SUSTAINABLE DEVELOPMENT AND SECURITY

Global and regional aspects

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PERSPECTIVES OF SUSTAINABLE DEVELOPMENT AND SECURITY – GLOBALLY AND LOCALLY –

Thematic Compendium

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CHALLENGES OF SUSTAINABLE TRANSPORT IN DANUBE NAVIGATION

Dávid NAGY[1]

Abstract

Sustainability has become a key aspect of the analysis of the development of transport, as indicated by the rising societal demand for the reduction of carbon dioxide emissions, noise and air pollution. Transport is currently undergoing a revolution with a globally transformative impact on shipping. One such sea change is the replacement of conventional internal combustion engines and energy resources. Although the capacity intensity of Danube freight transport has not increased over the last two decades, the reduction of carbon dioxide emissions and congestion on road networks points to growing demand for efficient and competitive inland waterway transport of goods. In particular if infrastructural and technological developments enable the systematic operation of electrically powered autonomous river vessels.

Another major challenge is the impact of climate change on Danube navigation. Water level fluctuations are the combined effect of the decreasing amount and extreme distributions of precipitation. The growing frequency of extreme weather events hinders navigation and damages inland waterway navigation infrastructure. Besides waterway development and its adaptation to the changing circumstances, the resolution of this problem requires the introduction of new types of vessels and fleet renewal.

Keywords: Danube, Danube navigation, sustainable transport, climate change

Introduction

Inarguably, freight and goods transport are essential for the functioning of the economy. A much more divisive issue is the extent to which the expansion of freight transport and the development of its underlying infrastructure should be promoted. Sustainable economic development poses a

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new challenge for transport policy and transport development, uprooting former organisational principles. Besides the traditional criteria of efficiency and economy, aspects of climate and environmental protection have increasingly come to the fore, overriding in some cases established practices in transportation. Geopolitical changes, power shifts and emerging conflicts and more recently, the coronavirus crisis have exposed the vulnerability of global supply chains. We are witnessing a rapid evolution of logistics systems facilitated by the integration of tools and practices of digitalisation and automation. The transportation network and freight infrastructure are struggling to keep apace with this evolution, but these systems are more static and slower to change. Freight transport placed heavy demands on rail transport and inland cargo shipping already in the past. These transport modes require substantial infrastructural developments, a mobilisation of public investment or international cooperation in some cases. Road transport proved more flexible in adapting to the new challenges, which explains its long-standing share of over 75% in the European Union, attaining 90% in the case of some (especially southern) Member States. In 2019, rail transport inland cargo shipping accounted for 17.6% and 6.1% of EU freight transport, respectively. The share of road transport is below the EU average in each of the Danube Region countries, while that of rail transport exceeds it.

As demonstrated by its indicators the Danube's passenger transportation sector has registered dynamic growth over the past two decades. The vessel fleet has expanded, newly designed vessels have been put into operation, new operating companies have been springing up, the number of programmes has increased with a concomitant rise in passenger numbers. This has triggered a marked expansion of vessel traffic, particularly in the Upper and Middle Danube sections. Importantly, this trend contrasts with the contraction of freight transport on the Danube, the economic dynamics of the sector, the composition of the fleet as well as the spatial distribution of vessel traffic, as the increase in cargo shipping affects only the Lower Danube section. From the viewpoint of Danube navigation, passenger transport is a good complement to cargo shipping if the sector aims at full capacity use to justify the further development of the waterway.

The European Union supports the development of inland cargo shipping and its privileging over rail and, even more importantly, road transport. This is primarily due to air and noise pollution, infrastructure needs and carbon dioxide emissions arising from the constantly growing volume of road freight transport. The European Union's Strategy for the Danube Region (European Commission 2010) set as a target a 20% increase in inland cargo shipping by 2020 compared to the 2010 baseline. Furthermore, it sought to ensure the year-round availability of the waterway of class VIb (AGN 1996) by the removal of bottlenecks blocking river navigation (Action Plan 2010,

p. 90). To this end, it supported the infrastructural development of fairways and ports and the upgrading of navigational and information systems. A number of obstacles were encountered in the implementation of the strategy, which undermined the realisation of these goals (Nagy et al. 2019). One such obstacle is climate change, which the EU sought to mitigate by a reduction of transport related greenhouse gas emissions. The aim of the paper is to present the implications of climate change on inland waterway navigation and the challenges that hinder the development of sustainable navigation on the Danube.

Theoretical background and brief literature review

The implications of environmental protection and climate change on navigation have previously been the subject of scholarly interest, but also strategic papers and development documents (Beuthea et al. 2014, Glock et al. 2019, Kortschak, B. 2019, Habersack et al. 2016, Mihic et al. 2011). The two major issues are the development of environment-friendly navigation and adaptation to low water levels.

The hydrological effects of climate models (for the period 2031-2060) for the Upper Basin have been investigated by German researchers, projecting a clear reduction in summer water run-off (Stagl, J. C.; Hattermann F. 2016).

The flow regime of the Danube, and in particular the incidence of extreme weather events, fundamentally shape the conditions of navigation. Analysing the flow regime is essential due to the absence of impoundments on the Hungarian section of the Danube (Baja, Nagymaros), where studies have have demonstrated the severity of extreme water regime fluctuations (Konecsny K. 2014).

The two major factors constraining navigation on the Danube are natural bottlenecks and weather and climatic conditions. Besides legal regulations restricting navigation, these represent the main obstacles to economic competitiveness. Low water levels create unfavourable conditions for the operation of larger vessels (over 3,000 tonnes), but overall low-water periods entail a substantial increase in costs for ship operators, reduced capacity utilisation and higher freight rates (Scholten, A., Rothstein, B., 2016).

A sustainability approach can present a good opportunity for the development of inland waterway transport, but to exploit its benefits, waterborne transport has to be integrated into the transport network in close cooperation with other modes (rail, road), instead of treating each

other as competitors. Countries with a high share of inland waterway transport (Germany, the Netherlands, Belgium) should not be presented as models to imitate, given their peculiar assets and organically developed shipping traditions (Fleischer T. 2010, p.11).

Studies on ship design have also addressed the challenges of climate change and reduced carbon emissions (Angheluță et al. 2019), presenting solutions not only for the retrofitting of new ships, but the environmentally-friendly conversion of operating vessels as well. The development of the regulatory environment and coastal infrastructure of sustainable navigation on the Danube should be prioritised (Kresojević et al. 2019).

Previous studies on EUSDR projects (Nagy et al. 2019) have shown that the level of commitment to the development of the Danube waterway varies among countries. The analysis of international projects has pointed to substantial differences in the engagement of individual Danube Region countries in international projects connected to EUSDR PA1 (Nagy et al. 2020).

Data and methods

Our study analyses the environmental impact of the transport sector and inland waterway navigation, with a special focus on greenhouse gas emissions, using the European Environment Agency (EEA) database available on the EEA website (https://www.eea.europa.eu). For the purposes of comparison, we present greenhouse gas emissions in carbon dioxide equivalents. Data for the Danube Region countries were only available for EU Member States (Germany, Austria, Slovakia, Hungary, Croatia, Romania and Bulgaria).

The meteorological data and figures were downloaded from the website of meteoblue AG website (https://www.meteoblue.com/). Since the scope of the present paper does not allow for assessing the climatic conditions of the full course of the river and its surroundings, the focus will be limited to the presentation of data for a critical region of the Middle Section (Baja-Mohács) exempt from the effects of the river's impoundment. By contrast, a frequent occurrence of low water levels detected in this area obstructs navigability, as illustrated by data provided by the Lower Danube Valley Water Management Directorate (http://www.aduvizig.hu/). The number of days of unhindered navigation will be presented using data from Via Donau.

The data on goods transport were obtained from the Eurostat database (https://ec.europa.eu/eurostat).

Results

The implications of environmental sustainability for Danube navigation

The development of inland waterway transport, alongside rail transport, has recently attracted increased attention in Europe due to its important contribution to meeting climate protection targets. This issue is of primary significance as domestic transport is the second largest carbon emission sector (Figure 1). And with the steady decrease of emissions from energy production and the increase of transport related emissions, it will shortly become the largest emitter. Unlike other sectors, the transport sector shows no evidence of reduced carbon emissions, but rather increased emissions, including domestic transport, international aviation and navigation.

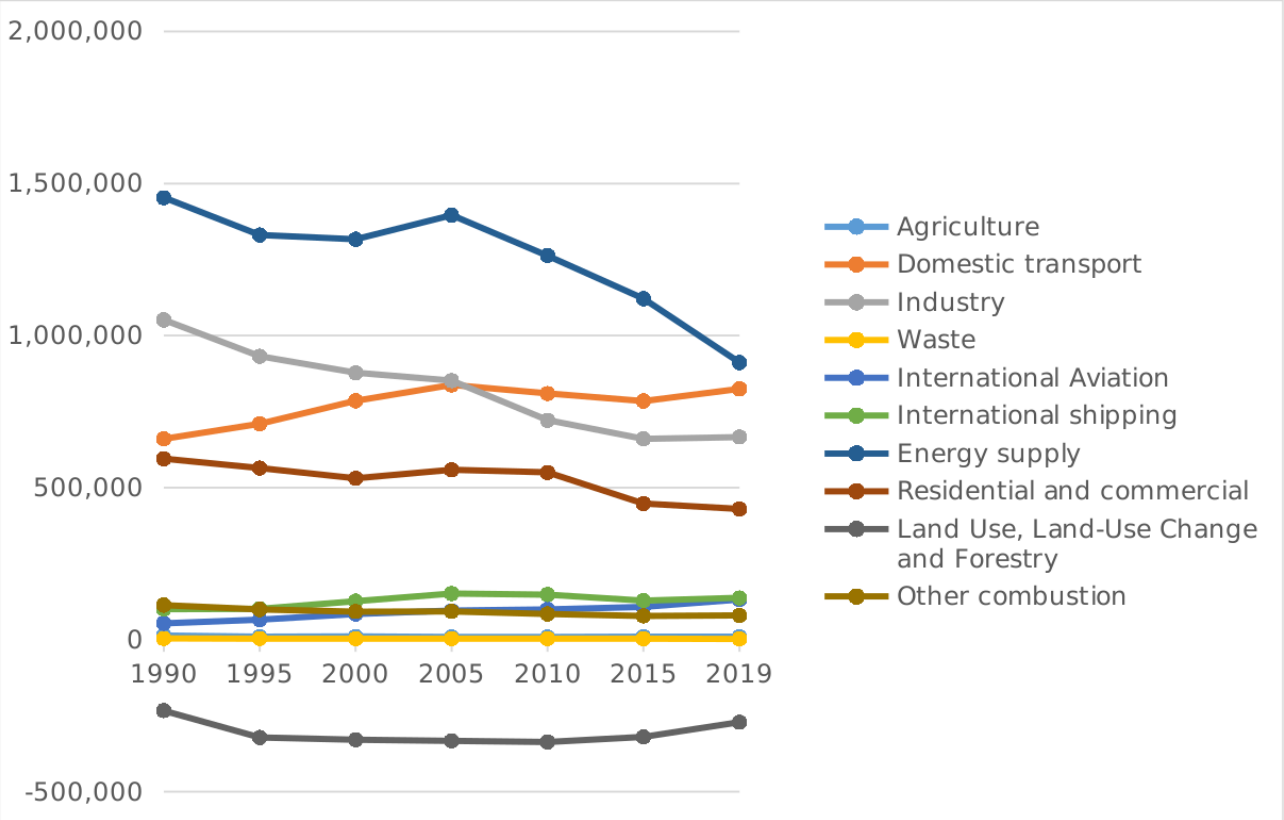

Figure 1: Change in CO2 emissions by sector in the EU-27, 1990-2019, Source: EEA

An examination of the specific CO2 emissions of various transport modes reveals road freight transport to be the largest polluter. Rail transport has the lowest carbon emissions per tonne-kilometre, but navigation related emissions are also lower compared to road transport. For this reason, the EU promotes modal shift actions as a potential means to reducing emissions. The carbon dioxide emission rate for road freight transport is 140 grams per tonne-kilometre, compared to 50 grams for inland navigation and less than 16 grams for rail (Figure 2). There has

been a significant reduction of emissions over time, whose rate amounted to 33.2% for inland waterway navigation, 32.3% for rail and only 4.2% for road transport between 2005 and 2014.

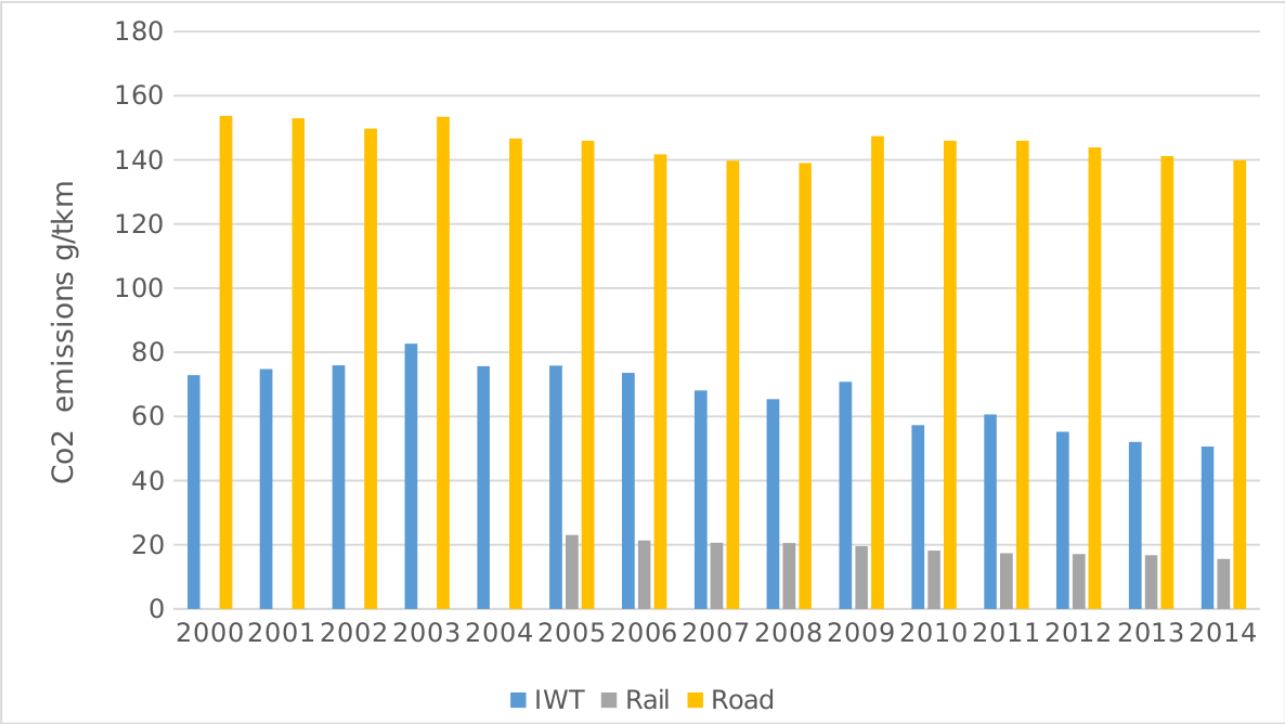

Figure 2: CO2 emissions per tonne-kilometre by transport mode in Europe (g/tkm), 2000-2014, Source: EEA, own edition.

An examination of the carbon dioxide emission levels for various modes of transport within the sector of domestic transport points to the clear dominance of road transport. As early as 1990, road transport accounted for 95% of emissions, rising to 97% by 2019 (Figure 3).

As indicated earlier, since the specific emissions for road transport have shown only a moderate decline, the share of total emissions from this transport mode has naturally increased. Overall the failure to cut emissions in the sector is explained, to a large extent, by the constantly high specific emissions from road transport and its predominance over other means of transport.

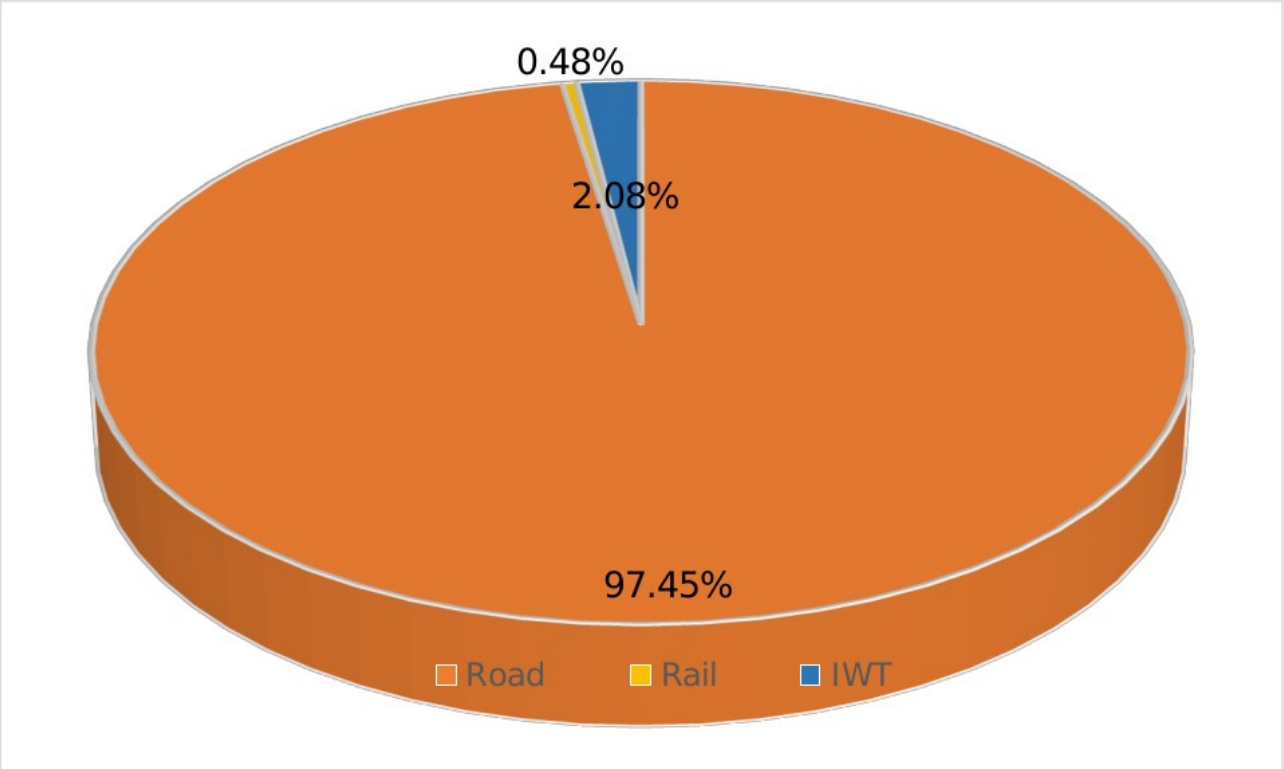

Figure 3: Distribution of CO2 emissions by transport mode in the EU-27, 2019, Source:EEA

An examination of greenhouse gas emissions from the transport sector of the various Danube Region countries (aggregated in carbon dioxide equivalents) demonstrates the clear dominance of Germany (Figure 3). This naturally stems from the huge potential of the German economy, the significance of exports and industrial production. Austria's emissions exceed those of Romania, owing among others to the greater role of rail and navigation in the modal split in Romania. Hungary is also a major emitter – for the size of its economy –, given its role as a transit country and its larger share of road transport relative to Romania.

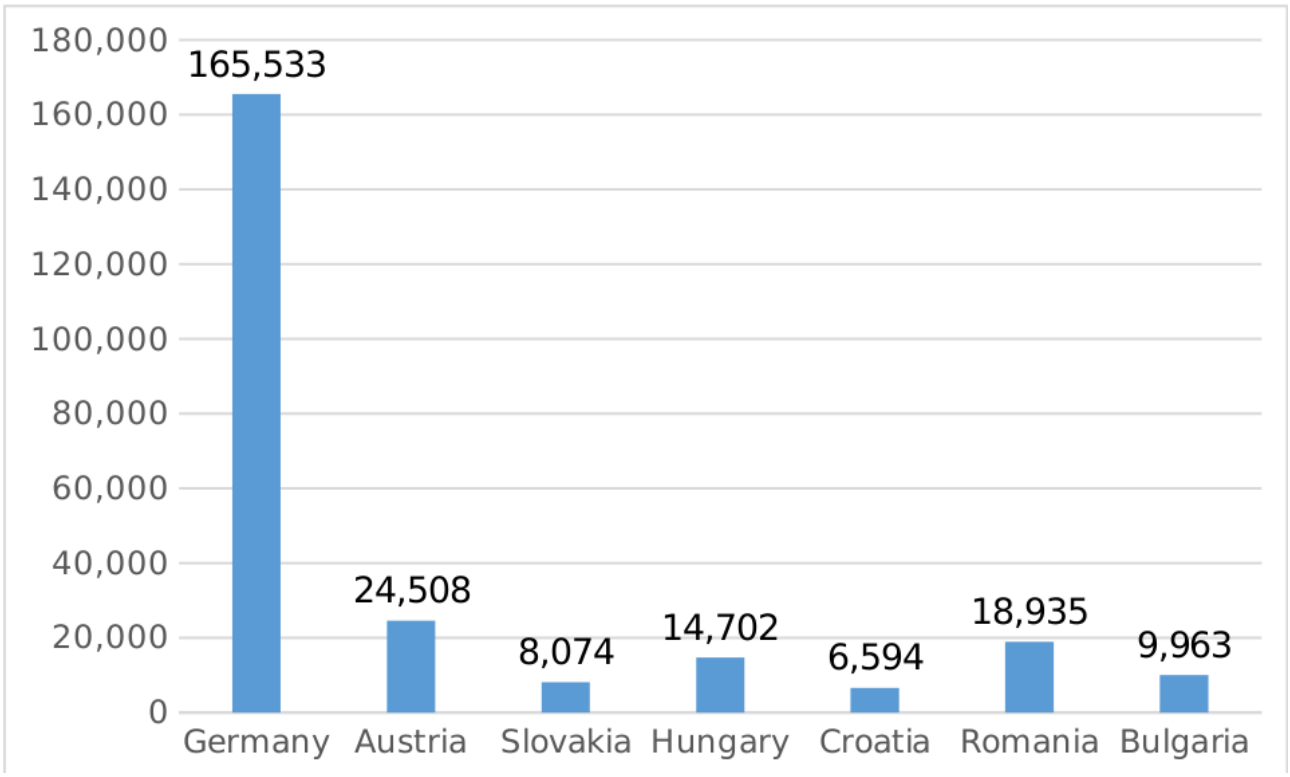

Figure 4: Greenhouse gas emissions (in carbon dioxide equivalent) from the transport sector in the Danube Region countries (Kt Co2), 2019, Source: EEA

When examining the post-2000 changes in transport-related emissions of the Danube Region countries, we can detect a significant increase for the new-accession EU member states (Figure 5). The economic development of these countries, their expanding volume of trade and transport of goods are primarily responsible for this. This period saw massive motorway developments and an expansion of the volume of cars and road cargo transport at the expense of rail and inland waterways. In terms of greenhouse gas emissions from a transport sector registering significant growth, the dominance of higher-emission transport modes was observed in new-accession countries. As a result, Austria experienced a substantial increase in transit traffic, with a significant share of shipments to and from Germany traversing the country. By way of example the total volume of goods traded from Hungary to Austria, amounted to 1.95 million tonnes in 2010, reaching 6.94 thousand tonnes in 2020 (data from Eurostat). The relatively high share of rail transport was unable to mitigate this phenomenon, especially given the important contribution of passenger road transport to emissions, witnessing significant growth with the free movement of labour over the last two decades. Emissions from the transport sector in Germany have decreased over the examined period, owing largely to the slower pace of growth in the volume of vehicles and cargo transport relative to the new-accession countries. On the other hand, the modernisation of the vehicle fleet and efforts to reduce emissions have begun to yield visible results.

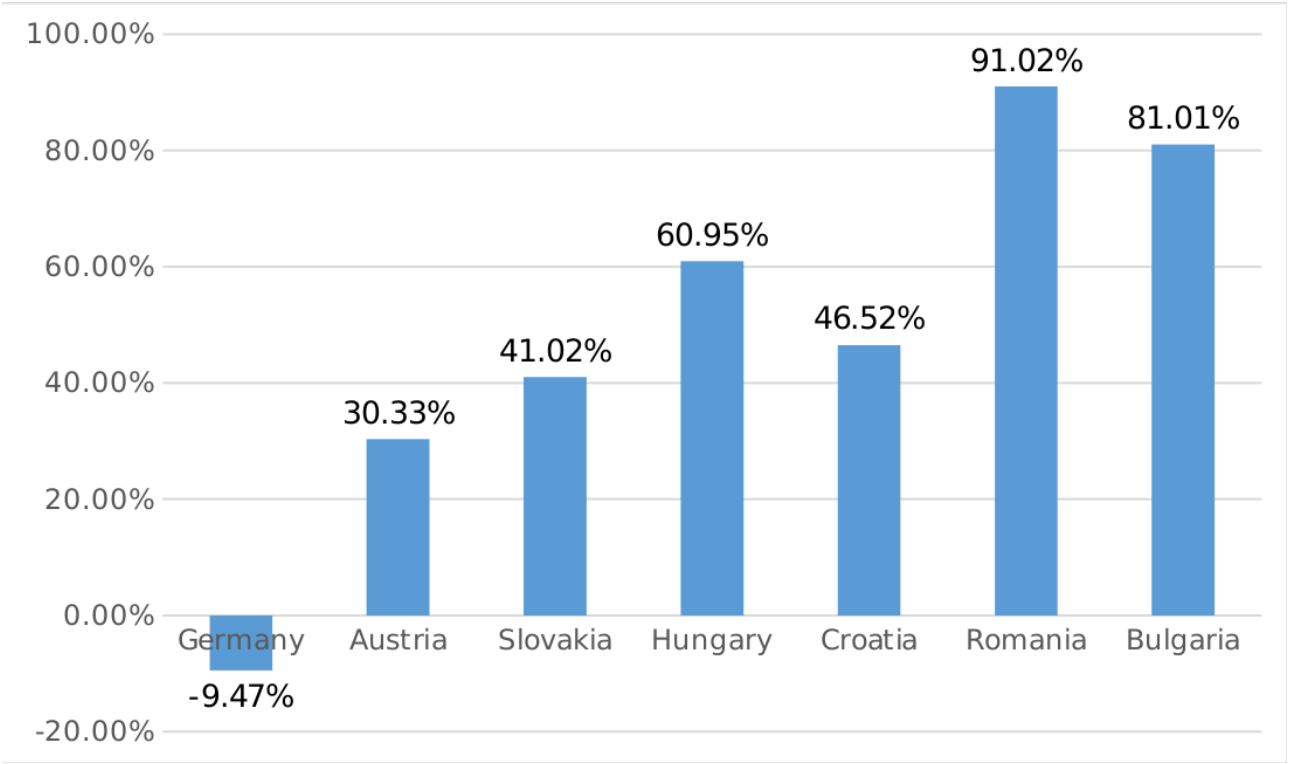

Figure 5: Changes in greenhouse gas emissions from the transport sector in the Danube Region countries, 2000-2019, source: EEA

As demonstrated earlier, road transport is the major emitter of greenhouse gases, in particular of carbon dioxide. As shown in Figure 6 below, the share of road transport in freight transport increased between 2010 and 2019 in all of the Danube Region countries apart from Bulgaria, with the largest changes detected in the case of Romania and Slovakia. The changing balance of modes of transport is not necessarily the result of a shift in transport policy but industrial restructuring, with shrinking or stagnating industrial output levels of the main sectors relying on rail freight leading to a decline of rail freight transport performance in the EU economy (Bucsky P. 2021, p. 202). The above statement also applies to the inland waterway transport of (primarily) raw materials. The modal shift of recent years is mostly attributed to the growing volume of road transport, and to a lesser extent to the declining performance of the other two modes.

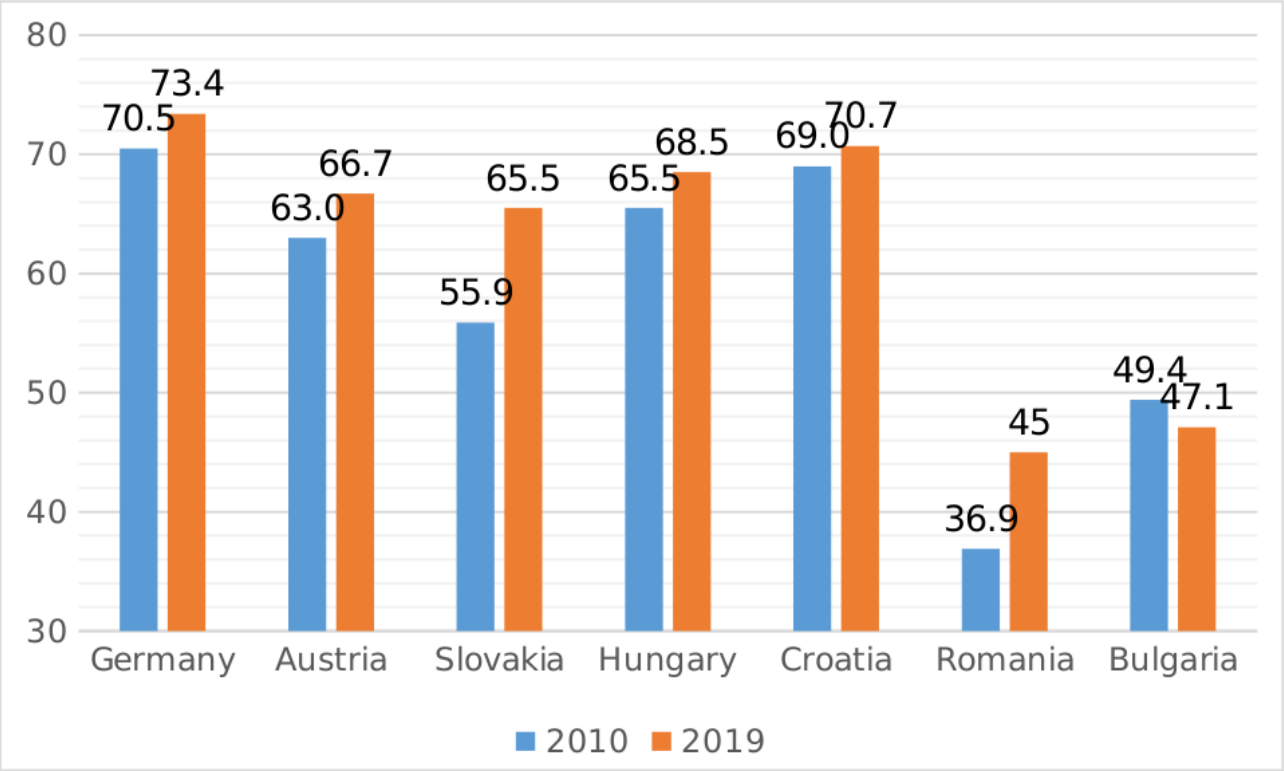

Figure 6: Change in the share of road freight transport in inland total freight transport, percentage, 2010-2019, Source: Eurostat

Impacts of climate change on Danube navigation

The previous section reviewed the role and significance of inland waterway transport in climate change efforts, with a particular focus on greenhouse gas emissions. The scientific literature and analyses carried out by experts of the relevant sectors (Stagl & Hattermann 2016; Scholten & Rothstein 2016; Konecsny 2014) has demonstrated that climate change, in particular the amount and distribution of precipitation and global warming pose serious challenges for Danube navigation. The retreat of glaciers, the decrease in snow cover in high elevation mountain regions and the acceleration of snow-melt are well-known global problems (Stagl & Hattermann 2016). In the Danube river basin the combination of these factors erodes the water storage capacity of the Alps and the Carpathians and the balancing effect of rivers on water levels. Flood waves and low water levels become more frequent along the river instead of the desired steady flows, and summer river flows decrease in the Upper Danube. The capacity of existing barrages and dams to mitigate these adverse effects remains limited all the more since they do not form a coherent system spanning the entire river.

German researchers have studied the hydrological effects of various climate models (2031-2060 period) in the Danube basin, projecting a general reduction in summer run-off for the Upper

Basin, and an even more pronounced and prolonged reduction in run-off for the Central Basin, from late spring to early autumn. By contrast, in most areas of the Danube basin, more run-off is modelled for winter and early spring. This is most typical to high mountain catchments of the Alps and the Carpathians. Accelerating climate warming is likely to lead to water use conflicts in the Central and Lower Danube basin (Stagl & Hattermann 2016, p. 34). The realisation of this scenario could have drastic implications on Danube navigation.

Extreme flows in the Middle Danube region (Nagymaros and Baja sections) were analysed using hydrological statistical methods for the period 1930-2013 (based on the ratio of annual maximum and minimum water levels and flows). The incidence of extreme water levels shows an upward tendency in the investigated period, with an even more marked rising trend over the last two decades (1992-2013). Water flow fluctuations in the first half of the examined period (1930-1971) show a different picture from the second period (1972-2013), with a slight variation detected during the first 42 years and a significant water yield increase in the second period (Konecsny K. 2014).

A further negative factor is the rise in average temperatures, which, in addition to its adverse effects on melting described earlier, naturally increases evaporation. Besides, a steady rise of river water temperatures is also detectable, putting a strain on the adaptability of river habitats, and raising further problems (e.g. its use as cooling water, the temperature of water discharged into rivers).

The analysis of data on Danube water levels provides a factual presentation of these problems, the graph depicting daily water level data indicates the extremity of changes underway and a return period of persistently low water levels (Figure 7). The linear trend line gives a fairly strong indication of a decline in water levels as a joint effect of the flow and the deepening of the river bed. The steady availability of a 25 dm water level required for navigation was not ensured in 2012, 2016, 2017 and 2018 during the examined period. In the meantime two very significant, historic floods have occurred on the river in June 2010 and June 2013, respectively.

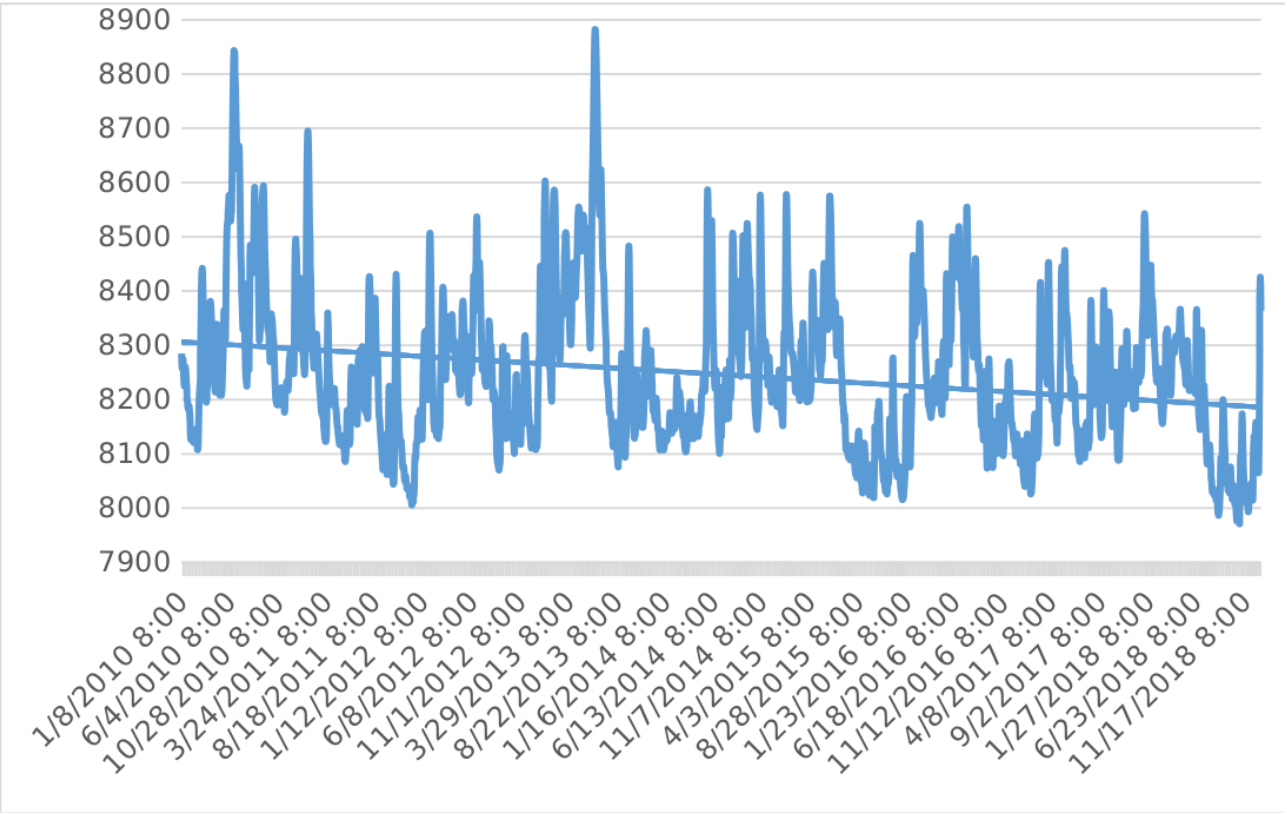

Figure 7: Water level of the Danube near Mohács (cmBF 7920), based on data from the Lower Danube Valley Water Management Directorate, 2010.01.01-2018.12.31.

Figure 8 depicts the variations in annual mean temperature values in the 30 km vicinity of Mohács. The dashed blue line indicates the linear trend of climate change. The figure shows a clear positive temperature trend over the region, which means that the area of Mohács is experiencing gradual warming. The so-called warming bands are displayed at the bottom of the graph. Each coloured band indicates the average temperature for a given year, the colour blue stands for years colder than the average, while years warmer than the average are displayed as red. For the period 2010-2020 under study, only 2010 was 0.2°C colder than average, the other 9 years were warmer, with a temperature anomaly of 1.6°C recorded in 2019. Overall the data suggest a steady annual warming trend, while the annual variations with prolonged hot and dry spells give even more cause for concern.

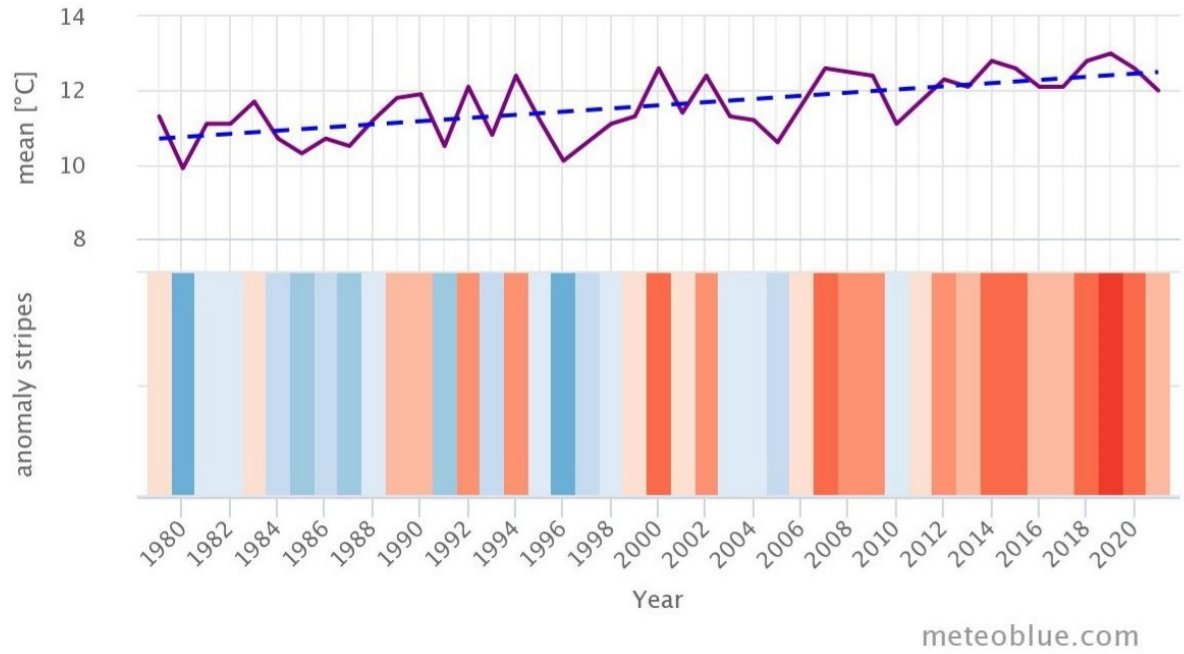

Figure 8: Annual variation of mean temperature values in Mohács, 1979-2021, source: meteoblue.com

The adverse effects of low water levels and water temperatures are most acutely felt in the summer. Therefore, the major cause for concern is not so much the increase in average annual temperatures, but rather the temperature and precipitation anomalies observed during the summer months. The temperature and precipitation anomalies observed in July 1979-2020 are illustrated by the figure below. Apparently, the effect of warming, reaching 2-3 °C in the warmest months, is most manifest in the evolution of monthly average temperatures.

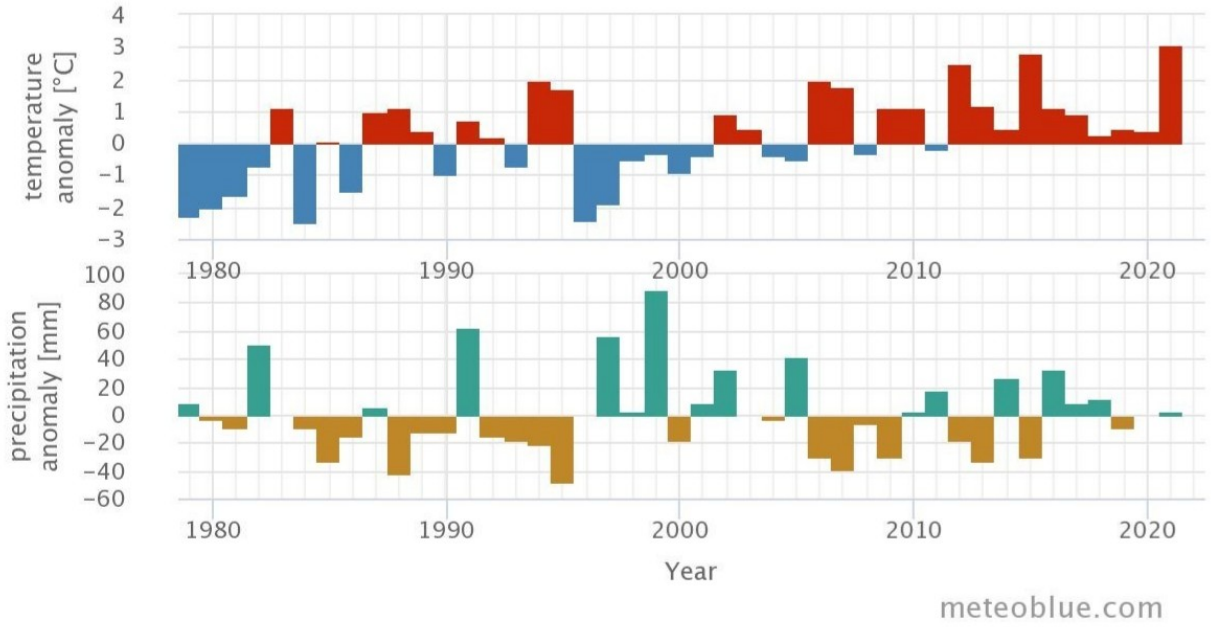

Figure 9: Temperature and precipitation anomalies in Mohács, 1979-2020, Source: meteoblue.com

The analysis of the evolution of the number of navigable days in recent years shows that the river is navigable for its entire course for roughly 300 days a year. A slight decrease in the number of navigable days can be observed during the examined period. Obstacles to navigation may stem from low water levels, but also from excessive water levels (e.g. due to passing under bridges), technical problems or navigation safety hazards. Such phenomena, nevertheless, do not suspend navigation on the river, since they affect only certain reaches and freight is transported mostly on inland waterways or to neighbouring countries. Persistent low water levels can be problematic, triggering prolonged disruptions along a significant section of the river.

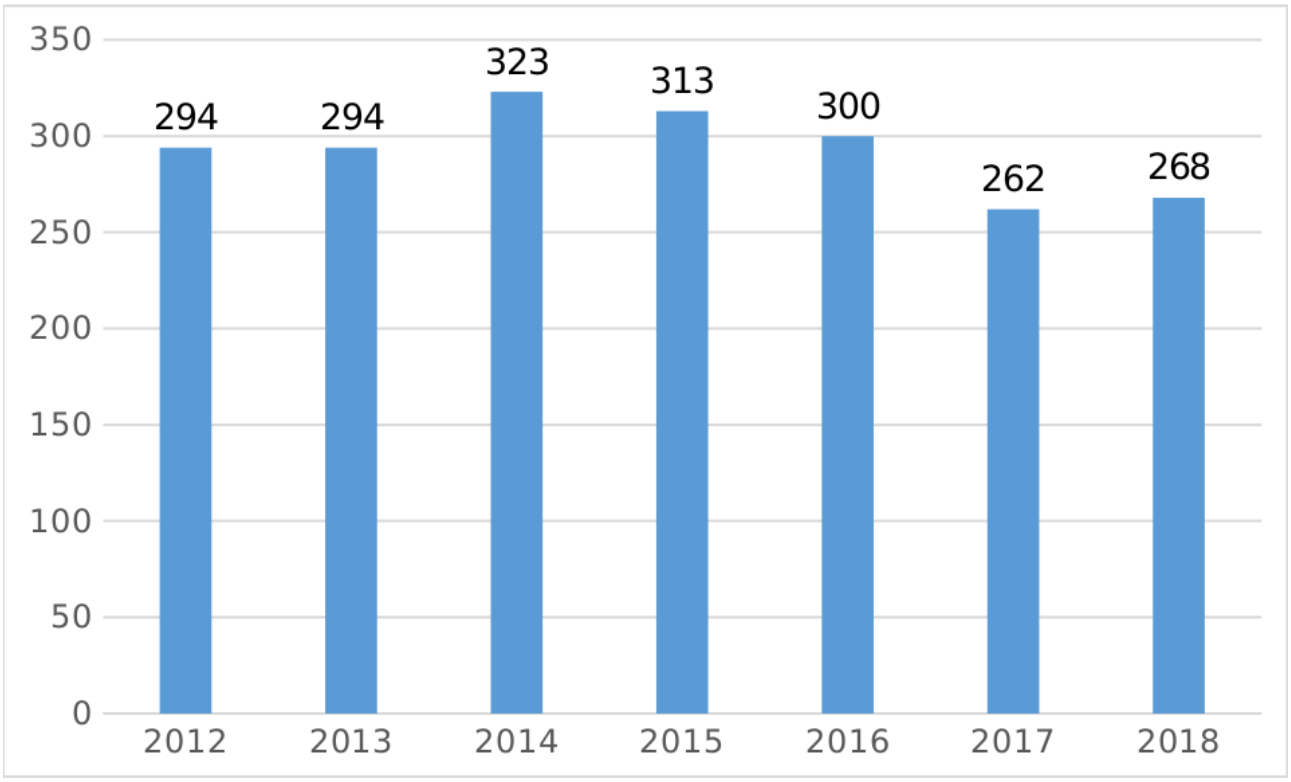

Figure 10: Number of days of unhindered navigation on the Danube, 2012-2018, data from Via Donau, own edition.

Discussion and conclusion

There has been a demonstrable increase of greenhouse gas (GHG) and particularly carbon dioxide emissions from the transport sector over the past three decades throughout the EU, especially in the new-accession, catching-up Member States. This is primarily due to the dramatic increase in freight transport and the growing weight of road transport. An analysis of these trends indicates that the development of inland waterway freight transport is unable to mitigate this double effect.

Rail freight plays a more important role in this respect, however, only a joint and not mutually exclusive development of the two alternative modes of transport could yield results. Decreasing the share of road transport is only one step to reversing this negative trend, it is also crucial to limit the growth rate of freight transport.

From the perspective of inland waterway cargo transport, it is worth examining the potential impact of a temporary or permanent reduction or suspension of vessel traffic on emissions. Presumably, since a significant share of cargo deliveries could not be realised by rail under such circumstances, this would entail a further increase of emissions from road freight transport.

The most likely factor triggering a suspension of vessel traffic on the Danube is the inadequate waterway caused by low water levels. Climate change, in particular the amount and distribution of precipitation and warming present a major challenge for Danube navigation.

In the Danube river basin the combination of these factors erodes the water storage capacity of the Alps and the Carpathians and the balancing effect of rivers on water levels. Flood waves and low water levels become more frequent along the river instead of the desired steady flows. The hydrological effects of climate models predict an overall deterioration of navigation conditions in the Danube basin, particularly in the Middle Danube section.

The examination of Danube water level data points to extreme changes underway, with rapidly receding flood waves and recurrent periods of persistently low water levels. The occurrence of extreme water levels shows a clear upward tendency. The adverse effects of low water levels and water temperatures are most acutely felt in the summer. Therefore, besides the weaker balancing effect on water levels discussed earlier, the major cause for concern is not so much the increase in average annual temperatures, but rather the temperature and precipitation anomalies observed during the summer months.

Overall, climate change has significant implications on Danube shipping, and these will only intensify in the coming decades, posing a serious threat to the viability of the sector. These adverse processes imply ecological, geopolitical, economic and social risks that go beyond the significance of inland waterway navigation. Inarguably, the development of inland navigation and its increasing share in freight transport are unable to mitigate greenhouse emissions from the transport sector in a meaningful way, making but a modest contribution in this direction. However, Danube navigation could play a crucial role in an integrated European transport system, by ensuring the coordination and rationalisation of rail and road transport modes. To this

end, climate protection aspects must be prioritised (even) over certain economic and competitiveness factors.

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