

## CHANGES OF THE GROUND WATER REGIME IN THE AREA LOCATED BETWEEN THE RIVERS DANUBE AND TISZA

J. SZALAI<sup>1</sup>

**ABSTRACT.** – Changes of the groundwater regime in the area located between the Rivers Danube and Tisza. Flatlands, especially the Great Hungarian Plain (also known as Alföld) play a significant role in the economic life of Hungary and play a determining role in agriculture and sylviculture. The hydrographical relations of flatlands define the framework of crop farming, within this the changes and movement of ground water in space and time. During the last decades the ground water regime of the Great Hungarian Plain has gone through significant changes. In certain regions, especially in the higher parts of the area located between the Rivers Danube and Tisza (also known as Duna-Tisza köze) the ground water level was significantly and permanently below the average of many years, which created new conditions and risks mainly for agriculture and forest management.

**Key words:** flatland, alluvial plain, groundwater, groundwater monitoring well, ground water level decline, risks, natural environment.

### 1. Introduction

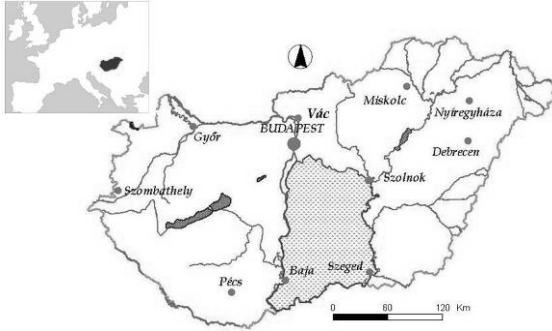
The area between the Rivers Danube and Tisza (also known as Duna-Tisza köze) is located in the middle of Hungary, in northern-southern direction with a unique water management system. During the last decades the area's ground water management system has gone through significant changes and resulted in significant ground water level decline affecting large areas (Figure 1).

This process was first detected in the higher areas of Hátság at the beginning of the 1970s, and later on spread to the edges and also to the lower-lying areas. By the end of the first third of the 1990s the territorial spread of the decline and the extent of the changes reached their peak. In the middle of the 1990s the process started to slow down, became stagnant and in certain areas the entire process reversed. In 1999 and 2000 the ground water stocks were significantly topped up for the first time for a very long time and in 2007 and 2010 similar

---

<sup>1</sup> VITUKI Environmental and Water Management Research Institute, 1095 Budapest, Hungary, e-mail szalai.jozsef@vituki.hu

tendencies were detected. During these years in certain parts of the area located between the Rivers Danube and Tisza with altitude above sea level extensive areas were covered by inland waters. Droughty summers (2000, 2007) and few years with low amount of precipitation were not favourable for the further increase of ground water stocks, and the ground water level started to decrease again.



**Figure 1.** Location of the area of case study.

This process was first detected in the higher areas of Háttság at the beginning of the 1970s, and later on spread to the edges and also to the lower-lying areas. By the end of the first third of the 1990s the territorial spread of the decline and the extent of the changes reached their peak. In the middle of the 1990s the process started to slow down, became stagnant and in certain areas the entire process reversed. In 1999 and 2000 the ground water stocks

were significantly topped up for the first time for a very long time and in 2007 and 2010 similar tendencies were detected. During these years in certain parts of the area located between the Rivers Danube and Tisza with altitude above sea level extensive areas were covered by inland waters. Droughty summers (2000, 2007) and few years with low amount of precipitation were not favourable for the further increase of ground water stocks, and the ground water level started to sink again.

As a result of the decline of ground water level and the reduction of surfaces covered in water not only the micro-climate of the area significantly worsened, but the natural endowments of the historical, traditional and area-specific agriculture have also changed. For agriculture and silviculture – especially in the region of Háttság – the relations of precipitation in space and time and also the changes of ground water levels constitute a huge risk. The importance of the water stocks stored in the ground is proved by the hydrological conditions of the year 2011. Despite of the periods with minimum precipitation during the spring, early summer and end of summer, favourable yields were due to the utilisation of water stocks stored in the ground.

## **2. Landscape of the area located between the rivers Danube and Tisza (also known as Duna-Tisza köze)**

The flatland located between the Rivers Danube and Tisza is bordered by the Rivers Danube and Tisza, the southern state border and Gödöllő Hills (Gödöllői-dombság) with a total ground-space of nearly 10 000 km<sup>2</sup> featuring

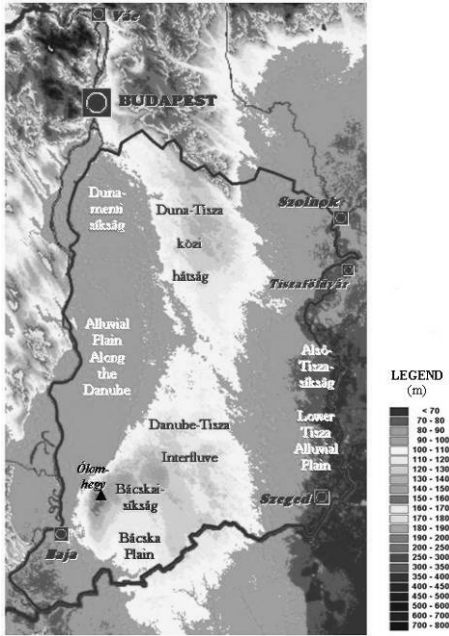
diversified landforms (bordered by approximately Vác-Szolnok-Szeged-Baja-Vác polygon) (Figure 1). The entire area consists of four geographical units: Alluvial Plain Along the Danube (Dunamenti-síkság), Danube-Tisza Interfluve (Duna-Tisza közí hátság) and Tisza, Bácska Plain (Bácskai-síkság) and Lower-Tisza Alluvial Plain (Alsó-Tisza-síkság) (Hajdú-Moharos, Hevesi, 1999) (Figure 2).

The western border is an alluvial cone flatland with a length of 240 kilometres and a width of 20 to 25 kilometres, stretching along the River Danube starting from the town of Vác and finishing at the southern state border, which was the former flood area of the river. In the northern part of this region, mainly in the capital's surrounding area diversified landforms can be seen. The higher areas feature terrace remnants, while the lower-lying parts are flood plains. The terraces are made of loessal sand and moving sand, while the flood plains are made of fine-grain fresh water sediment. In the south the surface carries on as a perfect flatland. The lower flood plains are covered in impermeable muddy-clay sediment, while the higher flood areas are covered in flood mud, flood sand and in some parts moving sand from the rivers. Saline lakes were formed in the abandoned river beds and in areas without outlets. A gravel layer of 10 to 20 metres is located underneath the surface formations (Pécsi, 1959, Bulla, 1962, Neppel et al. 1999).

The Danube-Tisza Interfluves (Duna-Tisza közí hátság) with an altitude of 100 to 130 metres, stretching from Gödöllő Hills (Gödöllői-dombság) to Bácska Plain (Bácskai-síkvidék) covers a total area of 7400 km<sup>2</sup>. The surface forms were mainly created by the wind and secondly by water. The curved formations located in the western part of the region were formed by the side branches of the River Danube. These areas were flooded by the river and were filled up by fine-grain sediment. Diversified sand forms and coves were formed as a result of the wind's surface-forming activity. The extensive flat or slightly rolling plains are broken up by island-like sand-dunes as a result of the wind activity with larger altitude difference. In general these sand dunes are only a few kilometres wide, but some of them feature a diameter of over 10 kilometres. The areas covered in moving sand are characterised by wind grooves, hummocks and remnant ridges, and even parabola dunes can be found in some areas. In the grooves between the sand dunes usually wet and boggy areas often with no outlets, lakes and meadows –temporary covered in water- were formed (Lóki, 1999, Mezősi, 2011). Underneath the boggy areas very often limestone sediment layers were formed with a total thickness of 20 to 30 cm. This sediment layer is called alluvium limestone, which is used by the construction industry.

Bácska Plain (Bácskai-síkvidék) located on the south-western part of the area between the Rivers Danube and Tisza (Duna-Tisza köze), with an altitude of 100 to 175 metres stretches beyond the state border, carries on in the territory of Serbia as a loess plateau and breaks off towards the west over the valley of the River Danube with a steep edge, while in the west, towards the Danube-Tisza Interfluves (Duna-Tisza közí hátság) the transition is gradual.

The diversified moving sand formations of the sediment cone are covered in loess and sandy loess layers with a thickness of few metres, offering a great basis for a high-quality black earth layer, rich in nutrients and limestone (Lóki, 1999a)



**Figure 2.** Physical geographical division of the area between the Rivers Danube and Tisza (Duna-Tisza köze) with the names of the main geographical units occurring in the text.

to 25 kilometres, stretching along the River Danube starting from the town of Vác and finishing at the southern state border, which was the former flood area of the river. In the northern part of this region, mainly in the capital's surrounding area diversified landforms can be seen. The higher areas feature terrace remnants, while the lower-lying parts are flood plains. The terraces are made of loessal sand and moving sand, while the flood plains are made of fine-grain fresh water sediment. In the south the surface carries on as a perfect flatland. The lower flood plains are covered in impermeable muddy-clay sediment, while the higher flood areas are covered in flood mud, flood sand and in some parts moving sand from the rivers. Saline lakes were formed in the abandoned river beds and in areas without outlets. A gravel layer of 10 to 20 metres is located underneath the surface formations (Pécsi, 1959, Bulla, 1962, Neppel et al. 1999).

The eastern border section of the area located between the Rivers Danube and Tisza is called the Lower Tisza Alluvial Plain (Alsó-Tisza-síkság) stretching from Tiszaföldvár all the way to the southern state border featuring a very low-lying area of 79 to 85 meters above sea level with a Holocene alluvial flatland. The western border of the geographical unit is marked by a definite border line provided by the edge of the ridge located between the Rivers Danube and Tisza (Danube Tisza Interfluves). Towards the east the area cannot be marked easily due to the gradual elevation of the surface. Here the surface is diversified by loop lakes, ox-bow lakes and deposit formations created by wind activity with eroding edges (Lóki, 1999b).

The western border is an alluvial cone flatland with a length of 240 kilometres and a width of 20

The Danube-Tisza Interfluves (Duna-Tisza közí hátság) with an altitude of 100 to 130 metres, stretching from Gödöllő Hills (Gödöllői-dombság) to Bácska Plain (Bácskai-síkvidék) covers a total area of 7400 km<sup>2</sup>. The surface forms were mainly created by the wind and secondly by water. The curved formations located in the western part of the region were formed by the side branches of the River Danube. These areas were flooded by the river and were filled up by fine-grain sediment. Diversified sand forms and coves were formed as a result of the wind's surface-forming activity. The extensive flat or slightly rolling plains are broken up by island-like sand-dunes as a result of the wind activity with larger altitude difference. In general these sand dunes are only a few kilometres wide, but some of them feature a diameter of over 10 kilometres. The areas covered in moving sand are characterised by wind grooves, hummocks and remnant ridges, and even parabola dunes can be found in some areas. In the grooves between the sand dunes usually wet and boggy areas often with no outlets, lakes and meadows –temporary covered in water- were formed (Lóki, 1999, Mezősi, 2011). Underneath the boggy areas very often limestone sediment layers were formed with a total thickness of 20 to 30 cm. This sediment layer is called alluvium limestone, which is used by the construction industry.

Bácska Plain (Bácskai-síkvidék) located on the south-western part of the area between the Rivers Danube and Tisza (Duna-Tisza köze), with an altitude of 100 to 175 metres stretches beyond the state border, carries on in the territory of Serbia as a loess plateau and breaks off towards the west over the valley of the River Danube with a steep edge, while in the west, towards the Danube-Tisza Interfluves (Duna-Tisza közí hátság) the transition is gradual.

The diversified moving sand formations of the sediment cone are covered in loess and sandy loess layers with a thickness of few metres, offering a great basis for a high-quality black earth layer, rich in nutrients and limestone (Lóki, 1999a)

The eastern border section of the area located between the Rivers Danube and Tisza is called the Lower Tisza Alluvial Plain (Alsó-Tisza-síkság) stretching from Tiszaföldvár all the way to the southern state border featuring a very low-lying area of 79 to 85 meters above sea level with a Holocene alluvial flatland. The western border of the geographical unit is marked by a definite border line provided by the edge of the ridge located between the Rivers Danube and Tisza (Danube Tisza Interfluves). Towards the east the area cannot be marked easily due to the gradual elevation of the surface. Here the surface is diversified by loop lakes, ox-bow lakes and deposit formations created by wind activity with eroding edges (Lóki, 1999b).

The area called Hátság is the part of the area located between the Rivers Danube and Tisza with an altitude of over 100 metres, and includes the parts of Danube Tisza Interfluves (Duna-Tisza közí hátság) and Bácska Plain (Bácskai-síkság) (VITUKI, 2006). The northern-southern section of Hátság shows a saddle-shaped picture. The northern part features an altitude between 140 to 150 meters; it

drops towards the south to 115–120 metres and increases over 170 metres. The highest point called Ólom-hegy (Ólom Hill) features an altitude of 174 metres above sea level. The area of Hátság features only very few surface waters; there is no permanent water course in the area. Surplus waters are transported by temporary water courses and internal water channels towards the Rivers Danube and Tisza. Majority of the channels established in the course of water management works dried up due to the lack of precipitation and ground water decline.

The focus area of this case study is an area smaller than the area located between the Rivers Danube and Tisza in terms of landscape geographical meaning. The ground water relations of the areas located up north, which are densely populated by residential and industrial areas, are strongly influenced; therefore it is suggested to investigate these areas separately.

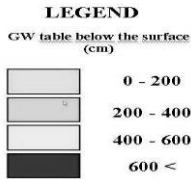
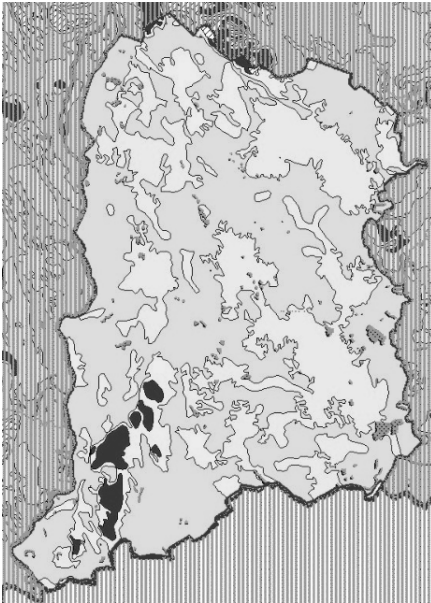
### **3. Changes of ground water levels in the area located between the rivers Danube and Tisza**

The knowledge about the placement of the water table below ground level is vital during resolving various water management tasks (e.g. agriculture, silviculture) both in terms of utilisable water stocks and the possibilities of replacement. In the area located between the Rivers Danube and Tisza during various analyses with respect to the period between 1956 and 1960, which was considered as a comparison period it was very obvious that the water table was located below 6 meters only in Bácska flatland (Bácskai-síkvidék) and in the southern foreground of Gödöllő Hills (Gödöllői-dombság) (Figure 3).

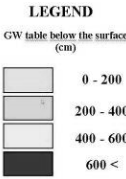
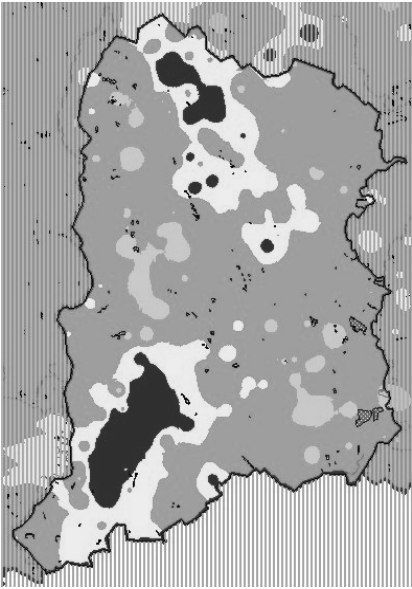
Northern and southern parts of the area located between the Rivers Danube and Tisza featured a ground water level of 4 to 6 metres below ground level. The ratio of such areas was very low, only accounted to 10%. The areas with a ground water level of 2 to 4 metres were significant, similar sized to the areas with a ground water level of 0 to 2 metres. The latter ones were located in the north-western, north-eastern and south-eastern parts of the areas located between the Rivers Danube and Tisza. In the middle, lower-lying areas also higher ground water levels were detected.

As a result of the analysis carried out in the year 2001 it can be stated that the ratio of areas with high ground water level (between 0 to 2 metres) has significantly dropped (Figure 4).

Larger areas remained only in the area of the flatland stretching along the River Danube. Also the size of the areas with a water table height between 4 to 6 metres has significantly increased. Their previous proportion has tripled, increased to over 30%. The area growth is detected mainly in the north-western and south-western parts of Hátság. The ratio of areas with a ground water level below 6 metres mainly increased in the higher districts of Hátság.

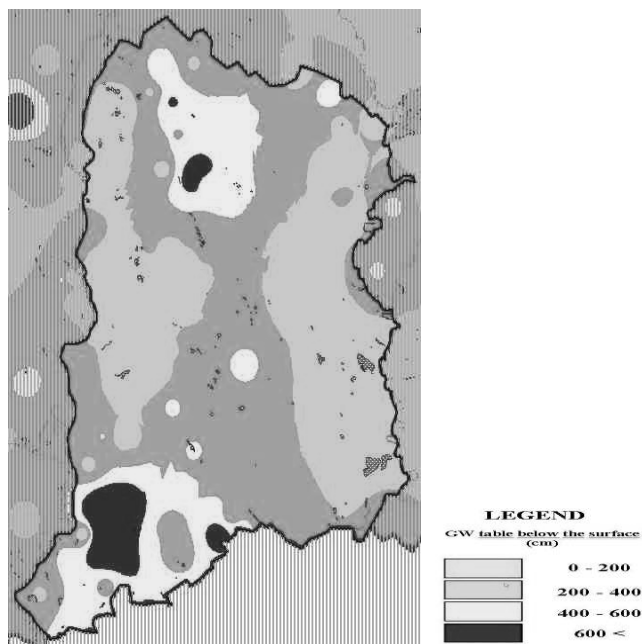


**Figure 3.** Average depth of the GW table below ground surface in the period of 1956-1960 (based on digitalised version of VITUKI, 1962.



**Figure 4.** Average depth of the GW table below ground surface in 2001.

As a result of the extremely wet year of 2010, the size of the areas with high ground water level (0-2 metres) has significantly increased in the flatland stretching along the River Danube (Dunamenti-síkság), in the Lower Tisza Alluvial Plain (Alsó-Tisza-síkság) and in the eastern edges of the Hátság area. In the flatland located between the Rivers Danube and Tisza, mainly in the Hátság area, furthermore in the edges of Bácska Plain (Bácskai-síkság) the ground water levels were about 4 to 6 metres below ground level. The size of the northern and south-western parts of the area located between the Rivers Danube and Tisza hit by the biggest drops was reduced. The replacement of the ground water stocks in such areas will only happen with a significant delay in time (Figure 5).



**Figure 5.** Average depth of the GW table below ground surface in 2010.

## REFERENCES

1. Bulla, B. (1962), *Magyarország természeti földrajza*, Tankönyvkiadó, Budapest.
2. Hoyk, E. (2006), *A szárazodás hatása a vegetáció alakulására a homokhátsági szikes tavak példáján*. In: *Táj, környezet és társadalom. Ünnepi tanulmányok (Keveiné Bárány Ilona professzor asszony tiszteletére)*, SZTE Éghajlattani és Tájföldrajzi Tanszék, SZTE Természeti Földrajzi és Geoinformatikai Tanszék, Szeged, Szerkesztette: Kiss A., Mezősi, G., Sümeghy, Z.
3. Hajdú-Moharos, J., Hevesi, A. (1999), *A kárpát-pannon térség tájtagolódása. Pannon Encyclopaedia Magyarország földje* (Pannon Encyclopaedia The land that is Hungary – geology, geography and cartography of Hungary and its surroundings) Karátson, D., pp. 274-284. Kertek 2000 Publishing House, Budapest, Hungary, ISBN 963-85792-3-4.
4. Kovács J., Szabó P., Szalai J. (2004), *A talajvízállás idősorok vizsgálata a Duna-Tisza közén*, Vízügyi Közlemények, LXXXVI. évfolyam, 3-4. füzet, pp. 607–624.
5. Kovács, J., (2007), *The application of modern geomathematical methods in practical hydrogeology* (in hungarian, with english abstract), Ph.D. dissertation, p. 122 (manuscript).
6. Lázár, M. (2007), *A Duna-Tisza közti talajvizek vizsgálata dinamikus faktoranalízissel*, Diplomadolgozat, ELTE TTK., Alkalmazott és Környezetföldtani Tanszék, Budapest.



7. Liebe, P. (1994), *A rétegvízkezelések és a nyomásszintek változása a Duna–Tisza közí hátságán és azok hatásai a talajvízszintekre.* – In: Pálfi I. (szerk.): *A Nagyalföld Alapítvány Kötetei 3. A Duna–Tisza közí hátság vízgazdálkodási problémái.* – Nagyalföld Alapítvány, Békéscsaba. pp. 111–126. ISBN 963 04 3942 1, ISSN 1216-4933.
8. Lóki, J. (1999a), *A dunai Alföld,* In: *Pannon Encyclopaedia Magyarország földje* (Pannon Encyclopaedia The land that is Hungary – geology, geography and cartography of Hungary and its surroundings) Karátson, D., Kertek 2000 Publishing House, Budapest, Hungary, pp. 298-299. ISBN 963-85792-3-4.
9. Lóki, J. (1999b), *A tiszai Alföld,* In: *Pannon Encyclopaedia Magyarország földje* (Pannon Encyclopaedia The land that is Hungary – geology, geography and cartography of Hungary and its surroundings) Karátson, D., Kertek 2000 Publishing House, Budapest, Hungary, pp. 300-301., ISBN 963-85792-3-4.
10. Major, P., Neppel, F. (1988), *A Duna–Tisza közí talajvízszint-süllyedések,* *Vízügyi Közlemények,* LXX. pp. 605-626.
11. Major, P. (1994), *Talajvízszint-süllyedések a Duna-Tisza közén.* A Nagyalföld Alapítvány kötetei 3. A Duna–Tisza közí hátság vízgazdálkodási problémái. – Nagyalföld Alapítvány, Békéscsaba. pp. 17–24. ISBN 963 04 3942 1, ISSN 1216-4933.
12. Mezösi, G. (2011), *Az Alföld természeti képezének kialakulása* In: Rakonczay J. (szerk.) 2011: *Környezeti változások és az Alföld* A Nagyalföld Alapítvány Kötetei 7 - Nagyalföld Alapítvány, Békéscsaba. pp. 15–24. ISBN 978 963 85437 8 3.
13. Pálfi, I. (1994), *Összefoglaló tanulmány a Duna–Tisza közí talajvízszint-süllyedés okairól, és a vízhiányos helyzet javításának lehetőségeiről.* – In: Pálfi I. (szerk.) 1994: *A Nagyalföld Alapítvány Kötetei 3. A Duna–Tisza közí hátság vízgazdálkodási problémái.* – Nagyalföld Alapítvány, Békéscsaba. pp. 111-126. ISBN 963 04 3942 1, ISSN 1216-4933.
14. Pécsi, M. (1959), *A magyarországi Duna-völgy kialakulása és felszínalakulása (Genesis and surface morphology of the Hungarian Danube Valley,* (in Hungarian). Földrajzi Monográfiák, Vol.3, Akadémiai Kiadó, Budapest.
15. Rakonczai, J. (2011), *Effects and Consequences of Global Climate Change in the Carpathian Basin,* *Climate Change - Geophysical Foundations and Ecological Effects,* J. Blanco and H. Kheradmand (Ed.), ISBN: 978-953-307-419-1, InTech, Available from: <http://www.intechopen.com/articles/show/title/effects-and-consequences-of-global-climate-change-in-the-carpathian-basin>.
16. Szalai, J. (2004), *A hidrológiai közelmúlt sajátosságai a talajvízszintekben,* *Vízügyi Közlemények,* 2004. 1-2. füzet.
17. Szalai, J., Nagy, Gy. (2006), *Az utóbbi évtized időjárási eseményeinek hatása a talajvízszintek alakulására a Duna-Tisza közén* – Magyar Hidrogeológiai Társulat XXIV. Országos Vándorgyűlése, Konferencia, Pécs, 2006.
18. Szodfridt, I. (1994), *Az erdők és a talajvíz kapcsolata a Duna–Tisza közí homokhátságán.* – In: Pálfi I. (szerk.) 1994: *A Nagyalföld Alapítvány Kötetei 3. A Duna–Tisza közí hátság vízgazdálkodási problémái.* – Nagyalföld Alapítvány, Békéscsaba. pp. 59–66. ISBN 963 04 3942 1, ISSN 1216-4933.
19. 20- VITUKI, (1962), *Talajvíztérkép,* Vízgazdálkodási Kutató Intézet, Vízrajzi Intézet, Budapest.

20. 21. VITUKI, (2002), *Régiók hidrológiai állapotértékelése – Duna-Tisza köze 2001*, p. 72, VITUKI Rt. Hidrológiai Intézet, Budapest.
21. 22. VITUKI, (2006), *A Duna-Tisza közti hátság hidrometeorológiai, felszíni és felszín alatti vizeinek mennyiségére vonatkozó mérő- és megfigyelőrendszer működtetése és értékelése*, Zárójelentés, VITUKI Kht., Hidrológiai Intézet, Budapest.
22. 23. VITUKI, (2010), *Magyarország vízkészleteinek állapotértékelése 14., kötet*, p. 29, VITUKI Nonprofit Kft, Hidrológiai Intézet, Budapest.

Riscuri și Catastrofe  
An X, Vol 9, Nr. 2/2011