Water resources management and its homeland security aspect in Hungary

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Summary

As a consequence of climate change, extreme weather events will have a profound impact on water resources, environmental security and long-term social compatibility. This is particularly true in the Danube river basin countries. Declining water resources and increasing foreign water use due to climate change could pose a serious security challenge for Hungary in the future. This is because our water resources are significant, but also vulnerable, as more than 95 percent of the water in our watercourses comes from across the border. This case study summarises the floods in the DRB over the last two decades and provides a more detailed analysis of Hungary. It also assesses water-related risks as a domestic security issue, based on national and international literature.

Keywords: floods, drought, water scarcity, climate change, security policy

Vízbiztonság mint belbiztonság Magyarországon

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Összefoglalás

A szélsőséges időjárási körülmények, mint az éghajlatváltozás következményei, negatívan hatnak a vízkészletekre, a környezet biztonságára és egyes közép-európai országok, mint például Magyarország, társadalmi viszonyaira is. A szélsőséges események, mint az árvizek és az aszályok fokozódása, jelentős hatással van a közgazdasági mutatókra is. Emellett a mindennapi életünk részévé váltak a korábban extrémnek minősített időjárási események, de negatívan hatnak a mezőgazdaságra, az erdőgazdaságra, az iparra, valamint az épített környezetre és az infrastruktúrára is. Az éghajlatváltozás miatt csökkenő vízkészletek és a növekvő külföldi vízfelhasználás Magyarország számára komoly biztonságpolitikai kihívást jelenthet a jövőben. Ennek oka, hogy bár a hazai vízkészletek jelentősek, ugyanakkor nagyon sérülékenyek is, hiszen vízfolyásaink vízkészleteinek több mint 95 százaléka a határon túlról származik. Az alvízi helyzetből való kitettségünk magas, ezért a vízkészletek tekintetében függünk a felvízi országoktól. Különösen igaz ez vízhiány idején. A 19 országot érintő Duna-vízgyűjtő területe a világ „legnemzetközibb" vízgyűjtőjének tekinthető, így számos kihívás éri a területén fekvő országokat. Egymástól való függőségük jelentős, ezért különösen fontosak a vízgyűjtő szintű együttműködések. Ilyen például az EU Duna Régió Stratégiája, amely integrált keretet biztosít a nemzetek közötti együttműködés megerősítéséhez. Ennek keretében 12 prioritási területen, 115 millió embert fog össze és teszi számukra a környezetet biztonságosabbá azáltal, hogy a célkitűzések között szerepel többek között az árvízkockázat csökkentése, valamint a vízhiányból fakadó kihívások kezelése. Ezekre a kihívásokra csak együtt lehet hatékony választ adni, európai, illetve regionális szinten történő összefogás keretében. A vízzel és éghajlatváltozással összefüggő természeti katasztrófák közül Európában jelenleg az árvíz a legkockázatosabb esemény. Az elmúlt évszázadok során a Duna-medence országai számos katasztrofális árvízi eseményt szenvedtek el. Ezzel összefüggésben a tanulmány ismerteti a Dunán az utóbbi két évtizedben levonult árvizek hatásait, különös tekintettel Magyarországra. Az elmúlt 20 év áradásai egyértelművé tették, hogy Magyarországon rendkívüli árvizekkel kell számolni a jövőben is. Hazánk szükségszerűen és helyesen ismerte fel az ár- és belvízi védekezés, valamint az árvízi kockázat csökkentésének belbiztonsági jelentőségét. Jelen cikk a hazai és nemzetközi szakirodalom alapján tárgyalja a Magyarországon és a Duna vízgyűjtőjén felmerülő, az előzőekben említett vízgazdálkodási témakörökkel összefüggő biztonságpolitikai kihívásokat és kockázatokat.

Kulcsszavak: árvíz, aszály, vízhiány, klímaváltozás, biztonságpolitika

Introduction

Security is a feeling that is of paramount importance to all people, which is why they want it. Throughout the history of mankind, a number of threats to security have been documented in contemporary sources, and these have expanded with, for example, globalisation, the development of scientific disciplines and climate change. Recognising the threats and taking the necessary action is essential to creating a secure future. Accordingly, the authors aim to review the threats to water security in Hungary and to outline possible directions. The results of the publication include the achievement of the objectives described above and the formulation of areas for intervention and recommendations.

In this publication, the following concepts are of particular importance: homeland security and its areas, and water security and its sub-areas. In the context of homeland security activities, we are talking about specialised counter-intelligence tasks that protect the geographical, social and economic interests of a country. The areas of homeland security include water security, which is not only the provision of drinking water of sufficient quality and quantity. It also includes protection against water damage and mitigation of damage caused by water shortages *(Ijjas–Somlyódy–Józsa 2017; Finszter–Sabjanics 2017)*.

About 70% of the Earth's surface is covered by water, while liquid freshwater accounts for only 1% of global water supplies. The amount of surface water stored in lakes, reservoirs, and rivers is only 0.007 percent of all water resources. Sufficient water supply, which is taken for granted, especially for the developed world, is therefore apparent, in fact it implies water as a limited natural resource. In the focus of global thinking on water are, responses to the key challenges that determine the state of this scarce resource, particularly population explosion, urbanization and climate change (*O'Neill 2018)*. The rate of global population growth is declining, yet by 2050 the world's population is still expected to grow to 9 billion. Within this, the population of cities is growing at an accelerating pace, especially in the developing world, and as a consequence of this realignment, the water supply and basic hygiene (sanitation/wastewater treatment) needs of the giant settlements are already unmanageable problems in many countries. As a result of growing demand, water abstraction rates have tripled in the last 50 years *(Wada–van Beek–Bierkens 2011)*.

One of the biggest challenges facing complex water science is the management of multi-scale and increasingly complex environmental and social crises, damage mitigation, development and implementation of adaptation strategies. Numerous studies show that the number and intensity of extreme weather events are increasing, and quite a few of them are directly related to the global water cycle *(Bozó 2017)*.

The hydrological cycle is becoming faster, due to climate change, wetter regions tend to get even wetter and drier areas are getting even drier. Extreme weather conditions, as consequences of climate change, have a negative effect on water resources, environmental safety and the long term social compatibility of some countries in central Europe, e.g. Hungary. Higher demand and in-

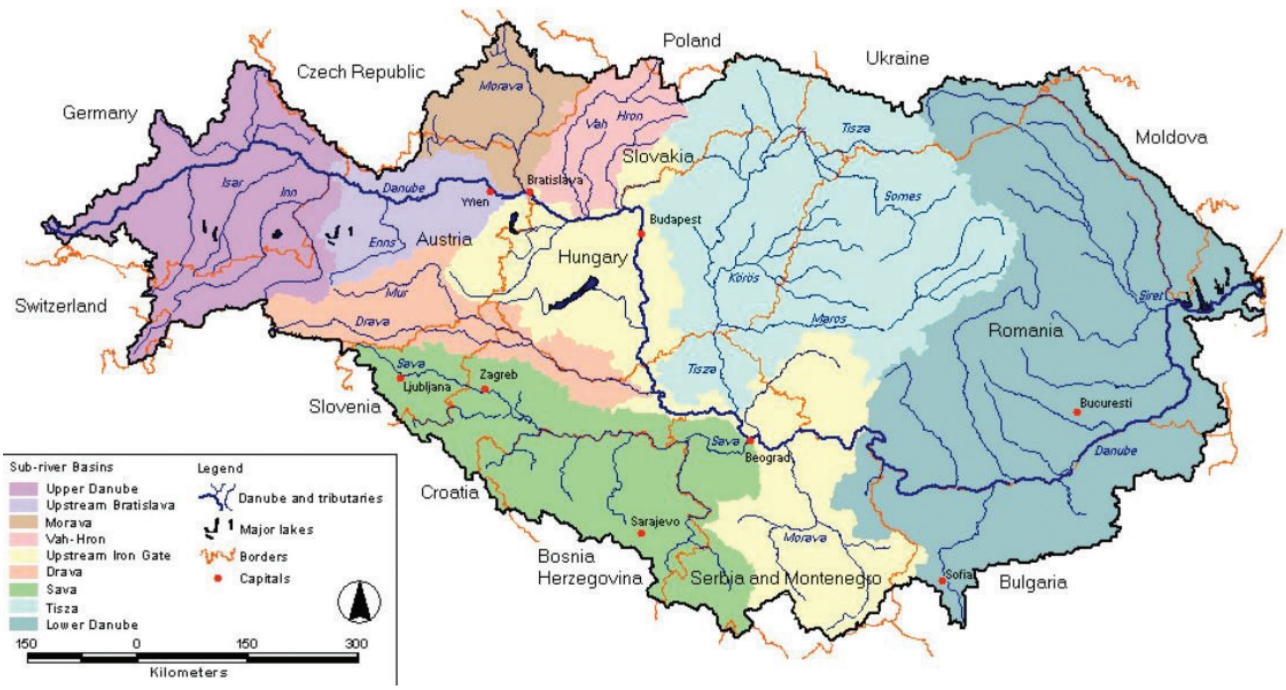

Figure 1 Danube River Basin

Source: ICPDR Flood Protection Expert Group, 2008 creased challenge of various economic sectors for ever decreasing water resources may be predicted. Climate change demands more and more attention and sustainable water usage needs to be a priority.

National and social status can only be sustained in case water resources are managed by strict economic and engineering standards and river basin-wide planning as well. Water resources can never be managed only by accepting engineering capacities, but officials need to manage complete river basins by carefully balancing different economic sectors' financial and social demands.

Geographical, hydrological background

The DRB is the "most international" river basin in the world, covering territories of 19 countries, with an area of 807 827 km², and Danube is the second largest River in Europe and has a lot of tributaries as well *(Figure 1)*. The DRB originates in the town of Donaueschingen, in the Black Forest of Germany, at the confluence of the rivers Brigach and Breg. The confluence of the Breg and Brigach is called the source of the Danube. The source of the Breg is the larger of the two rivers. The Danube flows predominantly to the south-east and reaches the Black Sea after approximately 2857 km, dividing into the 3 main branches, the Chilia, the Sulina, and the Sf. Gheorghe Branch. At its delta the Danube has an average discharge of about 6460 $m^3 s^{-1}$. The Delta lies in Romania and partly in Ukraine and is a unique "UNESCO World Heritage Site". The entire protected area covers 675 000 ha including floodplains, natural lakes and marine areas. The Danube is the largest tributary of the Black Sea.

EU Strategy for the Danube Region (EUSDR)

The EUSDR is a "Macro-regional strategy", that is an integrated framework endorsed by the European Council to address common challenges in a defined geographical area relating to EU Member States and third countries, which thereby benefit from strengthened cooperation, contributing to the achievement of economic, social and territorial cohesion.

The EUSDR intends to develop coordinated policies and actions in the area of the DRB, reinforcing the commitments of the Europe 2020 strategy towards smart, sustainable and inclusive growth, based on four pillars and twelve priority areas. These shall tackle key issues as mobility, energy, biodiversity, socio-economic development or safety.

The EUSDR is one of four EU macro-regional strategies (MRS) in Europe. It provides an integrated framework for strengthening cooperation between nations. Bringing together 115 million people from nine EU member states, three EU candidate countries and two EU neighbouring countries, it has an important integrative and cohesive function, whose 12 priority areas are listed below:

1a. Waterways Mobility.
1b. Rail-Road-Air Mobility.
2. Sustainable Energy.
3. Culture & Tourism.
4. Water Quality.
5. Environmental Risks.
6. Biodiversity, Landscapes, Air & Soil Quality.
7. Knowledge Society.
8. Competitiveness.
9. People & Skills.
10. Institutional Capacity & Cooperation.
11. Security. *(ICPDR 2019)*

All of these priorities are directly or indirectly linked to internal security, including water security. High priorities for water safety are the sustainable energy, the water quality, the environmental risks, the biodiversity, landscapes, air & soil quality and the security.

The Danube Region Strategy addresses a wide range of issues; these are divided among 4 pillars and 12 priority areas. Each priority area is managed by two countries as Priority Area Coordinators. The coordination of the Environmental Risks Priority Area (hereafter: EUSDR PA5) is managed by Hungary and Romania. The main focus of the work is to address the challenges of water scarcity and droughts in line with the Danube River Basin Management Plan, the report on the impacts of droughts in the Danube Basin and the ongoing work in the field of climate adaptation. Therefore, in the past few years EUSDR PA5 contributed to the elaboration of the ICPDR Climate Change Adaptation Strategy Update 2018, supported project elaboration and implementation of drought management and climate change related spatial planning, disseminated scientific results to anticipate regional and local impacts of climate change through research.

Flood risk management is also a significant target of the priority area. In order to achieve reduction of flood risk events EUSDR PA5 provides and enhances continuous support of the Danube Flood Risk Management Plan's implementation. The EUSDR PA5 supports the assessment of disaster risks in the Danube Region, encouraging actions to promote disaster resilience, preparedness and response activities.

Nowadays, it is not a question that climate change is real, and it is happening right now and we can all feel it on our skin. Almost all of the countries lack the capacity to cope with extreme weather phenomena, such as floods, flash floods, hail storms, water scarcity and drought events. In Europe, more frequent droughts, heatwaves and more intense rainfalls are forecasted or already observable as clear indications of climate change, pushing actions at different levels, such as governance territorial (Macro-region, Europe, countries, city) and as river basin based (Danube basin).

Climate change in the Danube basin

An intensification of extreme events, such as floods and droughts, leads to high impacts for agriculture, forestry and industry, as well as built-up areas and infrastructure. As a consequence of decreasing water availability, a shortage in water supply is expected in some areas. There will not be enough water to meet the requirements for irrigation in agriculture and the vegetation period will shorten in large areas in the south of the DRB. In contrast, in the northern parts there will be enough water for productive farming. A shift in species distribution and an increasing risk of invasive species is expected due to changing climatic conditions. An increase in air and water temperature, combined with changes in precipitation, water availability, water quality and increasing extreme events, such as floods, low flows and droughts, may lead to changes in ecosystems, life cycles, and biodiversity in the DRB in the long-term. These are frequently mentioned as the most relevant climate change impacts *(ICPDR 2015a)*.

Climate change increases the vulnerability of Hungary's water resources as well. Territorial and temporal extremes are increasing, reducing usable stocks and further increasing our dependence on water coming from abroad. Due to the expected further climate change, declining water resources and increasing foreign water use may pose a serious security policy challenge for Hungary in the future.

Floods, drought, wildfires and low-flow events, as well as water scarcity situations and extreme storms are likely to become more intense, longer and more frequent. Natural disasters occur more often worldwide, with serious impacts upon human life *(CRED 2020)*. *Van Aalst (2006)* proves that there are several reasons for this, however, the key one is climate change, which results in severe atmospheric and hydrologic events. An intensification of floods, hurricanes, droughts and other disasters obviously leads to high losses in human life. Furthermore, it has devastating consequences for private and public property, agriculture, forestry, industry and critical infrastructure, and it has a specific feature of multiplying negative impacts through cascading effects *(Lawrence et al. 2020; Setola–Theocharidou 2016; Zwęgliński–Smolarkiewicz–Gromek 2020)*. An increase in air and water temperature, combined with changes in precipitation, water availability, water quality and the increase in extreme events may lead to changes in ecosystems, life cycles, and biodiversity in the Disaster Resistance Business in the long-term. This is frequently mentioned to be one of the most relevant climate change consequences *(ICPDR 2019)*. Therefore, high impact, low probability events, such as major disasters, are recently more and more common. Among them, flood is broadly recognized to be the highest risk event among natural disasters in Europe and worldwide.

Through the centuries, the Danube basin countries suffered from many disastrous flood events. The most significant among these is the 1501 flood on the upper Danube, considered to be the largest summer flood of the last millennium, causing extensive devastation down to Vienna, and presumably its impact was extreme downstream to the Danube Bend at Visegrád. Among the ice jam-induced floods, the one of 1838 has historical significance. It devastated a number of settlements from Esztergom to Vukovar, including the towns of Pest, Óbuda and the lower parts of Buda on the territory of today's Hungarian capital.

Adaptation strategy of Hungary in terms of environmental risks, especially water related risks

Hungary is a flatland in the Carpathian Basin surrounded by the Alps, the Carpathians and the Dinaric Mountains. The huge volume of water flowing down from the mountains slows down on the plains, gets barred, ponded and drifts through the country causing extreme floods. The record floods of the last two decades had the Hungarian experts reconsider their view on flood control. The analyses have proved that the old methods of protection are not adequate anymore. The dykes are getting ever higher represent an increasing risk on the population. The constant heightening of the 4425 km long dyke system would put an enormous economic burden on the country.

At the same time the expectations of the population have significantly changed as well. While in the 19th century flood control, the protection of arable land, and to have as much farmland as possible was demanded, nowadays the protection of natural values, the improvement of ecological services, recreation and nature conscious solutions came into the foreground.

Accordingly, flood control often had to fulfil opposing conditions. The citizens expect the government to provide them the European standard, the protection against floods occurring once in a century. However, there is an excessive need to create wetland areas, rehabilitate oxbow lakes, establish recreational opportunities, protect flood plain forests and increase biodiversity. The rising popularity of water sports and hiking requires the creation of natural riverbed sections, the demolition of water control facilities and the focus on natural hydromorphological processes. On the other hand, every activity or development that puts newer and newer obstacles in the way of the flood degrades flood safety. The extremities affecting the economy made the Hungarian water management reforms necessary, to ensure the availability of water, water services (drinking water, irrigation, other water withdrawals), and water damage prevention with measures that are standardized at a river basin level.

Within the framework of water damage prevention it is to handle – with an integrated organization:

- excess water and drought protection, with the establishment of dual-operation, water supplementary and drainage system;
- flood control against design (modelled) flood levels with the improvement of the flood plains and the flood protection lines;
- extreme water balance situation caused by climate change with the establishment of water reservoir systems. *(Figure 2)*

The impacts of climate change are getting more powerful and the situation gets more complicated. The three biggest floods on the Danube happened in the last 15 years, whereas on the Tisza four record breaking floods occurred within 36 months around the millennium.

But if we talk about the damages of the surplus of water, we have to say a few words about the problems caused by the lack of water. 2002, 2003, 2012 were extremely dry years. Although droughts did not cause severe problems in Hungary as in other parts of the world, still it is becoming a factor that has to be calculated with. The floods of the past 20 years made it clear that extreme floods have to be reckoned with in Hungary.

One of the pillars of the Hungarian Water Strategy is preparing for the expected effects of climate change. Changes in the spatial and temporal distribution of water is the major challenge for Hungarian water management. Our country is threatened by the phenomenon of water surplus and water scarcity at the same time, and making efforts to overcome all these is not just an engineering task.

The periods of water surplus have resulted in extreme floods in streams over the past 20 years. Flash floods have multiplied local water damages, and the frequency of urban floods has reached unprecedented levels.

Between the period of 1998–2013 extreme floods beyond the previous water levels developed with unprecedented rapidity on the rivers of Hungary. While flood discharges are not increasing, water levels are intensely rising (water levels of the river Danube at Budapest broke a record 3 times – 2002, 2006, 2013 – in 10 years), which primarily is caused by the continuous reduction of the flood plain's water storage capacity. That fact pointed out that edifices, feral agricultural territories, proliferation of the forests' underwood located in the flood plain, restrain the natural territory of the river and create a heavy runoff obstacle in case of floods. De-

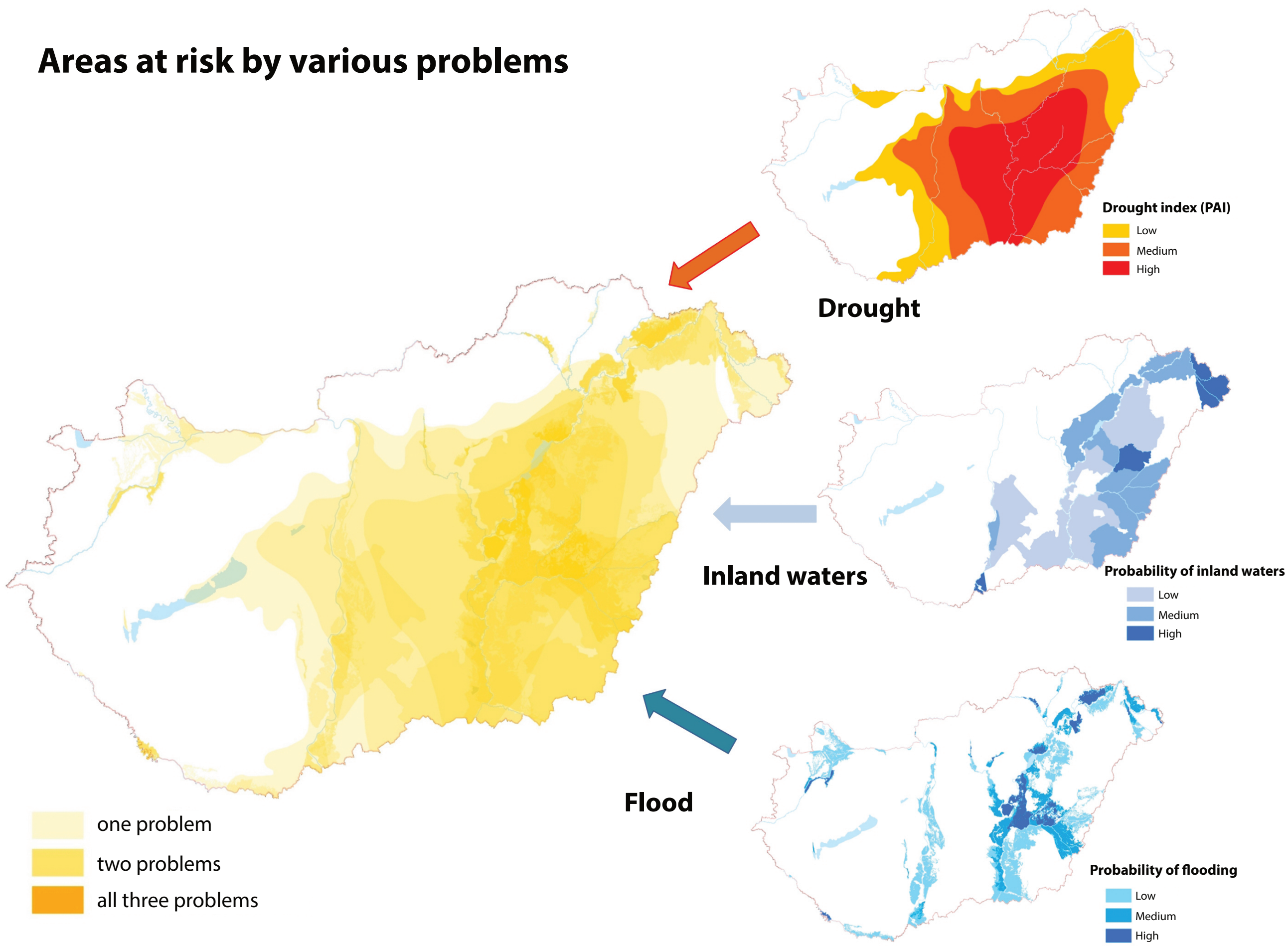

Figure 2 Water related risks in Hungary

Source: ICPDR, 2016b

grading flood plains, combined with rising peak water levels, results in the persistent re-evaluation of the safety and increases the value of the flood protection objects/ projects built from the budget. Thus the budget source covered by the tax-payer's money cannot reach its goal.

Besides this, the expenses of strengthening flood protection dykes are exponentially rising, not only because of the size of the dyke, but also because of the amount of salient waters arousing through growing water pressure. This requires the reforming of the water system of the protected areas too. That fact demanded the necessity to stabilize the location of flood on the flood plain, and to avoid its further destruction.

For the safe drainage of floods, Hungary has developed a special hydro-dynamical modelling process, which determines the flood plain's drainage and the optimal economic and public activity on the flood plain. The developed models and measures defined according to these ensure stabilization of the maintenance and drainage capacity of the flood plain, and helps to avoid further increase of peak water levels *(Zwègliński–Balatonyi 2021)*.

The definition of new design flood levels

The recent flood waves of the Danube – the second largest river of Europe – broke the record flood levels of the past 100–150 years. The more frequently occurring flood peaks made it necessary for the water management to generally supervise the earlier defined Design Flood Levels (hereafter: DFL), that are fundamental for the development and construction of the protection system.

The newly developed methodology is based on scientific grounds – besides the previous system based on water levels and water level statistics, it defines the DFL levels by the statistics of water flow. Furthermore, with generating time series based on possibly available data it can widen the database of 50–100 years to several thousand. Thus with taking the water flow statistics into consideration and evaluation, taking the riverbed condition into calculation, the widened database made it possible to define a professionally sound design flood level for every river in Hungary *(Zwègliński–Balatonyi 2021)*.

Based on the water management development strategy, a large number of embankments were built before 2000 to ensure safety. However, the flood control experiences of the last 30 years in Hungary have proven that, besides developing dyke systems along the rivers and building them to the specified size, applying new methods and solutions is also needed, therefore, besides others, regional flood control systems have to be deployed.

After 2000 – to prevent the effects of climate change – the development of reservoirs became increasingly important. Due to the high flood levels in 2010's, flood bed management plans were completed in 2015 to preserve protection level *(Zwègliński–Balatonyi 2021)*.

It is foreseeable that reaching the necessary dyke elevations will not be possible in the next 30 years. This is the reason why the system of differentiated flood control, which is the only solution for the rational management of the ever-increasing floods due to climate change, needs to be introduced.

Differentiated flood protection has emerged as a national risk management variant during the preparation of the flood risk management plan.

The alternative, differentiated by basins, contains two significant differences from the current version:

1. differentiate between design flood levels;
2. heights of dykes are only determined by technical considerations.

To introduce differentiation, it is recommended to quantify the technical and economic aspects on the basis of which we can determine the levels of protection. This requires the following aspects:

1. Protected or affected populations in basins.
2. Protected economic value or estimated flood damage in basins.
3. Ranking of affected populations and economic value.
4. Time advantage for each basin.
5. Subsoil and cross section problems.
6. Distances between dykes.
7. Engineering safety flood level.
8. Results and impact of developments up to 2020.
9. Impact of river basin management plans.

As the impacts of climate change are getting more drastic, the situation is getting more complicated. The floods of the past 20 years made it clear that Hungary has to be prepared for extreme floods in the future, and the unexpected events will definitely have impacts on the homeland security system.

Safety policy implications of water risks

Direct security risks

In recent years the major floods occurred in 2002, 2006, 2010, 2013 and 2014, resulting in casualties and damages to economic activities amounting to billions of euro *(ICPDR 2015b)*. An extremely rare coincidence of relatively large floods occurring in 2006 in the sub-basins of the Upper Danube at the same time as flooding on the Tisza, Sava and Velika Morava led to a very serious 100-year flood event along more than 1000 kilometres of the Danube River *(ICPDR 2015b)*. The flooding stretched from the Morava mouth to the southern tip of the Csepel Island in Hungary, downstream of the Tisza mouth in Serbia and along the whole Romanian section of the Danube where highest historical flows and water levels were recorded. The extent of flooding in Romania was the largest in the last hundred years.

Contrary to the massive single flood events on the Danube which occurred in 2002 or 2006 due to high precipitation volume in a short time, in 2010 the scattered character of the rainfall throughout the whole year and throughout most of the Danube River Basin led to a high number of damaging flood events at the local level. The floods in 2010 led to 35 casualties and the total damages reaching about 2 billion euro *(ICPDR 2015b)*.

The specific meteorological situation in Central Europe in the end of May 2013 led to massive floods in the Upper Danube catchment in the beginning of June which had an impact further downstream. In many tributaries of the Upper Danube the return periods of 100 years and more were recorded. The coincidence of peak flows of the Saalach River and Salzach River, as well as the Inn River and the Danube River led to a record water level at the Passau gauge that is only comparable to an event 500 years ago. In Hungary the highest ever Danube water levels were observed. Floods in June 2013 caused 9 casualties and the total financial consequences in the Danube River Basin amounted to 2.4 billion €. Disastrous floods occurred in May 2014 along the middle and lower parts of the Sava River Basin. New historical water level maxima were recorded on mid and lower Sava, as well as on its tributaries. 79 casualties, 137 000 evacuated people and damages of almost 4 billion euro underlined again the need for an effective flood risk management *(ICPDR 2015b)*.

Globally, in 2019 this type of disaster took the lives of more than five thousand people and affected 31 million others *(ICPDR 2019)*. In recent years this anxious tendency is also observed at a regional level. For example, in the DRB, most notably in 2002, 2006, 2013 and 2014, parts of the district were affected by very strong or extreme flooding events. These caused significant social and economic impacts. In 2006, four casualties were reported in the Czech Republic and Slovakia. The costs of damage amounted to almost 600 million euro in the whole basin. In 2010, it increased even further and as a consequence there were 35 casualties, and financial damage amounting to around 2 billion euro. The figure was surpassed to a greater extent in 2013 with 2.3 billion euro of damage, mostly in Germany and Austria as well as nine additional casualties reported from Austria and Romania. And, most recently, the Sava River Basin in Croatia, Bosnia and Herzegovina as well as Serbia was hit very hard in May 2014, affecting 2.6 million people, killing 79, and causing almost 4 billion euro of further damage across the three countries *(ICPDR 2015a)*.

Indicators are widely used in water resources and flood protection management for a variety of purposes. The objective of the Floods Directive (hereafter: FD) is to establish a framework for the assessment and management of flood risks to reduce the negative consequences of flooding on human health, economic activities, the environment and cultural heritage in the European Union. However, only the medium probability has been

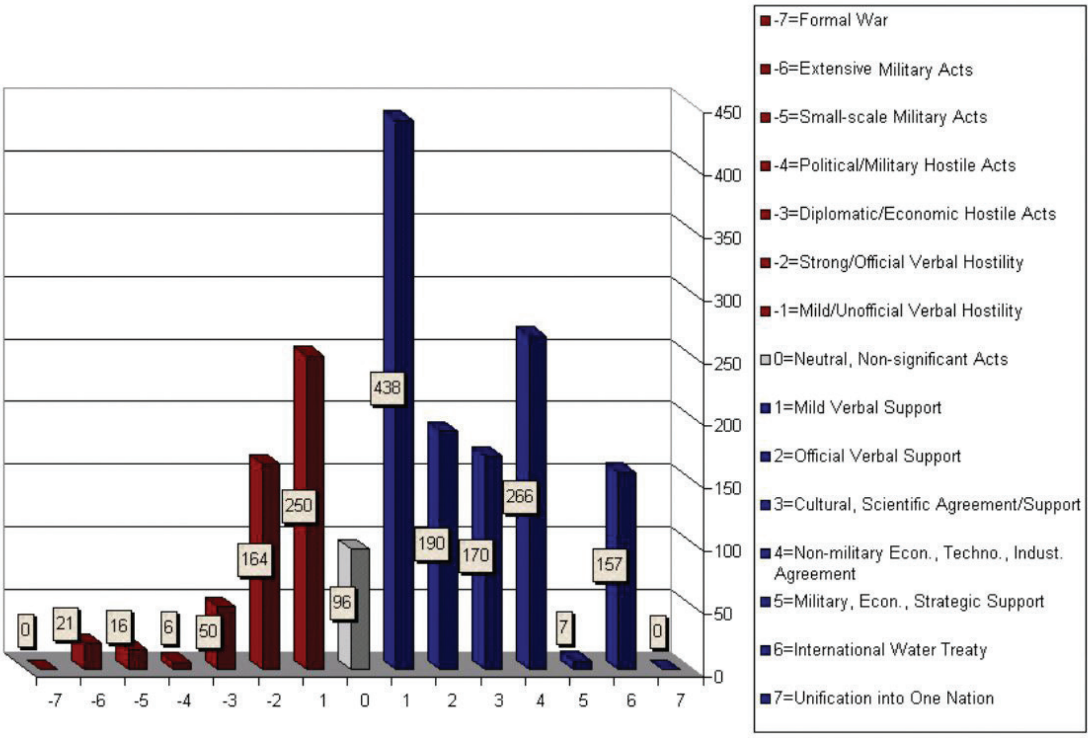

Figure 3 Number of events by BAR scale

Source: Wolf–Stahl–Macomber, 2003

clearly written in it (FD, article 6. 3/b). Based on the counties' differences it is not easy to use the same indicators, 100% same methodology for all member states, for all countries. There is only one indicator that can show how good, how successful the flood protection system is. It is the number of reported causaties. Among the Danube countries there were reports in 2013, however, Hungary was not reported. In Hungary there were not any causaties reported by fluvial floods since the ice floods on the Danube in 1956. Because of that reason Hungary is a good example for the other Danube countries in terms of water management, and flood protection activities. However, most surface waters, rivers, and small water courses in Hungary are shared with other countries, which might have a security (homeland) effect on the water resources management system.

Potential security risks

In terms of water management, Hungary is in a unique position: Although domestic water resources are significant, they are also very vulnerable, as more than 90 percent of the water resources in our watercourses come from across the border. Our exposure from the downstream location is high, so we are dependent on upstream countries regarding water resources, especially in times of water scarcity. In the field of environmental safety, Hungary, due to the outlined geographical and hydrological conditions, is increasingly affected by the environmental and civilizational damages occurring in the neighbouring countries of the Carpathian Basin; in addition to floods, water pollution as well as possible disasters. The downstream situation makes Hungary particularly sensitive to water pollution coming from outside. We share several transboundary groundwater bodies with other countries.

The solution of the quantitative and qualitative problems can only be achieved through bilateral or international coordination. The possible levels of water debate are illustrated *(Figure 3)* by the scale system developed in the following research at the University of Oregon.

The BAR project attempted to compile a dataset of every reported interaction between two or more nations, whether conflictive or cooperative, which involved water as a scarce and/or consumable resource or as a quantity to be managed during 50 years, from 1950–2000. In order to evaluate the intensity of interactions, either cooperative or conflictive, a scoring system was developed, which assigned BAR intensity values from –7 (indicating the highest level of conflict) to +7 (indicating the highest level of cooperation) to each event. The study documents a total of 1831 interactions, both conflictive and cooperative, between two or more nations.

The conflict around the Gabčíkovo–Nagymaros dam is an illustrative example from the past concerning the Danube region and Hungary within it – which corresponds to level –1 on the BAR scale and even reached level –3 at the peak of the conflict –, the effect of which continues to this day. The possibilities and debates about the utilization of the Danube are still burdened by the protracted nature of this conflict. In the case, Hungary and Slovakia appealed to the International Court of Justice in The Hague, which condemned both parties in 1997 for violations on both sides and ordered the two countries to settle the situation with interstate treaties, but this has not happened since.

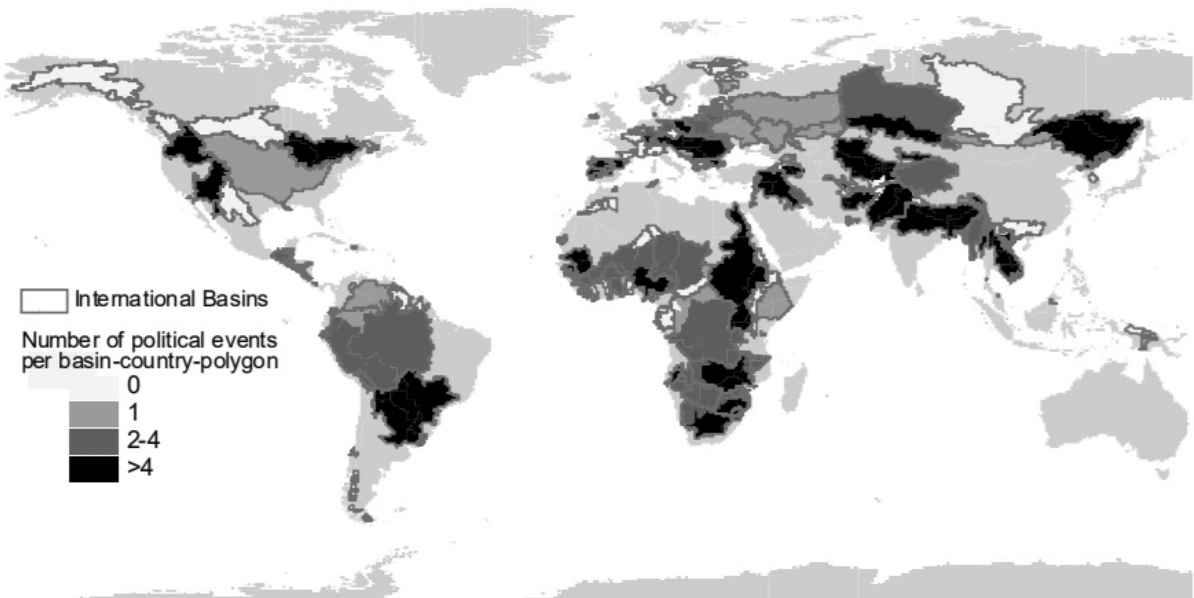

Figure 4 Number of reported political events in the basin-country-polygons

Source: Wolf–Stahl–Macomber, 2003

The figure below *(Figure 4)* shows well the high proportion of verbal, political events in the area under discussion, placing it in the top third. At these events, participants collectively seek solutions to water safety problems affecting the watershed

Despite past contradictions, the parties seek cooperation, as do most countries in the international arena in the field of water cooperation.

Conclusions and proposals

Changes in the natural environment, such as the quantity and quality of fresh water, directly affect people's living conditions. The environmental sector poses a security threat mainly due to environmental and climate change problems. A limitation in its management is that the effects of changes are not always felt in the short term, therefore, in many cases, they are not taken into account in everyday political practice, mainly because the cause of the problem and its sufferer in many cases do not match. Examining the environmental sector, within the water sector and in the context of security, we do not yet know when human activity, the exploitation of the natural environment, will reach the point where there is no going back, when the relationship between humans and the biosphere is completely upset. Challenges in the environmental sector, by their very nature, occur at a supranational, global level, however, the task of protecting the natural environment is the responsibility of states. Global climate change and its impact on the transformation of the physical environment, such as water quality and quantity problems, drinking water shortage is one of the most sensitive areas, which is a good example of the need for all states, all people, to act together to solve the problems of the sector *(Rada 2007)*.

One of the basic and potential water related problems in Hungary is that our exposure from the downstream character is large, thus, we are in a situation of dependence on upstream countries in terms of water resources, especially in times of water scarcity and drought. It is therefore vital that we urgently find a solution to preserve the surplus of the flood period in order to alleviate the increasing frequency of water shortages.

Water management based on water quality and quantity from abroad involves significant risks. Flood risk is also relatively high in Hungary, but based on the previous flood events have less impact on homeland security, however, the level of the floods is rising.

Areas of intervention

Scientific consensus suggests that the current water crisis is a crisis of governance. The root of the problem, therefore, lies not necessarily in the limited availability of water. Rather, how laws, policy and financial decisions on water are made, implemented and followed up by government and society. Such challenges surface with even greater force in interstate context where the action or inaction of a country may give rise to disproportionate negative impacts on the water resources available to others. Consequently, the knowledge of how to prevent, manage and resolve water conflicts at the domestic and international level will be a critical asset for the prosperity and stability of any nation in the 21st century.

All these problems and challenges pose an increasingly difficult and complex task for the international community. The EU encourages and supports all relevant stakeholders to develop transboundary arrangements and to set up institutional mechanisms designed to facilitate relations among riparian states in the future, to strengthen water governance at all levels and in cross-cutting sectors. International waters management has many stakeholders, including international development banks, development agencies, private organizations, government ministries, provinces, municipalities, civil society, and the environment sector. Each has their own appropriate role in contributing to the development of a global water governance culture that incorporates regional peace, environmental protection, and human security.

To take into account all those changes two year MA program in International Water Governance and Water Diplomacy has been developed in 2020 in Hungary at the National University of Public Service for supporting the wide scale knowledge of future decision-makers, on the shared, international river basins for a safer Earth.

References

van Aalst, M. (2006) The impacts of climate change on the risk of natural disasters. Disasters, Vol. 30. No. 1. pp. 5–18. DOI: 10.1111/j.1467-9523.2006.00303.x

Bozó L. (2017) A víz és a légköri folyamatok – a hidrológiai ciklus atmoszferikus rész. Magyar Tudomány, Vol. 178. No. 10. pp. 1198–1205. DOI: 10.1556/2065.178.2017.10.3

Centre for Research on the Epidemiology of Disasters - CRED (2020) Natural disasters 2019: Now is the time to not give up. Brussels, CRED, p. 8. pp. 5–6.

Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007, the assessment and management of flood risk. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007L0060 [Downloading: 10 Nov 2021]

Finszter G. & Sabjanics I. (2017) Biztonsági kihívások a 21. században, Budapest, Dialóg Campus Kiadó.

ICPDR (2015a) Annual Report on the Activities of the ICPDR 2014, International Commission for the Protection of the Danube River, Vienna, ICPDR, pp. 8–9.

ICPDR (2015b) Flood Risk Management Plan for the Danube river basin district. https://www.icpdr.org/main/activities-projects/flood-risk-management [Downloading: 10 Nov 2021]

ICPDR (2019) Climate change adaptation strategy, International Commission for the Protection of the Danube River. Vienna 2019, pp. 28–39.

ICPDR Flood Protection Expert Group (2008) Assesment of Flood Monitoring and Forecasting in the Danube river basin. https://www.icpdr.org/main/sites/default/files/OM-12%20-%203.6%20ASSESSMENTof%20Flood%20Monitoring%20FINAL.pdf [Downloading: 10 Nov 2021]

Ijjas I., Somlyódy L. & Józsa J. (2017) Vízbiztonság Európában, a Duna vízgyűjtőjén és Magyarországon. In: Finszter G. & Sabjanics I. (eds) Biztonsági kihívások a 21. században. Dialóg Campus Kiadó. pp. 423–462.
Lawrence, J., Blackett, P., & Cradock-Henry, N. A. (2020) Cascading climate change impacts and implications. Climate Risk Management. Vol. 29. 100234, https://doi.org/10.1016/j.crm.2020.100234
O'Neill, P. (1998) Environmental Chemistry. (3rd ed.) Routledge. https://doi.org/10.1201/9780203757161
Rada P. (2007) Átalakuló biztonsági kihívások. A biztonság dimenziói. In: Új világrend? Grotius könyvtár (1). Budapest, Corvinus Külügyi és Kulturális Egyesület; Ifjú Közgazdászok Közhasznú Egyesülete. pp. 53–72.
Setola, R., Rosato, V., Kyrkiades, E. & Rome, E. (eds 2017) Managing the Complexity of Critical Infrastructures. A Modelling and Simulation Approach. Cham, Springer International Publishing AG. pp. 19–42. DOI: 10.1007/978-3-319-51043-9
Setola, R. & Theocharidou, M. (2016) Modelling Dependencies Between Critical Infrastructures. In: Managing the Complexity of Critical Infrastructures. Studies in Systems, Decision and Control. pp. 19–41. DOI: 10.1007/978-3-319-51043-9_2
Wada, Y., van Beek, L. P. H., & Bierkens, M. F. P. (2011) Modelling global water stress of the recent past: on the relative importance of trends in water demand and climate variability. Hydrology and Earth System Sciences, Vol. 15, 3785-3808, https://doi.org/10.5194/hess-15-3785-2011
Wolf, A. T., Stahl, K. & Macomber, M. (2003) Conflict and Cooperation within International River Basins: The Importance of Institutional Capacity. International Studies Association, Portland, Oregon, 25 February – 2 March, p. 3.
Zwęgliński, T., & Balatonyi L. (2021) Impact of climate change on Hungarian Water Management Strategy as a case study for other European countries. Zeszyty Naukowe, Nr. 78., pp. 127–150. https://doi.org/10.5604/01.3001.0015.0085
Zwęgliński, T., Smolarkiewicz, M., & Gromek, P. (2020) Efekt kaskadowy współczesnym wyzwaniem zarządzania kryzysowego. Warszawa, Wydawnictwo Szkoły Głównej Służby Pożarniczej. pp. 13–38.