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3 Abbreviations

Abbreviation	Explanation
CEMT	Classification of inland waterway ships and barges in terms of size
FRMMP	Fairway Rehabilitation and Maintenance Master Plan
HNWL	Highest Navigable Water Level
IWT	Inland Waterway Transport
LNWL	Low Navigable Water Level
MWL	Mean Water Level
t	tonnes
Tkm	Tonne/kilometre

4 Executive summary

The Danube Transnational Program promotes economic, social and territorial cohesion in the Danube Region. As part of this program, a consortium of nine countries has implemented the *DIONYSUS project - Integrating the Danube Region into Smart & Sustainable Multimodal & Intermodal Transport Chains* for 2 years, aiming to transform Danube ports into high-performance multi and intermodal transport hubs, better connected and integrated with supply chain logistics.

Within this project, this *Report* and *Fairway maintenance impact calculation tool* were developed as outputs, aiming to highlight the effects of the insecurity of the depths recommended by the Danube Commission in the economic and social plan.

Based on the available data, published or communicated by the authorities and other relevant stakeholders, the report shall identify the critical points on the Danube and present a history of the periods when navigation was affected due to the restrictions imposed by the shallow depths.

It can be seen that in all the years of the analyzed period there were navigation restrictions, but in some of them, as is the case of 2018 when the values of the absolute minimum of the last 70 years of observations were recorded, the restrictions lasted a long time and the traffic on the Danube was severely affected.

The important role of inland waterway transport is recognized in the European transport network, especially because of its sustainability and efficiency, which provides a competitive alternative to road and rail transport, thus leading to improvements in energy consumption as well as gas emissions and noise.

However, efforts to maintain the waterway are not yet sufficient, as the economic and social impact of the lack of depths is major.

The effects triggered by non-maintenance on critical points on the Danube include the generation of blockages during the summer, exactly when transport demand is increased due to the grain season, and shipments by ships loaded at low capacity generate losses for transport operators, but also for all service providers related to river transport, increased freights to ensure that additional costs are covered, with effects on the entire supply chain, generated increased fuel consumption and additional staff costs, trends in reorienting transport solutions to other modes and routes, affecting the efficiency of port terminals due to the low degree of predictability, penalties for non-compliance with the terms of the transport contracts and the increased risk of losing business partnerships.

All the data analyzed in the report unequivocally reveal the need to increase efforts to ensure continuous conditions of safe navigation on the Danube, enabling inland waterway transport to develop, contributing to the economic growth of the areas crossed by the Danube, securing and developing jobs in the field of shipping and reducing the impact of transport on climate change.

5 Introduction

Calculation tool and the waterway maintenance impact report is a deliverable related to project DTP3-576-3.1- *DIONYSUS „Integrating Danube Region into Smart and Sustainable Multi-modal and Intermodal Transport Chains",* funded through the Danube Transnational Program 2014-2020 and therefore its realization will take into account both the general objectives of the mentioned project and the specific ones for which these deliverables have been included in the project activities.

The project is being developed with the determination that the Danube and its navigable tributaries provide significant capacity to increase cargo and passenger flows. The prosperity of the water transport sector contributes to a smarter and more sustainable transport system and, at regional level, to economic growth.

In addition to better navigation conditions, more modern, more energy-efficient and greener fleets on the Danube, more efficient, sustainable and better-connected investment planning solutions are required for inland waterways at maritime and river ports in the Danube region. The need for investment refers to the infrastructure and superstructure on the river banks in the Danube region, the rail and road transport connections, in order to better serve the inland area of the ports and the economy in general.

The general objectives of the above-mentioned project are:

- the development of the Danube, the Danube ports, as well as the ports of the Maritime Danube by creating multi / intermodal logistics hubs, intelligent, sustainable and well interconnected. These will become priority locations for industrial investment through EU funding instruments;
- identification of investment needs in port infrastructure, in access infrastructure (rail, road connections) in ports, so that ports are aligned with the European Commission policies and regional development plans. This will facilitate political and administrative action, thus allowing investments in infrastructure based on market-based analysis.
- o Identification of gaps in the integrated planning of the Rhine-Danube Corridor with the other transport corridors interconnected with this region. It will support the integration of the Danube corridor with neighboring European transport networks;
- performing analyses and studies on the areas that influence the multimodal and intermodal freight and passenger transport chains. It will result in recommendations (at national level) and consolidated strategies and action plans (at regional level);
- defining and implementing specific tools to support the port sector and formulating dedicated policies, thus contributing to their implementation by creating a better framework for port investments. This will result in a more efficient and sustainable transport system in the Danube region;
- the approach through the Port Digitization Strategy and the Digitization Trend Action Plan in the transport and logistics sector, as well as the resulting challenges for ports;

- drawing up plans of port development plans for selected ports in the Danube region in order to prepare infrastructure projects for their implementation under CEF II and national operational programs.

5.1 Current context

The market for freight transport on the Danube does not depend only on trade flows and on the conditions of the economic framework at local / regional level. The volume of freight transport depends to a large extent on ensuring the minimum navigation parameters set by the Danube Commission. These parameters are depth and width, radius of curvature.

Failure to ensure the minimum parameters of the waterway influences both the activity and the financial situation of ship operators, as well as the possibility of attracting new flows of goods to river transport. Ensuring depths of navigation throughout the year has a significant impact on both the costs borne by river carriers and the share of inland waterway transport in relation to road and rail transport.

Lack of navigation depths may result in (A.P.M., 2021):

- blocking navigation on the Danube, especially during the grain transport season;
- loading transport vessels at low capacity (for example, if a barge at a 2.5 draft can be loaded with 2000 tons of iron ore, at a draft of 1.6-1.7 m it can load only 1000 tons);
- blocking of terminals in seaports, without expected cargo volumes;
- losses due to the fact that the cargo does not reach the final destination (maritime terminals) and the shipping vessels incur waiting periods for which penalties are paid;
- losses due to delays in meeting the deadlines in the transport contracts;
- for ship-owners, higher fuel consumption, increased labor costs and delays that can lead to the loss of contracts;
- possible loss of customer portfolios due to decreased confidence in the transport on the Danube

Therefore, ensuring the minimum depths for navigation is a decisive factor for the competitiveness of inland navigation. For long-distance transport, there may be critical areas where the minimum navigation depths are not reached for five to ten days. At present, without a proper instrument in place, it is difficult to accurately make a forecast of rising / falling water levels, a context in which loading barges at maximum capacity for safe navigation relies heavily on the practical experience of transport companies.

The actual depths of the Danube waterway have a significant impact on the cost of production of IWT services and, consequently, on the competitive position vis-à-vis other modes of transport, in particular rail and road transport.

The current situation of the insufficiently maintained section of the Danube waterway is a major disadvantage for ship operators to remain competitive and gain new customers as well as new types of cargo. Reliability of transport is an essential requirement for transport decisions that navigation on the Danube can only provide if all waterway administrations ensure the technological state of maintenance of the channel at the recommended depth of 2.5 m for 343 days per year and consequently, homogeneous conditions to allow ships to operate cost-effectively.

5.2 Objectives of the study

The inland waterway maintenance impact report uses the calculation tool obtained as deliverable under the same project to quantify the economic impact of low water navigability conditions on different types of cargo, transport routes and ship characteristics. It will provide a basis for assessing the benefits of properly maintained channel areas in relation to maintenance costs. The report also estimates the economic losses affecting ship-owners' activity due to insufficient waterway maintenance.

The report has used available hydrological data on critical sections of the Danube, as well as economic data provided by river transport companies, providing an insight into the costs of operations in the absence of an adequate level of waterway depth.

The calculations were performed both for pushed convoys and for self-propelled units.

The maintenance, improvement and extension of inland waterways should always be carried out taking into account the economy of inland navigation, namely the link between existing infrastructure and transport efficiency.

The report shall identify the critical areas and their history, the periods affected and the depths found, which shall have a negative effect on the costs and losses caused by the berthing of ships and their non-loading at full capacity.

Also, the types / categories of goods affected are highlighted, for a more accurate estimate of losses, but also the fact that these negative effects discourage the attraction of new flows of goods compared to existing ones.

5.3 Research methodology

The methodology of the report includes:

Desk research

It involved researching relevant available documents targeting the field of study, provided by project partners or other organizations, as identified by the project team or following suggestions received from the beneficiary.

In order to conduct the desk research, documents were identified and requested from the project partners and other relevant organizations to ensure an adequate knowledge of the field of study, so that the deliverable includes valid results based on well-defined input elements.

Such documents included, but were not limited to:

- Dionysus project documents, in order to properly understand the role of deliverables in the project and their correlation with the project objectives, but also with the other deliverables that will provide input for those covered by this report, but also those that would follow to have as input the results of this deliverable, such as the formulation of policies dedicated to the development of inland waterway transport, etc.;
- documents that include statistics on Danube quotas;
- documents regarding the traffic on inland waters and the operation in the Port of Constanța of the goods transported on the Danube;
- documents regarding the organization of the transport on the Danube;
- legal and regulatory requirements regarding the transport on the Danube;
- recommendations and decisions that are subject to inland waterway transport;
- deliverables of other European-funded projects that have similar or related objectives to the Dinoysus project (eg DANTE, DAPhNE, FAST Danube, etc.);
- studies and other documents that address the subject of the report.

The analyzed documents contributed to the identification of the factual situation and the way of organization and realization of the inland water transport in the last 10 years, as well as the limitations generated by the transport infrastructure.

Field research

It involved the collection of information directly from administrations (Annexe 1), shipowners and other stakeholders (Annexe 2) throughout the Danube, directly or with the help of project partners.

In order to carry out this stage, the research team determined a list of relevant stakeholders, including in consultation with the beneficiary including authorities, inland waterway transport operators, logistics and shipping companies, etc.

In determining and collecting information for deliverables, the general objectives of the project as well as the specific objectives of the deliverables were continuously taken into account.

The information collected was analyzed and structured in such a way as to achieve the expected results in defining the objectives of deliverables.

Each time it was needed the collected information was cross-checked to ensure its applicability in the project.

6 Overview of inland waterway transport at European level

Inland waterway transport plays a very important role in the European transport network, especially because of its sustainability and efficiency, with a high potential to develop in relation to other modes of transport.

The inland water network connects hundreds of cities and regions in 13 Member States, totaling more than 37,000 kilometers of waterways[1].

Inland waterway transport is a competitive alternative to road and rail transport and offers a sustainable alternative in terms of both energy consumption and gas emissions and noise.

The energy consumption of inland waterway per tonne / kilometer of goods transported is about 17% of the road transport energy consumption and 50% of rail transport energy consumption. In addition, inland waterway transport ensures a high degree of safety, especially in the transport of dangerous goods.

The role of inland waterway transport in decongesting overcrowded road networks in dense population regions is noteworthy.

All these positive aspects of inland waterway transport compared to other modes of transport impose a proper concern on the investments made in providing its infrastructure, which currently involves much smaller amounts than those allocated to land transport modes.

Such an approach would also mean greater coherence with European Green Deal policies regarding reducing the impact on the environment, as well as a decrease in the contribution of transport to carbon emissions.

The high potential for economic development of inland waterways is also to be taken into account by the EU Member States, due to the increasing level of their usage, thus contributing to the overall objective of increasing economic, social and territorial cohesion.

Figure 1 shows the evolution of the quantities of goods transported on inland waterways in Europe, showing the downward trend in 2020 due to the COVID-19 pandemic, but also the effects of the periods of low water levels in 2011 and 2018.

The following chapter presents a history of navigation conditions on the Danube in recent years, clearly highlighting the limitations in freight transport due to the lack of sufficient measures for the rehabilitation and maintenance of the waterway.

[1] *https://transport.ec.europa.eu/transport-modes/inland-waterways_ro*

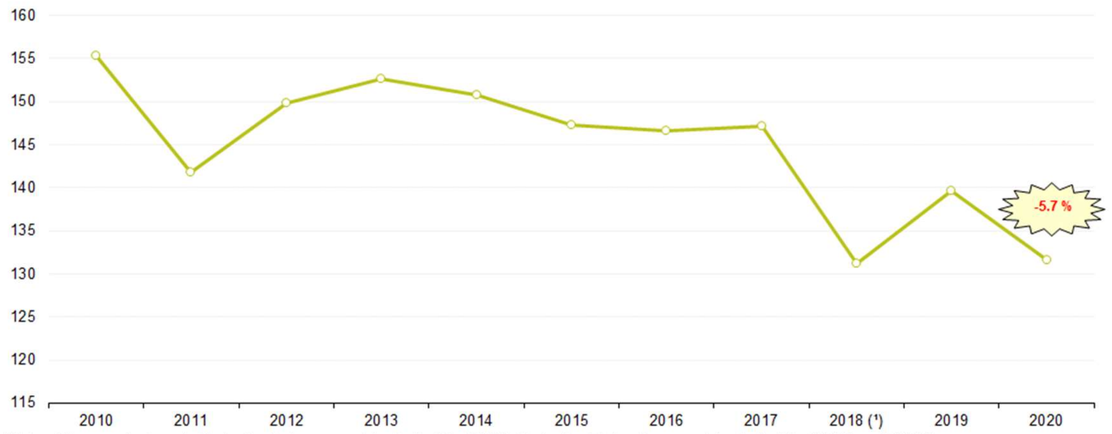

Figure 1 Inland waterways freight transport, EU, 2010-2020 (billion tonne-kilometres)

An analysis of the destination of goods transported by inland waterways shows a fairly balanced distribution between national, international or transit destinations, with international ones being just over half of the total. (Figure 2)

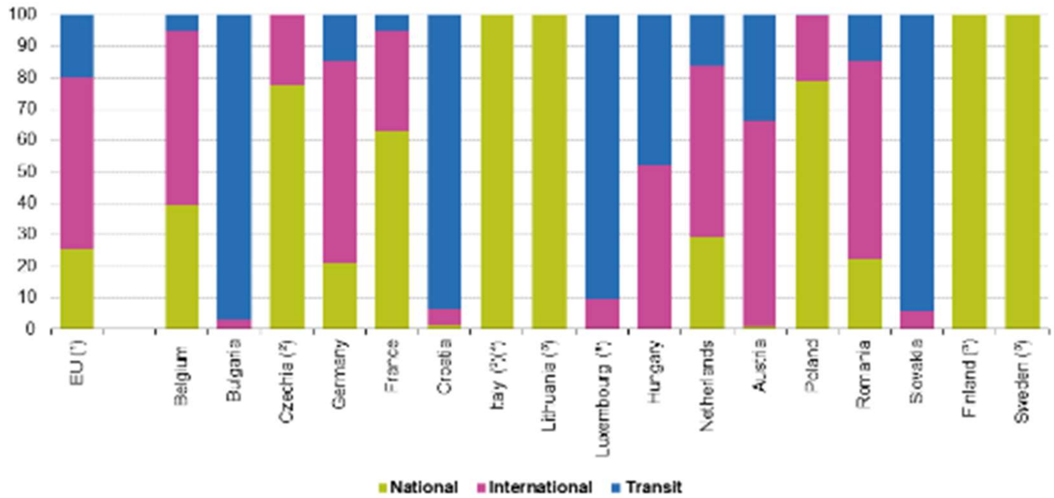

Figure 2 Inland waterways freight transport by type of transport, 2020 (%, based on tonne-kilometres)

It can be noted that European countries, depending on their position on the transport networks (in their center, at the end of the corridor connected to a large seaport, etc.) have different percentages on the three segments.

This is how Bulgaria, Croatia, Luxembourg and Slovakia stand out as transit countries. With the waterway network unconnected to maritime shipping, some countries carry goods mainly nationally: Italy, Lithuania, Poland, Finland, Sweden. Those connected to seaports have a significant share of international transport: Belgium, Germany, the Netherlands, Austria (connected by the Danube to the Black Sea) and Romania.

Almost all types of goods are transported by inland waterways, but the largest quantities are those of bulk goods: grains, ores, petroleum products. (Figure 3)

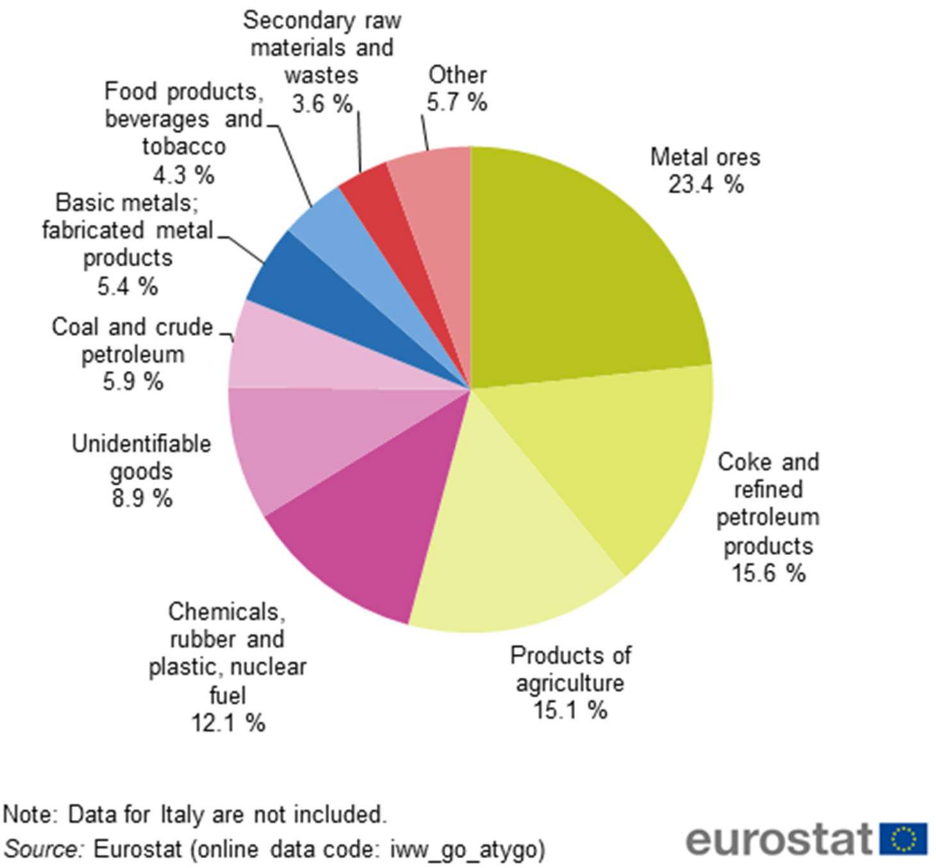

Figure 3 Inland waterways freight transport by main type of goods, EU, 2020 (%, based on tonne-kilometres)

It is worth noting again the role of situations in which navigation is limited due to blockages caused by low water levels or freezing events, often bringing a low level of predictability, which is difficult to accept in the transport of general cargo, especially containerized goods.

This aspect, together with those related to the general development of the markets, has recently led to significant increases for some types of goods (grains, raw materials) and decreases to almost all others. (Figure 4)

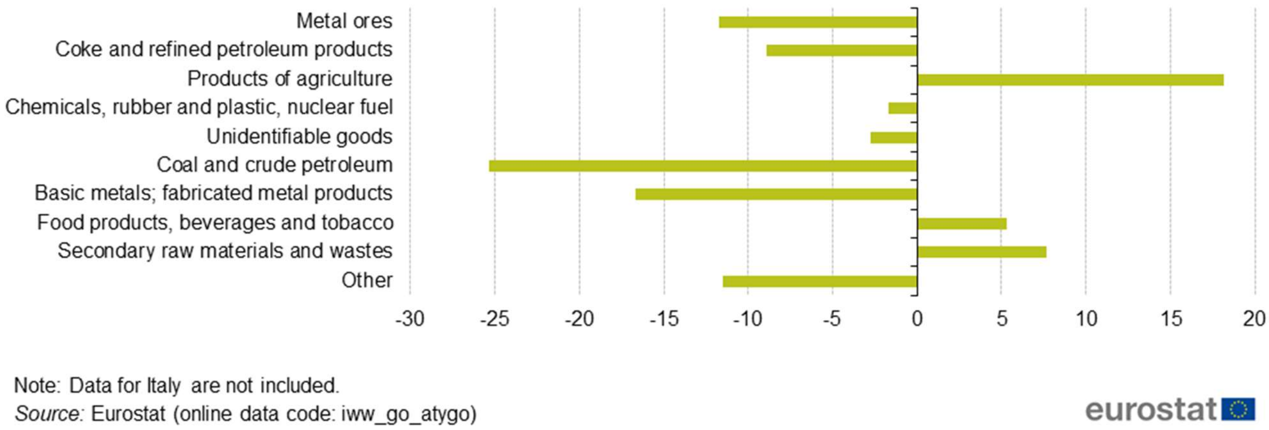

Figure 4 Inland waterways freight transport for main types of goods, EU, change between 2019 and 2020 (%, based on tonne-kilometres)

The negative effects of the lack of predictability of transport on some waterways, such as the Danube, make it very difficult to develop the containerized transport, the recent decline of which is associated to reduced freight flows due to the pandemic situation. (Figure 5)

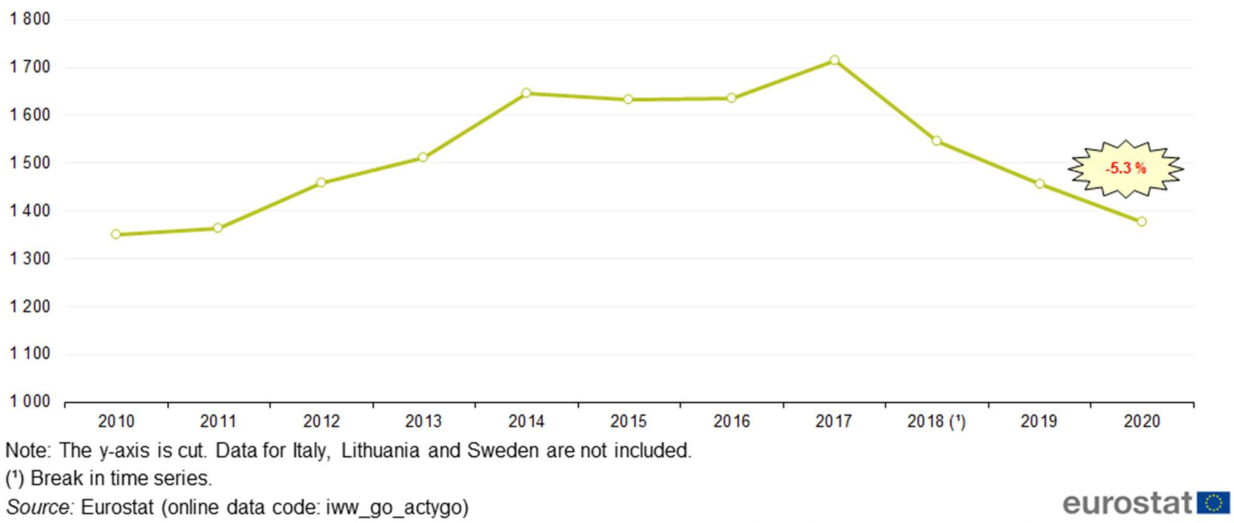

Figure 5 Inland waterways transport of containers, EU, 2010-2020 (million TEU-kilometres)

However, containers transported on European inland waterways remain associated to the Rhine area, while the Danube countries carry a limited number of containers. (Figure 6)

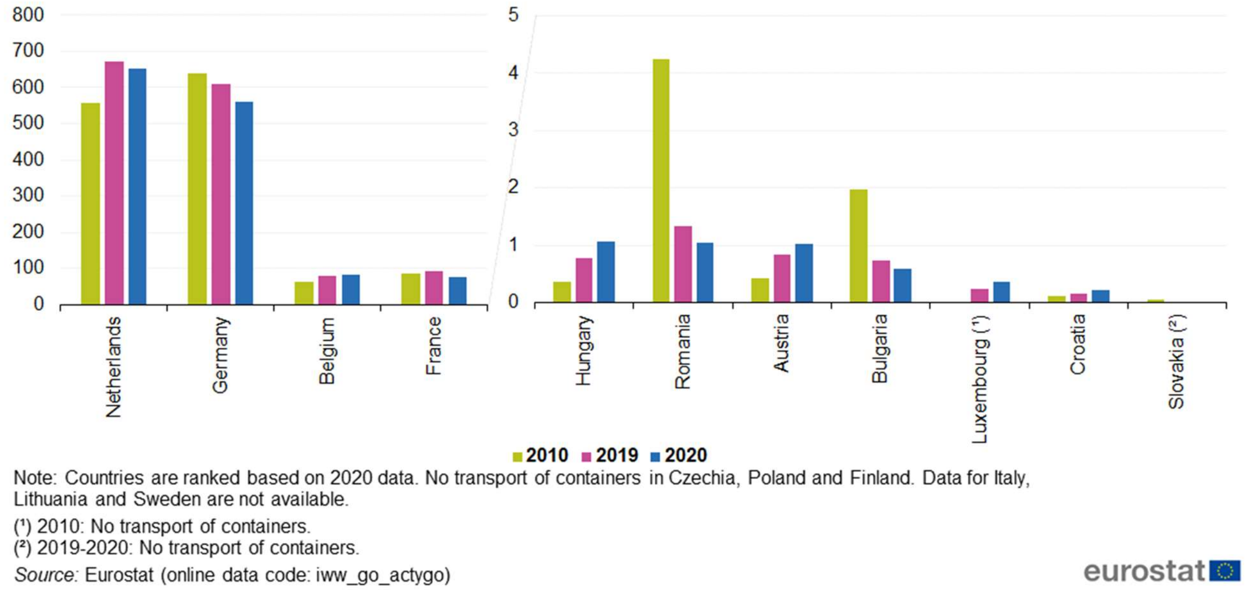

Figure 6 Inland waterways transport of containers, 2010, 2019 and 2020 (million TEU-kilometres)

We can also note that mainly empty containers are transported on the Danube (Croatia, Bulgaria, Austria, Romania), a situation generated by the navigation conditions mentioned above and described in detail in Chapter 7. (Figure 7)

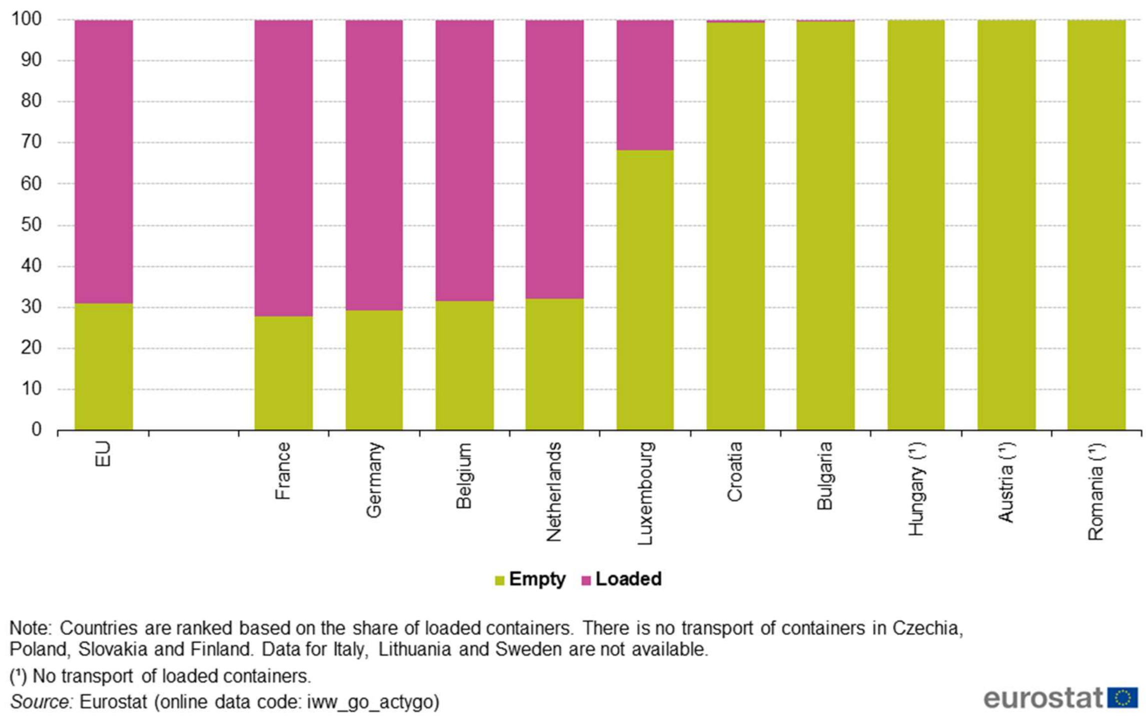

Figure 7 Inland waterways transport of containers by loading status, 2020 (%, based on TEU-kilometres)

However, due to the navigation conditions on the Danube, most of the quantities of goods transported remain in the Rhine area, with the Netherlands owning almost half of them. (Figure 8)

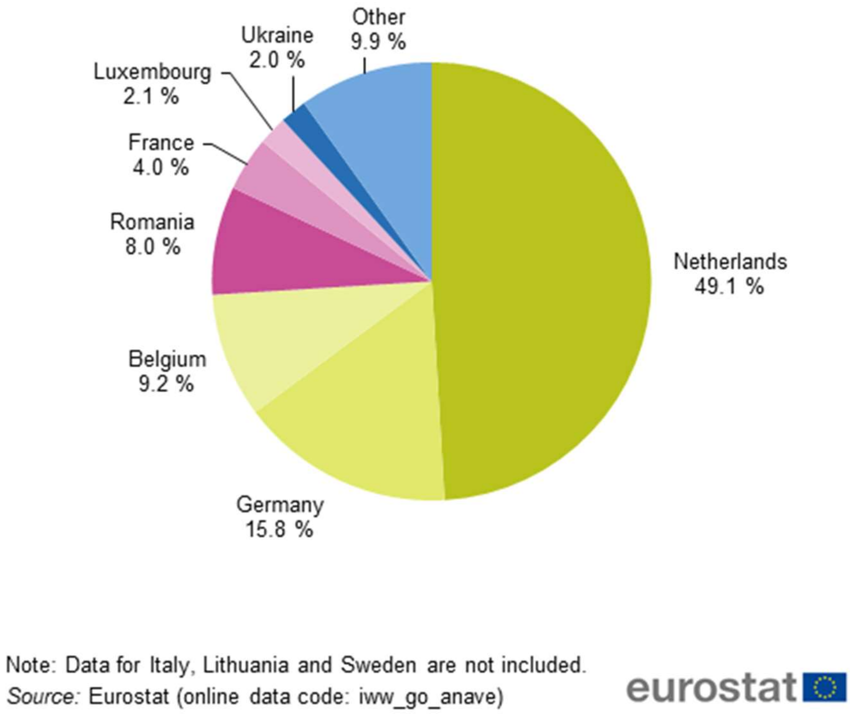

Figure 8 Inland waterways freight transport by main nationality of vessel, EU, 2020 (%, based on tonne-kilometres)

7 Identification of critical sectors on the Danube and history of periods when low water levels affected navigation

7.1 General aspects

Concerns at European level about increasing the use of inland waterway transport, also highlighted in the Danube Strategy[2], included funding for the FAIRway Danube project[3], the main objectives of which include analyzing navigation conditions and increasing waterway availability.

The deliverable "*Fairway Rehabilitation and Maintenance Master Plan for the Danube* (FAIRway, 2020)", presents the situation of the critical points as reported by the pertaining administrations.

The data presented below are based on these situations, as well as additional data provided by administrations or other relevant stakeholders, as well as from other cited sources.

The main aspects that mark the transport market on the Danube are shown in the annual report on "*Observation of the Danube Navigation Market*" (Danube Commission, 2021-2015) published by the Danube Commission[4], including elements on navigation conditions, fleet, freight traffic and their operation in the Danube ports. These reports constituted an essential sources of documentation for the production of this material.

7.2 The situation of critical points on the Danube in the 2012-2019 period

Blockage of navigation due to shipping accidents, frost periods, flood events as well as waterway maintenance works (complex dredging) and construction works (locks, dams etc.) are not included in this analysis.

Germany

Table 1 Number of days with channel depth ≥ 2.00 m (target value) for the main critical points in Germany

Critical Point	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Lock Straubing to Port Straubing Sand	352	362	335	258	344	326	214	308

[2] *www.mae.ro/strategia-dunarii*

[3] *www.fairwaydanube.eu*

[4] *www.danubecommission.org*

Port Straubing-Sand to Deggendorf	332	359	320	243	295	305	204	296
Deggendorf to Vilshofen	352	330	272	250	335	321	214	325

Table 2 Number of days with water level ≥ LNWL in the main critical points in Germany

Critical Point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Lock Straubing–Port Straubing-Sand	Pfelling	352	362	335	258	344	326	217	319
Port Straubing-Sand–Deggendorf	Pfelling	352	362	335	258	344	326	217	319
Deggendorf–Vilshofen	Hofkirchen	360	365	351	273	360	345	239	352

Austria

Table 3 Number of days with channel depths ≥ 2.50 m in the main critical locations in Austria for a channel width of 40-80 m

Critical Point	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Wachau	366	359	352	323	359	342	294	352
East of Vienna	318	315	222	224	326	317	258	326

Table 4 Number of days with water level ≥ LNWL in the main critical points in Austria

Critical Point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Wachau	Kienstock + Dürnstein	366	365	365	330	355	341	309	361
East of Vienna	Wildungsmauer + Thebenerstraßl	366	365	355	310	343	328	274	335

Slovakia

For the Slovak section of the Danube (common AT-SK, national, joint SK-HU), the main critical locations are the sections from km 1880 - 1863 with the reference station in Devin, km 1810 - 1785 with the reference station Medvedov and km 1765 - 1710 with reference point Sturovo station. The most critical section of the entire Slovak part of the Danube in terms of available width and depth is at km 1735.5 - 1733.7 (Cenkov = Nyergesujfalu) which is located on the common SK-HU portion of the Danube.

Table 5 Number of days with channel depths ≥ 2.5 m at the main critical locations in Slovakia for a channel width of 60 - 100 m on the Slovak-Hungarian section and 40-80 m on the Slovak-Austrian section.

Critical Point	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
part I. (km 1880 – 1863)	366	365	365	287	310	304	254	331
part II. (km 1810 – 1785)	360	341	359	307	338	324	236	302
part III. (km 1765 – 1710) including Nyergesújfalu	303	324	300	223	319	303	224	281

Table 6 Number of days with water level ≥ LNWL in the main critical points in Slovakia

Critical Point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
part I. (rkm 1880 – 1863)	Devin	366	362	349	294	345	340	324	357
part II. (rkm 1810 – 1785)	Medvedov / Gonyu	366	362	348	259	325	326	252	311
part III. (rkm 1765 – 1710) including Nyergesújfalu	Sturovo / Komarom	319	334	292	288	353	332	259	333

The main reason for the unavailability of 2.5 m depths, except for the unfavorable hydrological conditions, is that in parts II and III the bottom of the river is rocky, and no dredging is carried out, as it would require other technologies than those usually used. In Part I, the dredging intervention is carried out according to plan.

Hungary

Section km 1811 – 1708

Table 7 Number of days with channel depths ≥ 2.5 m in the main critical locations in Hungary (km 1811-1708)

Critical point	2012	2013	2014	2015	2016	2017	2018	2019
Nyergesújfalu, 60 meter wide channel	304	314	307	244	326	327	245	309

Nyergesújfalu, 100 meter wide channel	286	304	256	213	293	304	215	282

Table 8 Number of days with water level ≥ LNWL in the main critical points in Hungary (km 1811-1708)

Critical Point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Nyergesújfalu	Esztergom	366	365	360	294	349	336	261	332

Section 1,708 - 1,560 km

The critical location Kisapostag is not a critical point anymore and for this reason it will not be a part of future statistics.

Table 9 Number of days with channel depths ≥ 2.5 m at the main critical points in Hungary (km 1708-1560)

Critical Point	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Göd, 80-meter wide channel	287	284	286	208	299	266	229	296
Dömös, 120-meter wide channel	312	304	264	205	279	290	221	277
Budafok, 60-meter wide channel	318	308	319	229	310	257	244	296

Table 10 Number of days with water level ≥ LNWL in the main critical points in Hungary (km 1708-1560)

Critical Point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Dömös-alsó	Nagymaros	363	365	365	322	357	362	302	355

Göd	Budapest	366	364	357	320	357	352	304	362

Section km 1,560 - 1,433

Table 11 Number of days with channel depths ≥ 2.5 m in the main critical points in Hungary (km 1560-1433)

Critical point	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Solt, 60-meter wide channel	365	365	360	277	344	330	254	322
Solt, 100-meter wide channel	293	318	232	210	277	284	208	263

Table 12 Number of days with water level ≥ LNWL in the main critical points in Hungary (km 1560-1433)

Citical Point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Solt	Dunaföldvár	366	364	358	270	339	326	251	319

Croatia

Table 13 Number of days with channel depths ≥ 2.5 m at the main critical points in Croatia (for a channel width of 100 m)

Critical point	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Apatin	366	365	365	365	366	363	365	365

The strectch of the Danube in Croatia is characterized by sufficient depths, but due to the morphology of the river (large number of sandbanks and islands), the width of the channel is varied. The Apatin sector is characterized by an unstable bed, where the direction of flow during the drought is subject to change. Therefore, the depth available for the same water level may not have the same values. The table below shows the number of days relative to the width of the channel.

Table 14 Number of days less than 200/150/120 m wide (and more than 2.5 m deep) at the Apatin critical point

Critical point in 2018 (January-December)	*200 x 2,5*	*150 x 2,5*	*120 x 2,5*	*100 x 2,5*
Apatin	131	209	365	365

Table 15 Number of days with water levels ≥ LNWL in the main critical points in Croatia

Critical point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Apatin	Apatin	366	365	365	315	353	352	266	331

Bosnia and Herzegovina

The Sava River waterway requires rehabilitation works and large-scale reconstruction to ensure full use of it. Rehabilitation and reconstruction works should also ensure the necessary conditions for safe navigation along the Sava River, including regular tunnel maintenance. The Sava River waterway is included in the central transport network in Bosnia and Herzegovina, and rehabilitation is one of the priorities of the country's transport sector.

Serbia

Table 16 Number of days with channel depths ≥ 2.5 m in the main critical sectors in Serbia (canal width reduced to 100 m)

Critical sector	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Apatin	366	365	365	365	366	365	365	365
Futog	366	235	365	360	327	329	291	365

Table 17 Number of days with water level ≥ LNWL by main critical sectors in Serbia

Critical sector	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Apatin	Apatin	366	365	365	316	353	353	266	331
Futog	Novi sad	366	363	365	324	353	358	281	332

Romania

Table 18 Number of days with channel depths ≥ 2.5 m in the main critical points in Romania

Critical point	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Bechet (channel width 100 meters)	355	327	365	285	351	357	317	342
Corabja (channel width 100 meters)	348	335	365	272	352	355	317	308
Turcescu (100 meter wide channel)	281	297	345	260	301	312	253	265
Cochirleni (channel width 80 meters)	196	234	319	236	257	200	201	225
Seimeni (channel width of 100 meters)	323	329	365	336	347	352	339	363
Prut (channel width 80 meters and depth> 7.32m)	352	333	365	308	338	365	318	350
Tulcea (channel width of 100 meters and depth> 7.32m)	351	318	365	321	359	365	329	365

Table 19 Number of days with water level ≥ LNWL in the main critical points in Romania

Critical point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Bechet	Bechet	332	329	365	277	348	309	322	297
Corabia	Corabia	328	325	365	258	348	285	317	265
Turcescu	Calarasi	319	325	365	279	348	330	290	276
Cochirleni	Cernavoda	331	325	365	295	355	355	301	302
Seimeni	Cernavoda	331	325	365	295	355	355	301	302
Prut	Galati	366	365	365	365	353	353	334	316
Tulcea	Tulcea	366	365	365	365	359	350	318	314

Bulgaria

Table 20 Number of days with channel depths ≥ 2.5 m at critical points in Bulgaria

Critical point area	*Critical point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
From km 610 to km 607	Somovit	318	327	365	313	366	365	365	365
km 591 - km 584	Sredniak island Palets island	345	346	365	316	366	365	347	365
km 569 - km 561	Belene island Milka island Kondur island	283	275	337	212	273	220	280	277
km 548 - km 540	Vardim island	292	309	360	268	327	316	289	343

km 539 - km 530	Yantra River Giska Island	316	317	360	253	306	337	330	343
km 525 - km 520	Batin island	339	314	352	246	295	288	285	309
km 476 - km 472	Gostin island	337	326	365	365	366	365	349	365
km 463 - km 460	Mishka island	366	365	365	365	366	365	346	365
km 458 - km 455	Brashlian island	341	365	365	365	313	263	297	329
km 441 - km 435	Radetski island	366	365	365	365	366	365	365	365
km 426 - km 420	Kosui island Dunavets island	332	354	365	322	366	365	342	318
km 414 - km 410	Malak Preslavets island	345	341	365	365	366	361	302	329
km 408 - km 399	Popina island	342	365	365	311	304	269	293	313
km 395 - km 390	Vetren island	345	365	365	365	366	365	365	365
km 386 - km 382	Chajka island	346	358	365	365	366	365	349	365

The table includes the main critical points identified by Danube waterway users in the December 2014 Master Plan (marked in gray) and other critical points further identified by the Bulgarian administration.

Table 21 Number of days with water level ≥ LNWL at main critical points

Critical Point	*Reference point*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
567.00-566.70 – Belene island 562.00-561.50 – Coundur/ Milka island 541.60-541.00 – Vardim island 538.50-537 – Giska island	Svishtov km 554.300	337	326	365	285	348	334	293	298
523.80-523.20 – Batin island 475.70-475.30 – Gostin island	Ruse km 495.600	341	329	365	288	348	339	295	303
425.90-425.20- Kosui island 391.60-391.10 – Vetren island 383.50-382.50 – Chajka island	Silistra km 375.500	325	326	365	293	348	343	288	290

The Bulgarian-Romanian joint section (km 845,650-km 374,100) with a length of 471.55 km is characterized by a large number of critical sections for navigation, in which, at certain water levels, the required depths are not reached and this prevents and / or restricts navigation.

7.3 History of navigation conditions on the Danube in the last period

Important aspects of the Danube transport market are outlined in the annual report on "Observation of the Danube Navigation Market" (Danube Commission, 2021-2015) published by the Danube Commission[5], which includes elements on navigation conditions, fleet, freight

[5] *www.danubecommission.org*

traffic and their operation in Danube ports. In the following representation, data are taken from these reports, as well as from administrations or other relevant sources.

2021 (first half of the year)

Snow reserves in the Danube basin, before the beginning of 2021 in the mountainous and plain areas, as well as in the river basins that form the Upper Danube flow, as well as in the Middle and Lower Danube (Drava, Sava and Tisza basins) were insignificant, or below the long-term average values, respectively.

In the first ten and twenty days of January 2021, the water levels on the Upper Danube were below the LNWL level for 15-18 days, and only from the last ten day of the month did a sudden increase start to the MWL level with an amplitude exceeding the value of 2.5 - 3 m. On the Middle Danube, water levels in the first and second jobs of the month dropped from MWL to LNWL and below; from the middle of the third period of the month the increase started with reaching MWL values and higher by 1.2-1.3 m. On the Lower Danube, in the first period of the month, the levels were mainly above MWL, in the second and third period they fluctuated close to the MWL value with insignificant periodic decreases below this value and a sudden increase towards the end of the month (first wave of floods of winter).

From the first days of February on the Upper Danube there was a decrease in water levels compared to the the values of the amplitude reached; this decline reached MLW by the end of the month. On the Middle Danube, the beginning of the month was characterized by a sudden increase to about 3 m above the MLW value; with the beginning of the second period and until the end of the month, there was a consistent decline, which, however, was not less than MWL. On the Lower Danube, the beginning of the month was characterized by levels above MWL by 1.5-2.4 m; in the second ten-day period of the month there was a second wave of winter floods with amplitudes of 1.9-3.1 m, respectively, throughout the subsequent period the elevations were higher than MWL.

In March, water levels on the Upper Danube fluctuated in the range below MLW values by 50-40 cm. On the Middle Danube, from the middle of the month there was a slow decline in water levels and their stabilization below the MLW value with insignificant fluctuations (5-10 cm per day). On the Lower Danube, levels were mainly above MWL, with occasional decreases (at the end of the month) below MWL.

In April, water levels on the Upper Danube fluctuated in the range below MLW values by 40-20 cm; by the end of the month, levels were approaching LNWL values. On the Middle Danube during the month, the levels remained stable below MWL by 30-50 cm. On the Lower Danube, the levels fluctuated in relation to the value of MW in the intervals of exceeding or decreasing by 20-30 cm.

In May, the water levels on the Upper Danube fluctuated in the range below MLW values by 40-30 cm; starting the middle of the month, the levels exceeded the MWL values by 30-70 cm. On the Middle Danube, in the first part of the month, the levels remained stable below MWL by 40-50 cm; from the middle of the second period of the month, there was an increase with an amplitude of 1.6-1.8 m, followed, until the end of the month, by a decrease in MWL. On the

Lower Danube, the levels of the first period of the month fluctuated in relation to the value of MWL in the intervals of exceeding or decreasing by 20-60 cm; in the second ten-day period, there was an increase in levels with an episodic excess of MLW by 60-80 cm, which was replaced by a decrease by the end of the month.

In June, water levels on the Upper Danube fluctuated in the area of MLW values with an occasional increase of 40-80 cm. On the Middle Danube, during the month levels fluctuated near the MWL with insignificant increases. On the Lower Danube, levels fluctuated around MLW; by the end of the month, there was a decrease below MWL by 50-90 cm.

The absence of frost phenomena ensured a continuous navigation in the first quarter of 2021. The sufficiently stable water flow was ensured only in March, which made it possible to load vessels at a draft of 2.5 m and occasionally at a maximum draft of 2.7 m. In the following period, the work precipitation changed according to table 22.

Table 22 Available drafts for navigation in the first half of 2021

Month	*Upload, upstream (cm)*	*Loading, downstream (cm)*
January	230 (230)*	210 (210)
February	250 (250/260)	210/220 (210/220)
March	250 (250/270)	210/220 (220/230)
April	250 (230/240)	210/220 (200/210)
May	250 (210/220)	210/220 (190/200)
June	230 (230)	210/220 (210/220)

Note: The draft is shown in parentheses for the corresponding period of 2020.

2020

In December 2019, along the entire Danube, the water level remained low. On the Upper Danube, levels fluctuated around the low water level (LNWL) for the entire month. Only at the end of the month, due to short-term rainfall, did it rise to the average water level (MWL) and then decreased. Also, in the same period, on the Middle and Lower Danube, there was a similar increase in levels up to MWL with a subsequent decrease.

In the first ten days of January 2020, the water level along the entire Danube continued to fall from MWL to close to LNWL and remained constant throughout the month. On the Upper Danube, the minimum water levels in January were lower than in the same period of the previous year, by 70-80 cm, and the average water level by 30-40 cm, at the same time, towards the end of the month, the levels fell below LNWL in 6-8 days. On the Middle Danube, the minimum water levels in January were lower than the similar ones in the same month of 2019, by 60-70 cm, and the average water level by 90-100 cm. On the Lower Danube, the decrease in levels below LNWL at the end of the month at some stations was of 6-7 days.

In the first period of February, on the Upper and Middle Danube, the water level started to rise to 3.5 - 4.5 m for a period of 6-8 days. This increase ensured stable levels close to MWL values along the Danube, exceeding them intermittently. It should be noted that until the beginning of 2020, snow reserves were present only in the high mountain areas of the Upper Danube, which proved insufficient for the formation of active spring floods. The snow cover was largely absent from the Danube basin.

In March, water levels along the entire Danube fluctuated close to MWL values, intermittently exceeding them by 70-90 cm. On the Upper Danube, the average monthly water levels were 30-40 cm higher than MWL, on the Middle Danube 10-20 cm higher than the corresponding values in March 2019. On the Lower Danube the levels were below MWL.

In April, water levels along the entire Danube were below average long-term annual values. On the Upper Danube, from the beginning of the month until the end of the second half of the month, there was a steady decline to the LNWL level, and after that there was a slight increase, but by the end of the month the levels did not reach MWL values. On the Middle Danube, the decrease of levels continued in the first half of the month, after which they stabilized in the range below the MWL values by 140 - 180 cm, some stations registering a decline up to LNWL.

In May, water levels along the entire Danube were lower than the multiannual average values, and the traditional rise in water levels (the second wave of spring floods) did not take place. On the Upper Danube, by the end of the month, the levels were below LNWL for more than 10 days. On the Middle Danube, the levels throughout the month were below MWL by 60-80 cm. On the Lower Danube the elevations were below the MWL values by 160-180 cm; at some stations in the first half of the month the levels were below LNWL for 5-7 days.

In the first ten days of June, water levels along the entire Danube were below average for many years. With the beginning of the second half of the month, due to the precipitation on the Upper and Middle Danube, the increase started to MWL levels with peak values of 100 cm (Upper Danube) and 200 cm (Middle Danube). By the end of the month, the levels were in the MWL range. On the Lower Danube the levels remain below MWL by 50-80 cm and by the end of the second period, they have intermittently exceeded the MWL levels; at the end of the month, there was a sudden increase in the level above MWL with peak values of 150-180 cm.

In July, on the Upper Danube, water levels fluctuated in the range below the average annual values of MWL; in the middle of the second period and until the end of the third period of the month, the levels dropped intermittently to LNWL values and below. On the Middle Danube, water levels in the first ten days fluctuated in the MWL range with intermittent increases of up to 100-120 cm. During the second and third periods of the month, levels fluctuated in the MWL range. Overall, at the end of the month, the average water levels were 50-80 cm higher than in July 2019. On the Lower Danube, within a month, water levels were in the multi-annual average values of MWL with insignificant intermittent increases in the first ten days; During the second and third ten day periods of the month, levels fluctuated in the range below MWL values.

On the Upper Danube in the first 5 days of August, there was a sudden increase in the water level up to the peak value of 250 - 270 cm due to precipitation, which led to the increase of the navigability period by 3.5 days, but we registered a decrease by MWL and below by the end of the month; by the end of the month, this decline reached LNWL values below. On the Middle Danube, in the first period of the month, due to precipitation, there was a sudden increase in water level, with a peak value of 220-270 cm, registering a period of increase of navigation of 3.5 days, but by the end of the month, water levels fluctuated below MWL, but no decrease in levels to LNWL was observed. In general, by the end of the month the average water levels were higher than those of August 2019 by 50-69 cm. On the Lower Danube, during the month, water levels were in the range below the multi-annual average values of MWL by 120-150 cm, while no decreases in levels to LNWL were observed.

In September, on the Upper Danube, in the first period of the month, the levels were in the range below MWL. In the second half of the month, the levels started to gradually decrease to LNWL values and below (totally, the period below LNWL lasted for 14-15 days). In the middle of the third ten-day period of the month, due to precipitation, there was a sudden increase (a daily increase of 70-100 cm) and a return to the area close to MWL. On the Middle Danube, in the first period of the month, the increase of the levels over MWL (by 50-89 cm) was observed twice, which was later very quickly replaced with a sudden decrease until the end of the month; during the same period, due to precipitation, the daily increase in levels was of 50-79 cm, which provided for the return of levels to the value of MWL. On the Lower Danube, in the first period of the month, water levels were in the range below the average multi-annual MWL values by 120-150 cm, while in the second period of the month, there was a downward trend in LNWL levels.

In October, on the Upper Danube, in the first and second ten-day periods of the month, the levels fluctuated in the range of values below MWL; in the middle of the third ten-day period of the month, there was a short-term decline in the LNWL level, with a subsequent sharp rise in the MWL level. On the Middle Danube, in the first and second ten-day period of the month, the levels fluctuated in the range of MWL values; from the middle of the second ten-day period of the month there was a sudden increase with a peak value of 120-180 cm, which made the water level to be constantly above MWL. On the Lower Danube, during the month, the water levels were in the MWL range, exceeding them intermittently.

In November, on the Upper Danube, levels fluctuated around MWL; from the second half of the month the levels started to drop, and by the end of the month, the levels were below LNWL. On the Middle Danube, levels were slightly above MWL values; starting with the second half of the month, the levels started to decrease systematically, but the levels did not reach LNWL. On the Lower Danube, the levels remained below MWL by 100-140 cm.

In December, on the Upper Danube, most (over 20 days) levels were below LNWL; by the end of the month, due to precipitation, a slight increase in water started. On the Middle Danube, the levels were below the MWL values by 120-140 cm; at the end of the month a slight increase began. On the Lower Danube, the levels remained below MWL by 100-140 cm, occasionally approaching the LNWL level for short periods of time.

2019

In the autumn of 2018, rainfall in the Danube basin decreased by no more than 20-30% of the seasonal norm, water levels along the entire Danube waterway were below LNWL, and in some parts of the Middle Danube levels were below absolute lows during long-term observations. Rainfall in the second half of December led to a relative increase in levels and ensured a sufficient flow of water to ensure navigation.

In the first ten days of January 2019, along the Danube basin there was precipitation in the form of snow, which ensured sufficient snow reserves on the Upper Danube. Subsequent warming and melting snow in the plains of the river basin led to the formation of a minor winter flood. Consequently, the water levels on the Upper and Middle Danube fluctuated close to the MWL values with an episodic increase compared to it by 50-140 cm. On the Lower Danube, the levels approached the value of MWL only at the end of January.

In February 2019, water levels across the Danube fluctuated close to MWL values with occasional insignificant increases. In the second half of February, due to low air temperatures and lack of rainfall, there was no steady rise in levels above MWL. The absence of frost and ice phenomena ensured a continuous navigation in the first quarter of 2019.

Until the beginning of March 2019, snow reserves in the mountainous regions of the Danube basin were estimated as significant precipitation during long-term observations, but due to low air temperatures and lack of precipitation, no large waves of spring floods were observed. Water levels throughout the Danube fluctuated around MWL.

In April, the weather conditions in the Danube basin were characterized by cool and dry weather. The melting snow in the mountainous areas slowed down, and the rainfall was local only.

Monthly average, maximum and minimum levels were largely lower than in March. Water levels fluctuated mainly around MWL.

In May, average monthly air temperatures in the Danube basin were mainly above the multiannual average. Heavy rains in the second half of May on the Upper Danube and in the Sava, Drava and Tisza basins led to the formation of a significant spring flood wave with an amplitude of 2-2.5 m. At the same time, water levels were significantly higher than MWL values, and in some areas they were close to HNWL values.

In June, in the first ten days, a gradual water levels decrease began, but at the end of the month the levels remained close to MW values.

During the second half of June, the predominant problems along the Danube were the low water flow and the declining water levels.

The dynamics of shallow water in the summer-autumn period that began in July 2019 is compared to the same critical period that took place in 2018. This phenomenon was considered an extreme hydrological phenomenon, of very rare recurrence: according to preliminary estimates by experts, this phenomenon occurs more than once every 70 or even 100 years.

In July, on the Upper Danube, water levels fluctuated below the long-term average values of MWL with occasional decreases below LNWL.

On the Middle Danube, water levels fluctuated below the long-term average MWL values with insignificant short-term increases (about one day). The average values of the levels were slightly higher than the levels recorded in July 2018.

On the Lower Danube, during the month, water levels were below the long-term average values of MWL with a tendency to steadily decrease LNWL values. In some areas, there was a drop in levels below LNWL values.

In August, water levels dropped due to high air temperatures and a lack of sufficient rainfall.

On the Upper Danube, insignificant periodic rainfall provided water fluctuations around MWL, but their average values were higher than in August 2018.

On the Middle Danube, water levels fluctuated below MWL due to short-term rainfall, so no decrease in levels below LNWL was observed.

On the Lower Danube, there was a downward trend in water levels that persisted throughout the month, and at some stations the levels approached LNWL and remained below LNWL for 6 to 20 days.

In September, the entire Danube basin was dominated by abnormal hot and dry weather. The total amount of precipitation this month did not exceed 20-30% of the long-term average values.

There was a short-term rise in levels, followed quickly by a sharp decline, and in the second half of September a fall in levels below LNWL.

On the Middle Danube, there was an increase in short-term levels, which was then quickly replaced by a sharp decline as it approached the LNWL.

On the Lower Danube, levels continued to decline throughout the month, while levels were below the LNWL for 15-28 days.

In October, there was a critical state of the waters throughout the Danube basin. In some areas, based on local restrictions, basin levels approached the critical point.

On the Upper Danube, at the beginning of the month, the levels were below the LNWL values, followed by an insignificant increase due to the precipitations at the beginning of the second half by 1.3-1.8 m, followed by a decrease of the levels up to the values LNWL.

On the Middle Danube in the first half of the month, levels fluctuated close to LNWL values, followed by a slight increase due to precipitation at the beginning of the second half of the month by 1-1.3 m and then a decrease in levels until at values close to LNWL.

On the Lower Danube, levels remained below LNWL values with insignificant secondary deviations.

In the first half of November, significant rainfall occurred on the Upper Danube and in the basins of its tributaries - Sava and Drava, which caused a rise in water levels on the Upper and Middle Danube, which led to an improvement in the critical situation, a period that had lasted from July. In November, the number of days when the levels were below the LNWL values was, respectively: on the Lower Danube - 0-6 days, on the Middle Danube - 2-7 and on the Lower Danube - 11-15 days.

In December, water levels remained low along the Danube. On the Upper Danube, levels fluctuated around LNWL values during the month. It was only towards the end of the month that there was an increase due to short-term rainfall to the MWL level with a subsequent decrease. On the Middle and Lower Danube, a similar increase in levels took place by the end of the month near MWL, followed by a decrease.

The absence of significant frost phenomena during the winter ensured a continuous navigation in the first half of 2019. The water flow from March to May and partly in June made it possible to ensure the draft of ships of 2.5 m and more.

During the second half of June, there was a predominant tendency of decrease in the flow of the river and in the water level throughout the Danube basin. The availability of water depths (especially in October and November) led to significant restrictions on freight traffic.

2018

In December 2017, on the Upper and Middle Danube, water levels fluctuated close to the long-term average values of MWL; on the Lower Danube the elevations were 80-100 cm higher than the MWL values.

Unlike the situation in the first ten days of January 2017, when a stable level of low water was observed, followed by a sudden cooling, which led to the freezing of the river and the cessation of navigation, the hydro-meteorological situation on the Danube in early January 2018 made it possible to ensure the stable operation of navigation

At the beginning of the first ten-day period of January 2018, there was an increase in water on the Upper and Middle Danube with an amplitude of 250-300 cm in a period of 6 days. Then, in January, water levels were above average long-term values:

- on the Upper Danube - by 100-175 cm an episodic increase of the HNWL value;
- on the Middle Danube - with 70-160 cm;
- on the Lower Danube - with 70-135 cm.

In the first ten days of February, high-level fluctuations took place across the Danube in the area of average MWL values. Since the middle of the second ten-day period along the Danube, the increase in levels was replaced by a decrease and a relative stabilization at the MWL level.

Until the beginning of March, the snow reserves in the mountainous areas were estimated as average, therefore the first wave of spring floods, which formed in the first half of March, was mainly due to precipitation. The amplitude of the first wave of floods on the Upper and Middle Danube was 120 150 cm, on the Lower Danube - 250-300 cm due to the water content of the Sava River.

In April, on the Upper and Middle Danube, levels fluctuated around MW. On the Lower Danube, levels were above MWL; in some areas, have been reached maximum HNWL values.

In May, on the Upper and Middle Danube, levels fluctuated around MWL. On the Lower Danube, the levels remained close to the MWL values, but with a constant downward trend.

At the beginning of June, levels on the Danube fluctuated around MWL. In the middle of the month, the precipitations on the Upper Danube caused an episodic increase of the levels by 60-150 cm, but the downward trend persisted until the end of the month, in some areas the levels approached the LNWL values. On the Lower Danube, until the end of the month, the level fluctuations remained close to the MWL values.

The dynamics of water levels in July 2018 are comparable to similar critical periods that occurred in 2003, 2011 and 2015.

In July, on the Upper Danube, in the first half of the month, the levels fluctuated close to the minimum values of LNWL with occasional insignificant increases (by 10-15 cm) compared to this level; this situation persisted until the end of the month. At some locations (e.g., at Pfelling), levels were constant below LNWL for 26-30 days; a similar situation occurred in 2015

On the Middle Danube, insignificant rainfall since the beginning of the month led to a short-term rise (about a day) in levels, but from the end of the first ten-day period to the end of the month, there was a steady decline in levels to minimum-term values.

On the Lower Danube, at the beginning of the month, the levels were below the long-term average values - MWL by 20-40 cm; In the second half, a steady decline in long-term lows began - LNWL. It should be noted that at the same time in 2003, there were already critical points with shallow water levels below LNWL in almost all areas.

In August, drought and low levels intensified due to high air temperatures and lack of sufficient rainfall.

On the Upper Danube, the first half of the month began with elevations below LNWL by 40-50 cm; subsequently, this situation lasted until the end of the month, and occasionally minor rainfall did not correct the situation. In some areas (Pfelling), levels below LNWL lasted throughout the month.

On the Middle Danube, water levels were below LNWL, and in some areas they were close to critical levels. For example, at the Budapest and Mohacs stations, such situations were observed between 22 and 26 August. The short-term precipitation (during the day) at the end of the month did not lead to the stabilization of the levels, consequently until the end of the month they were at the level of the long-term minimum values -LNWL.

On the Lower Danube in the first ten-day period there was a steady decline in water levels, as the water content of the river was not supported by the rivers Sava, Tisza, Drava, and in the third ten-day period the water level approached LNWL. In some areas, levels below LNWL persisted for a long time (for example, at Kalafat - 26 days). It should be noted that the water level on the Lower Danube in August was more stable than in a similar situation in 2003 and

2015, when in almost the entire section they were absolutely below LNWL throughout the month.

In September, the critical state of shallow waters remained throughout the Danube.

On the Upper Danube, water levels, as in 2003, were below the LNWL for 13-20 days; the episodic increase of this level did not affect the water flow in this area.

On the Middle Danube in the first half of the month, the elevations were 35-100 cm higher than the LNWL, but from the second ten-day period the elevations were in the LNWL area and below (5-10 days). In some areas the water level has approached critical, thus reaching the values of the absolute minimum of the last 70 years of observations. In general, the navigation conditions were similar to those of 2003, with minor fluctuations in the range of 25-50 cm. A similar situation can be observed for 2015.

In October, the critical state of shallow waters remained as such throughout the Danube basin. On the Upper Danube, the water level was constantly below LNWL for 21-30 days; the episodic increase of precipitation (2 days) did not affect the water level in this area.

On the Middle Danube, water levels were constant below LNWL for 26-30 days; the episodic increase of precipitation (5 days) at the end of the month did not affect the water level in this area.

On the Lower Danube, water levels were below LNWL in the range of 50-70 cm fluctuations throughout the month.

In November, the critical state of shallow waters remained the same along the Danube.

On the Upper Danube, the water level was constantly below LNWL by 20-40 cm during the month.

On the Middle Danube, water levels were constant below LNWL by 20-40 cm; the episodic increase of precipitation (5 days) at the end of the month did not affect the water level in this area.

On the Lower Danube, water levels were constantly below LNWL, with minor episodic fluctuations.

In December, on the Upper Danube, in the first half of the month, due to rainfall, there was a short-term increase in water, followed by a decrease in LNWL; in the middle of the third ten-day period, a sudden increase with a maximum value of about 3 m stabilized the water level near MWL until the end of the month.

On the Middle Danube, due to rainfall, there was similarly a short-term increase in water levels, followed by a decrease in LNWL; in the second half of the month there was a sudden increase with a peak value of about 3 m, which stabilized the water level near MWL until the end of the month.

On the Lower Danube, the water level left the LNWL area only until the end of the month.

The total duration of the stagnation of water levels below the LNWL markings at the Upper and Middle Danube stations between July and October 2018, proved to be the highest of the similar indicators of previous years.

Table 23 Number of days that the levels at the main measuring stations were below the LNWL markings

Station name, km	*2018*	*2015*	*2011*	*2003*
Pfelling / 2305.53	149	107	51	94
Devin / 1879.80	83	66	37	104
Budapest / 1646,50	91	60	29	76
Bezdan / 1425,59	102	53	37	88
Calafat / 795,00	114	118	89	119
Călărași/370	82	75	42	102

The phase in which the water level on the Danube, in the summer and autumn of 2018 was low can already be evaluated as a rarely recurrent extreme hydrological phenomenon; according to preliminary estimates by experts, this phenomenon barely occurs more than once every 70 or even 100 years.

Significant losses in the carrying capacity of the fleet are mainly due to the fact that most of the ships on the Danube were built in the 1980s for the planned draft of 2.7 m, which in reality is only available for 2.5 - 3 months a year.

2017

In December 2016, stable shallow waters were observed throughout the Danube basin, with levels below 100-150 cm MWL, and at the beginning of January 2017, the levels on the Upper and Middle Danube at some stations were stable below LNWL.

At the beginning of the first ten-day period of January 2017, due to the invasion of the Arctic air masses, a sudden cooling and the drop in temperature to low water levels, frost phenomena started, primarily on the Middle and Lower Danube. In the first phase, at the beginning of the frost phenomena there is loose ice with a concentration of 40-50%, turning into finely broken ice with a thickness of 7-10 cm. Consequently, on January 8-11, the cessation of navigation on the Serbian, Hungarian, Romanian and Slovak sections of the Danube was announced.

The rapid freezing of the river led to the fact that the entire fleet was not able to settle in shelters in time; some ships remained in the ice stretches, and works were needed in order to salvage them by means of an icebreaker. Icebreakers were also used to release damaged pontoons during the movement of the ice.

At the beginning of the first ten days of February, the ice conditions on the Danube were alternating drifting ice sections (10-30%), coastal ice fields and ice-free water areas; by the end of the ten-day period, ice drift (20-50%) continued on the Lower Danube.

As of the 20th February, the works to restore the situation of the navigation and the movement of the fleet in the Upper and Middle Danube sectors started.

The campaign related to the actions associated with the frost phenomenon ended on February 22-23.

In the first ten days of March, water levels along the Danube approached MWL values and occasionally exceeded it by 20-30 cm on the Upper Danube and by 60-80 cm on the Lower Danube.

In April, water levels were generally in line with long-term average values; Rising water levels in early May across the Danube did not ensure stabilization of levels close to MWL values.

In June, water levels along the Danube were generally below average; throughout the month, there was a steady decrease in levels below MWL by 80-100 cm; this decline in some areas of the Upper and Lower Danube periodically reached LNWL values.

In July, water levels along the Danube were below MWL:

- on the Upper Danube there was a sudden episodic increase of 50-60 cm at the end of the month, with an amplitude of up to 2 m and a subsequent sudden decrease below MWL;
- on the Middle Danube there was a sudden episodic increase of 100-150 cm at the end of the month with an amplitude of about 2 m and a subsequent sudden decrease below MWL;
- on the Lower Danube - a 2-2.5 m decrease in values below LNWL.

In August and September, the water level was constantly low.

In October, the water level along the Danube continued to be below MWL; occasionally, insignificant increases were accompanied by a decrease and closer to LNWL levels.

In November, a gradual increase in water flow began along the Danube, but only on the Upper and Middle Danube did episodic exceedances of MWL values occur.

In December, water levels in the Upper and Middle Danube were unstable and fluctuated around MWL; on the Lower Danube, the levels were higher than the MWL values.

The rapid development of frost at the beginning of the year led to the fact that in some sections of the river a significant number of ships were caught in the ice. The reasons for this situation (as in the same period in 2012) are seen in insufficient attention, both by individual ship-owners and by ship-masters, to the official information of the competent authorities on the threat of navigation in ice areas.

Unlike the steady state of the levels in the busiest months for shipping: May - June (including the previous year 2016), the beginning of the shallow water phase in the summer period in 2017 took place much earlier (in fact, in mid-June), which led to an earlier limitation of the ship drafts.

The relative stabilization of the water level in March - April allowed the transport to operate at a draft of 2.5 m and more, but in June the draft decreased to 2.2 - 2.3 m.

In mid-June, the entire Danube experienced a sharp drop in levels well below the long-term average. From mid-July to the end of September, there were sharp fluctuations in levels on the Upper and Middle Danube relative to long-term average values, and on the Lower Danube - shallow water was relatively stable.

In general, in the second half of this year, the shallow water period was about 80 days, which periodically led to the cessation of traffic on the Lower Danube and significant losses for ship-owners

The draft of the ships during this period was 2.2 - 2.3 m.

2016

The situation on the Danube in the first half of 2016 was largely determined by the following hydro-meteorological factors:

- the absence of long periods of severe frost during the winter which could lead to restrictions or closure of navigation;
- the snow reserves in the Danube basin at the beginning of March were generally considered insignificant and for this reason the snow remained only in the mountainous regions, therefore the formation of spring-summer floods on the Danube depended almost entirely on the amount of precipitation distribution in the river basin;
- The increase of water levels on the Danube took place in several stages, due to heavy rainfall on the Upper Danube and in the Drava and Sava basins.

The first ten-day period of January was characterized by extremely low levels:

- on the Upper Danube - in the LNWL value area;
- on the Middle Danube - below the LNWL values by 10-20 cm;
- on the Lower Danube - below the LNWL values by 40-70 cm.

Levels grew up only in the second ten-day period; maximum level height, for example, on the Middle Danube was 2.2 m, while the elevations were approaching average (MWL) and even exceeded them for a short time.

After a sharp drop in levels until the end of January, there was a second rising wave in the first ten days of February which caused a rise in levels:

- on the Upper Danube - 30-80 cm above MWL;
- on the Middle Danube - 40-90 cm above MWL;
- on the Lower Danube - by 2.5 - 3 m.

In March, the levels exceeded the MWL values:

- on the Upper Danube - by 50-150 cm;
- on the Middle Danube - by 30-130 cm;
- on the Lower Danube - from 3 to 3.5 m, also due to significant rainfall in the Serbian region.

In the third ten-day period of March, a gradual decline in levels began, and in April their values were already below MWL:

- on the Upper Danube - by 15-20 cm;
- on the Middle Danube - by 50-60 cm;
- on the Lower Danube - by 20-50 cm.

In the first ten days of May, the levels were lower than the MWL values:

- on the Upper Danube - by 30-60 cm;
- on the Middle Danube - by 60-85 cm;
- on the Lower Danube - by 20-40 cm.

Significant rainfall and the onset of high water levels in the middle of the second ten-day period of May led to a general increase in water levels along the Danube; exceeding MWL levels being:

- on the Upper Danube - 60-90 cm;
- on the Middle Danube - 20-60 cm;
- on the Lower Danube - 140-160 cm.

In June, there were 2 consecutive increases in water levels along the entire Danube; During this time, the levels were higher than the MWL values:

- on the Upper Danube - 90-120 cm;
- on the Middle Danube - with 130-200 cm;
- on the Lower Danube - 80-90 cm.

In July, on the Upper and Middle Danube, a short-term increase in water levels made it possible to maintain levels above MWL by 30-105 cm, but on the Lower Danube, levels fluctuated around MWL and below.

In August, two successive increases in water levels on the Upper and Middle Danube made it possible to maintain levels above MWL, but with sudden fluctuations from 50 to 100 cm; by the end of the month there was a sharp drop in levels below MWL by 50-120 cm. On the Lower Danube, the insignificant short-term increase in levels did not allow the MWL value to be approached; by the end of the month, the levels were below MWL by 100-120 cm.

In September, two successive increases in water levels on the Upper Danube and the Middle Danube made it possible to briefly reach MWL levels; by the end of the month the quotas had decreased in relation to MWL by 60-100 cm. On the Lower Danube the levels continued to decrease, and by the end of the month, the levels were below MWL by 150-180 cm.

In October, the entire Danube experienced a steady low water level, with insignificant fluctuations; on the Upper and Middle Danube, the levels were on average 50-80 cm below MWL. On the Lower Danube, levels continued to fall, in some areas, this decline led to the LNWL border and even below.

In November, in the second period of the month, there was an increase in levels along the Danube; in some parts of the Upper and Lower Danube, levels occasionally exceeded MWL, followed by a sharp decline.

In December, stable shallow waters were observed throughout the Danube basin with level values below MWL of 100-150 cm.

In conclusion, in the first half of 2016, there were no significant stops in navigation due to extreme hydro-meteorological factors, therefore, the navigation conditions during this period are considered satisfactory.

The lack of constant and sufficient rainfall in the Danube basin in the second half of 2016 led to a 20-30% decrease in ship cargo compared to the first half of the year.

The comparative data show that in 2016, in terms of the characteristics of shallow water, respectively the number of days when the quotas at the main stations were below LNWL, we had a more favorable navigation than in 2015.

2015

The situation on the Danube in the first half of 2015 was largely determined by the following hydro-meteorological factors:

- absence of prolonged periods of extreme cold during the winter, as a result of which frost phenomena could be observed which could lead to restrictions or closure of navigation; minor frost phenomena were observed only on the Lower Danube;
- the accumulations of snow in the Danube basin at the beginning of March were generally considered insignificant, the snow remaining only in the mountains, therefore the formation of spring-summer floods on the Danube depended almost entirely on the amount and spatial and temporal distribution of precipitation in the river basin;

- the floods on the Danube occurred at three moments, especially due to heavy rains on the Upper Danube and in the Drava and Sava basins; the maximum levels along the navigable Danube were during this period 100 to 200 cm lower than the HSWL markings;

Minimum levels did not drop to LNWL values. In January, there were two short-term increases, as precipitation did not stabilize the high-water levels in the Upper Danube and the Middle Danube; towards the end of the month they approached the indicators of the multiannual average level -MWL.

On the Lower Danube, levels varied around MWL.

In February, the water levels on the Upper Danube and the Middle Danube were stable at a low level, their values not approaching the MWL indicators until the end of the month. On the Lower Danube, levels higher than MWL by 150 to 200 cm have been set.

The number of days with levels below MWL observed at some stations during January-February was:

- Upper Danube - 18-17;
- Middle Danube - 13-17;
- Lower Danube - 15-14.

In March, on the Upper Danube and the Middle Danube, the level values exceeded LNWL throughout the month. There was a short period of time with MWL. On the Lower Danube, the high elevations that exceeded MWL from 150 to 250 cm were maintained.

In April, following an increase in water at the beginning of the month, the MWL indicators were exceeded on the Upper Danube by 80 to 100 cm, on the Middle Danube by 40 to 50 cm; on the Lower Danube the levels exceeded MWL by 180 to 200 cm.

The number of days with levels below MWL observed at different stations in March-April was as follows:

- Upper Danube - 23-16;
- Middle Danube - 14-14;
- Lower Danube - 14-17.

In May, all over the Danube, following the floods, sufficiently high elevations were maintained, exceeding MWL on the Upper Danube from 40 to 150 cm, on the Middle Danube from 40 to 50 cm, on the Lower Danube from 60 to 100 cm.

In the first ten-day period of June, the Middle Danube and the Lower Danube were crossed by the maximum amounts of the third wave of floods with spring-summer rains, followed by a significant decrease in level.

The number of days with levels below MWL observed at different stations during May-June was as follows:

- Upper Danube - 17-16;
- Middle Danube - 18-22;
- Lower Danube - 16-15.

Altogether, the navigation conditions in the first half of 2015 should be recognized as favorable to navigation.

At the beginning of July, in the hydrological regime of the Danube, there was a clear tendency of drought and an accentuated complication of the navigation situation.

In middle of July, the water level dropped below MWL on the Upper and Middle Danube by 90-190 cm, and on the Lower Danube by 80-100 cm.

By the end of June, the levels on the Upper Danube had dropped by 20-90 cm compared to MWL, and in some areas they had dropped even below LNWL. At the same time, the elevations on the Middle Danube decreased in relation to MWL by 100-120 cm, and on the Lower Danube the elevations decreased below LNWL by 20-50 cm.

By the end of July, the draft was limited to less than 200 cm. As the depth in some areas decreased, so did the width of the channel; for example, in the Milka section (569-567 km) this width was 60 m (in deep water conditions this value is 110-120 m).

Due to the decrease in the depth and width of the passage in certain critical sections of the Lower Danube, the convoys crossed with difficulty.

In the first ten days of August, levels continued to fall along the Danube, while their fluctuations were already at the LNWL. It should be noted that the declines were more significant than in 2011, in critical conditions for shallow waters.

Light rainfall on the Upper Danube in mid-August formed a short-term increase in waterfall of 50-70 cm on the Upper and Middle Danube, after which elevations continued to decline until the end of the month. At the same time, levels fluctuated close to LNWL values and never approached MWL values. On the Lower Danube, level fluctuations were stable in the area below LNWL with short-term increases of 5-10 cm.

In the first and third ten-day periods of September, two insignificant increases (20-30 cm) of water were noticed on the Upper and Middle Danube due to precipitation, but this did not lead to a significant change in the situation on the entire Danube. Until the end of the month, in some areas, the width of the channel allowed only the movement of ships in one direction; for example, in the Milka section (569-567 km), it was 40 m wide.

In October, there were two consecutive increases in water levels, due to rainfall throughout the Danube, and on the Lower Danube there was a short-term record (up to 2 days) of MWL values. However, by the end of the month the levels fell again, and at the beginning of November on the Upper and Middle Danube they reached the LNWL values again.

At the same time, some shipping companies were forced to partially stop the movement of ships on the Upper and Middle Danube.

In the first ten days of November, the decline in water levels continued throughout the Danube basin, while level fluctuations coincided with the situation in 2011.

At the end of the second ten-day period and in the middle of the third ten-day period of November, due to rainfall, there was an increase in levels throughout the Danube, which made it possible to restore the movement of ships.

In mid-December, after a sharp rise (up to 2 m) in water levels for two days on the Upper Danube, there was a sharp drop to LNWL levels.

If we take into account the number of days when the levels at the main stations were below LNWL, then it turns out that 2015 was as critical as 2003 and 2011.

At the same time, the loading of ships, for example, in August-September, was at the level of 60-65% compared to January-June.

In conclusion, in the first half of 2015 there were no significant navigation interruptions due to extreme hydro-meteorological factors, so the navigation conditions during this period must be considered satisfactory.

The deterioration of the navigation situation, in the early appearance of shallow waters in the first ten days of July, led to a decrease in the number of vessels on the Middle Danube and an increase in the number of temporary delays on certain sections of the Danube.

The lack of stable and sufficient rainfall in the Danube basin in the second half of 2015 led to a 35-40% decrease in ship load compared to the first half of the year, a forced delay of ships to pass critical sections and even a stoppage temporary navigation.

Comparative data show that 2015 is similar to 2003 and 2011 in terms of shallow water characteristics (duration and nature of declining levels).

8 Economic losses caused by insufficient maintenance of waterways

8.1 Introduction

The importance of IWT at European level due to its low impact on the environment and high efficiency has led to a continuous observation of the conditions of navigation on the Danube and to a need to analyze how the limited conditions of navigation produce a negative socio-economic impact.

Several studies have been carried out on European-funded projects or at the request of the European Commission, which have addressed this issue, all of them showing a significant negative impact due to the periods of low water level.

This is a major impediment to the increase in the share of inland waterway transport compared to other modes of transport, as the business community has difficulties investing in an area with such vulnerabilities and a low level of predictability.

Also, the fact that river carriers are affected by the navigation conditions on the Danube leads to significant difficulties in reducing the average age of used ships, but also to imposing measures to limit the impact on the environment.

Another unpleasant effect is the considerable limitation of the development of container transport or the establishment of new logistics chains that include a component of river transport.

8.2 Structure of the Danube fleet

In the analyses carried out for the development of the *Fairway maintenance impact calculation tool*, the classifications of inland waterway vessels were taken into account, as shown in the tables below:

Table 24 Waterway classes according to the AGN
(Source: United Nations Economic Comission for Europe 2010)

Motor cargo vessels						
Type of vessel: general characteristics						
Waterway class	Designation	Max. lenght L (m)	Max. width B (m)	Draught d (m)	Tonnage T (t)	Min. height under bridges H (m)
IV	Johann Welker	80-85	9.5	2.5	1,000-1,500	5.25 / 7.00

Va	Large Rhine vessel	95-110	11.4	2.5-2.8	1,500-3,000	5.25 / 7.00 / 9.10
Vb	Large Rhine vessel	95-110	11.4	2.5-2.8	1,500-3,000	5.25 / 7.00 / 9.10
VIa	Large Rhine vessel	95-110	11.4	2.5-2.8	1,500-3,000	7.00 / 9.10
VIb	Large Rhine vessel	140	15.0	3.9	1,500-3,000	7.00 / 9.10
VIc	Large Rhine vessel	140	15.0	3.9	1,500-3,000	9.10
VII	Large Rhine vessel	140	15.0	3.9	1,500-3,000	9.10

Pushed convoys						
Type of convoys: general characteristics						
Waterway class	Formation	Lenght L (m)	Width B (m)	Draught d (m)	Tonnage T (t)	Min. height under bridges H (m)
IV		85	9.5	2.5-2.8	1,250-1,450	5.25 / 7.00
Va		95-110	11.4	2.5-4.5	1,600-3,000	5.25 / 7.00 / 9.10
Vb		172-185	11.4	2.5-4.5	3,200-6,000	5.25 / 7.00 / 9.10
VIa		95-110	22.8	2.5-4.5	3,200-6,000	7.00 / 9.10
VIb		185-195	22.8	2.5-4.5	6,400-12,000	7.00 / 9.10

VIc		270-280	22.8	2.5-4.5	9,600-18,000	9.10
		195-200	33.0-34.2	2.5-4.5	9,600-18,000	9.10
VII		275-285	33.0-34.2	2.5-4.5	14,500-27,000	9.10

According to the statistics of the Danube Commission (based on data received from shipowners from the DC member countries) on the Danube on December 31, 2017 there were about 3.5 thousand units (CCNR, 2019), which included:

- self-propelled ships for transport of dry cargo - 409 units, approximately 0.4 million dwt;
- non-motorized ships (barges) for transport of dry goods - 2,100 units, with a total deadweight tonnage of approximately 2.6 million t;
- self-propelled ships for transport of liquid goods - 74 units;
- non-motorized tankers - 128 units with a total capacity of approximately 0.22 mil t;
- pusher boats- 400 units, pusher tugs - 242 units, with a power of about 500 thousand kW.

Most of the goods are transported on the Middle and Lower Danube in convoys.

A pushed convoy consisting of a pusher and four barges of the type Europe IIb, for instance, can carry about 7,000 tons of goods - the equivalent of the goods carried by 280 trucks (with 25 net tons each) or 175 railway wagons (with 40 tons net each) (Muilerman, 2019).

Even more impressive is the transport capacity of a convoy of 9 units such as those used on the Middle and Lower Danube. Such a convoy can carry 15,750 tons of cargo and therefore can replace 630 trucks or 394 railway wagons (which is the equivalent of about 20 fully loaded block trains). On the lower course of the Danube, convoys of up to 16 pushed barges can be formed due to the width of the waterway and the fact that there are no limitations caused by locks[6].

As can be seen in Figure 9, the Danube countries transport on ilndand waters dry goods in dry bulk, mainly by barge, although in the EU Member States this segment covers only 20% of the total number of Tkm.

[6] *https://navigation.danube-region.eu/working-groups/wg-3-fleet-modernisation/*

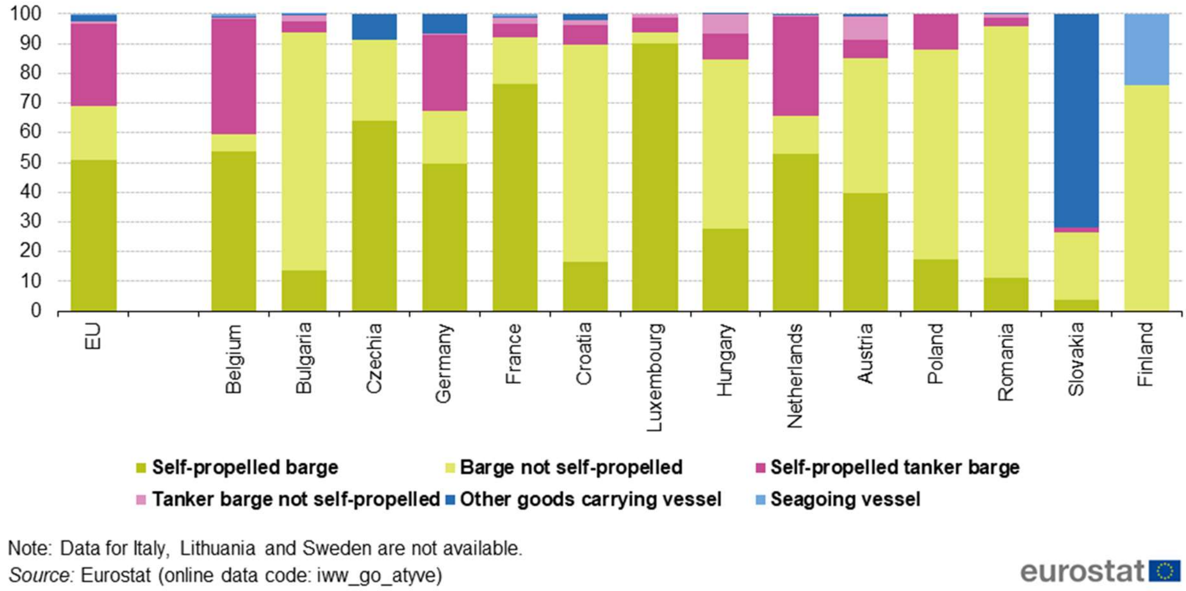

Figure 9 Inland waterways freight transport by type of vessel, 2020 (%, based on tonne-kilometres)

8.3 Aspects regarding the socio-economic impact of low water levels periods

The data collected during the reporting show numerous situations in which periods of stopping navigation have been recorded in these years. For example, a report made by the Calarasi Captaincy on September 23, 2011 reported the following convoys stationed between km 373-396, anchored on the left bank of the Danube (Figure 2):

- Km 396: Karadorde pusher with 8 barges (8,150 t ore and coal), Stig pusher, Zemun pusher;
- Km 390: Butnikov pusher with 5 barges (7,775 t ore, rolled steel and salt), S / M Mekanik Suskov with 5 barges (7,831 t salt, ore);
- Km 382: Bala tug in assistance to 4 barges of the Mercury pusher;
- Km 378-380: convoy 4 barges (4,914 t stone) of the Bocșa pusher, S / M Bogdan with one unit (1,050 t salt, metal products), Kaimaicealean pusher with 6 units (4,377 t petrol), S / M Wolker with a tank barge (2,406 t diesel), Pedro Valadin pusher with 8 tank barges (7,160 t petrol), convoy with 8 barges (8,874 t coal) of the Sretna Gora pusher, S / M Metal Trade 1 with 4 units (4,350 t phosphate) , S / M Opatovac with 2 tank barges (1,934 t LPG);
- Km 373: Proconsul pusher with 5 barges (fertilizers) and 2 empty barges, convoy 2 barges (stone) of the Bordușani pusher.

Figure 10 Convoys waiting in the Calarasi area in September 2011

Navrom Galați - one of the most important shipowners on the Danube - recorded significant losses due to the low water level at various critical points on the Danube. It notes a large number of convoys that have been affected, being forced to wait due to the closure of the navigation or to pass the barges one by one (Figure 11).

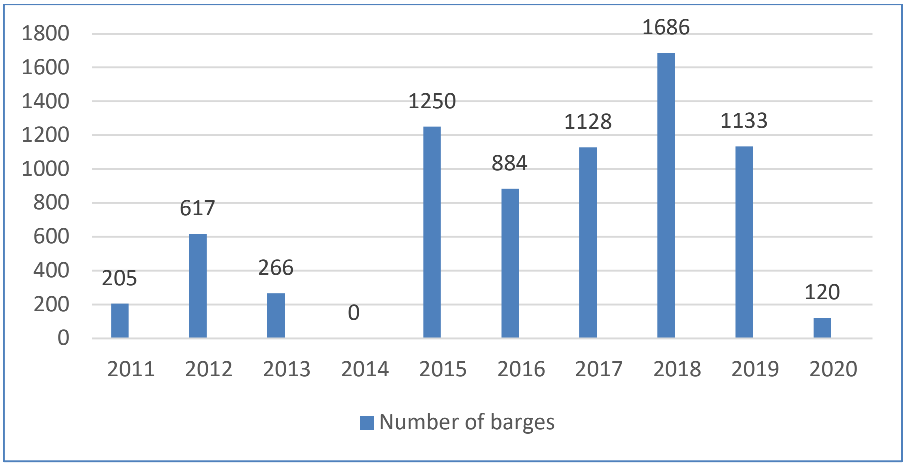

Figure 11 Barges of Navrom Galați affected by low water level in the period 2011-2020

The shipowner also reports closed periods due to frost (42 days in 2012 and 41 days in 2017), affecting 118 barges (105,850 t of cargo) in 2012 and 242 (193,886 t of cargo) in 2017, respectively. Great difficulties are encountered with large capacity vessels and especially in trying to develop containerized transport.

For example, a self-propelled vessel with the characteristics: length 135 m, width 11.45 m, maximum draft 359 cm, tonnage 3,938 m, capacity 4,800 cm, 192 TEU on 3 layers is forced to greatly reduce its transport capacity when the waters decrease to 250 cm (depth recommended by the Danube Commission), being forced to increase the corresponding freight (by about 30%) the transport becoming completely uncompetitive. If the water level drops to 220 cm or 200 cm, the transported capacity falls below half.

It should be borne in mind that it can take up to 30 days (in the case of imports from the Far East) between accepting a booking for containers and loading them, and the lack of predictability exposes the inland carrier to risks that are difficult to assess.

While in the case of bulk cargo (grains, ores, etc.) or bagged cargo the situation can be solved by easing the burden (unloading the extra cargo by means of a floating crane into standard barges) transhipment of containers with a total mass of 27 t onto another barge or motor ship, sometimes involves unsolvable issues.

In this case, the use of a floating crane with a capacity of 35-40 t and, of course, the transhipment to a ship capable of loading containers (appropriate double-hull and strengthened double bottom vessel) is required.

All these unplanned expenses are always the sole responsibility of the river carrier and cannot be re-billed to customers.

The impact analysis of loading limitations on ships and blockages due to low water levels also includes the following socio-economic issues:

- increased difficulties and blockages during the summer, when there was insufficient rainfall, which overlaps during the growing season for transport demand for grains;
- the obligation to load ships at low capacity with significant economic effects on transport operators, but also on all service providers related to inland waterway transport;
- situations where in order to ensure coverage of additional costs, freights need to be increased, thus leading on the one hand to economic losses throughout the supply chain, and to a disruption of the flow of goods on the other hand;
- changes in the values of the cost structure (see figure 12) generated by increased fuel consumption and additional staff costs;
- an increase in the risks of reorienting transport solutions to other modes and routes with economic and social effects on companies in the field and jobs provided by them;
- a decrease in the efficiency of port terminals due to the fact that the low degree of predictability leads to delays and additional costs generated by non-compliance with operational process planning;
- losses associated with non-compliance with the terms of the transport contracts and increased risks of losing business partnerships;
- reducing the effectiveness of efforts to reduce the impact of transport on climate change by encouraging road transport;
- decreased confidence in river transport with negative effects on the investment decision in areas adjacent to river ports.

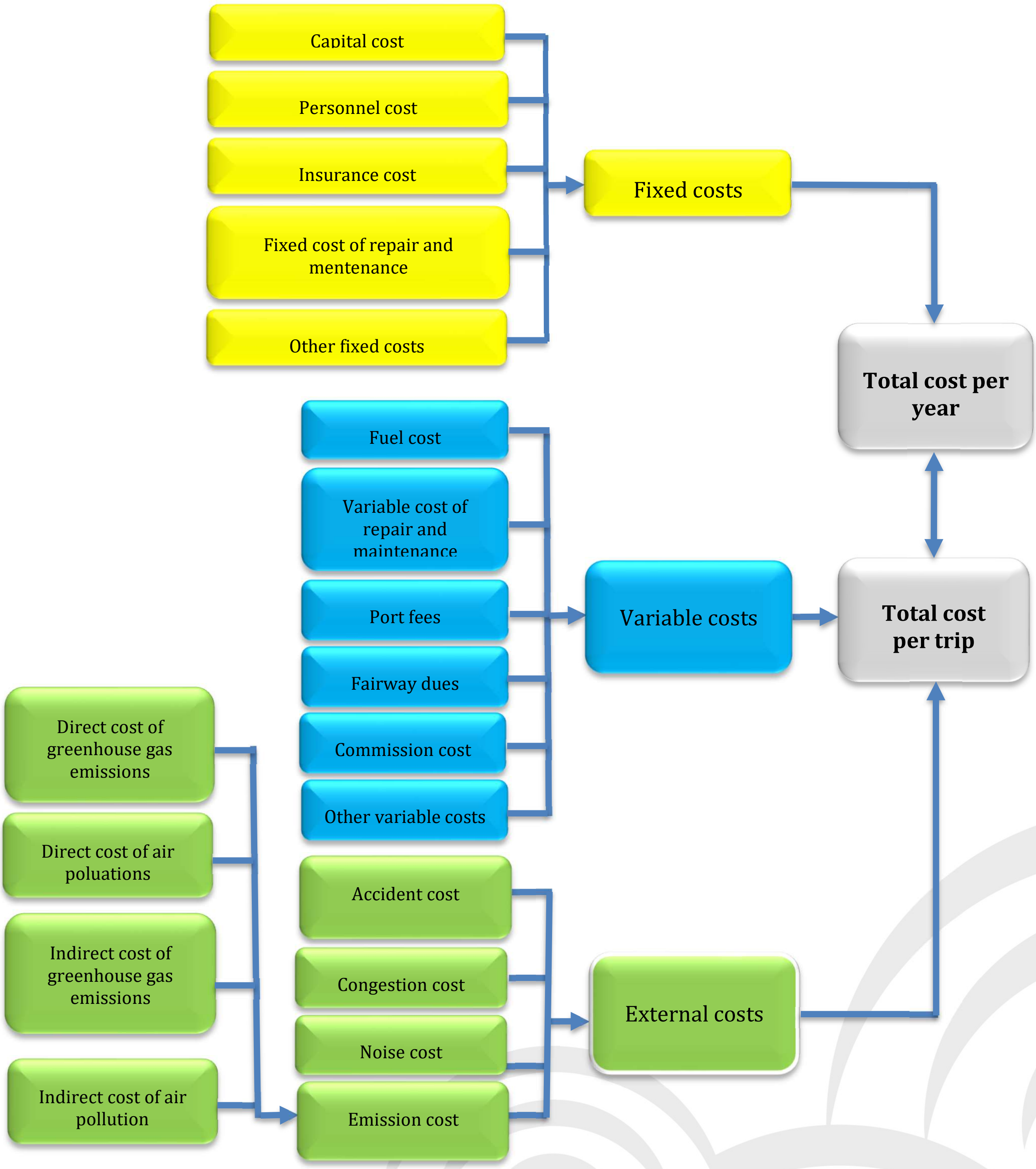

Figure 12 Costs classification in river transport

(source: Al Enezy, O.; van Hassel, E.; Sys, C.; Vanelslander T., Developing a cost calculation model for inland navigation, Research in Transport Business and Management, ISSN 2210-5395-23 (2017), pp 64-74

In an analysis of the cost structure in river transport (Figure 12) (Al Enezy, van Hassel, Sys, & T., 2017) we can see the fixed costs, which will always be directly reflected in the losses of a shipping company, whenever there are delays.

However, as ships are also in operation during shipping jams, a number of variable costs will also be partially reflected in losses.

IWT companies point out that every time there have been periods of shallow water they have experienced significant losses, which have had a negative impact on their financial results as well as on the potential for fleet modernization in line with current environmental concerns.

If we take into account the average daily costs of a barge of 250 euros / day and the number of barges affected, e.g. 1128 barges were reported for 2017 by one of the shipowners, (see Figure 11) we will find 282,000 euros losses for one day .

We can see that the same shipowner also reports a significant number of days in the same year when the navigation was closed for other reasons, such as ice.

Using the *Fairway Maintenance Impact Tool* we can see that for a convoy of four barges (2 of 2000 tons and 2 of 1500 tons) for a transport of grain on the route Novisad-Constanța with UKC 10 cm and the depth limit of 210 cm losses would be 4600 euros compared to the recommended depth of 250 cm and about 13,560 euros compared to their load capacity.

Given the complexity of the data to be analyzed along with the direct economic impact of the low level of Danube waters, such as those related to the indirect impact spread horizontally in related areas including investment in new business development or transport routes, there are few sources to highlight the total economic losses generated by this aspect. Below there are examples of results of calculations to reduce the efficiency of river transport.

Based on navigation data on the Upper Danube, the Environmental Economics Center in Hungary conducted financial analyses on the losses of IWT companies resulting from a partial use of the ship's capacity observing a 25% decrease in efficiency due to waterway problems. Thus, the estimated losses in terms of reducing the draft by 40 cm would be EUR 9-13 million per year (Centre-MAKK, 2007).

The technical report *Navigation on the Danube - Limitations by low water levels and their impacts* (Comisa Europeană) (Anja Scholten, 2016) mentions the economic losses calculated for different routes, due to low Danube levels below 280 cm, based on average values of freight.

These are estimated at € 455,000 / month for shipments from Hungary to the Netherlands for the freight values of November 2010 and € 490,000 / month for June 2012. Losses for the Germany-Austria route are also shown (Figure 13).

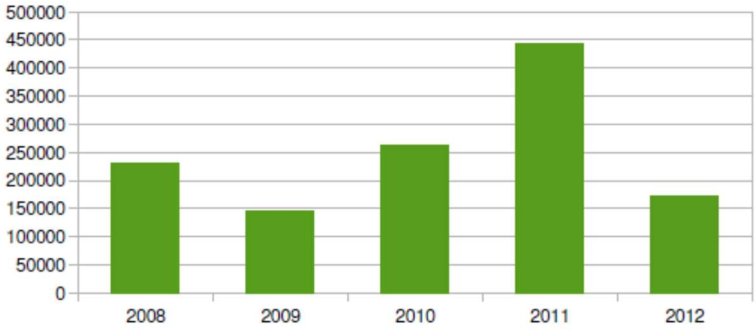

Figure 13 Economic losses (€) of river transport on the German-Austrian route due to low water

The summary of the Transport Operational Program 2021-2027 in Romania mentions the lack of reliability and navigability at the level of the navigable channel and estimates the fact that a month of blocking the transport on the Danube costs around € 2 million[7].

[7] *https://mfe.gov.ro*

9 Investment needs and maintenance of inland waterways

9.1 Approaches to investment and maintenance of inland waterways

Following the European inland waterway development policies, the FAIRWay Danube[8] project was funded, which implements the *Fairway Rehabilitation and Maintenance Master Plan for the Danube and its navigable tributaries*, as part of the Rhine-Danube TEN-T Corridor.

The results of the implementation of the master plan are under the scrutiny of the transport ministers of the countries involved, who regularly monitor (2014, 2020) the evolution of the implementation[9] (Strategy, 2020).

The good hydrological conditions of the first seven months of 2019 together with the maintenance and rehabilitation measures of the waterway contributed to reaching the recommended water level in many critical sections.

This was only possible by ensuring a sufficient national operating budget. In order to achieve better conditions for the waterway channel and to avoid critical situations in the coming years, further maintenance and rehabilitation measures must be ensured. Consequently, the necessary national operational budgets need to be secured and significant investments need to be made.

Operational costs

In view of the *Fairway Rehabilitation and Maintenance Master Plan for the Danube and its navigable tributaries* [10], a number of European countries have allocated specific budgets to operational costs for the activities they have undertaken.

The operational budgets for 2019-2020 are shown in the table below (FAIRway, 2020):

Table 25 Operational budgets for waterway rehabilitation and maintenance

	Requested operational budget 2019 (Eur)	*Operational expenses 2019 (Eur)*	*Requested operational budget 2020 (Eur)*	*Insured operational budget 2020 (Eur)*
Austria	5 384 429	4 574 139	5 212 172	5 212 172

[8] *http://www.fairwaydanube.eu*

[9] *https://navigation.danube-region.eu/danube-ministers-of-transport-sign-again-conclusions-on-effective-waterway-rehabilitation-and-maintenance/*

[10] *http://www.fairwaydanube.eu/master-plan/*

Slovakia	2 088 000	1 755 435,28	1 551 406	1 551 406
Hungary	966 000	244 435	966 000	966 000
Croatia	1 183 000	1 131 000	1 183 000	1 183 000
Romania	17 520 267 (5 688 330 for locks)	13 196 991 (4 400 246 for locks)	15 095 059 (5 120 835 for locks)	15 095 059 (5 120 835 for locks)
Bulgaria	4 033 751	2 865 496	3 831 751	4 893 649

Investment costs

Significant investments have been made in the last years since the launch of the Master Plan (FRMMP). Amounts vary, with Croatia, Romania and Bulgaria meeting more than half of the declared investment needs in 2014.

Hungary has invested much more than the investment needs declared in 2014. Many of the investments were made under the Danube FAIR-way project and most of the available investment budget is based on EU co-financing, as shown in Table 25 (FAIRway, 2020).

Table 26 Investment budgets for waterway rehabilitation and maintenance

	2014-2020 investment budget according to FRMMP (Eur)	*Insured investment costs (national budget and other funds) (Eur)*	*% of EU co-financing (Eur)*	*Funding difference (% of investment costs required according to FRMMP (Eur)*
Austria	0	568 000	0%	0%
Slovakia	8 080 000	1 989 200	84%	75.4%
Hungary	4 333 700	25 057 987	72.7%	1.3%
Croatia	4 588 000	2 756 000	53.4%	48.3%
Romania	41 058 000 (for locks: 400 000)	29 271 660 (for locks: 200 000)	41.8% (locks: 85%)	28.7% (locks: 50%)
Bulgaria	21 132 000	19 434 767	85%	24.7%

The investment needs in the rehabilitation and maintenance of the waterway identified by the riparian countries refer to the following aspects:

- Minimum fairway parameters (width/depth);
- Surveying of the riverbed;
- Water level gauges;
- Availability of locks / lock chambers;
- Information on water levels and forecasts;
- Information on fairway depths;
- Information on marking plans;
- Meteorological information;
- Other needs.

10 Conclusions

Inland waterway transport plays a very important role in the European transport network, especially because of its sustainability and efficiency, with a high potential to develop in relation to other modes of transport.

It is a competitive alternative to road and rail transport and offers a sustainable alternative in terms of both energy consumption and emissions and noise.

All these positive aspects of inland waterway transport compared to other modes of transport require a proper concern for investments in its infrastructure, which currently involves much smaller amounts than those allocated for land transport modes.

In recent times, transport on the Danube has seen periods in which navigation was significantly limited and even closed for a large number of days due to shallow waters.

In addition, blockages caused by frost have also contributed to inland waterway transport.

All these aspects have generated great losses for the shipping companies and represent a major impediment in the development of the transport on Danube.

A summary of the problems caused by the lack of depth assurance as recommended by the Danube Commission includes:

- blockages during the summer, when there is not enough rainfall, which overlap with the season in which the demand for transport of grains increases;
- loading ships at low capacity with significant economic effects on transport operators, but also on all service providers related to river transport;
- increasing freight to ensure that additional costs are covered, leading on the one hand to economic losses throughout the supply chain and to disruption to the flow of goods on the other hand;
- changes in the structure of costs generated by increased fuel consumption and additional staff costs;
- a tendency to reorient transport solutions to other modes and routes with economic and social effects on companies in the field and the jobs they provide;
- efficiency of port terminals affected due to the fact that the low degree of predictability leads to delays and additional costs generated by non-compliance with operational process planning;
- penalties due to non-compliance with the clauses of the transport contracts and an increase in the risks of losing business partnerships.

All these aspects are major impediments in increasing the share of inland waterway transport compared to other modes of transport, the business environment having difficulties to invest in an area with such vulnerabilities and a low level of predictability.

Also, the impact of river carriers on the navigability conditions on the Danube leads to significant difficulties in reducing the average age of used ships, but also in taking measures to limit the impact on the environment.

Another undesirable effect is the considerable limitation of the development of container transport or the establishment of new logistics chains that include a component of river transport.

Irreseptive of the perspective approached for the analysis of data on the evolution of traffic on the Danube, its major impairment can be clearly seen due to lack of rehabilitation and maintenance on the waterway, with considerable economic and social implications for all areas along the Danube. It is estimated that a month of blockage on the Danube could lead to losses of about 2 million euros.

Therefore, an appropriate allocation is required to ensure the navigation conditions to be addressed: ensuring depth parameters (dredging), riverbed surveys, water level arrangements, availability of locks, ensuring water level information and forecasts, markings and weather conditions.

Taking these steps is a necessity that is part of the efforts to meet the objectives generated by public environmental policies (Green Deal).

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12 Annexe 1 Danube fairway maintenance impact questionnaire - administrations

Atlas Research is developing for Maritime Ports Administration Constanta a *Fairway maintenance impact calculation tool* and a *Fairway maintenance impact report* as output for the project Dyonisus, co-financed by Interreg Danube Transnational Programme.

That is way we kindly ask you to provide information regarding the bottlenecks on the Danube where the navigation was affected due to lack of depth recommended by the Danube Commission.

The calculation tool will analyse the impact of cargo quality transported by self-propelled ships and barges in connection with water level, as well as the socio-economic loss related to the above mentioned events. If there is no data for the entire reviewed period, please fill in the available information.

1. Events related to restricted navigation on Danube

Year	***Period***	***No. of days***	***Critical point***	***No .of affected ships***	***Estimated economic loss (€)***
2020					
	Comments				
2019					
	Comments				
2018					
	Comments				
2017					
	Comments				
2016					
	Comments				
2015					
	Comments				
2014					
	Comments				
2013					
	Comments				

2012					
	Comments				
2011					
	Comments				

2. Please add a list of bottlenecks on the Danube river in the area of your responsibility

Please comment

3. Please mention other relevant information related to impact of low water on Danube navigation

Thank you for your kind assistance!

Organization's details

13 Annexe 2 Danube fairway maintenance impact questionnaire – shipowners

Atlas Research is developing a *Fairway maintenance impact calculation tool* and a *Fairway maintenance impact report* for the Maritime Ports Administration Constanta as output for the Dyonisus project, co-financed by Interreg Danube Transnational Programme.

That is why we kindly ask you to provide information regarding the bottlenecks on the Danube where the navigation was affected due to lack of assurance of depth recommended by the Danube Commission.

The calculation tool will analyse the impact of cargo quality transported by self-propelled ships and barges in connection with water level, as well as the socio-economic loss related to the above mentioned events. If there is no data for the entire reviewed period please fill in the available information.

4. Events related to restricted navigation on Danube

Year	***Period***	***No. of days***	***Critical point***	***No .of affected ships***	***Estimated economic loss (€)***
2020					
	Comments (including social aspects and business loss)				
2019					
	Comments (including social aspects and business loss)				
2018					
	Comments (including social aspects and business loss)				
2017					
	Comments (including social aspects and business loss)				
2016					
	Comments (including social aspects and business loss)				
2015					
	Comments (including social aspects and business loss)				
2014					
	Comments (including social aspects and business loss)				
2013					
	Comments (including social aspects and business loss)				
2012					
	Comments (including social aspects and business loss)				

2011					
	Comments (including social aspects and business loss)				

5. Transport capacity of different ship types at different water levels

No.	***Ship type***	***Displacement at 3.5m draft***	***Displacement at 3.0m draft***	***Displacement at 2.5m draft***	***Displacement at 2.0m draft***	***Displacement at 1.5m draft***
1						
2						
3						
4						
5						

Please comment

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____

6. Please mention other relevant information related to the impact of low water and lack of fairway maintenance for your business

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Thank you for your kind assistance!

Company details

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14 Annexe 3 List of stakeholders consulted

Company name	Country
National Company Maritime Ports Administration SA Constanta	Romania
Association „Pro Danube Romania" – Association for the promotion of transports on the Danube	Romania
Ministry of Transport, Infrastructure and Communications	Romania
Romanian River Ship Owners and Port Operators Association	Romania
Wiser Consult SRL	Romania
Galati Lower Danube River Administration	Romania
Trading Line Fleet SRL	Romania
Ennshafen Port - Ennshafen OÖ GmbH	Austria
iC consulenten Ziviltechniker Gesmbh	Austria
Pro Danube Management GmbH	Austria
Bulgarian-Romanian Chamber of Commerce and Industry	Bulgaria
Port of Bulmarket	Bulgaria
Public Institution Port Authority Vukovar	Croatia
Hungarian Federation of Danube Ports	Hungary
Fluvius Schifffahrts	Hungary
DDSG Mahart	Hungary
Technical University of Moldova	Republic of Moldova
Port Governance Agency	Serbia
University of Belgrade - Faculty of Transport and Traffic Engineering	Serbia
Public Ports, JSC	Slovakia
State Enterprise "Ukrainian Sea Ports Authority"	Ukraine