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# Flood issues and climate changes

## Country Report
## Hungary

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# Acknowledgements

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|---|---|
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# Contents

# Chapter 1 Introduction

Describe the current legal and institutional background in (HUNGARY), related to:

- institutions responsible for Floods Risk Management, roles and level of responsibility (national, regional, local, municipal etc.) - 1.000 words

The General Directorate of Water Management (OVF) is established in 1953 as an independently operating institute and a central government body in water issues, currently operates under the direction and supervision of the Minister of Interior, Hungary. The OVF is responsible for supervising and coordinating the professional activities of the 12 Regional Water Directorates. The OVF is also responsible for the flood risk management planning at national, sub-regional and cross-border level, as well.

**<u>Controlling flood protection activities: (Country level)</u>**

The <u>National Technical Committee</u> (OMIT) is a flood control organization in the General Directorate of Water Management of which operated if several Water Directorates have flood protection activates in the same time. It is necessary to better flow of information, and moving flood resources (human, machines, materials). The OMIT coordinate the flood protection activities of 12 Regional Water directorate.

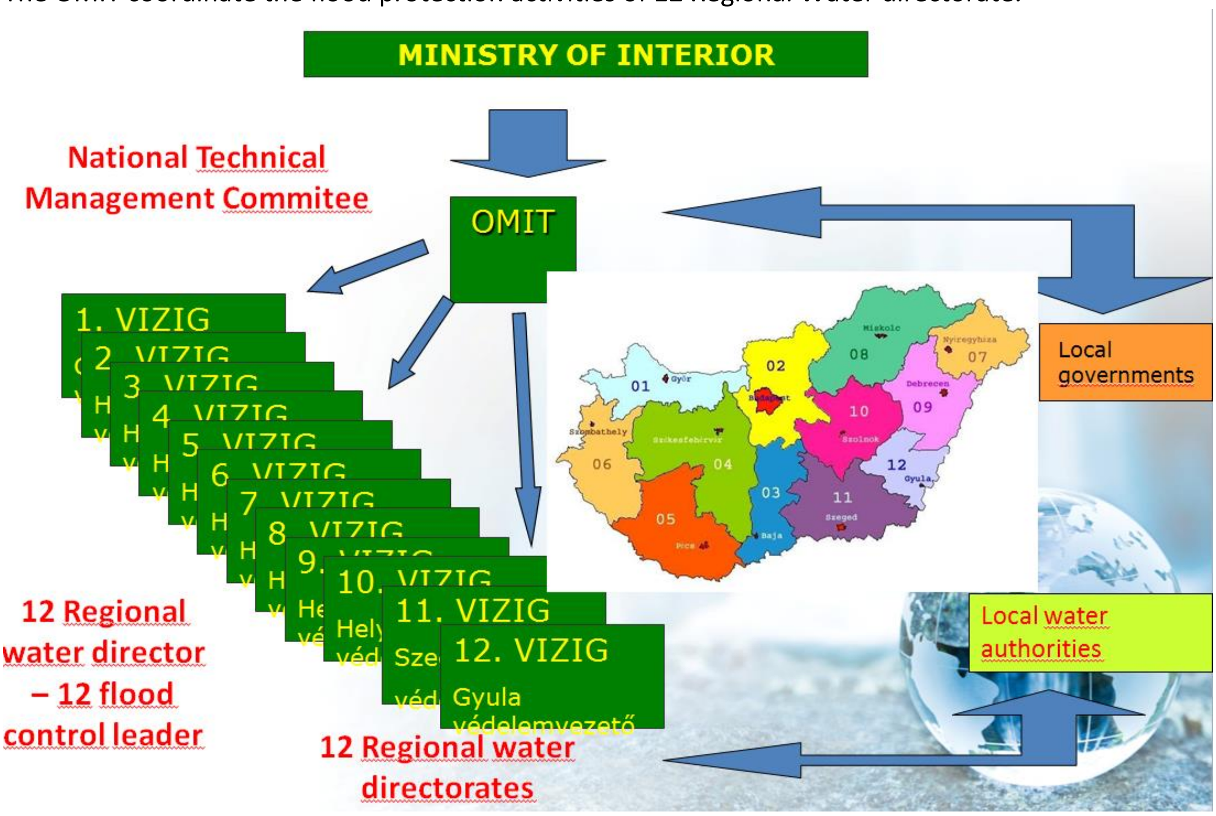



Figure 1.1 Controlling flood protection activities in country level

The National Technical Committee main tasks are:

**1. Summarize nationally the data of the Flood protection activities**

- Evaluate the flood protection, and the current load situation
- Making daily flood protection and other reports.

**2. Supervise and keep in touch with:**

- Regional Water Directorates,
- Budapest local flood protection Committee

- By the local leader of the flood protection Mayor's activities who responsible for the local flood protection.
- In case of borderline divided river basin, keep in touch neighbour country's water management organization.

**3. Do the information about the flood protection activities in country-level.**
**4. Operating Groups**
**5. Involving external resources to prepare national-level decision.**
**6. After the Flood protection activities:**

- Preparing the closing report of the flood protection and submissions.
- Supervising of restoration work in III. Flood alert , replacement of flood protection material s and perform the central tasks related to these activities.

**Making decision in technical issues**, ordering **interventions**:

- Prepare for **using Flood control reservoir**, or overfilling, possibly drain off
- **Opening flood protection dykes**, or **closing** of levee breaking.
- **Building localization line/structure** which not contain the localization plan
- In critical status  decide to **continue or stop the flood protection activity**
- **Limited** of excess water pumping – if it is necessary.
- Opening of dyke at the excess water channel
- **Storage of excess water**
- **Overfilling** of excess water storage
- suggestion of **restriction of transport**
- Data managing, **deviation from existing flood protection plans**
- **forecasting** and publication of the forecast
- cl) Handling any technical case which related in flood protection activity.
- cm) Preparing for **government decision in written form** related in protection activities.
- cn) Water regulation for the proper **water quality protection activities**

Do the coordination resources in nationally, and allow **interventions about the resources (human, material, machines) – if suggesting of the local flood control leader -, particularly:**

- Using of the nationally flood protection material stocks
- Using of **Hungarian Defence Forces**, or law enforcement agencies.
- **Standby and operate protection squads**, and ordering to other Water Directorates area.
- **Ordering flood control alert** which **Water directorate don't defence against the flood.**
- **Moving human resources** to the protective Water directorate. – depends on the flood situation.
- Ordering **technical management/experts** to help the local governments in flood protection activities.
- Ordering of **external advisor** (Universities designer).
- Making intervention of any resources.
- Permitting and supervising of **Icebreaking explosion** or **flood controlling explosion**
- Standby, operation and supervising of **Icebreaking ships**
- **Technical assistance** for any Water Directorate, or other country.

The organization of National Technical Committee
**TECHNICAL GROUPS:**

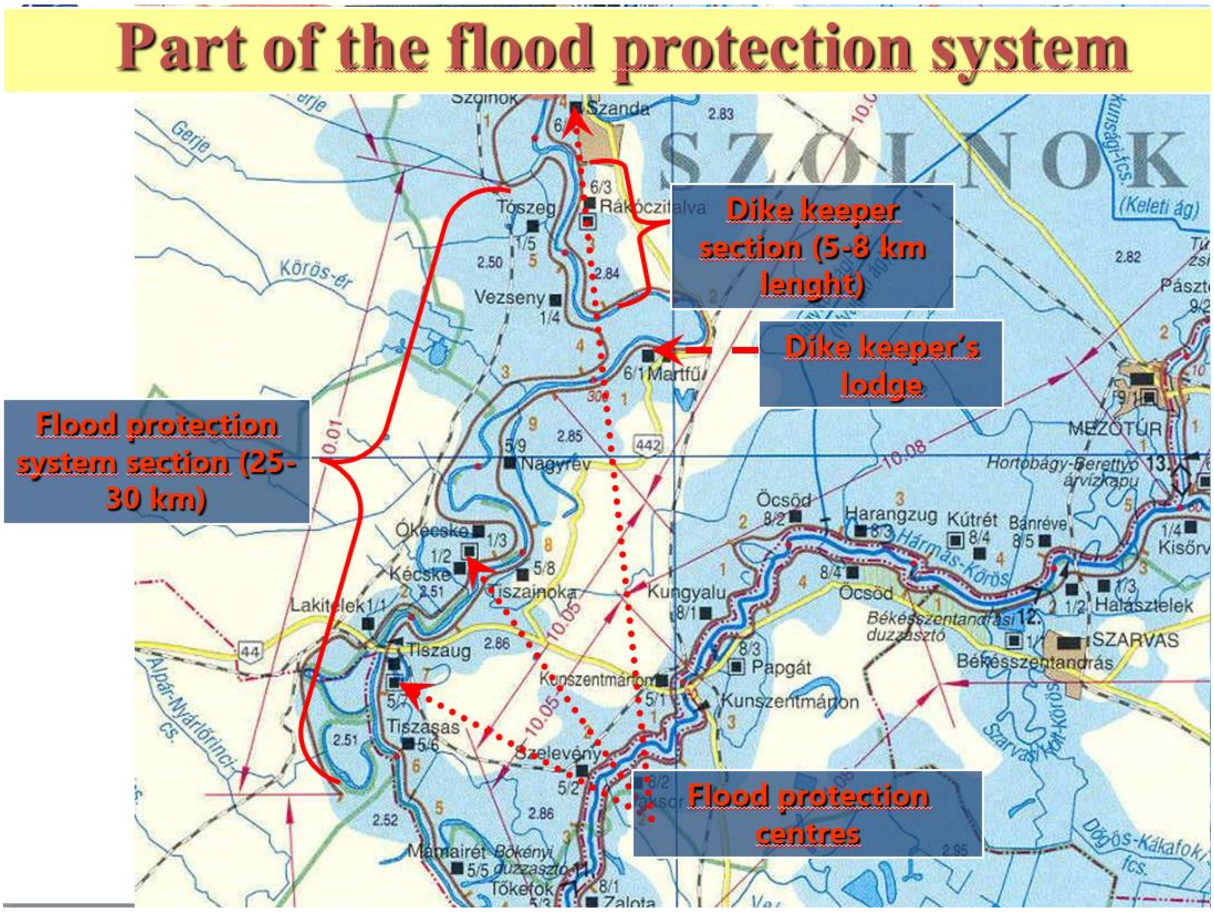
1. **Hydrometeorology and forecasting Group**
2. **Localization Group**
3. **Water quality and water demanding Group**
4. **Surveying and Mapping group**
5. **Levee exploration group**

**PROVIDER GROUPS:**

1. **Informatics and Communication Group**
2. **Supplying of Machine, material and human resources Group**
3. **Technical Group**
4. **Financial Group**
5. **Legal Group**
6. **PR (news conference) Group**

**Controlling flood protection activities: (Regional level)**

In regional level the leading of the flood protection actives is the Regional Water Directorate. The head of the regional flood protection is the director. Under the director operating the Technical Committee, hydrological group, and some groups like at National Committee. The protection system is built up by the flood protection lines (30-50 km), dyke keeper's section (5-8 km).



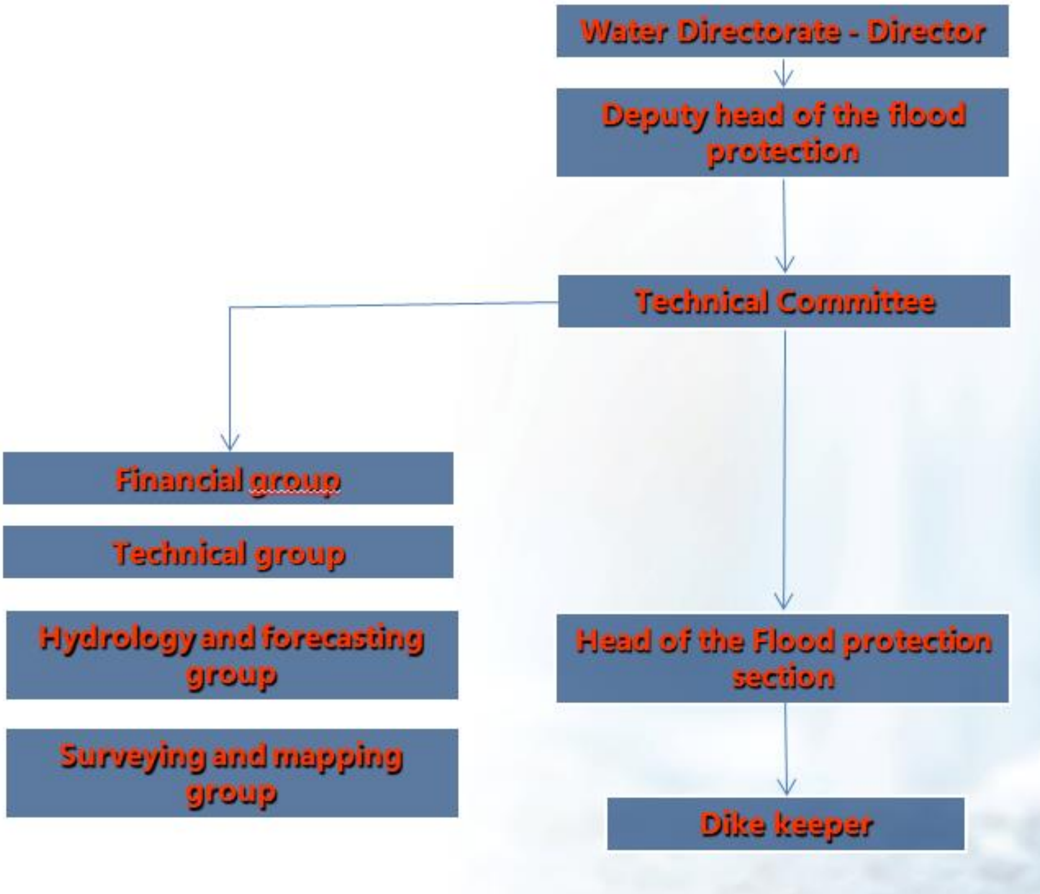



Figure 1.2 Controlling flood protection activities in regional (Water Directorate) level

# Chapter 2 General description of the Tisza River Basin

## Relief

Hungary lies in the central part of the Pannonian (or Carpathian) Basin, surrounded by the ranges of the Alps, Carpathians and Dinarides. The major part of the country is low-lying and flat; the greatest elevation scarcely exceeds 1000 m. The size of the Tisza river basin in Hungary is 46,380 km$^2$, with a total of 465 water bodies (334 watercourses and 131 standing water).

Most of the sub-basin area is plain, with its northern edge where the Northern Mountains lie [Figure 2.1]. The area's topography is two-faced; the lowland section is characterized by a very low altitude (78-140 m) and poor morphological fragmentation. In contrast, the mountainous regions are relatively high. This river basin has the lowest (Szeged-Gyálarét – 75,8 m), and the highest (Kékes – 1014 m) points in Hungary.

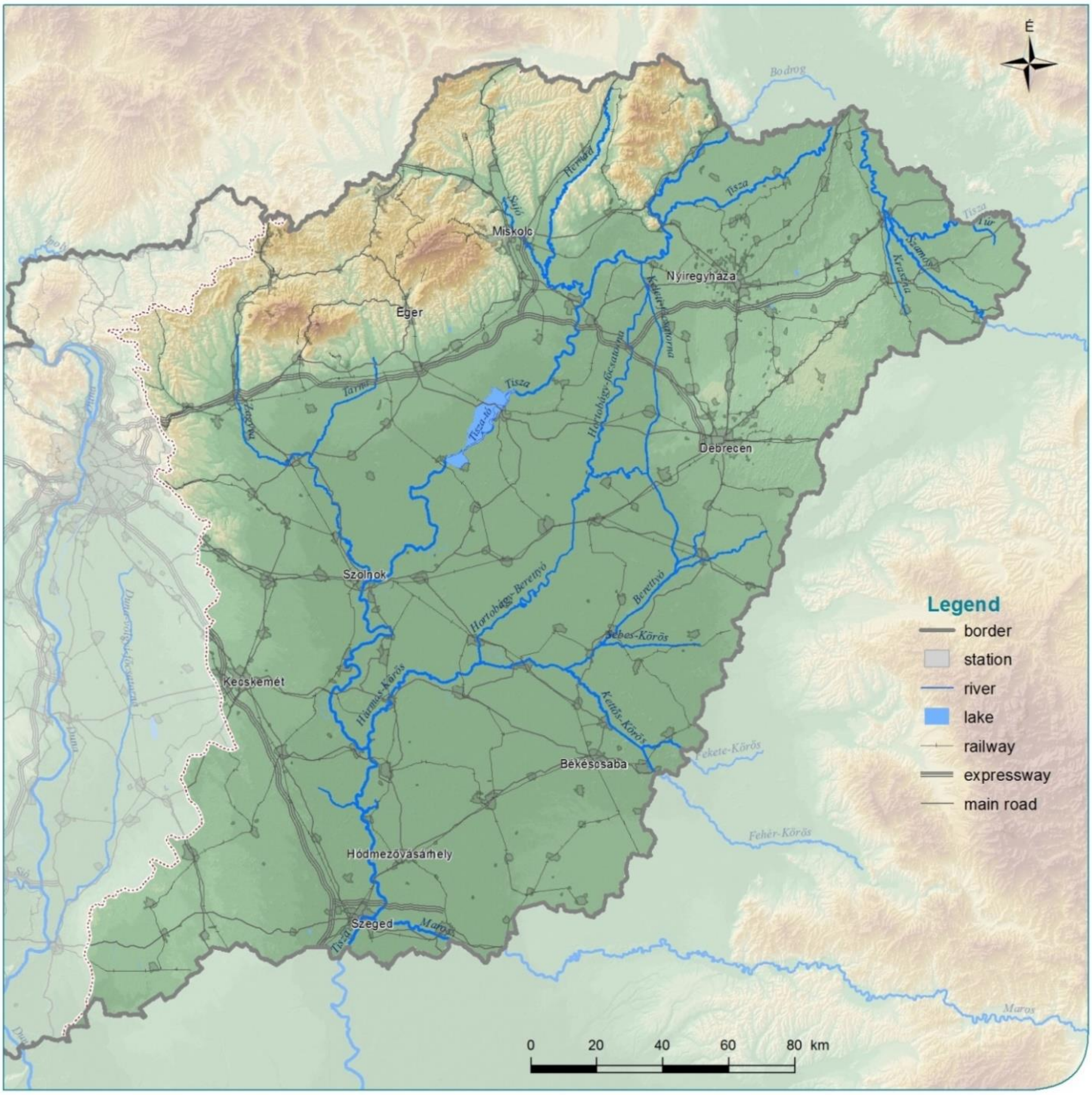



Figure 2.1 Hypsometric map of the Tisza River Basin in Hungary

# Geology

The pre-Cenozoic geologic structure shows various effects ranging from rifting to collisional mountain building in several stages, reflecting motions os the European and African Plates from Paleozoic to the Cenozoic. Tertiary events led to the formation of young basin system through crustal thinning beneath the area, with sediment fill reaching 7-8000 m. Consequently, the geology of the country can be summarised as a process whereby complicated plate collision-type orogeny was followed by the formation of young basin in which a relatively complete sequence of basin infill has been preserved.

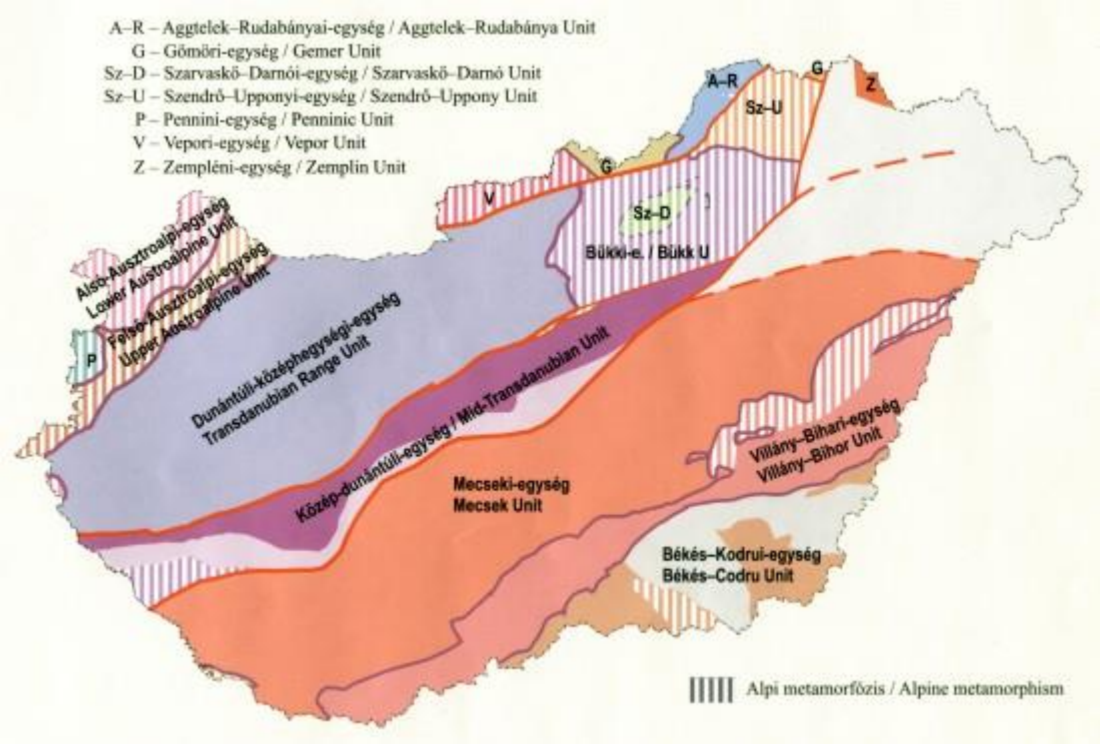



Figure 2.2 Pre-Cenozoic structural units in the basement of Hungary
(Haas J., Budai T., Csontos L., Fodor L., Konrád Gy. 2010. Magyarország pre-kainozoos földtani térképe)

The recent image of Hungary is determined by two lowlands occupying about 70% of the territory of the country. These are the Great and Little Plains, which started to be formed only 19 million years ago, in the Miocene. Their formation was affected by two factors: by an earlier extensional lengthening of the crustal and mantle lithospheres and by a later mantle diaper (dome-like protrusion), which thinned from below the mantle lithosphere, which reacted by isostatical sinking. Basaltic lava originating from the mantle formed several volcanic cones in the vicinity of the Balaton Highlands such as the Badacsony, Kab-hegy, Somló, etc. and in northern Hungary around Salgótarján (Karancs, Medves). Because of the thinning of the lithosphere the average thickness of the Earth's crust below Hungary is only 25–28 km, however the geothermal gradient is very high (5–6 C°/100 m). Due to this Hungary is very rich in geothermal energy. The oldest rocks of Hungary are located in the Tisza sub-basin (e.g. 1100 million years old crystal slate). After the Ice Age, the rivers and the wind formed and shaped the surface on sub-basin. The rivers flooded their floodplains (e.g. Nagykunság), while the wind piled the sand into dunes and bucks (e.g. Kiskunság, Nyírség).

*References: György Less 2011 Geology of Hungary; János Haas (ed) 2012 Geology of Hungary*

## Climate

There are four climatic zones in the area: the Northern Mountains, the northeast part of the Great Plain, the middle part of the Great Plain, and the southeast part of the Great Plain.
The northeast region has the coldest winter, the middle region has the driest climate, and the southeast region has the warmest summer. The Hungarian part of Tisza sub-basin has the warmest summer; the mean temperature is around 21°C in July.
In the area of the Northern Mountains, the fragmented surface created a diverse microclimate. This includes the windy Bükk Plateau with cool summer, the drier and warmer Nógrád Basin, the Mátraalja and Bükkalja, which are the fast transitions between the mountains and the Great Plain. Temperature fluctuation decreases with higher elevation. This mountainous region has the coldest winter. In this area, the sunshine is low, because of high cloudiness. The humidity is also high. The amount of rainfall is average in domestic terms; it is between 550 and 700 mm. The wind climate of the area is varied, and the dominant winds follow the running of the valleys. The shadowing effect of the North Carpathians weakens the power of the winds.
The average annual temperature in the mountains is 8-9°C. In the middle of the Great Plain, the annual average temperature is between 10-11°C, and remains below 10°C in the northeast part of the Great Plain. In the south-eastern borderline it reaches 12°C. The mean annual temperature fluctuation is 20,0-22,5°C in the Northern Mountains, and it is 23,0-24,5°C in the Great Plain. The annual amount of sunshine hours in the Great Plain is over 2000 hours; it is increasing towards the southern border.
Since temperature measurements have been documented in Hungary, the highest temperature was 41,9°C in Kiskunhalas on 19. July 2007. The lowest temperature was -35,0°C near Miskolc in 17. February 1940, so the absolute annual temperature fluctuation is 76,3°C.
The winds flow through the lower parts of the mountains around the Carpathian Basin to the territory of our country, primarily between the Alps and the Carpathians, so the domintant wind direction is northwest in Hungary. The average wind speed is 2-4 m/s. Due to the protection of the mountains; winds are less prevalent in the Northern Mountains ridge. But where the wind blows among the mountains, also the NW-NE direction is characteristic. The dominant wind directions are the north and the northeast in the Nyírség (northeast region of the country). Its strength is higher than in the middle of the Great Plain, where the moderate northwest winds are characteristic. Along the southern border, there are often south wind blows.
The annual rainfall is 500-700 mm in the basin. Most of it falls near the Mátra and the Bükk, the least falls in the middle of the Great Plain. The precipitation distribution varies in time. There are two more rainy periods: primary in early summer (May-June), and secondary in autumn (October). The least precipitation falls in January and February.
Less cloud, less relative humidity, and scarce, unequal precipitation favor summer droughts, mainly in the central area of the Great Plain.

## Water resources

Hungary's water network is basically determined by the fact that the country lies in the Carpathian Basin. There are about 9800 registered watercourses in our country. Over 90% of the total water flow is delivered by 24 large and medium-sized water streams from abroad.
The Tisza is the second most significant river in the country. In the last century, during the large river regulation works, the 950 km long Hungarian section of the river was shortened to 590 km. The Tisza's full gradient is 30 m (5 cm/km) in Hungary. In Szeged, the typical water flow is 170 $m^3/s$ at low water level, 800 $m^3/s$ at medium water level, and 3400 $m^3/s$ at high water level. The Tisza supplies a significant amount of floating sediment, which also fetermines the color of its water. Major tributaries of the Hungarian section are: Túr (Tur), Szamos (Somes), Kraszna (Crasna), Bodrog, Sajó (Slaná), Zagyva, Körös (Crus) and Maros (Mures).

In the rivers of Hungary, two significant floods are expected annually: the early spring flood (ice flood) is caused by snow melting, and the early summer flood (green flood) is due to rainfalls in May-June.

Table 2-1: Characterization of the rivers along the Tisza River basin

| Water body code | River name | River length in Hungary [km] | Catchment size [$km^2$] | Average discharge (1971-2000) [$m^3/s$] |
|---|---|---|---|---|
| AEP322 | Berettyó | 74.38 | 7055 | 13.7 |
| AEP334 | Bodrog | 51.07 | 12337 | 119.6 |
| AEP335<br>AEP336 | Bódva | 55.48 | 1770 | 6.25 |
| AEP431<br>AEP432 | Dong-éri-főcsatorna | 40.47 | 1527 | 0.859 |
| AEP471 | Fehér-Körös | 9.74 | 4498 | 23.2 |
| AEP475 | Fekete-Körös | 20.51 | 3438 | 33.2 |
| AEP953<br>AEP954 | Sebes-Körös | 58.63 | 10259 | 38.8 |
| AEP668 | Kettős-Körös | 37.29 | 10474 | 58.36 |
| AOC778<br>AOC779 | Hármas-Körös | 91.48 | 27464 | 102.9 |
| AEP579<br>AEP580 | Hernád | 121.92 | 5447 | 31.9 |
| AEP594 | Hortobágy-Berettyó | 78.74 | 4306 | 4.06 |
| AOC785 | Hortobágy-főcsatorna | 94.62 | 2241 | 2.15 |
| AEP625 | Kálló-ér | 29.39 | 2234 | 2.10 |
| AOC795 | Kati-ér | 70.59 | 435 | 0.435 |
| AEP729 | Kraszna | 46.24 | 3199 | 8.22 |
| AEP766 | Lónyay-főcsatorna | 45.19 | 2042 | 3.11 |
| AEP783<br>AEP784 | Maros | 50.83 | 30641 | 180.8 |
| AEP927 | Rima | 32.05 | 1065 | 2.62 |
| AEP931<br>AEP932 | Sajó | 123.87 | 12990 | 62.2 |
| AOC852 | Sarkad-Mérges-Sáros-ér | 28.84 | 447 | 0.446 |
| AEP971 | Szamos | 50.00 | 15857 | 135.7 |
| AEQ039<br>AEQ040<br>AEQ041 | Tarna | 97.47 | 1955 | 4.38 |
| AEQ058<br>AEQ056<br>AEQ059<br>AEQ060<br>AEQ055<br>AEQ057<br>AIW389<br>AEQ054 | Tisza | 588.40 | 139271 | 872.5 |
| AEQ082<br>AEQ083 | Túr | 30.04 | 1713 | 12.2 |
| AEQ140<br>AEQ139<br>AEQ138<br>AEQ137 | Zagyva | 190.79 | 5562 | 9.89 |

*The hydrological characteristics refer to the outflow section of the river.

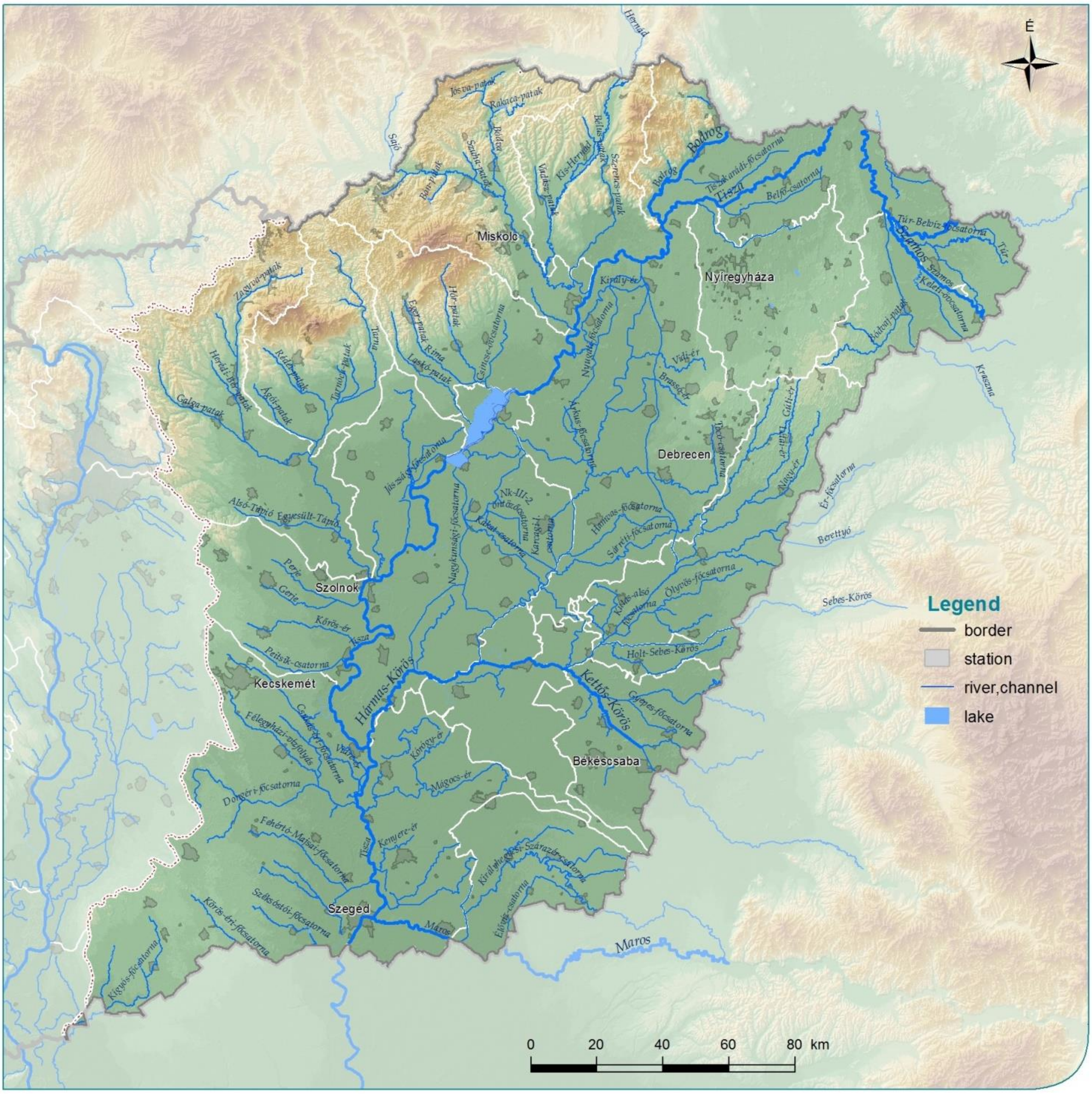



Figure 2.4. Tisza River Network in Hungary

## Major channels along the Tisza River basin

In Hungary, about three-quarters of the water is transported by the Danube and the Drava, while almost only a quarter of it is transported by the Tisza. The territorial and temporal distribution of water resources is also extreme. Large-scale water management systems were created to reduce these differences. The distribution system (TIKEVIR) built on the Tisza River Basin supplies water from the Tisza to the Körös. This system can supply the Jászság, the Nagykunság, and a part of the region between the Körös and Maros river with water for irrigation, and also for the ecological water supply of the Körös River.

Table 2-2: The main channels in the Tisza River basin in Hungary are the following:

| Water body code | Channel name | Channel length [km] | Water management classification | Main utilization |
|---|---|---|---|---|
| AEP261 | Algyői-főcsatorna | 17.21 | dual purpose channel | drainage, water supply |
| AEP306 | Bársonyos-öntöző-főcsatorna | 62.07 | irrigation channel | water supply |
| AEP313 | Belfő-csatorna | 40.79 | dual purpose channel | drainage, water supply |
| AEP392 | Csincse-övcsatorna | 23.54 | dual purpose channel | drainage, water supply |
| AEP462 | Ér-főcsatorna | 8.49 | drainage channel | drainage |
| AEP599 | Hosszú-fok–Határ-ér–Köles-éri-főcsatorna | 36.54 | dual purpose channel | drainage, water supply |
| AEP620 | Jászsági-főcsatorna | 21.52 | irrigation channel | water supply |
| AEP623 | Kadarcs–Karácsonyfoki-csatorna | 25.25 | drainage channel | drainage |
| AEP950, AEP951 | Keleti-főcsatorna | 99.01 | irrigation channel | drainage, water supply |
| AEP707 | Kórógy-ér | 49.80 | dual purpose channel | drainage, water supply |
| AEP722 | Kösely-főcsatorna | 26.79 | dual purpose channel | drainage, water supply |
| AEP731 | Kurca-csatorna | 39.12 | dual purpose channel | drainage, water supply |
| AEP804 | Millér-csatorna | 37.60 | dual purpose channel | drainage, water supply |
| AEP834 | Nagykunsági-főcsatorna | 74.50 | irrigation channel | water supply |
| AEP835 | Nagykunsági-főcsatorna keleti ág | 18.07 | irrigation channel | water supply |
| AEP844 | NK-III-2. öntözőcsatorna | 26.91 | irrigation channel | water supply |
| AEP849 | Nyugati-főcsatorna | 69.54 | dual purpose channel | drainage, water supply |
| AEQ080 | Öreg-Túr | 67.31 | dual purpose channel | drainage, water supply |
| AEQ102 | Veker-ér-csatorna | 44.73 | dual purpose channel | drainage, water supply |

## Characterization of the standing waters along the Tisza River basin

In the sub-basin of the Tisza there are countless standing water, some of them are artificial. Most of the natural standing waters are the old beds of the Tisza or its tributaries (Holt Sebes-Körös), or lakes which were created by the wind (szegedi Fehér-tó).

The lake system (Zab-szék, Kelemen-szék, Pipás-szék, Lake Kisréti) to the west of Szabadszállás and Fülöpszállás is the largest connected lake system of Kiskunság, which was supplied by the floods of the Danube before the water management works. Nowadays, only precipitation and ground-water provide their water supply.

In the Hungarian territory of the Tisza River Basin, 5 standing water are also highlighted at sub-basin level (ICPDR). All of them are larger than 10 km$^2$ with one exception.

Table 2-3: These lakes are the following:

| Water body code | Water body name | Water surface [km2] | Water management classification | Main utilization |
|---|---|---|---|---|
| AIH054 | Csaj-tó | 9.65 | natural lake | fishing |
| AIG926 | Begécsi-halastavak | 11.79 | reservoir | fishing |
| AIH127 | Szegedi-Fehér-tó | 14.48 | natural lake | fishing |
| AIG967 | Hortobágyi-öregtavak | 16.48 | reservoir | nature protection |
| ANS560 | Tisza-tó | 120.83 | reservoir | water supply |

## Characterization of the standing waters along the Tisza River basin

95 groundwater bodies are bordered by a neighboring country. Of these, 40 water bodies are considered transboundary water bodies as agreed by Border Commissions of the countries. The ICPDR deals with 7 types of water bodies (significant at the Danube level, or 4000 km$^2$ larger), containing 28 groundwater bodies.

Another important hydrological feature of the groundwater bodies is the relationship with surface waters, and wetlands. There are 41 groundwater bodies in the Tisza sub-basin, which have an important water-dependent ecosystem connection.

Table 2-4: The groundwater bodies in the Tisza River basin, which are significant at the Tisza level, or 1000 km$^2$ larger are the following:

| Water body code | Water body name | Geological type | Aquifer type | Water temp. | Water body size (km$^2$) | Cross border agreement |
|---|---|---|---|---|---|---|
| p.2.11.2 | Alsó-Tisza-völgy | clastic | porous | cold | 1 423.09 | yes |
| sp.2.11.2 | Alsó-Tisza-völgy | clastic | porous | cold | 1 423.09 | yes |
| p.2.5.2 | Bodrogköz | clastic | porous | cold | 750.07 | yes |
| sp.2.5.2 | Bodrogköz | clastic | porous | cold | 750.07 | yes |
| h.2.5 | Bükk, Borsodi-dombság - Sajó-, Hernád-vízgyűjtő | mixed | mixed | cold | 1 955.84 | no |
| sh.2.5 | Bükk, Borsodi-dombság - Sajó-vízgyűjtő | clastic | porous | cold | 1 253.32 | no |
| kt.2.1 | Bükki thermalkarszt | calcareous | carst | thermal | 4 636.61 | no |
| pt.2.1 | Dél-Alföld | clastic | porous | thermal | 6 447.20 | no |

| | | | | | | |
|---|---|---|---|---|---|---|
| pt.2.3 | Délkelet-Alföld | clastic | porous | thermal | 7 822.76 | no |
| p.2.10.2 | Duna-Tisza köze - Közép-Tisza-völgy | clastic | porous | cold | 5 037.38 | no |
| sp.2.10.2 | Duna-Tisza köze - Közép-Tisza-völgy | clastic | porous | cold | 5 037.38 | no |
| p.2.11.1 | Duna-Tisza közi hátság - Tisza-vízgyűjtő déli rész | clastic | porous | cold | 1 669.36 | yes |
| sp.2.11.1 | Duna-Tisza közi hátság - Tisza-vízgyűjtő déli rész | clastic | porous | cold | 1 669.36 | yes |
| p.2.10.1 | Duna-Tisza közi hátság - Tisza-vízgyűjtő északi rész | clastic | porous | cold | 2 303.66 | no |
| sp.2.10.1 | Duna-Tisza közi hátság - Tisza-vízgyűjtő északi rész | clastic | porous | cold | 2 303.66 | no |
| pt.2.2 | Észak-Alföld | clastic | porous | thermal | 10 585.88 | no |
| pt.2.5 | Északi-középhegység medencéi | clastic | porous | thermal | 2 503.29 | no |
| p.2.9.1 | Északi-középhegység peremvidék | clastic | porous | cold | 2 203.89 | no |
| sp.2.9.1 | Északi-középhegység peremvidék | clastic | porous | cold | 2 203.89 | no |
| pt.2.4 | Északkelet-Alföld | clastic | porous | thermal | 11 420.78 | no |
| p.2.6.2 | Hortobágy, Nagykunság, Bihar északi rész | clastic | porous | cold | 3 147.81 | yes |
| sp.2.6.2 | Hortobágy, Nagykunság, Bihar északi rész | clastic | porous | cold | 3 147.81 | yes |
| p.2.9.2 | Jászság, Nagykunság | clastic | porous | cold | 3 148.03 | no |
| sp.2.9.2 | Jászság, Nagykunság | clastic | porous | cold | 3 864.27 | no |
| p.2.16.1 | Kígyós-vízgyűjtő | clastic | porous | cold | 972.73 | yes |
| sp.2.16.1 | Kígyós-vízgyűjtő | clastic | porous | cold | 972.73 | yes |
| p.2.13.2 | Körös-Maros köze | clastic | porous | cold | 3 744.15 | yes |
| sp.2.13.2 | Körös-Maros köze | clastic | porous | cold | 3 744.15 | yes |
| p.2.12.2 | Körös-vidék, Sárrét | clastic | porous | cold | 4 161.76 | yes |

| | | | | | | |
|---|---|---|---|---|---|---|
| sp.2.12.2 | Körös-vidék, Sárrét | clastic | porous | cold | 4 161.76 | yes |
| p.2.3.2 | Kraszna-völgy, Szamos-völgy | clastic | porous | cold | 542.66 | yes |
| sp.2.3.2 | Kraszna-völgy, Szamos-völgy | clastic | porous | cold | 542.66 | yes |
| p.2.13.1 | Maros-hordalékkúp | clastic | porous | cold | 1 245.26 | yes |
| sp.2.13.1 | Maros-hordalékkúp | clastic | porous | cold | 1 245.26 | yes |
| p.2.4.1 | Nyírség - Lónyay-főcsatorna-vízgyűjtő | clastic | porous | cold | 2 264.16 | no |
| sp.2.4.1 | Nyírség - Lónyay-főcsatorna-vízgyűjtő | clastic | porous | cold | 2 264.16 | no |
| p.2.6.1 | Nyírség déli rész, Hajdúság | clastic | porous | cold | 1 693.75 | yes |
| sp.2.6.1 | Nyírség déli rész, Hajdúság | clastic | porous | cold | 1 693.75 | yes |
| p.2.3.1 | Nyírség keleti perem | clastic | porous | cold | 607.18 | yes |
| sp.2.3.1 | Nyírség keleti perem | clastic | porous | cold | 607.18 | yes |
| p.2.8.2 | Sajó-Takta-völgy, Hortobágy | clastic | porous | cold | 2 145.37 | no |
| sp.2.8.2 | Sajó-Takta-völgy, Hortobágy | clastic | porous | cold | 1 429.13 | no |
| p.2.1.2 | Szatmári-sík | clastic | porous | cold | 491.53 | yes |
| sp.2.1.2 | Szatmári-sík | clastic | porous | cold | 491.53 | yes |
| kt.1.3 | Budapest környéki thermalkarszt | calcareous | carst | thermal | 2 185.40 | no |
| kt.1.9 | Dél-Baranya, Bácska thermalkarszt | calcareous | carst | thermal | 2 073.32 | no |
| pt.1.2 | Nyugat-Alföld | clastic | porous | thermal | 9 130.76 | no |

## Soil

In the Tisza sub-basin dominate the lofty sedimentary rocks in the top 10 m caprock formations. The most sedimentary rocks are clay and sand and between the Danube and Tisza are located the most blown sand. Most of the soils are typically well-productive, so a significant part of the sub-basin area is suitable for agricultural activity and for forestry.

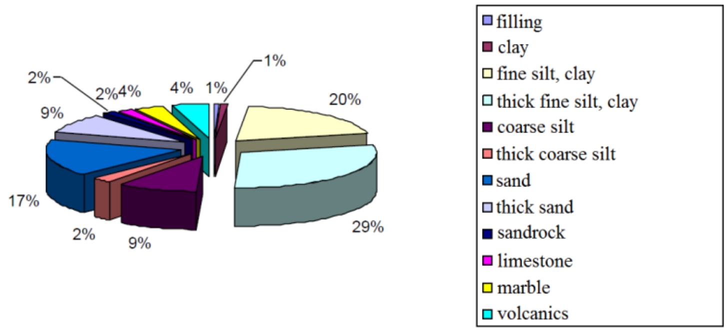



Figure 2.5. The development of the near-surface rock (10 m)

The typical genetic soil type in the Tisza sub-basin is the chernozem (27%). The best quality black earth developed in Bácska, Hajdúság and Körös-Maros. Large areas covered with meadow and alluvial soils, which are common in the floodplains, so it is not surprising that they occur mainly along the Bodrogköz and Sebes-Körös. Brown earth can be found in the Central Range areas. The pread of paludal soils are not significant, but we can encounter them in the inland areas of Upper Tisza and Bodrogköz. The proportion of alkaline soils is exceptionally high in the Hortobágy-Berettyó region.

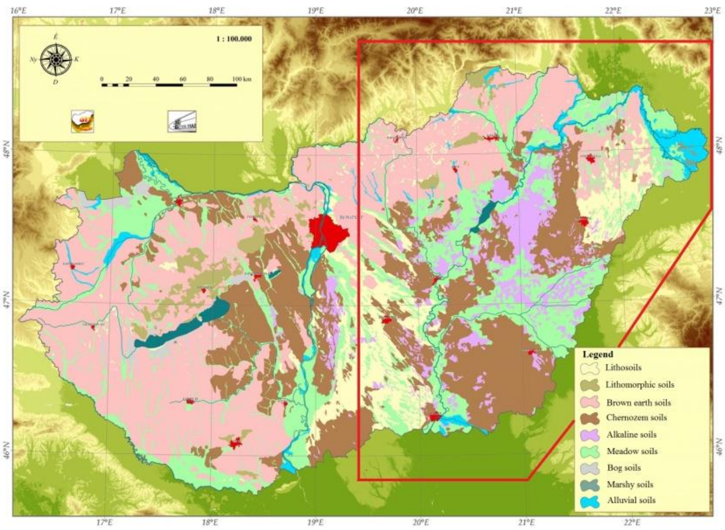



Figure 2.6. Soils types in the Tisza sub-basin (Source: MTA TAKI)

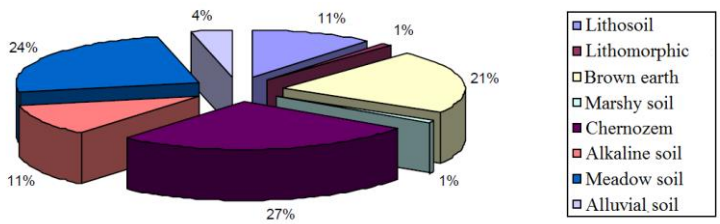



Figure 2.7. The proportion of typical soil types in the Tisza sub-basin

For soil fertility, physical, chemical and biological properties are good, adverse soil damage is relatively low, country soil conditions are more favorable than in some Western European countries. In this sub-basin the most typical is salinisation of soils, with this fertility inhibiting factor we can found almost everywhere. Areas threatened by wind erosion occur in the Nyírség and the Danube-Tisza.

## Population and human settlements

The sub-basin comprises four regions: this includes the largest part of the Northern Hungarian region, the whole of the Northern Great Plain region, three quarters of the Southern Great Plain region and the smaller, eastern part of the Central Hungarian region. It covers all of Borsod-Abaúj-Zemplén County, Szabolcs-Szatmár-Bereg County, Hajdú-Bihar County, Heves and Jász-Nagykun-Szolnok counties, Békés and Csongrád counties and Nógrád County Pest and Bács-Kiskun County East half. The 46 376 km$^2$ population of the sub-basin is 4 048 562, its population density is 87.3 persons / km$^2$, well above the national average. In this sub-basin there are three major cities in the countryside: Debrecen, Miskolc and Szeged, where more than half a million people are living together. In the last decade, the suburbanization processes of the region's settlement network have been primarily formed around the big cities, where the so-called " Suburban zones have emerged: from home to work, but to work there and entertain families. At the same time, the reverse process is also present: in recent decades, many have migrated from rural areas to more developed, mainly industrial areas of the country.

In addition to the towns and villages, not a negligible element of the settlement network is the so-called „Inhabited places in the outskirts, which are generally smaller parts of the population. This group is quite complex, the forestry house, the lonely farmland, the farmhouse, the former manor house, the late estate~~,~~ and so on. They are among them. The extent and density of the Great Plain farms has dropped to a great extent today.

## Land use

The environmental status of the river basins, the load from diffuse pollution of water bodies, as well the estimation of drainage and infiltration from the precipitation, it is necessary to consider land use.

Table 2-5 Distribution of land use in the Tisza sub-basin

| **Land use** | **Tisza** | |
|---|---|---|
| | km$^2$ | % |
| Built environment | 2496 | 5,4 |
| Arable land | 26041 | 56,2 |
| Vineyards, fruit trees | 843 | 1,8 |
| Mixed agricultural | 2204 | 4,8 |
| Meadow, pasture | 7372 | 15,9 |
| Forest | 6519 | 14,1 |
| Inland marshes | 315 | 0,7 |
| Water bodies | 592 | 1,3 |
| **Summary** | **46 380** | **100** |

The size of the agricultural land is the largest in Hungary in the Tisza sub-basin, but from agricultural ecological point of view this land use is considered to be the most unfavorable structure. Typical arable land is too high and they are low proportion of intensive cultures (vegetables, fruits). A significant part of the agricultural area consists of arable land (56%) and lawn (16%), while the share of the garden, fruit and grapes represent only about 5%. The peculiarities of this river basin are the relative importance of fish ponds. The proportion of forest areas does not reach 15%. Larger areas can be found in the northern part of Tisza sub-basin (Zagyva, Tarna, Sajó, Hernád and Bodrog). From the CORINE CLC50 categories we can analyze the catchment areas biological activity value. The biological activity value in most parts of the country is moderate (54%) or poor (30%) certified. The proportion of excellent areas are only 2,1 %. Good and excellent areas are the forested lands of the Northern Mountains (Bükk, Borsodi Hills, Aggteleki karst land, Zempléni

Mountains). In the Great Plain, in a larger coherent spot, only Hortobágy can be found natural vegetation. There is not bad classification area, which shows that concentrated anthropogenic impacts are limited to a small area (large cities and industrial area).

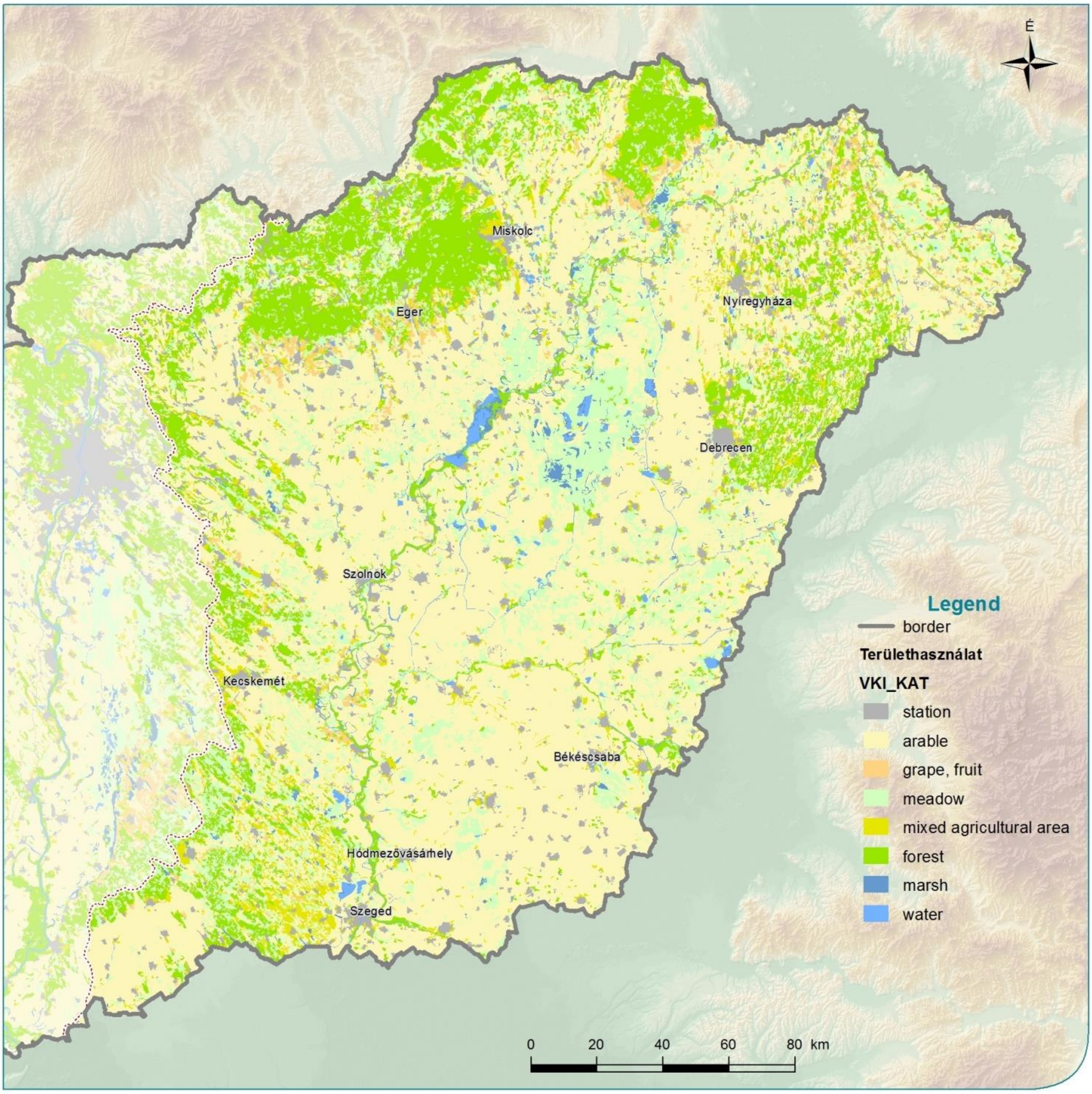



Figure 2.8 . Land use in Tisza River Basin in Hungary

## Economic activity

The Tisza sub-basin area is extremely demarcated for economic performance. The Central Hungarian region is the most dynamically developing region in the Tisza sub-basin, in contrast, the Great Plain regions and Northern Hungary are the most underdeveloped micro-regions in the Tisza sub-basin. In general, the Central Hungarian area of the sub-basin surveyed and the environment of big cities are economically most dynamically developing areas, while the areas of the South Great Plain and the North Hungarian region are more or less stagnant.

26% of all gross domestic product of the country is produced in this sub-basin, while 40% of the population lives here. In the production of GDP, the contribution of individual economies is different for each region. Two-thirds of the country's GDP is from service providers, one third comes from commodity branches (agriculture, industry, construction).
In the northern regions of the sub-basin, the industry is much larger, whereas agriculture in the southern regions is the driving force. Of the water-related sectors of agriculture, the highest performance of fisheries is water use, followed by irrigation management. Irrigation management is in a disadvantaged position in Hungary today, while irrigated areas do not reach 2% of the area. The relative high water demand for livestock production does not appear in the sub-basin as livestock production has dropped significantly. Overall, agriculture demands the major water use in the Tisza sub-basin.
One quarter of GDP is produced by the industry. The largest water users in the country are industrial plants/factories. Three quarters of all extracted water is used by the industry. Special - non-abstraction - industrial water use is the so-called "in situ" surface water use of hydroelectric power plants. All ~ 20 billion cubic meters of water per year from water use ~ 15 billion cubic meters of water per year pass through the turbines of hydro power plants, which produce electricity produced annually with ~ 200 thousand MWh hydroelectric power plants. This type of water use in the Tisza sub-basin is very high, with 93% of all water consumption, as there are significant hydroelectric power plants in Hungary.

## Biodiversity and Protected areas

The flora of the sub-basin is very diverse: in Hungary 10 out of 25 flora district are partially or completely located here. There are also many protected plant species in the Northern Mountain range and Great Plains which are also endemic in these areas (e.g. *Onosma tornense*, *Dianthus diutinus*). Special habitats are the alkaline steppe habitats.
The size of protected areas is significant. In the Tisza sub-basin there are the Bükk, Aggtelek, Hortobágy, Kiskunság and Körös-Maros National Parks and there are several significant landscape protection areas.
Ramsar areas can be found here too (eg. Upper-Tisza, Hortobágy). The largest continuous Natura 2000 sites (SCI, SPA) are also located in this sub-basin:, connecting the Szatmári Plain, Bodrogköz, Zemplén, Tisza Lake, the Tisza river and Körös river areas.
Forests are located on nearly 16% of the sub-basin, and most of them are protected. Forests have an important role in the hydrology of river basins as they influence the flow and infiltration of precipitation. The area of forests has been growing steadily since the middle of the last century, approaching 732 800 hectares by 2012. Forest areas are concentrated, extensive forest areas are found in the north-western part of the Tisza basin. Different types of wood species have different water supply. The climatic, hydrographic and soil conditions of Hungary favour the hard-limbed trees, so in recent years their proportion has increased, while the percentage of pine plantations has decreased. The most widespread tree species of the sub-basin is the black locust, which is non-native and gives 24% (175 900 hectares) of all forest areas of Hungary by 2012. The largest black locust plantations are in the county of Bács-Kiskun (60 200 hectares), but Szabolcs-Szatmár-Bereg (56 400 thousand hectares) and Pest county (47 800 hectares) has significant black locust plantations too.. Along the Tisza river, typical alluvial softwood forest habitat patches are still presented. 18% of the forests are protected and the proportion of the strictly protected forests exceeds 3%.

## Cultural heritage

Surface and groundwater activities in the sub-basin area are significant, for example: fishing, aquatic tourism, natural beaches. The number of settlements affected by natural beaches is relatively low. Although we do not have exact data, it is common knowledge that areas not designated as natural beach sites are also used for bathing.

In the river basin there are mainly small and medium-sized ports. Those wishing to unwind here have the opportunity to connect their recreational activities with our surface waters, either by chartering boats or by hiking.
Most of our fishing lakes are artifical (mine lakes, reservoirs), but many fishing communities utilize old-beds of the River Tisza and its tributaries.
In Hungary, due to the favorable conditions, the spas, wellness baths are available for large numbers of tourists. One of the most popular Hungarian spa is in Hajdúszoboszló.
One of the most utilized areas of the sub-basin is the Lake Tisza. Every year a significant number of tourists visit the artificial reservoir. The aquatic world and its associated bird populations are a huge value for the region. Ports provide organized water tours and sailing opportunities. Around the reservoir, vibrant cycling tourism has evolved.
Every year between late spring and early summer, the Tisza River "blooms" and millions of "Tiszaflowers" swarm at parts of the Tisza River. The "Tiszaflower", Palingenia Longicauda, is a long-tailed mayfly – Europe’s largest mayfly. After three years spent at the bottom of the river, the larvaes of the mayfly break for the surface where males moult and females hatch and the beautiful bridal-dance of the male and female – or "blooming" – begins before sunset.
There are several famous Hungarian wine regions in the water catchment area: Tokaj Mountan, Bükk Mountain, Mátra Mountain, and the Kiskunság.
Hungary has 8 World Heritage Sites, and 4 of these are located on the Tisza River basin: the Caves of Aggtelek Karst, the Hortobágy National Park, the Old Village of Hollókő and its surroundings, and the Tokaj Wine Region.

# Chapter 3 Flood risk at Tisza River Basin Level

## Flood protection infrastructure

With close to 25% of the country comprising floodplains, most of the rivers having a very dynamic water regime and 25% of the population living in reclaimed floodplains, flooding is a major issue. 21,712km$^2$ of Hungary's floodplains are below the rivers' flood level. This area includes 1.8 million ha arable land, 32% of the railway network, 15% of the road network and more than 2000 industrial plants. The highest flood discharge in the Danube is 20 times higher than low flow. In smaller rivers, such as those of the Körös system, this ratio is several hundred to one and floods can develop in a few hours. On larger rivers, they can last several months. Devastating, fast-rising ice-jam floods are especially dangerous. Technical and financial components make up the complex operation of flood protection. The objective is to recover as well as decrease the loss caused by flood.

**The main flood protection infrastructures in Hungary:**

The existing flood protection structures built since the middle of the 19th century comprise the following structures:

- **The main-line levees** of 4200 km total length (3973 km earth embankment, 30 km flood wall) along the rivers. The total volume of the embankments is approximately 120 million m 3,
- **floodways** on three rivers to split the flood discharge among them and to transfer it into the valley of another stream, serving other purposes (road and railway embankments have
- **low-land emergency storage reservoirs** to retain flood peaks on flashy rivers carrying relatively smaller discharges (with 223 km$^2$ total area and 389 million m$^3$ aggregate capacity),
- **Secondary defenses** to confine inundation in the event of a levee failure. For this purpose suitable terrain features, or existing structures

Flood control efforts over past centuries have resulted in the construction of 4181km of defenses (consisting mainly of earthen embankments). Ten lowland emergency flood reservoirs, of 360 million m$^3$ total volume, relieve flood load on the levees and protect 97% of the floodplains.

Most of our flood protection dykes in Tisza valley followed the rising of flood water levels has been continuously developed. The continuous developing has created an "onion" structure at the flood protection structures that causes dangerous flood phenomenon. It can also cause more harmful flood phenomenon if the subsoil stability is poor, and also the oxbow flood protection dyke crossings. Further problems are caused by the lack of height and cross-sectional flood protection dykes. The General Directorate of Water Management assessed the current level of building of the flood protection system in the Tisza valley. There are 2942, 9 km length flood protection dyke along the Tisza River, 2826 km of which is lack of height. It means that 96 % of the Tisza valley's flood protection dykes don't reach the Designed Flood Water Level + safety.

Flood protection dykes in Tisza valley:

| | Flood protection dykes in Tisza valley | | |
|---|---|---|---|
| | Length (km) | Length of lack of height flood protection dykes (km) | Average lack of height Designed Flood Water Level (DFWL) + Safety (m) |
| Upper-Tisza | 724,5 | 724,5 | 0,9 |
| Middle-Tisza | 1314,7 | 1215,0 | 1,1 |
| Lower-Tisza | 903,1 | 886,5 | 1,0 |
| **Summarized:** | **2942,9** | **2826** | **1,0** |

*(References:* ***Hungarian Flood Risk and hazard mapping – Country report, General Directorate of Water Management, 2015)***

The main works for flood protection will be provided in table form,that is proposed below.

## *Table 3- 1 Dikes*

| Crt. nr. | Dike name[1] | Water course | Dike position[2] | Locality name[3] | Length (m) | Medium high (m) | YCO[3] | Normal operating conditions: Probability of exceeding (pc%) | Normal operating conditions: Q ($m^3/s$) | Status[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 07.01 | Tisza | LB | Nagyhalász-Vencsellő-buji | 24469 | 3 | n.r. | 0 | | satisfying |
| | | Lónyay | LB | | 2113 | 3 | n.r. | 0 | | satisfying |
| 2 | 07.02 | Tisza | LB | Veresmart-nagyhalászi | 22727 | 3,5 | n.r. | 0 | | satisfying |
| 3 | 07.03 | Tisza | LB | Zsurk-veresmarti | 27773 | 3,5 | n.r. | 0 | | satisfying |
| 4 | 07.04 | Tisza | LB | Vásárosnamény- zsurki | 31240 | 3,5 | n.r. | 0 | | satisfying |
| 5 | 07.05 | Tisza | LB | Szatmárcseke-olcsvaapáti | 31300 | 3,5 | n.r. | 0 | | satisfying |
| 6 | 07.06 | Batár-patak | LB | Magosliget-tiszakóródi | 9940 | 3,5 | n.r. | 0 | | satisfying |
| | | Tisza | LB | | 16082 | 3,5 | n.r. | 0 | | satisfying |
| 7 | 07.07 | Tisza | RB | Vásárosnamény-lónyai | 31000 | 3,5 | n.r. | 0 | | satisfying |
| 8 | 07.08 | Tisza | RB | Tarpa-vásárosnamé nyi | 29469 | 3,5 | n.r. | 0 | | satisfying |
| 9 | 07.09 | Lónyay | LB | Kótaj-vencsellői | 9654 | 3 | n.r. | 0 | | satisfying |
| | | Lónyay | RB | | 7566 | 3 | n.r. | 0 | | satisfying |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 07.10,07.11 | Lónyay | LB | Berkesz-kótaji | 24738 | 3 | n.r. | 0 | | satisfying |
| 11 | 07.12 | Kraszna | LB | Mérkvállaj-vásárosnaményi | 59777 | 3 | n.r. | 0 | | satisfying |
| 12 | 07.13 | Kraszna | RB | Ágerdőmajor-olcsvai | 40482 | 3 | n.r. | 0 | | satisfying |
| 13 | 07.14 | Szamos | LB | Csenger-olcsvai | 46650 | 3 | n.r. | 0 | | satisfying |
| 14 | 08.01 | Laskó | LB | Sarud-négyesi | 4600 | 3 | n.r. | 0 | | satisfying |
| | | Tisza | RB | | 12944 | 3 | n.r. | 0 | | satisfying |
| | | Rima | LB | | 7826 | 2,5 | n.r. | 0 | | satisfying |
| | | Rima | RB | | 7955 | 2,5 | n.r. | 0 | | satisfying |
| | | Eger | LB | | 1100 | 2,5 | n.r. | 0 | | satisfying |
| | | Eger | RB | | 1045 | 2,5 | n.r. | 0 | | satisfying |
| | | Csincse | LB | | 4159 | 2,5 | n.r. | 0 | | satisfying |
| | | Csincse | RB | | 4200 | 2,5 | n.r. | 0 | | satisfying |
| 15 | 08.02 | Tisza | RB | Négyes-tiszakeszi | 25332 | 3 | n.r. | 0 | | satisfying |
| 16 | 08.03 | Tisza | RB | Tiszakeszi-sajószögedi | 24451 | 3 | n.r. | 0 | | satisfying |
| | | Sajó | RB | | 6051 | 3 | n.r. | 0 | | satisfying |
| 17 | 08.04 | Tisza | RB | Inérhát-tokaji | 45381 | 3,5 | n.r. | 0 | | satisfying |
| | | Bodrog | RB | | 1394 | 3,5 | n.r. | 0 | | satisfying |
| 18 | 08.05 | Tisza | RB | Zalkod-tiszacsermelyi | 31600 | 3,5 | n.r. | 0 | | satisfying |
| 19 | 08.05 II | Tisza | RB | Tiszacsermely-zemplénagárdi | 36342 | 3,5 | n.r. | 0 | | satisfying |
| 20 | 08.06 | Sajó bp. | LB | Bánréve-felsőzsolcai | 30263 | 3,5 | n.r. | 0 | | satisfying |
| | | Névtelen | LB | | 947 | 2,5 | n.r. | 0 | | satisfying |
| | | Névtelen | RB | | 950 | 2,5 | n.r. | 0 | | satisfying |
| | | Keleméri | RB | | 764 | 2,5 | n.r. | 0 | | satisfying |
| | | Keleméri | LB | | 950 | 2,5 | n.r. | 0 | | satisfying |
| | | Szörnyűv. | LB | | 414 | 2,5 | n.r. | 0 | | satisfying |
| | | Szuha | RB | | 1400 | 2,5 | n.r. | 0 | | satisfying |
| | | Szuha | LB | | 1500 | 2,5 | n.r. | 0 | | satisfying |
| | | Vörös | RB | | 1300 | 2,5 | n.r. | 0 | | satisfying |
| 21 | 08.07 | -Nagycsécsi | RB | Miskolc-sajópüspöki | 1094 | 3 | n.r. | 0 | | satisfying |
| | | - Ónodi | RB | | 2642 | 3 | n.r. | 0 | | satisfying |
| | | Sajó | RB | | 26281 | 3,5 | n.r. | 0 | | satisfying |
| | | Szinva | RB | | 300 | 2,5 | n.r. | 0 | | satisfying |
| | | Szinva | LB | | 450 | 2,5 | n.r. | 0 | | satisfying |
| | | Mercse | RB | | 977 | 2,5 | n.r. | 0 | | satisfying |
| | | Hangony | RB | | 840 | 2,5 | n.r. | 0 | | satisfying |
| | | Hagony | LB | | 837 | 2,5 | n.r. | 0 | | satisfying |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 08.08 | Hernád | RB | Hernádnémeti - hernádszurdoki | 27240 | 3 | n.r. | 0 | | satisfying |
| | | Vadász | RB | | 1300 | 2,5 | n.r. | 0 | | satisfying |
| | | Vadász | LB | | 1580 | 2,5 | n.r. | 0 | | satisfying |
| | | Garadna | RB | | 1832 | 2,5 | n.r. | 0 | | satisfying |
| | | Garadna | LB | | 1800 | 2,5 | n.r. | 0 | | satisfying |
| 23 | 08.09 | Hernád | LB | Hidasnémeti-bőcsi | 26424 | 3 | n.r. | 0 | | satisfying |
| | | Gönci | RB | | 870 | 2,5 | n.r. | 0 | | satisfying |
| | | Gönci | LB | | 1000 | 2,5 | n.r. | 0 | | satisfying |
| 24 | 08.10 | Sajó | LB | Inérhát-taktaföldvári | 8000 | 3,5 | n.r. | 0 | | satisfying |
| | | Takta | LB | | 28643 | 3 | n.r. | 0 | | satisfying |
| | | Takta | RB | | 6706 | 3 | n.r. | 0 | | satisfying |
| 25 | 08.11 | Bodrog | LB | Viss-felsőberecki | 39799 | 3,5 | n.r. | 0 | | satisfying |
| 26 | 08.12 | Tarna | LB | Jászjákóhalma-káli | 36214 | 3 | n.r. | 0 | | satisfying |
| 27 | 08.13 | Tarna | RB | Jászdózsa-káli | 35728 | 3 | n.r. | 0 | | satisfying |
| | | Ágói | RB | | 5417 | 2,5 | n.r. | 0 | | satisfying |
| | | Ágói | LB | | 5392 | 2,5 | n.r. | 0 | | satisfying |
| | | Gyöngyös | RB | | 6827 | 2,5 | n.r. | 0 | | satisfying |
| | | Szarvágy | LB | | 3010 | 2,5 | n.r. | 0 | | satisfying |
| | | Szarvágy | RB | | 3019 | 2,5 | n.r. | 0 | | satisfying |
| | | Gyöngyös | LB | | 6826 | 2,5 | n.r. | 0 | | satisfying |
| | | Gyangya | RB | | 1705 | 2,5 | n.r. | 0 | | satisfying |
| | | Gyangya | LB | | 1619 | 2,5 | n.r. | 0 | | satisfying |
| | | Bene | LB | | 8845 | 2,5 | n.r. | 0 | | satisfying |
| | | Bene | RB | | 8857 | 2,5 | n.r. | 0 | | satisfying |
| | | Tarnóca | RB | | 11931 | 2,5 | n.r. | 0 | | satisfying |
| | | Tarnóca | LB | | 11969 | 2,5 | n.r. | 0 | | satisfying |
| 28 | 08.14 | Bodrog | RB | Bodrogkeresztúr - sátoraljaújhelyi | 10175 | 3 | n.r. | 0 | | satisfying |
| | | Ronyva | RB | | 2327 | 3 | n.r. | 0 | | satisfying |
| | | Ronyva | LB | | 1811 | 3 | n.r. | 0 | | satisfying |
| 29 | 09.01 | Tisza | LB | Tiszafüred-tiszakeszi | 41000 | 3,5 | n.r. | 0 | | satisfying |
| 30 | 09.02 | Tisza | LB | Tiszatarján-rakamazi | 66820 | 3,5 | n.r. | 0 | | satisfying |
| | | Keleti-fcs. (main channel) | RB | | 4755 | 3 | n.r. | 0 | | satisfying |
| | | Keleti-fcs. (main channel) | LB | | 4725 | 3 | n.r. | 0 | | satisfying |
| 31 | 09.03 | Berettyó | RB | Kálló menti | 1587 | 3 | n.r. | 0 | | satisfying |
| | | Kálló | RB | | 11210 | 3 | n.r. | 0 | | satisfying |
| 32 | 09.04 | Berettyó | RB | Darvas-pocsaji | 44500 | 3 | n.r. | 0 | | satisfying |
| | | Kálló | LB | | 1925 | 3 | n.r. | 0 | | satisfying |
| | | Ér | RB | | 8700 | 3 | n.r. | 0 | | satisfying |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 33 | 09.05 | Sebes-Körös | RB | Szeghalom-darvasi | 10187 | 3 | n.r. | 0 | | satisfying |
| | | Berettyó | LB | | 25000 | 3 | n.r. | 0 | | satisfying |
| 34 | 09.06 | Berettyó | LB | Darvas-kismarjai | 47365 | 3 | n.r. | 0 | | satisfying |
| 35 | 09.07 | Berettyó | RB | Érmelléki | 5820 | 3 | n.r. | 0 | | satisfying |
| | | Ér | LB | | 8100 | 3 | n.r. | 0 | | satisfying |
| 36 | 09.08 | Sebes-Körös | RB | Szeghalom-körösszakáli | 32265 | 3 | n.r. | 0 | | satisfying |
| 37 | 09.09 | Hortobágy-Berettyó | LB | Bucsa-nádudvari | 24119 | 3 | n.r. | 0 | | satisfying |
| | | Holt-Kösely | LB | | 9811 | 3 | n.r. | 0 | | satisfying |
| 38 | 10.01 | Tisza | RB | Lakitelek-tószegi | 55 637 | 3,5 | 1984 | 0 | 584 | satisfying |
| | | Közös-főcsatorna (main channel) | RB | | 4 500 | 2 | 1984 | 0 | 0,69 | satisfying |
| | | Közös-főcsatorna (main channel) | LB | | 4 500 | 2 | 1984 | 0 | 0,69 | satisfying |
| 39 | 10.02 | Tisza | RB | Szolnok-Újszász-szórói | 27 458 | 4 | 1984 | 0 | 584 | satisfying |
| | | Zagyva | RB | | 23 928 | 4 | 1984 | 0 | 9,89 | satisfying |
| | | Zagyva | LB | | 22 643 | 4 | 1984 | 0 | 9,89 | satisfying |
| | | Tápió | RB | | 6 320 | 3 | 1984 | 0 | 0,25 | satisfying |
| 40 | 10.03 | Tisza | RB | Doba-kanyari | 49 406 | 5 | 1984 | 0 | 584 | satisfying |
| 41 | 10.04 | Tisza | RB | Kiskörei - tározó menti | 22 900 | 4,5 | 1984 | 0 | 571 | satisfying |
| | | Tisza | LB | | 32 200 | 4,5 | 1984 | 0 | 571 | satisfying |
| 42 | 10.05 | Tisza | LB | Kunszentmárton-nagyrévi | 48 100 | 5,5 | 1984 | 0 | 584 | satisfying |
| | | Hármas-Körös | RB | | 25 166 | 4,5 | 1984 | 0 | 103 | satisfying |
| 43 | 10.06 | Tisza | LB | Tiszaföldvár-pityókai | 56 980 | 5 | 1984 | 0 | 584 | satisfying |
| 44 | 10.07 | Tisza | LB | Fegyvernek-ledencei | 33 500 | 4,5 | 1984 | 0 | 584 | satisfying |
| 45 | 10.08 | Hármas-Körös | RB | Öcsöd-bánrévei | 32 354 | 4 | 1984 | 0 | 101,5 | satisfying |
| 46 | 10.09 | Hortobágy-Berettyó | RB | Mezőtúr-himesdi | 30 500 | 3 | 1984 | 0 | 4,05 | satisfying |
| 47 | 10.10 | Hortobágy-Berettyó | RB | Pusztaecseg - őzesi | 39 980 | 3 | 1984 | 0 | 4,05 | satisfying |
| | | Német-ér | RB | | 3 300 | 2,5 | 1984 | 0 | 0,056 | satisfying |
| | | Német-ér | LB | | 9 100 | 2,5 | 1984 | 0 | 0,056 | satisfying |
| 48 | 10.11 | Zagyva | LB | Százberek-jászberényi | 45 380 | 2,5 | 1984 | 0 | 3,9 | satisfying |
| | | Zagyva | RB | | 43 422 | 2,5 | 1984 | 0 | 3,9 | satisfying |
| | | Tápió | LB | | 10 912 | 2 | 1984 | 0 | 0,25 | satisfying |
| 49 | 11.01 | Tisza | RB | Gyála-Szeged-Algyői | 31 512 | 5 | n.r. | 0 | | satisfying |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 11.02 | Tisza | RB | Algyő-dongéri | 23 759 | 4,5 | n.r. | 0 | | satisfying |
| | | Dong-ér | RB | | 4 693 | 5 | n.r. | 0 | | satisfying |
| 51 | 11.03 | Tisza | RB | Dongér-Csongrádi | 35 233 | 4,5 | n.r. | 0 | | satisfying |
| | | Dong-ér | LB | | 4 693 | 4 | n.r. | 0 | | satisfying |
| 52 | 11.04 | Tisza | LB | Marostorok-Mártélyi | 29 598 | 4,5 | n.r. | 0 | | satisfying |
| | | Maros | RB | | 5 406 | 4,5 | n.r. | 0 | | satisfying |
| 53 | 11.05 | Tisza | LB | Mindszent-Szentesi | 31 764 | 4,5 | n.r. | 0 | | satisfying |
| 54 | 11.06 | Maros | LB | Torontáli | 12400 | 4,5 | n.r. | 0 | | satisfying |
| | | Tisza | LB | | 28640 | 4,5 | n.r. | 0 | | satisfying |
| 55 | 11.07 | Maros | RB | Maros jobb parti | 44800 | 4 | n.r. | 0 | | satisfying |
| | | Sámson-Apátfalvi | RB | | 9510 | 4 | n.r. | 0 | | satisfying |
| | | Sámson-Apátfalvi | LB | | 9510 | 4 | n.r. | 0 | | satisfying |
| 56 | 11.08 | Hármas-Körös | LB | Szentes-öcsödi | 35913 | 4 | n.r. | 0 | | satisfying |
| 57 | 12.01 | Hármas-Körös | LB | Szarvasi | 49117 | 4 | n.r. | 0 | | satisfying |
| 58 | 12.02 | Kettős-Körös | LB | Mezőberényi | 35040 | 4 | n.r. | 0 | | satisfying |
| | | Fehér-Körös | LB | | 9286 | 4 | n.r. | 0 | | satisfying |
| 59 | 12.03 | Hármas-Körös | RB | Zsófiamajori | 28413 | 4 | n.r. | 0 | | satisfying |
| 60 | 12.04 | Kettős-Körös | RB | Dobozi | 36193 | 4 | n.r. | 0 | | satisfying |
| | | Fekete-Körös | RB | | 15829 | 3,5 | n.r. | 0 | | satisfying |
| 61 | 12.05 | Fehér-Körös | RB | Mályvádi | 9475 | 4 | n.r. | 0 | | satisfying |
| | | Fekete-Körös | LB | | 20490 | 4 | n.r. | 0 | | satisfying |
| 62 | 12.06 | Hortobágy-Berettyó | RB | Ecsegfalvai | 43000 | 3,5 | n.r. | 0 | | satisfying |
| 63 | 12.07 | Sebes-Körös | RB | | 14013 | 3,5 | n.r. | 0 | | satisfying |
| | | Berettyó | RB | | 21313 | 4 | n.r. | 0 | | satisfying |
| 64 | 12.08 | Sebes-Körös | LB | Fokközi | 57966 | 3,5 | n.r. | 0 | | satisfying |

[1] Dike name is the number of the flood protection line. The first number represent the Regional Water Directorate which operating.
[2] left bank (LB) or right bank (RB)
[3] Year of Commissioning; in many case not relevant for the flood protection method. In Hungary the operation doesn't connected to discharge. The flood protection alert is ordered by water levels.
[3] technical status: very good, satisfying, non- satisfying/bad. – we indicated "satisfy" the whole flood protection system, because the technical status is good, but the the Tisza valley's flood protection dykes don't reach the Designed Flood Water Level + safety.

## Table 3 - 2 Permanent reservoirs

| Crt. Nr. | Reservoir name | Water course | Nearest locality name | High dam (m) | Type of dam | Volume at NRL (mn.m3) | Volume at MEL (mn.m3) | Attenuation volume (mn.m3) | Use |
|---|---|---|---|---|---|---|---|---|---|
| *1* | *Tisza-tó* | *Tisza* | *10.04 Kiskörei - tározómenti* | *8* | *ferro-concrete, steel* | *155* | *170* | *not relevant* | *Agricultural, ecological, and tourist water storage* |

[1] – arch/gravity from concrete/earth etc.
[2] – flood protection, water supply, industry, irrigation etc.
[3] Normal Retention Level
[4] Maximum Exploitation Level

## Table 3 - 3 Temporary reservoirs

A temporary reservoir is a reservoir that is empty and is used for peak flow attenuation during floods. Temporary reservoirs should all recorded.

| Crt. nr. | Reservoir name | Water course | Type of dam | High dam (m) | Total volume (attenuation volume) (mn.m$^3$) |
|---|---|---|---|---|---|
| - | - | - | - | - | - |

Notes: Our temporary reservoirs are indicated in the polders section, because the technical description is fitter than in table 3 -3 . There are 11 temporary reservoirs in the Tisza valley. They are built in Framework Vasarhelyi Plan. The technical parameters are shown in table 3-9.

## Table 3 - 9 Polders

A polder represent an embanked flooded area in natural regime, with dikes and draining systems with no connections with water other than through operating facilities.
It should be mentioned only polders with a volume > 1.000.000 m$^3$.

| Crt. Nr. | Polder name | Water course | Locality name | Dike type | Length (km) | High dike (m) | Total surface (ha) | Total volume (attenuation volume, mn.m3) |
|---|---|---|---|---|---|---|---|---|
| *1* | *Tiszaroffi* | *Tisza* | *10.07 Fegyvernek - Ledencei* | *lateral* | *14* | *2,9* | *2280* | *97* |
| *2* | *Nagykunsági* | *Tisza* | *10.07 Fegyvernek - Ledencei* | *lateral* | *25* | *4* | *4000* | *99* |
| *3* | *Hanyi-Tiszasülyi* | *Tisza* | *10.03 Doba - Kanyari* | *lateral* | *32* | *2,9* | *5570* | *247* |
| *4* | *Jásztelki* | *Zagyva* | *10.11 Szászberek - Jászberényi* | *lateral* | *27* | *1,5* | *2000* | *13* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *5* | *Borsóhalmi* | *Zagyva* | *10.11 Szászberek - Jászberényi* | *lateral* | *24* | *2* | *2000* | *23,5* |
| *6* | *Beregi* | *Tisza* | *07.08./T Beregi tározói* | *lateral* | *50,7* | *2,11* | *2470* | *58* |
| *7* | *Szamos-Kraszna közi* | *Szamos* | *07.14./T Szamos-Kraszna közi tározói* | *lateral* | *21* | *3,2* | *5110* | *126* |
| *8* | *Cigándi* | *Tisza* | *08.05/II-T. Cigándi-Tiszakarádi Árvízi tározó* | *lateral* | *24* | *4,5* | *2470* | *94* |
| *9* | *Mályvád* | *Fekete-Körös* | *12.05. Mályvádi* | *lateral* | *8,9* | *2,27* | *3470* | *75* |
| *10* | *Kisdelta* | *Fehér-Körös* | *12.02. Mezőberényi* | *lateral* | *3,6* | *4,2* | *550* | *26* |
| *11* | *Mérges* | *Kettős-Körös, Sebes-Körös* | *12.07. Körösladányi* | *lateral* | *7,8* | *3,8* | *1820* | *87,2* |

[1] lateral/contour/partition/perimeter/enclosure etc.

## *Table 3 - 10 Diversion canals*

A diversion canal it is a canal with supplement the tributary flow into a reservoir, to assure the water demand for irrigation through the transit from a basin into another, to assure the industrial or potable water, transition for fisheries and for peak flow attenuation. There are significant modifications of the flows of water where the diversion canals are present.
The locality means the nearest municipality.
The diversion canal should be mentioned only with a derived flow > 1m$^3$/s.

| ***Crt. nr.*** | ***Name*** | ***Locality name*** | ***Derived stream*** | ***Receiver water course*** | ***Length (km)*** | ***Derived discharges (m$^3$/s)*** |
|---|---|---|---|---|---|---|
| *1* | *Nagykunsági-főcsatorna* | *Abádszalók Kunhegyes Kenderes Fegyvernek Örményes Kisújszállás Kuncsorba Törökszentmiklós Kétpó Mezőhék Öcsöd* | *Tisza-tó* | *Hármas-Körös* | *74,36* | *10,1* |
| *2* | *Nagykunsági-főcsatorna Keleti-ág* | *Kisújszállás Kuncsorba Mezőtúr* | *Nagykunsági-főcsatorna* | *Hortobágy-Berettyó* | *17,988* | *2,3* |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | *Túrkeve* | | | | |
| *3* | *Nk.III-2. fürtfőcsatorna* | *Kunhegyes Karcag* | *Nagykunsági-főcsatorna* | *Karcagi II.* | *26,805* | *2,34* |

*Table 3 - 11 Hydraulic complex facility*

| Crt. nr. | Name | Water course | Locality name | Maximum derived discharges (m3/s) |
|---|---|---|---|---|
| *1* | *Kisköre hydropower plant* | *Tisza* | *10.04 Kiskörei - tározó menti* | *1700* |
| *2* | *Tiszalök barrage and hydropowerplant* | *Tisza* | *09.02. Tiszatarján-rakamazi* | *4000* |

A simplified water management scheme (a figure) that include elements only on the principal water course.

The Tisza–Körös Valley Management System (TIKEVIR) is a system of natural watercourses, dams, sluice gates, inter-basin diversion canals transferring and distributing water resources of the Tisza–Körös rivers over an area of 15 000 km2. The original purpose of the system was to provide irrigation water with the additional benefit of hydropower generation. In the last 20 years, recreational uses and nature conservation have had a limiting effect on the use of the water resources. The average inflow to the system is 680 m3/s, while the summer low flow is 157 m3/s. The permitted intake from the Tisza is 114 m3/s, although the actual annual average intake is about 25 m3/s. The flow rate is managed or controlled to some extent, as water systems are partially regulated.

(References: http://www.oecd.org/hungary/Water-Resources-Allocation-Hungary.pdf)


Figure 3.1. Water management scheme in Tisza River Basin in Hungary (TIKEVIR)

## Drainage systems

45% of the area of Hungary is endangered by inland (excess) water. The total length of drainage canals in Hungary is 48513 km, out of this irrigation and with dual function are 4326 km. Most endangered area is located in the Tisza River Basin due the low terrain. In the Tisza River Basin we have 59 main drainage systems, 17704 km of canals, which are operated in exclusive state ownership. There are 395 inland water pump stations in the Tisza River valley.

The table form proposed is below.

*Table 3- 12 Drainage system*

| Crt. nr. | Name | Function | Drained area (km²) | Receiver river |
|---|---|---|---|---|
| 1. | Vajai (III.sz.) főfolyás völgye | Drainage | 344 | Lónyai main channel |
| 2. | Kállói (VII.sz.) főfolyás völgye | Drainage | 451 | Kállói vízfolyás, Lónyai main channel |
| 3. | Tisza-Túr-Szamosközi | Drainage | 442 | Szamos |
| 4. | Felsőszabolcs felső | Drainage | 655 | Lónyai main channel, Tisza |
| 5. | Kraszna balparti | Drainage | 688 | Kraszna |
| 6. | Érpatak (VIII.sz.)-Simai (IX.sz.)főfolyások völgye | Drainage | 727 | Érpatak-vízfolyás |
| 7. | Máriapócsi (IV.sz.)-Bogdányi (V.sz.)-Sényői (VI.sz.) főfolyások völgye | Drainage | 421 | Máriapócs főfolyás |
| 8. | Felsőszabolcs alsó | Drainage | 292 | Belfő main channel, Tisza |
| 9. | Szamos-Krasznaközi | Drainage | 416 | Kraszna, Szamos |
| 10. | Beregi | Drainage | 378 | Tisza |

| | | | | |
|---|---|---|---|---|
| 11. | Felsőszabolcs középső | Drainage | 176 | Tisza |
| 12. | Tisza-Túrközi | Drainage | 213 | Gögő-Szenke, Tisza |
| 13. | Inérhát-tiszadobi | Drainage | 110 | Tisza |
| 14. | Prügy-taktaföldvári | Drainage | 146 | Tisza |
| 15. | Rigós-Sajózugi | Drainage | 301 | Tisza |
| 16. | Tiszavalk-sulymosi | Drainage | 281 | Tisza |
| 17. | Bodrogzug-Törökéri | Drainage | 307 | Bodrog |
| 18. | Laskó-csincsei | Drainage | 463 | Tisza-tó, Tisza |
| 19. | Tiszakarád-ricsei | Drainage | 300 | Tisza |
| 20. | Alsónyírvíz-Nagy-éri | Drainage | 512 | Nagyér |
| 21. | Tiszai-középső | Drainage | 401 | Tisza |
| 22. | Kálló | Drainage | 623 | Nagyér |
| 23. | Kösely-felső | Drainage | 520 | Kondoros, Tocó |
| 24. | Kösely-alsó | Drainage | 724 | Keleti main channel |
| 25. | Tiszai-felső | Drainage | 325 | Keleti main channel, Tisza |
| 26. | Hamvas-sárréti | Drainage | 951 | Keleti main channel, Hortobágy-Berettyó |

| | | | | |
|---|---|---|---|---|
| 27. | Tiszai-alsó | Drainage | 728 | Tisza |
| 28. | Berettyó-felső | Drainage | 375 | Berettyó |
| 29. | Kadarcs-Karácsony-foki | Drainage | 935 | Keleti main channel |
| 30. | Alsónyírvíz-Kati-ér | Drainage | 297 | Nagyér |
| 31. | Berettyó-alsó | Drainage | 521 | Berettyó, Sebes-Körös |
| 32. | Jászberényi | Drainage | 606 | Zagyva |
| 33. | Kiskörei | Drainage | 639 | Tisza |
| 34. | Ceglédi | Drainage | 1 115 | Tisza/Zagyva |
| 35. | Mezőtúri | Drainage | 832 | Hortobágy-Berettyó |
| 36. | Tiszakécskei | Drainage | 784 | Tisza |
| 37. | Karcagi | Drainage | 424 | Hortobágy-Berettyó |
| 38. | Kunhegyesi | Drainage | 378 | Tisza |
| 39. | Cibakházi | Drainage | 596 | Tisza, Hármas-Körös |
| 40. | Kisújszállási | Drainage | 787 | Tisza |
| 41. | Jászkiséri | Drainage | 752 | Tisza |
| 42. | Torontáli | Drainage | 251 | Tisza |
| 43. | Dong-ér-Kecskeméti | Drainage | 992 | Dong-ér, Tisza |
| 44. | Dong-éri | Drainage | 976 | Dong-ér, Tisza |

| | | | | |
|---|---|---|---|---|
| 45. | Kurcai | Drainage | 1 193 | Kurca main channel, Tisza, Hármas-Körös |
| 46. | Vidreéri | Drainage | 252 | Tisza |
| 47. | Algyő-Tápé-Gyála-Körös-éri | Drainage | 2 028 | Tisza |
| 48. | Sámson-Élővízi | Drainage | 1 649 | Maros |
| 49. | Mártély-Tisza-Maroszugi | Drainage | 963 | Tisza |
| 50. | Gyomai | Drainage | 484 | Hortobágy-Berettyó, Hármas-Körös |
| 51. | Réhelyi | Drainage | 166 | Hortobágy-Berettyó |
| 52. | Holt-sebes-körösi | Drainage | 355 | Sebes-Körös |
| 53. | Dögös-káka-foki | Drainage | 817 | Élővíz main channel |
| 54. | Kettős-Körös jobb parti | Drainage | 287 | Kettős-Körös |
| 55. | Szeghalmi | Drainage | 256 | Berettyó |
| 56. | Mezőberényi | Drainage | 470 | Hármas-Körös |
| 57. | Hosszú-foki | Drainage | 454 | |
| 58. | Fehér-Fekete-Körös közi | Drainage | 87 | Fehér-Körös, Fekete-Körös |

| | | | | |
|---|---|---|---|---|
| 59. | Élővíz-csatornai | Drainage | 733 | Kettős-Körös |
| 60. | Körös-ér | drainage | 475,60 | Tisza |
| 61. | Csukás-ér | drainage | | Kőrös-ér |
| 62. | Körös-ér-Nyilas-ök. cs. | drainage | | Kőrös-ér |
| 63. | Peitsik-cs. | drainage | 302,90 | Tisza |
| 64. | Határmenti | drainage | 172,30 | Zagyva |
| 65. | Kisgyepi-cs. | drainage | | Zagyva |
| 66. | Eresztőhalmi-I. cs. | drainage | | Zagyva |
| 67. | Közös-cs. | drainage | 865,90 | Tisza |
| 68. | Gerje | drainage | | Közös-cs. |
| 69. | Perje | drainage | | Közös-cs. |
| 70. | Gerje-mellékcs. | drainage | | Gerje |
| 71. | Perje-felső | drainage | | Perje |
| 72. | Rekettyés-ér | drainage | 333,58 | Zagyva |
| 73. | Kunere-cs. | drainage | | Zagyva |
| 74. | 119 | drainage | 44,30 | Zagyva |
| 75. | Sajfoki-cs. | drainage | 570,60 | Tisza |
| 76. | 12. cs. | dual operation | | Sajfoki-cs. |
| 77. | 12-28. ök. cs. | dual operation | | 12. cs |
| 78. | Hanyi-cs. | drainage | | Tisza |
| 79. | Hanyi-Sajfoki ök. cs. | drainage | | Sajfoki-cs. |
| 80. | 14. cs. | drainage | | Hanyi |
| 81. | Csátés-cs. | dual operation | 617,30 | Tiszasülyi-28.cs. |
| 82. | Tiszasülyi-28. cs. | dual operation | | Tisza |
| 83. | 22. cs. | dual operation | | Tiszasülyi-28.cs. |
| 84. | Tiszasüly-Sajfok-ök. cs. | drainage | | Tiszasülyi-28.cs. |
| 85. | Millér-cs. | dual operation | | Tisza |
| 86. | 33. cs. | dual operation | | Millér-cs. |
| 87. | Doba-cs. | dual operation | 175,60 | Tisza |
| 88. | 19. cs. | drainage | | Doba-cs. |
| 89. | Tiszaderzsi-3. cs. | drainage | 256,60 | Tisza |
| 90. | Nagyfoki-I. cs. | drainage | | Tiszaderzsi-3. cs. |
| 91. | Nagyfoki-II. cs. | drainage | | Tiszaderzsi-3. cs. |
| 92. | Kisfoki-cs. | drainage | | Bal parti szivárgó |
| 93. | Érfűi-cs. | drainage | | Tisza |
| 94. | Mirhó-Gyólcsi-cs. | dual operation | 163,10 | Tisza |
| 95. | Tiszabői-cs. | dual operation | | Tisza |
| 96. | Kakat-cs. | dual operation | 947,60 | Hortobágy-B. |
| 97. | Kisújszállási-II. cs. | drainage | | Kakat-cs. |
| 98. | Villogó-cs. | dual operation | | Hortobágy-B. |

| | | | | |
|---|---|---|---|---|
| 99. | Karcagi-I. cs. | drainage | | Hortobágy-B. |
| 100. | Karcagi-II. cs. | dual operation | | Karcagi-I.cs. |
| 101. | Német-ér | drainage | | Hortobágy-B. |
| 102. | Karcagi-III. cs. | drainage | | Hortobágy-B. |
| 103. | Szajoli-I. cs. | drainage | 381,40 | Tisza |
| 104. | Büdös-ér | drainage | | Tisza |
| 105. | Cibak-Martfűi-cs. | dual operation | 146,80 | Cibaki-HT. |
| 106. | Tégláslaposi-cs. | drainage | | Tisza |
| 107. | Túrkevei-cs. | drainage | 354,60 | Hortobágy-B |
| 108. | Álomzugi-cs. | drainage | | Hortobágy-B |
| 109. | Mezőtúri-VI. cs. | dual operation | | Hármas-Körös |
| 110. | Kútréti-I. cs. | dual operation | | Mezőtúri-VI. cs. |
| 111. | Mezőtúri-XIII. cs. | dual operation | | Hortobágy-B |
| 112. | Harangzugi-I. cs.*15638 | dual operation | 398,40 | Hármas-Körös |
| 113. | Harangzugi-I-c. cs. | dual operation | | Harangzugi-I. cs. |
| 114. | Kungyalui-I. cs. | dual operation | 256,90 | Hármas-Körös |
| 115. | Máma-Tőkefoki-cs. | drainage | | Hármas-Körös |
| 116. | Tóköze cs. | drainage | | Hármas-Körös |

## Significant historical floods and Areas with Potentially Significant Flood Risk

Short description of historical floods in Tisza River Basin in (HUNGARY) - max. 500 words.

The floods generated in Ukraine, Romania and Slovakia are mainly rapid floods and last from 2-20 days. Large floods on the Tisza in Hungary and in Serbia, in contrast, can last for as long as 100 days or more (the 1970 flood lasted for 180 days). This is due to the very flat characteristic of the river in this region and multi-peak waves which may catch up on the Middle Tisza causing long flood situations. Also characteristic of the Middle Tisza region is that the Tisza floods often coincide with floods on the tributaries, which is especially dangerous in the case of the Someş/Szamos, Crasna/Kraszna Bodrog, Criş/Körös and Mures/Maros Rivers. Following a relatively dry decade, a succession of abnormal floods has annually set new record water levels on several gauges over the last four years. Over 28 months between November 1998 and March 2001, four extreme floods travelled down the Tisza River. Large areas were simultaneously inundated by runoff and rapid floods of abnormal height on several minor streams. The extreme Tisza flood in April 2006 was preceded by several floods in February and March generated by melting snow and precipitation. The situation was worsened on the lower Hungarian stretch and in Serbia by the extreme flood on the Danube that very seldom coincides with that of the Tisza. The catastrophic floods of the last decades in Hungary have been caused not only by the major rivers (Danube and Tisza), but by their tributaries as well. For instance, high water stages during the last 15 years in the catchment area of the Tisza River proved to be critical in 1998, 1999, 2000, 2001, 2006 and 2010.
In 2001 there are two dike failures occurred on the left hand side of the River Túr among unique hydrological conditions during the Upper Tisza flood of 2001. Although the level of the water was decreasing in the river itself, volumes of water were retained in the reservoirs of the River Túr on the Romanian side upon Hungarian request, thereby reducing water level in the vicinity of the failure so as to prevent the breaches from widening and to allow blocking as soon as possible.

In 2006 the series of floods in February and March had already filled the Tisza riverbed and its tributaries prior to the period of intensive warming and raining at the beginning of April. Due to flooding on the Hármas-Körös River, the Hortobágy-Berettyó floodgate at Mezőtúr had to be closed on 2 April. In order to control the Hortobágy-Berettyó, water arriving from the Hortobágy River was diverted firstly, closing the Ágota gate to the Nagyiván detention basin (64 million m³ capacity) and secondly, evacuating water into the Hármas-Körös using mobile pumps at the Mezőtúr flood gate. The Tisza flood culminated at Tokaj at 892 cm on 8-10 April, almost reaching the recorded historic maximum of 1999. Flooding on the downstream part of the Tisza was heavily influenced by backwater from the Danube, having also reached a new historical record on the Serbian stretch thus blocking the conveyance of the Tisza flood. At Titel the Tisza flood culminated at 818 cm, exceeding the historical record by 27 cm. Although the Danube water levels started falling in the middle of April, a series of heavy rainfall episodes triggered repeated floods on the Körös/Crisul and Maros/Mures rivers, which led to new flood records along the Lower Tisza.

*Flood risk assessment in floodplains which protected by dykes:*

In the past period there were a plenty of flood protection developments along the rivers, the boundary of the floodplains must have been reviewed. We had to modify the numbers of the floodplains and the effects of the waterproofing objects. Due the changing of Designed Flood Water Level inundation effects, we also significantly expanded the floodplains territorial extent. We examined some smaller floodplains together during the modeling process, and some floodplains were divided in two parts because of the decisive effect of the line structures (e.g. motorways) built in the meantime.

During the flood mapping process we have prepared terrain models and 2D hydrodynamic models for 120 floodplains.
The mapping of flood risk method main steps:

- identifying the flood protection dyke section to be examined, defining the resistance of the flood protection dyke
- indicate the places of dike breaking point, and the hydrological and hydraulic characteristics
- determine the load flood waves, and the load flood water levels
- Running of 2D flood simulations
- Flood hazard mapping

For the total of 745 flood protection dyke breaking points in eight designed areas (three designed areas are located in Tisza River Basin) 1367 scenarios were calculated. During the 2 D hydraulic modeling process we worked by Mike 21 FM HD model used (50 m*50 m) square grid. As a result of the 2 D hydraulic modeling the inundation maps are ready. The inundation maps show which areas are endangered if the flood protection dyke is breaking, and show the maximum water depths in these areas due to hydrological and hydraulic conditions in the scenario. The prepared database and model system are suitable in the future to prepare inundation map in any probability flood wave and the flood risk maps may be renewed.

*Flood risk assessment in unprotected floodplains:*

We ran MIKE 21 FM models in unprotected floodplains which based on flexible grid. We didn't implement the hydraulic modeling one smaller unprotected floodplain but planning boundaries of the river management plans. The preliminary studies and the river management plans have also shown that the calibration of the river bed and the floodplain is very important for the proper implementation. In some river sections we could only produce 1-1, 5 m water level difference by changing the roughness coefficient. We used the previous flood waves measured flood peak water levels. These databases were provided by the Regional Water Directorates. We adopted terrain model from the River Management Plans and not use HYDRODEM. As a result of the 2 D hydraulic modeling the inundation maps are ready. The inundation maps show which areas are endangered if the water level overflows from the river bed and show the maximum water depths in these areas due to hydrological and hydraulic conditions in the scenario. We provided 1‰, 1 %, and 3 % probability flood hazard maps.

A figure with map representing the flood hazard (including the Tisza River Basin):

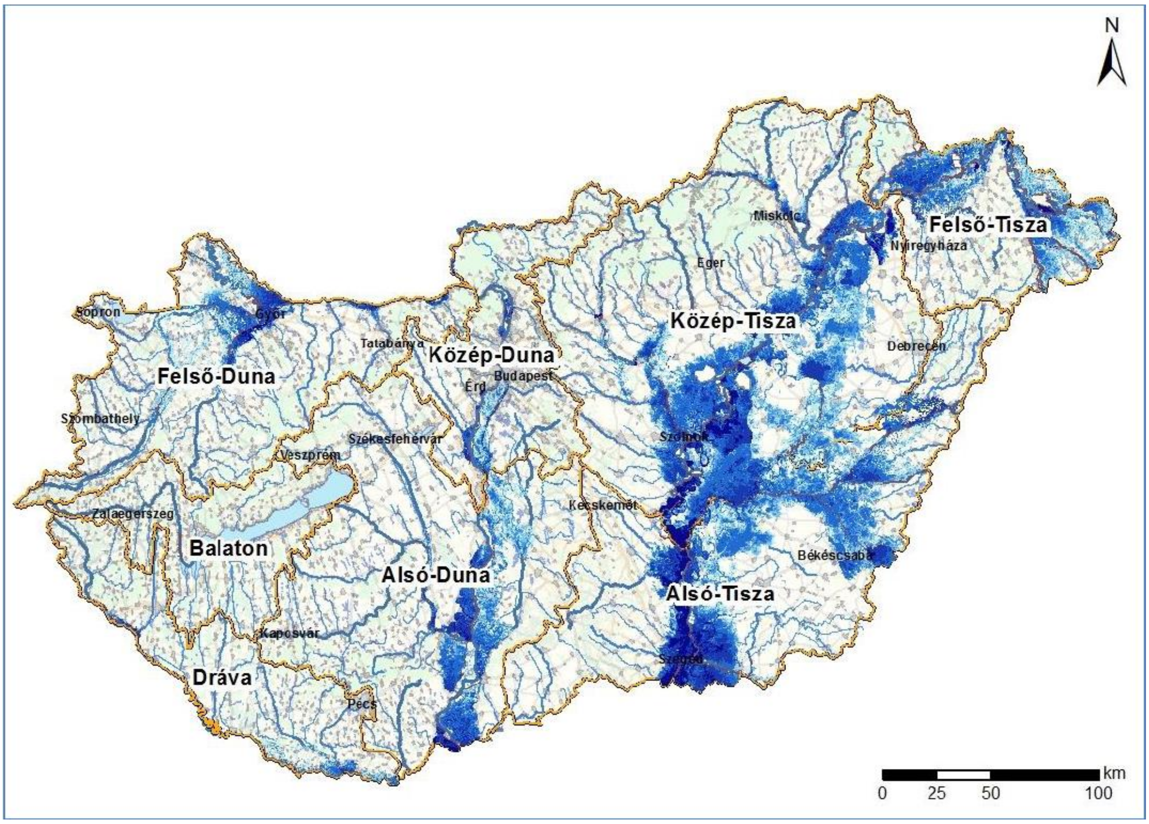



Figure 3.4. Flood hazard map in Tisza River Basin in (HUNGARY) - 1‰ probability.

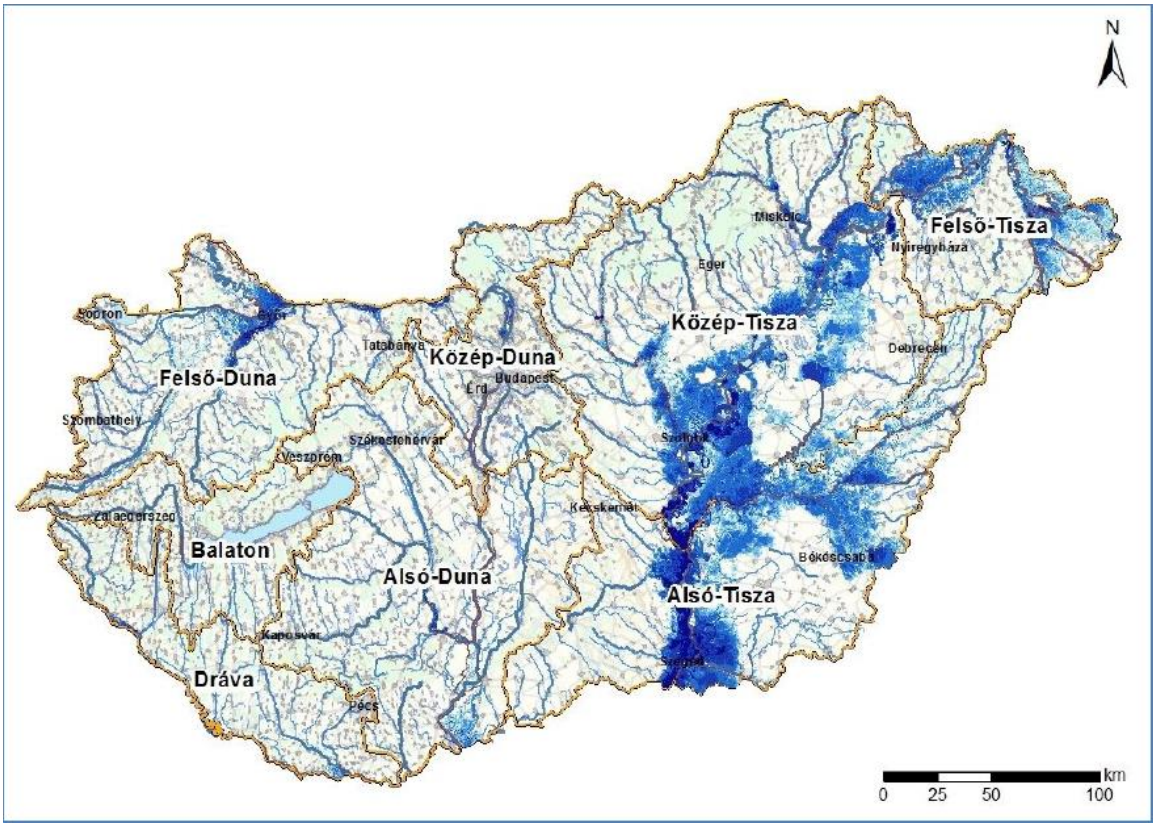



Figure 3.5. Flood hazard map in Tisza River Basin in (HUNGARY) – 1% probability.

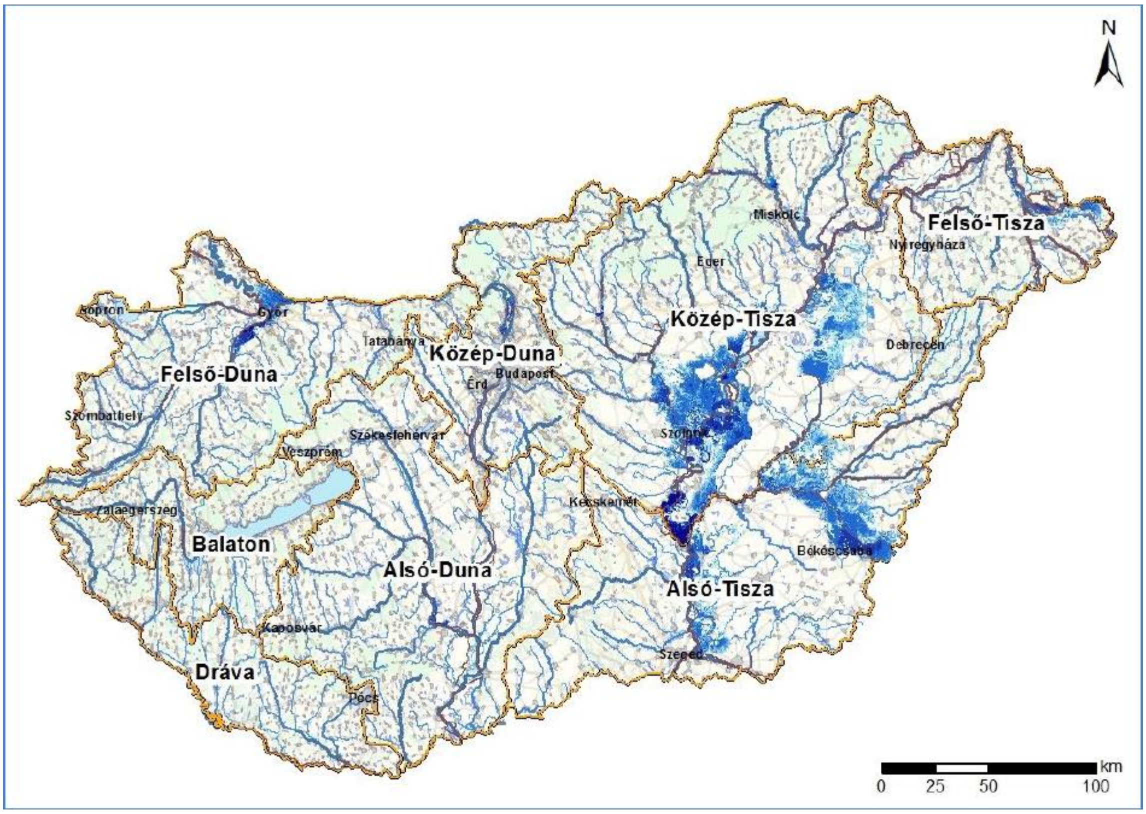



Figure 3.6. Flood hazard map in Tisza River Basin in (HUNGARY) – 3% probability.

*Flood risk assessment*

The flood risk is the probability of flooding inundation of exposure and the sensitivity of exposures to flooding. The probability of occurrence with the parameters of the hazards (water depth, water velocity) is included in the flood hazard maps. The damage curves refer to sensibility and classification of non-property values, which is the degree of inundation to what extent, damages the different values. The exposure is the sum of property and non-property values in the examined area (according to land use categories). The risk maps are produced in 50 *50 m square grid.

The flood risk assessments are made in:

- Financial risk
- Human life risk
- Evaluation of cultural heritage
- Environmental effects

A figure with map of representing the flood risk.

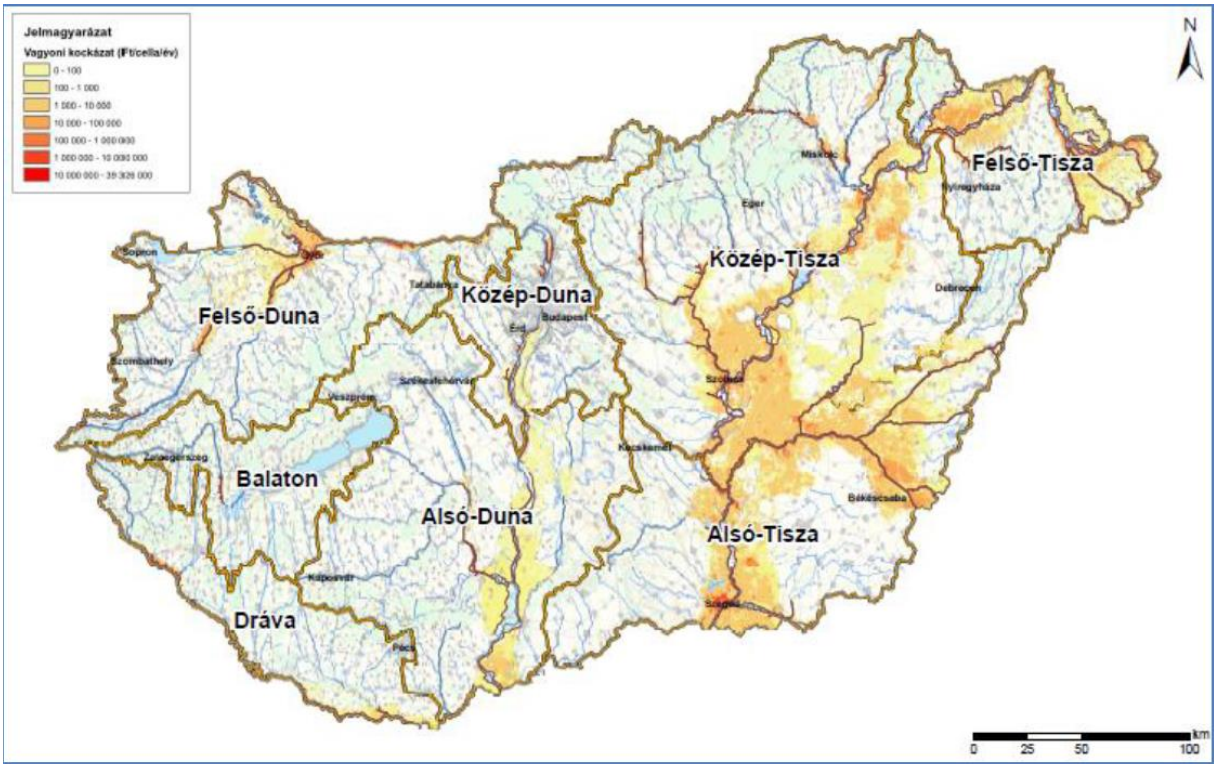



Figure 3.7. Flood risk (financial risk) map in Tisza River Basin in Hungary

*(References:* ***Hungarian Flood Risk and hazard mapping – Country report, General Directorate of Water Management, 2015)***

## Potential adverse consequences

Financial risk (Ecological damages):

The financial risk map displays the expected annual average loss value in HUF, which can be interpreted at the cell level or as a cumulative numerical value (expected annual average flood damage) in a practically delimited area.

| | Amount of financial risk (Million HUF/year) |
|---|---|
| Upper-Tisza | 16 455 |
| Middle-Tisza | 54 402 |
| Lower-Tisza | 65 486 |
| **Summarized:** | **136 343** |

Human life risk:

The human life risk values were determined as a function of flooding probability, density and load class. The load classes were created in accordance with the depth of pouring water in the area. The risk value of human life is calculated as the product of the load classes and probability of inundation.

Evaluation of cultural heritage:

We examined the size of the areas per floodplains with cultural heritage. Within this we examined the proportion of areas where objects with high risk are found.

| | Area which contains cultural heritage (ha) | The area of objects (ha) | Number of floodplains which exceed 10% |
|---|---|---|---|
| Upper-Tisza | 1356 | 140 | 3 |
| Middle-Tisza | 2262 | 116 | 3 |
| Lower-Tisza | 4670 | 36 | 1 |
| **Summarized** | **8288** | **292** | **7** |

Environmental effects (ecological damages):

The actual ecological impacts of the flood are determined by the degree of the inundation, durability, water quality and the affected type of habitat.

| | Number of affected floodplain | Area of ecological benefit (ha) | Neutral; damages and benefits appear equally (ha) | Area of ecological damages (ha) |
|---|---|---|---|---|
| Upper-Tisza | 6 | 10770 | - | 361 |
| Middle-Tisza | 16 | 2372 | 960 | 7600 |
| Lower-Tisza | 8 | 20808 | 23202 | 2474 |
| **Summarized:** | **30** | **33950** | **24162** | **10435** |

A table with statistical risk indicators at the Tisza river basin level, is proposed below:

*Table 3- 15 Statistical risk indicators*

| Consequences categories | Potential adverse consequences | Quantification (number/lenght/etc.) |
|---|---|---|
| Economic (financial risk) | **136 343** | **Million HUF/year** |
| Social | **no data** | **no data** |
| Environment (Ecological damages) | **10 435** | **ha** |
| Cultural heritage | **8 288** | **ha** |

## Estimation of the impact of Climate Change on flood risk

Describe the impact estimation of Climate Change on flood risk in (HUNGARY), related to:

- available studies regarding climate changes at national level,

http://www.met.hu/eghajlat/eghajlatvaltozas/megfigyelt_valtozasok/Magyarorszag/
http://www.kormany.hu/download/6/55/01000/Nemzeti%20V%C3%ADzstrat%C3%A9gia.pdf
http://klima.kvvm.hu/documents/14/National_Climate_Change_Strategy_of_Hungary_2008.pdf

- estimation of the impact of Climate Change on high flow at relevant hydrometric stations, max. 900 words

The model studies about the global warming argue that the climate of the Carpathian basin will be changed, the signs of which are already perceived by the Hungarian water sector. The General Directorate of Water management assessed the impacts of climate change on floods. The following changes can be observed in the water of Hungary: In Danube River a rearrangement of annual run-off can be observed which means decreasing summer low water, increasing water temperature and decreasing of ice formation. In between the Danube and the river Tisza also experienced the decreasing of run-off and the ground water level. In the Tisza River basin the annual run-off is decreasing, the flood events are more frequent. Another result of the climate change is the increasing frequency of high intensity of rainfall events, which increase the local water damage events. If the precipitation of summer decade decrease and precipitation of the winter time increase we will have to count by decreasing of infiltration and increasing of run-off. In addition to the usual spring floods, sudden and significant floods must be prepared at the most unexpected times. Data were collected and processed in connection with the Flood Risk Management Project coordinated by the General Directorate of Water Management with the involvement of the Regional Water Directorates. In summary the impact of climate change on the smaller streams and the flash floods seem clear. Larger rivers have a much greater risk uncertainty.

## International Cooperation in the Tisza River Basin

Synthesis of Bilateral Agreement/Memorandum of Understanding, etc. – max. 350 words

In order to ensure the safety against of floods in Hungary the cross-border connections are very important. That is why our country has all of the seven adjacent states with a Bilateral Water management Agreement. The conventions are based on an intergovernmental agreement for which they are responsible for the implementation of trans boundary committee or their leaders, the two co-operating government nominated and authorized alternates. The General Directorate of Water Management roles in the Hungarian-Slovakian and in the Hungarian-Serbian trans boundary committees is deputy of government agent in the Hungarian-Slovakian, Hungarian-Serbian and in Hungarian-Croatian trans boundary committees is subcommittee leader. The cross-border cooperation covers all areas of water management activities which besides the professional guidance of the General Directorate of Water Management, belong to the activities of Regional Water Directorates (flood protection, regulations, developments, EU projects, maintenance and operation of water related/hydraulic structures, hydrological data collection, data exchange, forecasts, joint reviews, etc. In the Tisza River Basin we cooperated with Ukraine, Romania, Slovakia, and Serbia.

<u>Organization of trans boundary committees (related in Tisza River Basin):</u>

Hungarian-Slovakian trans boundary committee:

- Duna Subcommittee
- Ipoly Subcommittee
- Tisza and tributaries Subcommittee
- Common Water Quality and Hydrologic Subcommittee
- Financial Subcommittee

Hungarian-Ukrainian trans boundary committee:

- Protection against water damages group
- Hydrology and water management group
- Protection against water quality damages group

Hungarian-Romanian trans boundary committee:

- Flood protection and protection against excess water subcommittee
- Water management and hydrological subcommittee
- Water quality subcommittee
- Expert group of Water Framework Directive

Hungarian-Serbian trans boundary committee:

- Protection against Water damages subcommittee
- Water management subcommittee
- Protection against water quality damages subcommittee

Bilateral agreements (related in Tisza River basin):

| Name of the bilateral agreement | Date and place of sign | Announcement of bilateral agreement |
|---|---|---|
| Between the Government of Hungarian Republic and the Government of **Czechoslovakian** on regulating water management issues | Budapest, 31st May 1976 | 55/1978 (XII.10.) Ministerial Decree |
| Between the Government of Hungarian Republic and the Government of **Ukraine** on trans boundary water management issues | Budapest, 11th November 1997 | 117/1999 (VIII 6.) Governmental Decree |
| Between the Government of Hungarian Republic and the Government of **Romania** on protection of trans boundary water courses and sustainable water management | Budapest, 15th September 2003 | 196/2004 (VI.21.) Governmental Decree |
| Between the Government of Hungarian Republic and the Government of **Yugoslavia** on water management issues | Belgrade, 8th August 1955 | Applicable from 19th August 1955 |

**Citation from the Tisza Declaration signed in Szolnok, 03. 30.2011.**

„The Tisza Valley has a key role in the Carpathian Basin from hydrogeographical point of view. River Tisza is the most significant tributary of the Danube River Basin, and its largest sub-basin in the same time. 90% of the water flow - which originates from Slovakia, Ukraine, Romania and discharges into the Danube in Serbia - runs through our country. Most of Hungary's water management and water quality problems are related to River Tisza.

The Tisza River Basin forms a unified water system and shared by several countries. Thus the work to find common and effective answers on water management problems is essential. The only possible way of solving these problems is to cooperate within a unified framework. Different interests caused by fragmentation must be solved within the basin by responsive cooperation of countries and stakeholders, in accordance with the regulations of the European Union and with the adaptation of the subsidiarity principle.

Due to its high magnitude, an independent group within the International Commission for the Protection of the Danube River (ICPDR) deals with the integrated water management of the Tisza River Basin as a sub-basin, furthermore it appears as a separate unit in the Danube River Basin Management Plan as well. The Integrated Tisza River Basin Management Plan has been developed with the aspects of water damage prevention and integrated management of water quality and quantity, that goes beyond the requirements of the Water Framework Directive and mutually important for the five interested countries. Coordination and supervision of the implementation, avoidance of parallelisms and reinforcement of synergies are important tasks of the plan."

„Further objectives are to facilitate the implementation of the EU Strategy for the Danube Region in the Tisza River Basin, the integrated management of water quantity and quality issues, elaboration of proposals concerning the mitigation of effects of climate change.”

# Abbreviations

| | |
|---|---|
| Abbrev 1 | Text text text |
| Abbrev 2 | Text text text |
| Abbrev 3 | Text text text |
| Abbrev 4 | Text text text |
| Abbrev 5 | Text text text |

# References


1. http://www.oecd.org/hungary/Water-Resources-Allocation-Hungary.pdf

2. *György Less 2011 Geology of Hungary; János Haas (ed) 2012 Geology of Hungary*

3. Hungarian Flood Risk and hazard mapping – Country report, General Directorate of Water Management, 2015

4. http://www.environ.hu/public/Publikaciok/2001_arviz_angol.pdf

5. https://www.icpdr.org/main/sites/default/files/Flood%20and%20Drought%20Strategy%20of%20the%20Tisza%20River%20Basin_V_clean.pdf

6. http://www.met.hu/eghajlat/eghajlatvaltozas/megfigyelt_valtozasok/Magyarorszag/

7. http://www.kormany.hu/download/6/55/01000/Nemzeti%20V%C3%ADzstrat%C3%A9gia.pdf

8. http://klima.kvvm.hu/documents/14/National_Climate_Change_Strategy_of_Hungary_2008.pdf

Project co-funded by the European Union (ERDF, IPA funds)

Partners: General Directorate of Water Management, Hungary | Global Water Partnership Central and Eastern Europe, Slovakia | International Comission for the Protection of the Danube River, Austria | Ministry of Environment, Water and Forest, Romania | Ministry of Foreign Affairs and Trade, Hungary | National Administration "Romanian Waters", Romania | National Institute of Hydrology and Water Management, Romania | Public Water Management Company "Vode Vojvodine", Serbia | Regional Environmental Center for Central and Eastern Europe, Hungary | The Jaroslav Černi Institute for the Development of Water Resources, Serbia | Water Research Institute, Slovakia | World Wide Fund for Nature Hungary

Associated Partners: Interior Ministry, Hungary | Republic of Serbia Ministry of Agriculture and Environmental Protection – Water Directorate | Secretariat of the Carpathian Convention (SCC), Austria | State Agency of Water Resources of Ukraine | Tisza River Basin Water Resources Directorate, Ukraine