

Hydrography

The Danube and its Tributaries

The whole of the Carpathian Basin, including Hungary belongs to the catchment area of the *Danube* (817,800 km²). The river extends over 17 countries and has a total length of 2,860 km, of which 410 km lie in Hungary (*Figure 34*). The water regime of the Danube is mainly governed by snowmelt and glacial melting in the Alps, the consequence of which is that low water phases accompany snow accumulation in the winter, whilst high water levels and floods are confined to the late spring and early summer. The minimum and maximum discharges at Budapest are between 600 m³/sec and 10,500 m³/sec and the annual fluctuation in the water level can reach 8 metres. Mean discharge (1,000–1,500 m³/s) occurs most frequently during the critical agricultural growing season, whilst in the eastern part of the Carpathian Basin semi-desert weather conditions may prevail.

The Danube is the longest river of the European Union; from its source in the Black

Forest in Germany to the edge of the Carpathian Basin it has an upper stream character with a channel gradient of 45–50 cm/km. After having flown into the basin (and Hungary), its gradient drops abruptly within some kilometres to 30–35 cm/km. As a result, the load transported in the main channel is deposited, forming a typical Pleistocene-Holocene alluvial debris fan with bars and islets. After leaving the alluvial fan (from the confluence with the Rába) the Danube proceeds in a channel with a very low gradient (8–10 cm/km). Subsequently it turns from flowing in a west–east direction, into a north–south direction at the Danube Bend, by which time the isles are already stabilised but the main channel still shows a tendency to form bars.

Arriving in the Carpathian Basin (from Bratislava/Pozsony) the Danube divides into three big branches and forms two large islands (Szigetköz and Žitný ostrov/Csallóköz). Later, it absorbs the waters from the catchments of



the tributaries: Váh (Vág), Nitra (Nyitra), Hron (Garam), and *Ipoly* (Ipel'), nevertheless they hardly affect the Danube's discharge rates. The *Rába* (Raab) river-system carries the waters of the Alpine, north-west Transdanubian region into the Danube.

The *Dráva* (Drau), a border river between Hungary and Croatia with a catchment basin of 40,497 km² and a length of 749 km, is the only right-bank tributary of the Danube in Hungary with a significant water discharge.

The Tisza and its Tributaries

The entire watershed of the *Tisza* (157,135 km²) – the largest left-bank tributary of the Danube – is to be found within the Carpathian Basin (Figure 35). The Tisza rises from the Marmarosh Mountains (Ukrainian Carpathians) and flows after 1,260 km into the Danube at Titel (Serbia). From the point where the main branch of the Tisza reaches the Alföld (Great Hungarian Plain) 5–6 cm/km maximum gradients prevail, and along the lower stretches of the river they are reduced to 2–3 cm/km. Therefore, the river meanders lazily, forming sinuous loops, fens and oxbow lakes. The Tisza often changed course prior to its regulation, and frequent floods used

to inundate 1,963,770 ha of the Alföld. As a result of the regulation and control measures (1846–1880) the length of the river between Tiszabecs and Titel decreased from 1419 to 966 km, forming 589 km of 'dead arms', oxbow lakes and newly cut riverbeds of 136 km.

The Tisza floods with a frequency of 57.9% and experiences two peaks of high stages: one in early spring and another in early summer. Floods last for 5–20 days in the upper reaches, whereas in the Lower Tisza valley the travel time can be 20–200 days. The river has a highly fluctuating water regime where the difference between the low and high water discharge, e.g.



at Szolnok, could be 63-fold (60 and 3,800 m³/sec, respectively).

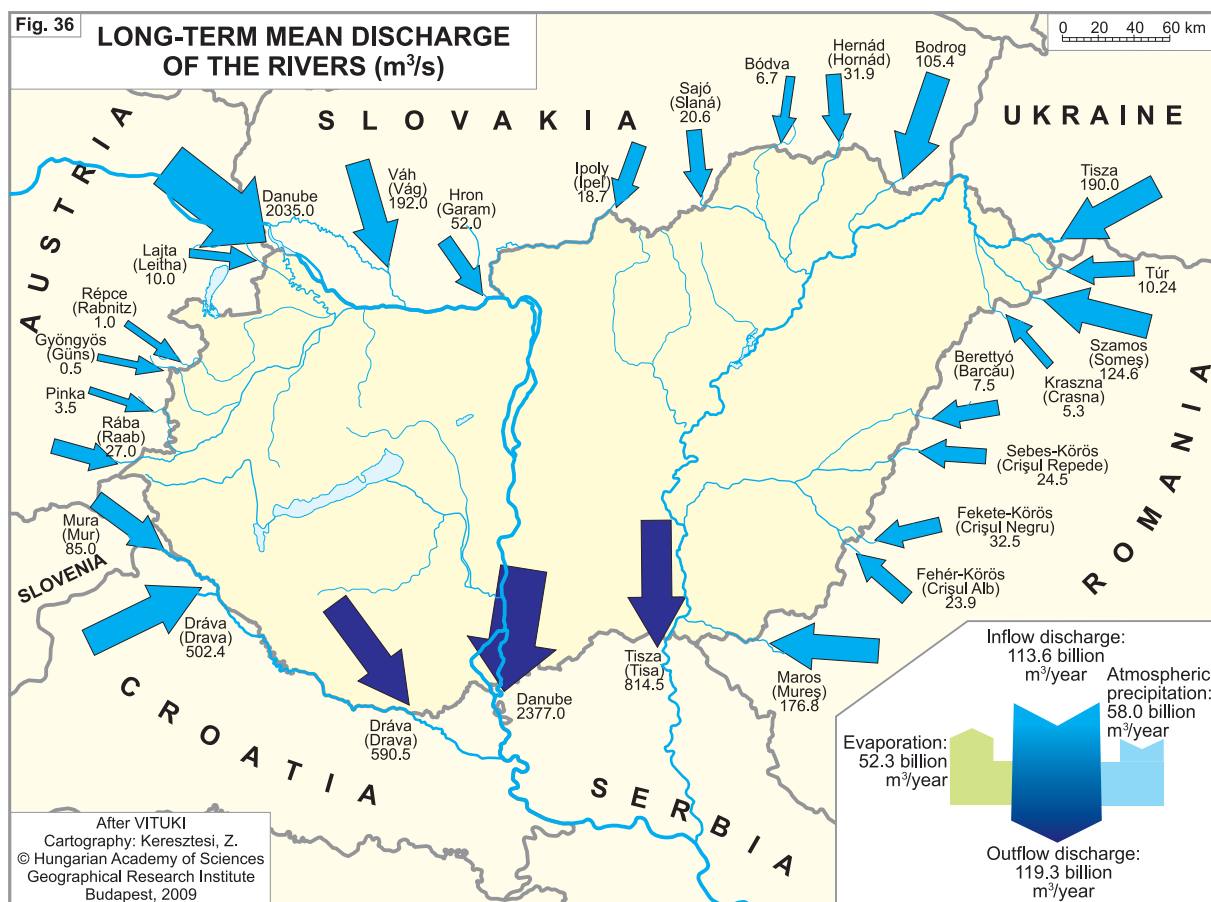
This phenomenon is due to the major tributaries of the river. On the right-bank in Hungary, the *Bodrog* formed by the confluence of five rivers joins the Tisza at Tokaj. Arriving from the Slovakian Ore Mountains, the *Sajó* (Slaná) collects the waters of the rivers *Bódva* and *Hernád* (Hornád) before its confluence with the Tisza. Downstream the other right-bank tributaries are of little importance as sources of water supply. On the left bank at Vásárosnamény,

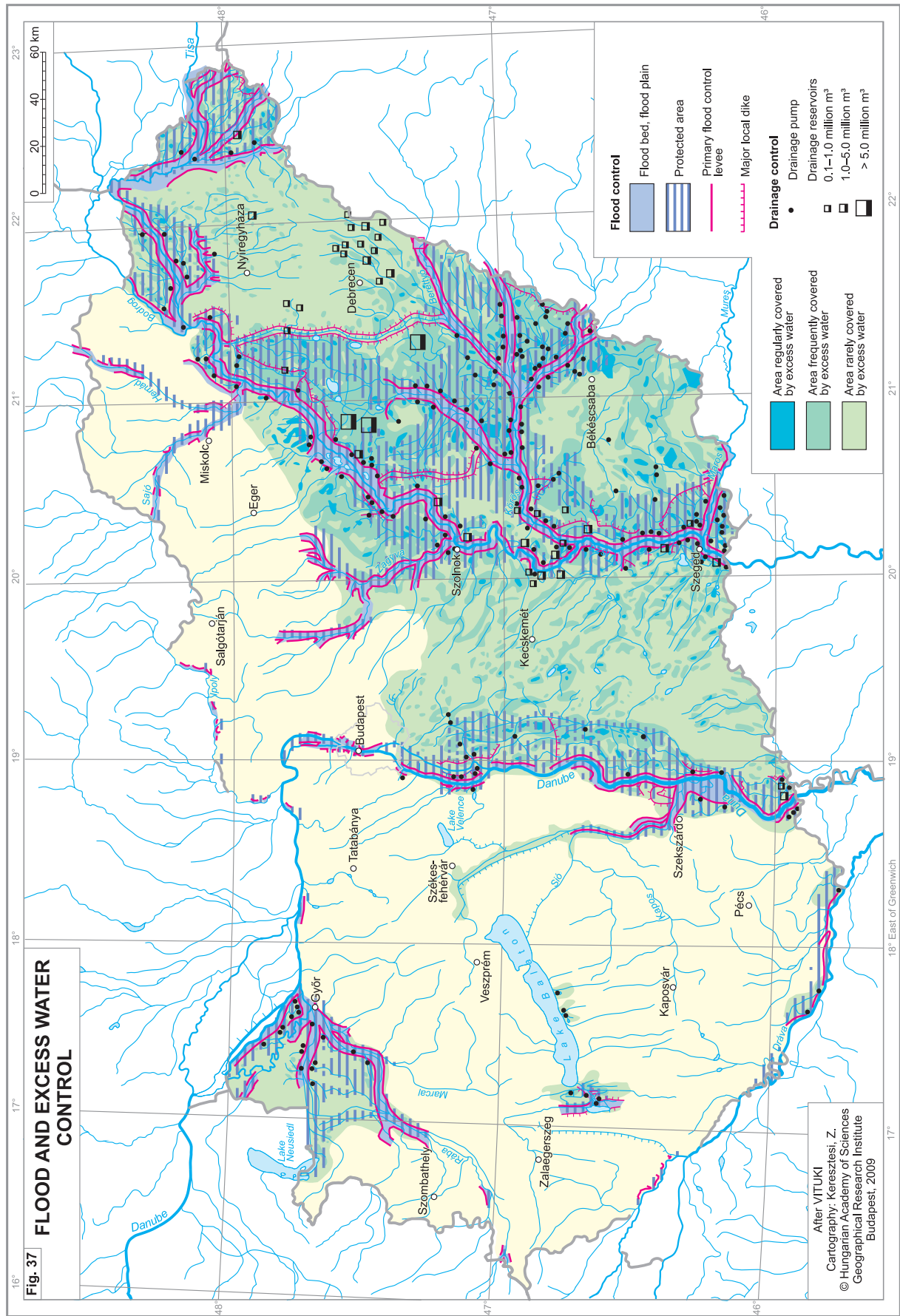
the rivers *Szamos* (Someş) and *Kraszna* (Crasna) join the Tisza, which drain the northern part of the Transylvanian Basin. The *Körösök* mainly collects the waters of the Fehér-Körös (Crişul Alb), Fekete-Körös (Crişul Negru), Sebes-Körös (Crişul Repede) and Berettyó (Barcău) from a total catchment area of 27,537 km². The Tisza's largest tributary is the *Maros* (Mureş) at 761 km, which drains waters mainly from South Transylvania and reaches the Tisza near Szeged following a short section in Hungary.

Flood Control, River Regulation and Water Management

Following the Ottoman occupation, during the 18th century a reactivation of the drainage network started, together with the instigation of water regulation measures and development of the flood control system. Peace treaties fol-

lowing the two world wars drew the Hungarian state borders along the rim of the basin and most of the Danube's catchment area became subdivided between the successor states of the Austro-Hungarian Monarchy. As a result most





of the active drainage area came to be located beyond the national borders, to such an extent that at present virtually no runoff is formed on the territory of Hungary.

The whole drainage network of contemporary Hungary is incorporated into that of the Carpathian Basin. 95% of the long-term discharge of the largest rivers leaving the country across the southern border, arrives from abroad, merely flowing through the country, and barely 5% is formed on its territory. Although the Tisza catchment represents ca half of the country's territory, the river provides for a mere 20–25% of the total discharge leaving Hungary, whereas 75–80% is transported by the Danube and Drava rivers (Figure 36).

14 Hungarian rivers that are critical for water management have their catchment area providing abundant runoff outside of the country, and only 4 minor watercourses rise within the territory and do not leave its borders. Rivers entering Hungary have high channel slope gradients, which serves as a source of considerable flood hazard. Flood plains extend over 23,800 km² protected by levees of 4,220 km in length (Figure 37). The regime of rivers flowing into the plains shows extreme values. The upper reaches of tributaries are particularly wild; especially dangerous are those of the Upper Tisza and of the Körösök (the latter empties into the Lower Tisza) where the water level might rise 8–10 m within 20–30 hours following intense rainfall. Hungary occupies a prominent position in European comparison with regards to the extension of its land protected from floods, and connected flood control structures (Figure 38).

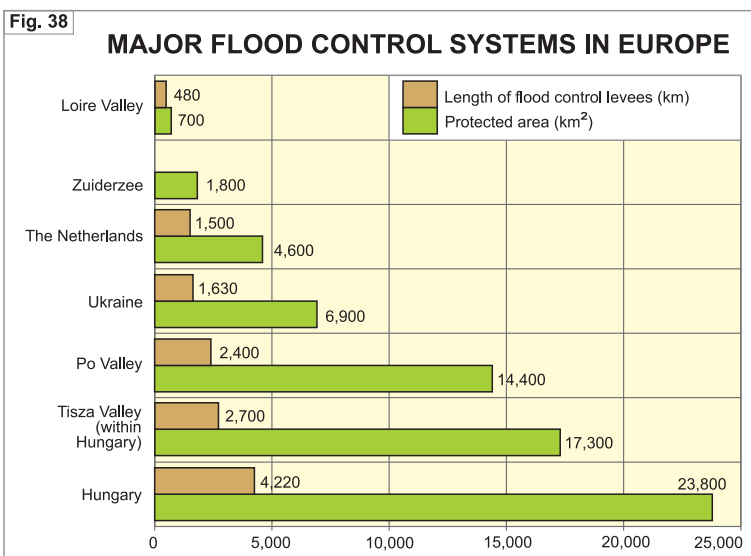
To mitigate the extreme flood hazard, drainage regulation measures and the construction of flood control embankments started nearly 200 years ago and their alteration – amongst others, the establishment of detention reservoirs – has been continuous ever since. With the regulation of the Danube, its Hungarian section has shortened by nearly 100 km. The length of the Tisza channel on the present-day territory of Hungary has been reduced from 1,213 km to 759 km. All these have resulted in increasing flood subsidence (especially on the Upper Tisza), however, it may also result in grave situations developing on the Lower Tisza, dependent on the coincidence of, or difference between high water stages of the tributaries. Hungary is among the countries in Europe most severely endangered by floods.

A frequent occurrence is that high stages on the tributaries of the Tisza delay or dam up the flood waves, thus lengthening their travel time and raising the height of the flood level. In extraordinary cases, a simultaneous high water stage on the Danube might dam water in the Tisza channel up to the confluence of the Maros and, though very rarely, up to that of the Körösök.

In order to drain waterlogged areas and those with excess water in springtime, drainage canals were built in the terrain beyond the protected areas, with a length of 42,493 km, primarily in the Tisza catchment area.

Water management difficulties are numerous, such as those stemming from a hydrographic network that is divided between two catchments; the task of draining floods on the Tisza; and difficulties caused by a deficit of moisture over wide areas during the growing season. Difficulties are potentially further aggravated by disastrous water pollution events. All the subsurface waters of the Eastern Alps and Carpathian Basin flow through the country, floods (and pollution) travel on its major rivers, but low stages also occur during arid periods.

To reduce the impact of extremities and other problems, barrages were constructed in the Tisza catchment at Tiszalök (1954) and Kisköre (1973). The former di-



rects water to a 108 km long channel, the East Main Canal (carrying 80 m³/s) to the lands situated north of the Körösök river suffering from frequent summer droughts, and provides water for the irrigation of 130,000 ha. The barrage at Kisköre has created the largest flatland reservoir in the Carpathian Basin with a surface

area of 127 km². Besides ensuring the irrigation of 350,000 ha in the Middle Tisza, the Kisköre reservoir (also known as '*Lake Tisza*') has become one of the country's most popular holiday destinations as a result of the attractive natural environment and the development of tourism infrastructure.

Lakes

Lake Balaton is the largest shallow water lake in Central Europe, and a most important tourist destination of the country, second only to Budapest. Since 1918 when Hungary became landlocked, it has often been referred to as the 'Hungarian Sea'. The 76.5 km long lake with an average depth of 3.3 metres has a total surface area of 588.5 km², of which only 17 km² is covered by reeds. The basin of the Balaton is divided into two parts by the Tihany Peninsula. Evaporation from the water surface (900–950 mm/year) exceeds annual precipitation. The primary water supplier is the Zala river, with a catchment of 2,627 km². The water level is regulated by the only outflow, the Sió. The entire surroundings of the lake are canalised and refuse water is drained off the catchment area. Due to the shallow nature of the lake, the average water temperature during summer is 25°C, which makes the beaches of Lake Balaton especially attractive. The reflection of strong sunshine from the water body functions as secondary radiation, affecting the microclimate of the Balaton

region favourably, from which the orchards and vineyards of the south-facing slopes benefit considerably.

The shallow *Lake Fertő* (Neusiedler See) lying in the Austrian-Hungarian borderland is the second largest lake in the Carpathian Basin with an area of 309 km², nearly a quarter of which belongs to Hungary. The fluctuation in the water level is caused mostly by climatic conditions; as a result the lake bed has dried up on several occasions in the past. 180 km² out of the lake surface is covered by reeds, primarily in the Hungarian parts.

The third largest area of still water in Hungary is *Lake Velence*. Because of its shallowness and the sunny climate it is one of the warmest lakes in Europe (with summer temperatures of 26–28°C). One third of the small (26.5 km²) area of the 1.1–2.2 m deep lake is covered by reeds. Two reservoirs were constructed in the catchment area to regulate its water level. Due to its close location to Budapest and the motorway, it is a popular tourist destination.