July to 7 September in the central and eastern part of the Balkan Peninsula in Moldova, Romania, Bulgaria, Serbia and in some parts of Hungary, Croatia, Bosnia and Herzegovina. Mid-August the peak of the drought finished with abundant rainfalls which brought some significant relieve to the vegetation in the country. However, the amount of rainfalls was not enough to end the overall drought situation. The drought thus continued throughout September and early October, when the precipitation deficit rose up to 180 mm.<sup>1</sup> This continuation was even recognizable in Austria in November and December with observation of the highest precipitation deficits in 2015 compared to the long term average.

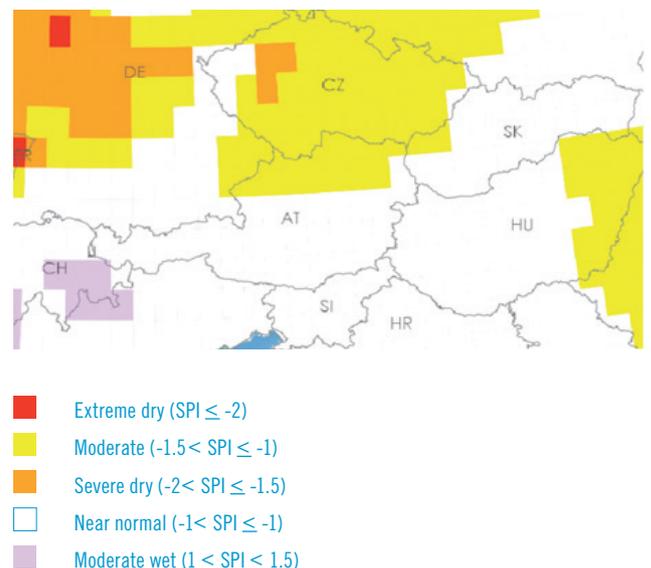
#### Standardized Precipitation Index (SPI)\*

SPI blended and interpolated July 2015 (1 month)

FIGURE 2a



#### SPI blended and interpolated July 2015 (3 months)

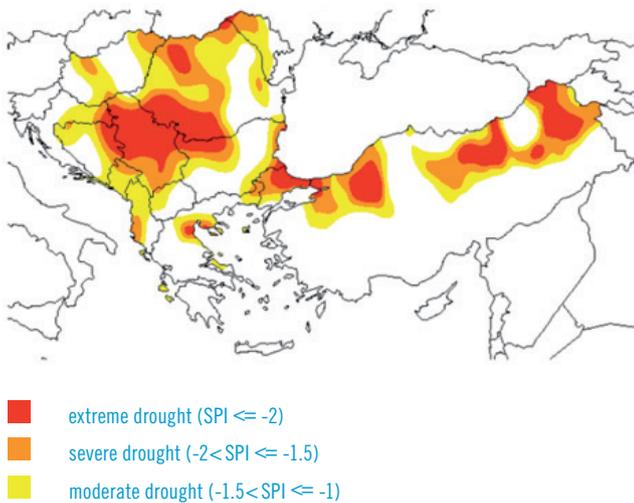


\* source: European Drought Observatory (EDO), <http://edo.jrc.ec.europa.eu>.

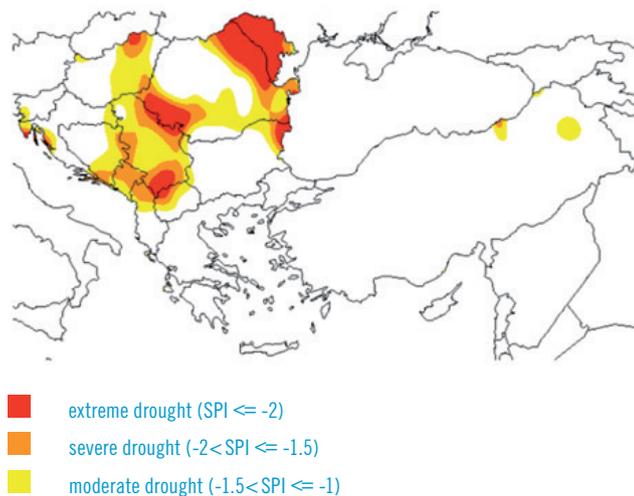
<sup>1)</sup> Czech Hydrometeorological Institute (CHMI), Drought in the Czech Republic in 2015.

### Standardized Precipitation Index (SPI)\*

SPI Jul 2015 (1 month), GPCCC first-guess analysis FIGURE 2b



SPI Jul 2015 (3 months), GPCCC first-guess analysis



The standardized precipitation index<sup>1</sup> for July showed an extreme lack of precipitation in the central part of the Balkan Peninsula. The lack of rain in the whole northern part of the Peninsula coincided with extreme high air temperatures. Moderate and extreme drought conditions due to the SPI were presented from Moldova in the east, in some areas in Hungary in the north, continental part of Croatia and parts in Bosnia and Herzegovina in the west and parts of the countries which border southern Serbia like Bulgaria and Montenegro. SPI for 3 months, from May to July showed larger very dry areas in eastern Romania and in Moldova. Another dry area was detected from eastern Hungary in the north to the western Romania at the east, through Serbia to the southern Bosnia and Herzegovina and Montenegro. Milder lack of rain was felt in the belt from western Slovenia to north-western Croatia.

### 3.4 Discharge of the Danube at selected monitoring sites

As a result of the previously explained circumstances and in particular due to the lack of precipitation, the water levels of the Danube were significantly below the long-term average. This was the case for the 2015 yearly average, but in particular for the second half of the year from June onwards.

At the Upper Danube, gauging station Vienna, the average monthly discharge in July reached a value of 1,480 m<sup>3</sup>/s which is approx. 40% below the long-term average value of 2,442 m<sup>3</sup>/s. Monthly average minimum discharge values occurred in November with 925 m<sup>3</sup>/s, and average daily minimum discharge values in the end of December with 754 m<sup>3</sup>/s (see Figure 4). At Mohac in Hungary the average monthly discharge in 2015 was lowest in September with 1,280 m<sup>3</sup>/s and therefore about 38% below the long-term average value of 2,051 m<sup>3</sup>/s for this month. In July the average monthly value was 42% below the monthly long-term average (see Figure 6). At gauging station Reni in Romania towards the mouth of the Danube, similar discharge patterns were observed. The average monthly discharge in 2015 was lowest in September with 3,000 m<sup>3</sup>/s and therefore 34% below the long-term average value of 4,580 m<sup>3</sup>/s. Average daily minimum discharge values in 2015 also occurred in September with 2,790 m<sup>3</sup>/s (see Figure 7).

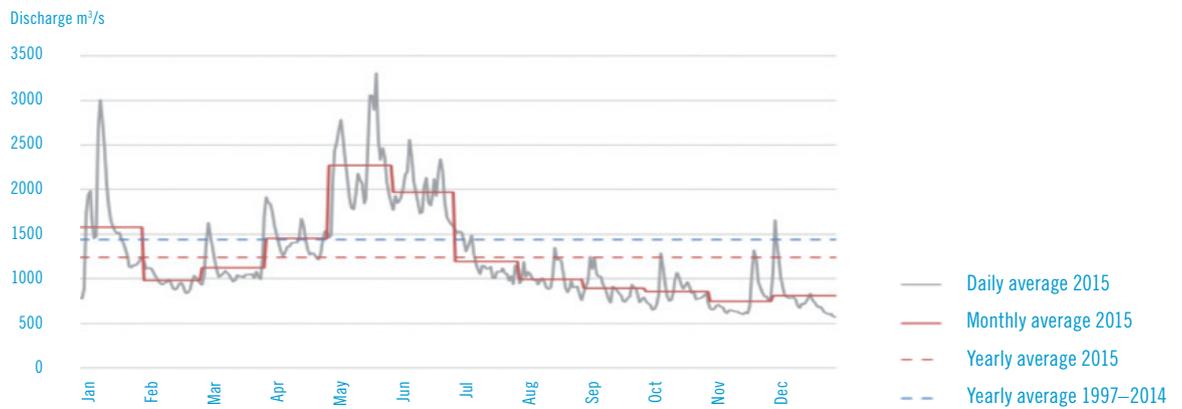
\* source: DMCSEE, [www.dmcsee.org](http://www.dmcsee.org)

<sup>1)</sup> The drought situation with regard to the precipitation accumulation is presented by Standardized Precipitation Index (SPI). The SPI calculation is based on the distribution of precipitation over long time periods (e.g. 30 years).

Values significantly below the long-term average were monitored at all gauging stations from the beginning of summer onwards throughout the rest of the year.

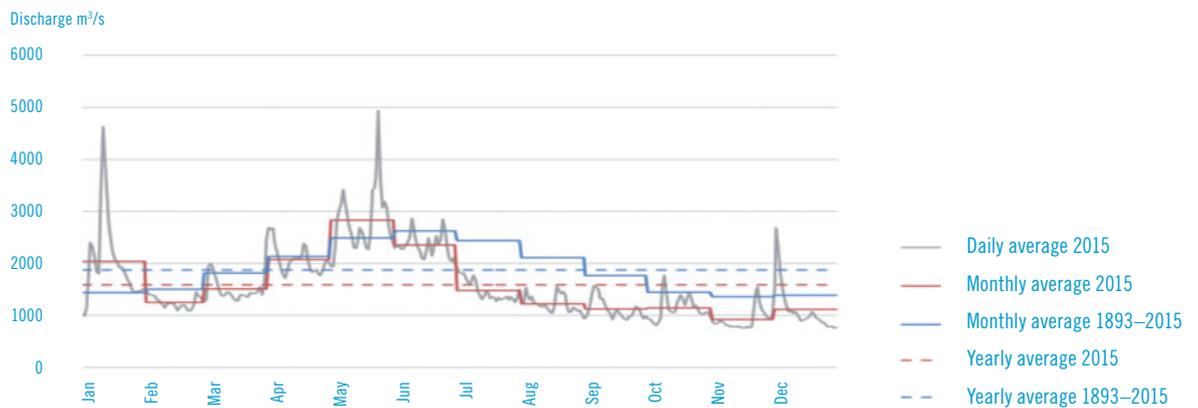
**2015 and long-term average discharge of the Danube at Jochenstein (DE)**

FIGURE 3



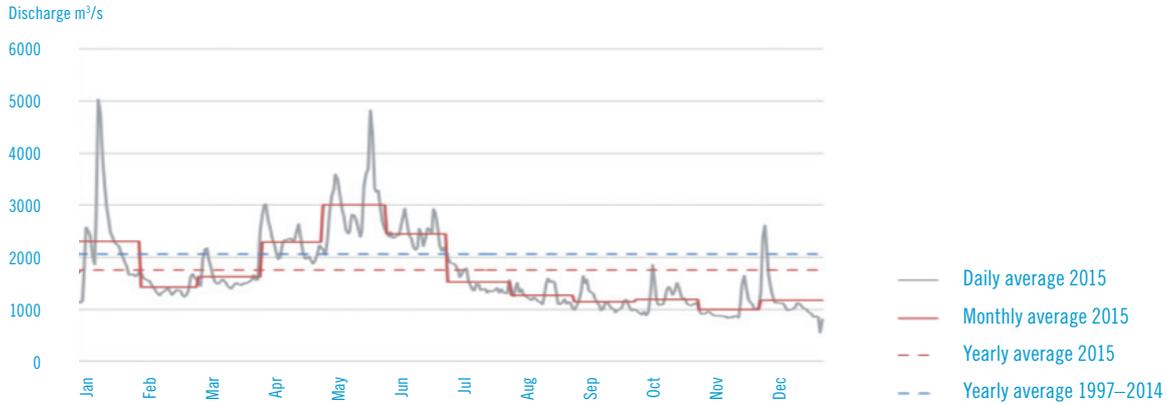
**2015 and long-term average discharge of the Danube at Vienna (AT)**

FIGURE 4



**2015 and long-term average discharge of the Danube at Bratislava (SK)**

*FIGURE 5*



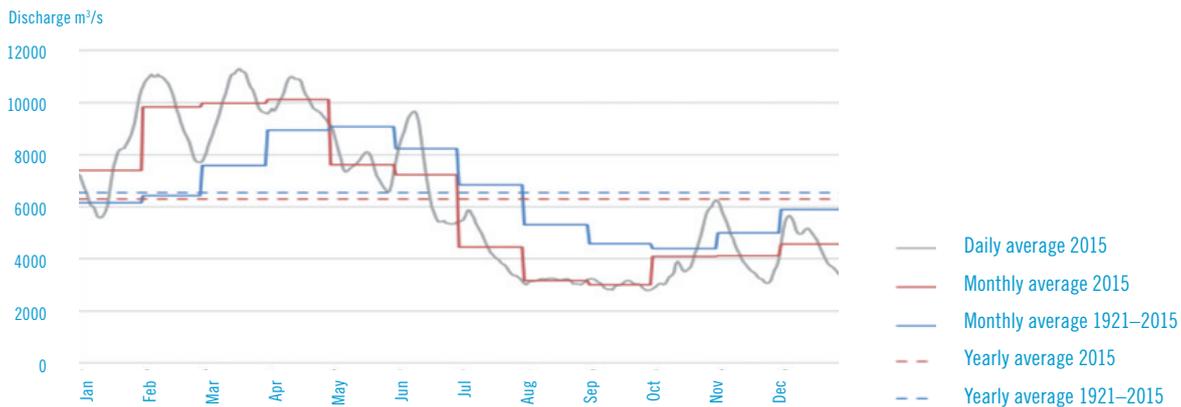
**2015 and long-term average discharge of the Danube at Mohac (HU)**

*FIGURE 6*



**2015 and long-term average discharge of the Danube at Reni (RO)**

*FIGURE 7*



## 4. Impacts and measures

The drought effected economic sectors, the environment and society, leaving a variety of impacts in its wake. The overall impact of drought in a specific area is almost always negative; in exceptional cases, some consequences of droughts such as long periods of no rain and high temperatures might be seen as positive (e.g. in tourism). This chapter describes the impacts of the 2015 droughts on the water-dependent sectors such as agriculture, navigation, water supply, energy, industry, water quality, ecology and recreation in the Danube basin based on responses received from Danube countries through a specific “Questionnaire on the 2015 Droughts in the Danube River Basin”<sup>1</sup>.

For those Danube countries which experienced a significant drought phenomena during 2015, agriculture was by far the most impacted sector. Austria, Bosnia and Herzegovina, Czech Republic, Croatia, Hungary, Serbia, the Slovak Republic and Moldova reported high impacts on agriculture. In areas with periodical irrigation in Austria, such as the Marchfeld region, water demand was significantly above the long-term average due to precipitation deficits starting with March/April and continuing in June/July 2015. The most significant impact was on corn production (Austria, Croatia, Serbia, Slovak Republic). Other countries observed also lower yields at later harvested plants like soya, sugar beet or rape seed.

### Corn crops impacted by 2015 drought in Romania\*

FIGURE 8



\* source: Evenimentul Zilei Newspaper.

<sup>1</sup> Information provided is based on expert judgement on national level, unless quantitative information was available for providing the relevant information; data collected for each Danube country is available following this link: [www.icpdr.org/main/resources/annex-report-2015-droughts-danube-river-basin](http://www.icpdr.org/main/resources/annex-report-2015-droughts-danube-river-basin).

Austria reported a considerable impact of the drought on navigation; low impacts on navigation were described by the Czech Republic, Germany, Croatia, the Slovak Republic and Moldova. As a response to the low discharge conditions starting with July and lasting until the end of the year 2015, critical fairway depths were registered at the free flowing sections east of Vienna and at Wachau for certain days<sup>1</sup>, which resulted in significantly reduced mean levels of capacity of ships, but shipping was ensured without interruptions. Interruption or limitation of navigation during certain days were reported from Germany and Croatia; the navigation sector was affected by low water levels in Serbia and the Slovak Republic, but shipways were not interrupted. In Moldova, additional equipment was needed to operate vessels during this period.

Water supply (drinking water) is a particular issue in Bosnia and Herzegovina and in the Ukraine, when looking at the impacts of the drought. Low impacts were reported by Austria, the Czech Republic, Germany, Croatia, Serbia, the Slovak Republic and Moldova. In Austria, the minor impact was a result of measures which have been implemented as a consequence of the drought in 2003 aiming at improving the resilience of public water supply in vulnerable regions. These include interconnections of supply networks of different regions and strengthening multiple resource use as basis for supply security. In particular small and/or individual water supply companies and/or suppliers had to accept some restrictions/service limits in Austria and Germany. In Serbia, water-saving measures were introduced in a number of cities due to depleted water sources.

Low impacts on the energy sector (hydropower) have been reported by Austria, Bosnia and Herzegovina, Czech Republic, Germany, Hungary, Moldova, Slovak Republic and Ukraine.

As for industry (e.g. cooling water), Ukraine stated a high impact by the drought, Bosnia and Herzegovina and the Czech Republic noted a low impact.

In terms of water quality, Austria reported an impact on water temperatures; Bosnia and Herzegovina, Hungary, Moldova, Serbia and the Slovak Republic reported low impacts caused by the drought. Where measurements from the regular surface water quality monitoring program in Austria were available, observed water temperatures in July exceeded the long-term monthly average (1991–2014) at 94% of stations and the observed long-term monthly maximum at 45% of the stations.

High impacts on the ecology were reported by the Czech Republic and Moldova; low impacts were described for Austria, Bosnia and Herzegovina, Germany, Croatia, Hungary, Serbia and the Slovak Republic. Many small water courses were reported as completely dry in the Slovak Republic, mainly in the Morava River basin. In Austria, in the most affected regions were side arms of larger rivers or headwater of some small streams which suffered from extremely low water levels or even fell dry, e.g. side arms of the Danube river east of Vienna (Lobau). In few areas in Bavaria, eutrophication in small rivers with low flow velocity was observed. As for Moldova, large scale fires of dried vegetation were reported.

Low impacts were reported on recreation for Bosnia and Herzegovina and for Moldova.

Other impacts of the drought 2015 were observed in regard the forestry sector (Croatia), fish farming (Czech Republic) and water quantity (Slovak Republic).

<sup>1)</sup> Fairway Rehabilitation and Maintenance Master Plan for the Danube and its navigable tributaries: National action plans, Update May 2016.

Table 1 provides a comprehensive overview of water-related sectors impacted by the 2015 droughts in the Danube basin countries based on expert judgement on national level.

Overview of water-related sectors Danube countries experienced impacts from 2015 droughts

TABLE 1

	AT	BA	BG	CZ	DE	HR	HU	RS	SI	SK	MD	ME	RO	UA
Agriculture	XX	XX	/	XX	X	XX	XX	XX	X	XX	XX		X	X
Navigation	XX	0	/	X	X	X	0	0	0	X	X		/	/
Water supply (drinking water)	X	XX	/	X	X	X	0	X	0	X	X		/	XX
Energy (Hydropower)	X	X	/	X	X	0	X	0	0	X	X		/	X
Industry (cooling water)	na	X	/	X	0	0	0	0	0	0	0		/	XX
Water quality	XX	X	/	0	0	0	X	X	0	X	X		/	/
Ecology (Biodiversity)	X	X	/	XX	X	X	X	X	0	X	XX		/	/
Recreation	0	X	/	0	0	0	0	0	0	0	X		/	/
Others	/	/	/	X	0	X	/	/	/	X	/		/	/

0 – no impacts; X – low impacts; XX – high impacts; na – no information available; / – not relevant

As a consequence of the 2015 droughts, several measures to mitigate or manage the impacts were put in place in Danube countries, with the exception of Bulgaria, Slovenia, the Slovak Republic and Ukraine. Measures range from monitoring, legislative, operational, funding, economic, technical, scientific and environmental activities. In some countries, measures which have been put in place as a consequence of the drought in 2003 have proven their effectiveness; additional future measures as a consequence of the droughts in 2015 are planned. Discussions on improved drought response activities are currently taking place in Slovenia.

Additionally, the issue of droughts has been addressed in the updated River Basin Management Plans and in other management plans in Austria, Bulgaria, Croatia, the Czech Republic, Germany, Moldova, Romania, Serbia and the Slovak Republic.

Table 2 provides an overview of measures included in the national River Basin Management or other plans, such as measures to increase the efficiency of irrigation or reducing leakage in water distribution networks, natural water retention measures, wastewater recycling, rain water harvesting, drought mapping/forecasting, education of public on water-saving measures (e.g. water efficient appliances), market-based or incentive instruments (e.g. user pays principle, block tariffs, penalties for excessive consumption) and others.

Examples for other measures are interconnections of drinking water supply networks between different regions/operators and the multiple resource use (e.g. using different resources of spring water or groundwater for drinking water supply as back-up) as basis for supply security in vulnerable regions (Austria), the revision of issued water abstraction permits (the Slovak Republic), measures to decrease illegal water abstractions and well drilling activities, artificial recharge to groundwater, water supply for rehabilitation of water dependent ecosystems and measures against alien invasive species (Hungary), measures related to forestry (Bulgaria).

Overview of measures related to 2015 droughts included in RBMP or other management plans

TABLE 2

	AT	BA	BG	CZ	DE	HR	HU	RS	SI	SK	MD	ME	RO	UA
Measures to increase efficiency of irrigation	x	/	x			x	x	x	x		x		x	/
Measures for reducing leakage in water distribution networks		/	x			x	x	x	x	x	x		x	/
Natural water retention measures	x	/	x	x		x	x	x	x	x			x	/
Wastewater recycling		/					x						x	/
Rain water harvesting		/					x				x			/
Drought mapping/forecasting		/			x		x	x	x	x	x		x	/
Education of public on water-saving measures (e.g. water efficient appliances)	x	/					x	x	x		x		x	/
Market-based or incentive instruments (e.g. user pays principle, block tariffs, penalties for excessive consumption)		/		x			x	x		x			x	/
Others	x	/	x				x			x				/

X – low impacts; / – not relevant

# 5. Lessons learned and conclusions

Droughts are expected to become one of the major topics for water management in the near future. Due to the amount of damage costs caused by droughts in the previous years, it is obvious that this issue will be one of the future priorities in water management closely coordinated with the implementation of the EU Water Framework Directive and its River Basin Management Plans as well as the EU Floods Directive and its Flood Risk Management Plans.

In terms of activities on [Danube basin wide level](#), it is foreseen that the issue of droughts and its impacts will play a significant role in the framework of the updated ICPDR Strategy on Adaptation to Climate Change planned for the year 2018; the results will be fed into the third Danube River Basin Management Plan and second Danube Flood Risk Management Plan to be elaborated until 2021. Even though the water scarcity and drought issue was not considered an issue of basin-wide relevance at this stage in the ICPDR Ministerial Declaration 2016, Ministers asked the ICPDR to maintain its activities expanding the knowledge and facilitating the exchange of information on best practice examples and progress in research. In addition relevant activities at EU level are of particular importance for the ICPDR.

On [national level](#), it is obvious that a drought management system and a proactive and operative way of thinking will help to be better prepared in the future. The issue also has a significant political dimension. The drought situations in the years 2003 and 2015 appear to be a good blueprint to shape action for the adaptation to climate change, as the conditions of the last drought phenomena seem to be quite close to situations, which are forecasted in the future. Actions taken in some Danube countries as a consequence of the drought in 2003 to make water supply more resilient against effects of droughts have proven their effectiveness in 2015 and should be further developed to address future challenges.

For those Danube countries which experienced a significant drought phenomena during 2015, agriculture was by far the most impacted sector. Better preparedness concerning the effectiveness of water use in the agricultural sector is necessary in order to avoid or reduce the damage by droughts. Many countries acknowledged the need for better data monitoring data especially concerning the withdrawal of water in the agricultural sector. This could be a good starting point for enhancing the dialogue between the water and the agricultural sector to address the drought issue and discuss solutions leading to a win-win situation for both sides.

As the negative impact of future droughts on other water-dependent sectors might further increase, the engagement with drought management on all levels is crucial to address potential competition on water e.g. between drinking water supply and agriculture at an early stage in case of the absence of legislative frameworks. This also includes guidelines on how to manage the distribution between sectors in case of water shortage.

The following lessons learned summarise potential lines of actions aiming at the improvement of the current situation in Danube countries towards a better preparedness for droughts. However, proposed potential actions have to be tailored to the national situation in place and might not be appropriate for and adapted to all Danube countries; actions should only be applied, where relevant for the national situation. River Basin Management Plans, and more specifically the Programme of Measures (PoM), are an excellent opportunity to integrate all aspects of drought management.

## Issues worthwhile for further considerations on national level are:

### Droughts management

- Drought Management on national level including legislation and planning instruments, drought indices, measurement procedures and methods for the assessment of droughts

### Droughts monitoring and forecasting

- Improved droughts monitoring and forecasting data by monitoring both quantity and quality parameter including discharge at low water levels, sharing of data and forecasting

### Droughts and agriculture

- Particular focus on droughts impacts on agriculture including advanced technologies for irrigation and for improved nutrient management to increase water use efficiency and its sustainability
- Promotion of good agricultural practices and a policy of “right crop at the right place” through incentives for farmers in relation to their land use, agricultural management and sustainable water resources use
- Potential for more reuse of recycled wastewater to be explored

### Conjunctive management

- Greater application of conjunctive use of groundwater and surface water as a part of drought management
- Artificial recharge to aquifers, aquifer storage and recovery and promoting use of natural water retention measures in catchment areas to increase water availability

### Exchange and cooperation

- Consultation on competing use and priorities of water with relevant stakeholders from different water-related sectors (agriculture, navigation, water supply, energy, industry, tourism, environment and nature protection) in case of absence of relevant legislative framework
- Exchange of existing practice examples in Danube countries (e.g. Low Water Information Service Bavaria, Hungarian Operative Drought and Water Scarcity Monitoring System, Adaption Strategy of the Slovak Republic to negative impacts of climate change and others) with particular focus on drought management including all sectors (agriculture, drinking water supply and others), monitoring and forecasting
- Raising public awareness on drought phenomena and their impacts
- Close cooperation with international drought management institutions to coordinate and facilitate the development, assessment and application of drought risk management tools for improving drought preparedness and reducing drought impacts (e.g. Drought Management Centre for Southeastern Europe – DMCSEE, European Drought Observatory – EDO)
- Knowledge and expertise by supporting research programmes on droughts, their impacts and the expansion of mitigation measures



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