Sustainable Transport in Danube Region

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Sustainability of transport systems is a key issue in transport. The main question is whether high levels of road and railway transport in areas along navigable waterways is an effective solution for this issue. The Danube waterway is an example. Cargo transport is mainly provided by road and railway transport. Air transport is not suitable for many types of goods. On the other hand, inland water transport provides many possibilities. It is suitable for the transport of bulk, general, and liquid cargo for longer distances. The Danube, which flows through Central and Eastern Europe, creates many possibilities for sustainable and environmentally friendly transport. It is the part of the waterway Rhine–Main–Danube that links the North and Black Seas and fifteen European countries.

Keywords: inland river transport ; Sustainable Transport ; Danube Region

1. Road Transport in Europe

The total length of the road network in Europe is more than 71,423 km. The density of the road network depends on different factors, such as the density of the population, morphology of the country, density of the road network and motorways in industrial and port areas [1][2].

The largest density of regional motorways in Europe is around the port of Bremerhaven in Germany (205 km/1000 km^2). Other high levels of density of road transport are observed in the Netherlands in the port of Rotterdam and Utrecht (125 km/1000 km^2).

The states in the Danube region also belong to the countries with the densest motorway networks in the capital regions [2], especially Germany, Hungary, Austria and Slovakia (50 km/1000 km^2). For example, the density in Budapest (120 km/1000 km^2) is 2.4 times higher than that in Ile de France. However, the length of the road network in the city centre in Budapest is only 61 km long and the length of network in the city centre in Ile de France is 613 km long. These aspects support the effort of the European Union to transfer a significant part of the traffic performance from road transport to other means of transport (railway transport and inland water transport). From this point of view, the Danube offers ideal opportunity for transport systems in the regions in Central and Eastern Europe.

European roads belong to the safest roads in the world. The average number of road accidents in Europe is around 23,000 per year and the average number of injuries is 1.2 million per year. Nowadays, the European Union has presented new “Vision Zero”. The main idea of this programme is to decrease the number of deaths on European roads to almost zero by 2050. This concept is focused on key safety indicators, such as vehicle safety, seat belts, post-crash care and so on [3].

The most dangerous region of the European Union, regarding the accident rate, is Notio Aigaio in Greece with 161 road fatalities per million inhabitants. On the other hand, the safest region from this point of view is a Finnish autonomous archipelago of Åland with zero fatalities.

Looking at the Danube region, the highest rate of accidents is observed in Bulgaria and Romania. The overall number of road fatalities in these countries is at least 100 deaths per 1 million inhabitants [3]. On the other hand, the average number of fatalities in Germany and Austria is from 10 to 14 deaths per million inhabitants.

2. Rail Transport in Europe

The density of railway infrastructures in Europe is affected by historical development. It is possible to observe regional differences across the European Union. The rail infrastructure is in many eastern countries of the European Union denser than in western regions, thanks to the reliance of former communist countries on railway transport [4].

Nowadays, the density of the railway infrastructure rises mainly in northern France, Germany and in Benelux, thanks to a favourable connection to the railway system with eastern European countries. These regions are characterised by high-density populations. This fact also contributes to investments, which are mainly oriented into the high-speed rail network [4].

On the other hand, the lowest density of the rail network is situated in peripheral regions of Greece, Spain, France, Cyprus, Portugal, Malta and Finland [4]. For example, the density of the rail network in the Dytiki Makedonia region in Greece is only about 9 km/1000 km^2.

Looking at states around the river Danube, it is clear that the highest density rail infrastructures are in the capital cities and their surroundings, for example, around Berlin (736 km/1000 km^2), Budapest (379 km/1000 km^2) or Bucuresti-Ilfoy (159 km/1000 km^2) [4].

3. Transportation on the River Danube

The river Danube originates as the confluence of two mountain rivers, Breg and Brigach, in Schwarz Wald. The overall length of the Danube from the confluence of Breg and Brigach to the estuary into the Black Sea is 2858 km [5]. The Danube River Basin is more than 801,463 square kilometres. The Danube also creates a vast delta before entering into the Black Sea.

The Danube waterway crosses the territory of ten European countries. The commercial navigation starts in a German town of Kelheim and afterwards, it crosses the territory of Austria, Slovakia, and Hungary. Subsequently, it crosses the territory of Southeast Europe. The last part of the flow crosses through the territory of Moldova and the Ukraine. Based on this information, it is possible to say that the Danube waterway could be considered the only waterway in the world that crosses through the territory of ten countries. Inland river boats and pushed convoys also cross through four capital cities: Vienna, Bratislava, Budapest, and Belgrade [5].

The Danube as an individual flow is characterised by different characteristics in individual sections. Based on the natural character of the river, it is possible to distinguish three parts: the Upper Danube, the Middle (Central) Danube and the Lower Danube.

The section of the Upper Danube is more than 624 km long. This section is characterised as a mountain river with an inclination of 37 centimetres per kilometre. The Upper Danube crosses the territory of Germany, Austria and Slovakia and ends as a natural border between Slovakia and Hungary, near the town of Gonyu (rkm. 1791, 33). From this point of view, it is important to say that the connection of waterways of Central and Eastern Europe with the Western European waterway network is by the Main–Danube Canal. It is located at the beginning of this section near the German town of Kelheim (rkm. 2414). To secure favourable conditions for inland navigation, electricity production and flood protection 16 dams with locks were constructed on the Upper Danube. Most of them are in the territory of Austria. One of these constructions is situated in Slovakia, too [6]. The average speed of vessels, according to the direction of inland navigation and type of vessel, is 16–18 km per hour (downstream) and 9–13 km per hour (upstream).

The Middle Danube is characterised as a lowland river. This section between Gonyu and Drobeta Turnu Severin is 860 km long. This section crosses the territory of five countries: Slovakia, Hungary, Croatia, Serbia and Romania. There is also one of the most important dams on the Danube: Iron Gate I. The average speed of vessels in this section is 18–20 km per hour (downstream) and 9–13 km per hour (upstream).

Afterwards, the Lower Danube creates the final section of the Danube. This section is bound by Drobeta Turnu Severin and the estuary of the Danube (rkm 0.0). There is a significant dam: Iron Gate II. The nature character of this section is characterised as a lowland river with an inclination of 4 centimetres per kilometres. The average downstream speed of vessels and pushed convoys in this section is 11–15 km per hour [6].

Inland waterways are divided into individual classes, according to AGN (European agreement on main inland waterways of international importance). The aim of this classification is to secure the fluency and safety of inland navigation. Each class defines the dimensions and arrangement of inland river vessels and pushed convoys for which the waterway is intended.

The section (est. 69 km long) between Straubing and Vilshofen belongs to the class VIa. On the other hand, the section between Regensburg and Budapest is classified as class VIb. This class determines that this section is suitable for pushed convoys, consisting of an inland river tug and four inland river barges, DE IIb. The classification of the next section between Budapest and Belgrade allows the inland navigation of a tug and six inland river barges, DE IIb (class VIc) [7]. The largest convoys on the Danube are operated on the lower section between Belgrade and the estuary of the Danube (classified as class VII). These convoys consist of inland tugs and nine inland river barges, DE IIb.

Information about the length of different sections and cargo handling create an important part of the presented model. Firstly, it is necessary to summarise this basic information, the length of section (km) and the development of cargo handling in ports, within this section. Next, it is necessary to express the future development, according to the basic least squares method. Afterwards, the presented model compares this estimated future development with the real state as expressed in official statistics. Thanks to this comparison, this model expresses the level of available capacity in individual sections and the overall level of the available transport capacity on the Danube. Then, the case study presents the amount of emissions produced by inland water transport in a particular route. The main contribution is to connect these topics together. The conclusion of this study is to express the overall emissions produced by road transport to transport the amount of volume of cargo corresponding to the available capacity on the Danube. At the end, this amount is compared by the overall emissions produced by vessels to transport the same amount of cargo corresponding to the available capacity on the Danube. Thanks to this comparison, it is possible to express a reduction in CO_2 emissions, thanks to the transition from road transport to inland river transport [7].

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