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MANAGING ENVIRONMENTAL RISKS – flood protection experiences and cooperation in the Danube River Basin

EU Strategy for the Danube Region

The Danube Region represents one fifth of the European Union's total area and is home to more than 100 million inhabitants. The region is comprised of 9 EU (*Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Romania, Slovakia and Slovenia*) and 3 accession countries (*Bosnia and Herzegovina, Montenegro, Serbia*) and also involves 2 Non-EU countries (*Moldova and Ukraine*). The states show significant regional disparities in economic and social development. In order to increase growth and strengthen cooperation at a macro-regional level the European Union adopted the EU Strategy for the Danube Region (EU SDR) in 2011 under the period of the Hungarian EU Presidency. EU SDR is established with eleven priority areas to harmonise development policies connecting these 14 countries. Hungary committed itself to coordinate three from the eleven priority areas of the Danube Region Strategy: one with the Czech Republic (PA2 - To encourage more sustainable energy) one with Slovakia (PA4 - To restore and maintain the quality of waters) and one with Romania (PA5 - To manage environmental risks). 2017 is the year of the Hungarian Presidency of the EU Strategy for the Danube Region. It is our pleasure to introduce you the current special edition of the magazine, in which you can get a short overview of the financing possibilities for water-related projects in the Danube region, as well as you can get a view on the ongoing capitalisation process, initiated under the Danube Transnational Programme and gives specifics about the concerned project, too. As an important element of our task, the issue will also highlight areas where transboundary cooperation is a great potential– since being the core element of the EUSDR.

Managing water quality

Water is one of the most important natural resources, basic elements of the human life and its quality determines the quality of our life. Priority Area 4 (PA4) of the EUSDR aiming at to maintain and restore the quality of waters, to 'safeguard Europe's water resources', furthermore to assist in the implementation of the EU Water Framework Directive (WFD) and the Urban Waste Water Treatment Directive. EUSDR PA4 gives a hand, e.g. in the promotion of measures addressing waste water treatment measures in non-EU countries, the facilitation of sub-basin activities or the improvement of fish migration.

To address the above mentioned environmental issues, it is important to map available financial resources and funds and to do so PA4 – together with other priority areas – organises stakeholder networking conferences and seminars, where actual open funds are introduced.

The water quality priority area (EUSDR PA4) successfully cooperate with relevant institutions as well as international organisations among others with the International Commission for the Protection of the Danube River (ICPDR) or the Sava Commission, assists in the process of alignment of funding, facilitates project proposal developments and project implementation as well as gives platform to create networking opportunities towards setting up project consortiums. It is also vital to us to reveal professional areas where further actions are needed. We are aiming at to introduce those topics to the wider public and to call the attention to the need of future collaborations.

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Managing environmental risks

The Environmental Risks Priority Area (PA5) has three major objectives to follow during its work in close cooperation with the ICPDR and shares the responsibility for the realization of them. First, PA5 addresses the challenges of water scarcity and droughts based on the 2013 update of the Danube Basin Analysis and the ongoing work in the field of climate adaptation. Second, support to implement Danube wide flood risk management plans – under the Floods Directive – to reduce flood risks significantly by 2021. Third, it works to update the accidental risk spots' inventory at the Danube River Basin level.

The most significant activity in the field of environmental risks is to facilitate the flood protection of the Region and to enhance the flood safety of the whole Danube Basin. In order to secure the long-term management possibilities the technical education needs consolidation and a training scheme is under elaboration by the PA5. Though the emphasis is on high water regime, PA5 still considers drought and ice management as equally potential scarcities. Our intention is to actively support the ICPDR Climate Change Adaptation Strategy 2018 update process and review of EU directives is a part of our work programme. We aim to step forward in the awareness and preparedness level of the inhabitants with pilot sites for coordination of operative flood management and civil protection plans. To achieve the goals we heavily support project preparations and executions, creating informational material and provide dissemination via the website, plus organizing and participating on project kick-off meetings, consultations and project development workshops, seminars. PA4 and PA5 are working closely to gain additional values.

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TRANSNATIONAL EFFORTS

(Forrás: https://www.danube-region.eu/communication-tools/590654-glossary)

Interreg
Danube Transnational Programme

DANUBE REGION strategy Water Quality

https://www.danubewaterquality.eu/

DANUBE REGION strategy Environmental Risks

https://www.danubeenvironmentalrisks.eu/

Financing possibilities for water projects in the Danube region in 2017

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Abstract
The paper gives a short overview of the financing possibilities for water projects in the Danube region in 2017, highlighting the most relevant funding programmes from territorial cooperation to sectoral programmes, listing also Danube- specific funding instruments open in 2017.

Keywords
Macro-regional strategies, Danube Strategy, water management, alignment of funding, Priority Areas Water Quality and Environmental Risks, cross-border cooperation (CBC) programmes

EUSDR ALIGNMENT OF FUNDING

Six years after the launch of the EU Strategy for the Danube Region (EUSDR) and approaching the edge of the current financing period of 2014-2020, cooperation between the Danube Countries has entered a new phase with even stronger *focus on funding opportunities* and specifically on *more efficient use of funds.*

The importance of using funds efficiently was stressed already by the Ministers in charge of EU Funds, European Affairs or European Integration from the participating States and Regions and the European Commissioner for Regional Policy gathered in the EUSDR Annual Forum in Ulm in 2015 (*Ulm Statement 2015*). In their Joint Statement the Ministers agreed *that the success of the EUSDR implementation requires the alignment of relevant programmes and use of these EU Funds in line with the EUSDR Priority Areas and targets. The Ministers emphasised that EUSDR countries should put all efforts in using other possible funding sources on national, regional or local level and called upon the European Commission to further enable stronger synergies between EU Macro-Regional Strategies, regional multilateral agreements and EU Programmes directly managed by the European Commission such as Horizon 2020, Erasmus+, Creative Europe, COSME, LIFE, CEF and the EU Fund for Strategic Investments. Ministers agreed that the link between the European Territorial Cooperation Programmes (known as Interreg) and the EUSDR is crucial.*

The Ministers stressed the importance of the ongoing exchange of information about successfully implemented mechanisms and good practices of the smart use of various regional, national and EU funding possibilities for relevant EUSDR projects. In this regard, they agreed to take further steps to:

1. *Improve the exchange of information between the actors managing the ESIF Programmes and the equivalent instruments for non-EU countries, and those in charge of the EUSDR implementation.*
2. *Enhance coordination between the relevant ESIF Operational and Cooperation Programmes and the equivalent instruments for non-EU countries and EUSDR actors.*
3. *Streamline project selection within the applicable legal framework and where appropriate, the 2014-20 ESIF Programmes can use part of the funds to co-finance actions or projects of macro-regional scope and interest*
4. *Consider EUSDR related calls and where relevant, such calls aim at allocating funds in a well-targeted manner through specific calls for EUSDR projects within Priority Axis of Operational Programmes or to a duly justified limited geographical perimeter.*
5. *Facilitate exchange of experience and development of joint solutions within the Danube Region.*

Finally, the Ministers have called upon all interested parties to join efforts and continue to ensure progress in the implementation process of the EUSDR by *identifying and promoting suitable projects that can add value* for the benefit of the inhabitants of the Danube Region.

Taking on the conclusions from the referred Joint Statement, discussions continued within the EUSDR on stock-taking exercise of aligning EUSDR with European Structural and Investments Funds (ESIF). At the National Coordinators´ meeting in Brussels, 10 December 2015 the National Coordinators (NC) provided practical examples to ensure financing of the EUSDR relevant projects from which discussions the following conclusions were drawn:

- At the strategic document level: in general, the *EUSDR objectives are well embedded in the Partnership Agreements´ and Operational Programmes***´** texts in the Member States.
- At the operational level**:** *a few countries already apply specific selection criteria* in some of their programmes (i.e. giving bonus points, earmarked budget, etc.)
- Internal coordination: *many countries are already using different approaches*, which in general seem suitable for involving the programmes into the process.
    - Several *NCs are taking part in the Monitoring Committee meetings* of ESIF Funds as member or as observer to help to facilitate funding of relevant projects.
    - The involvement of *Steering Group members of the specific priority areas at national level into the work of ESIF programmes* (i.e. into the work of the Monitoring Committees, etc.) via the NCs or directly brings tangible results in the implementation, while increasing own-

ership. Steering Groups members must be active in identifying the funding sources and describing the added value of the projects to the Managing Authorities (MA) in their respective countries.

- When identifying priority projects, _the Managing Authorities should be involved_ to minimise the risk of developing projects, which are not suitable for the identified programmes.

A recent study (*Metis 2017*) examining embedding macro-regional strategies stressed *that* _*macro-regional strategies do not have a dedicated budget of their own,*_ *which makes their implementation relying on a mobilisation of funding from other relevant sources (EU national, regional, private, etc.) and on a well-coordinated use of available funding streams at different levels.* It also pointed that *all ESIF programmes (national / regional, ETC) have in most cases not specifically earmarked (ring-fenced) budgets for macro-regional strategies, but one third of the 23 examined EU funding programmes have "earmarked" often substantial amounts of their EU contribution for supporting an implementation of the EUSDR.* The study provided many recommendations to policy-makers to improve alignment further, notably advised the European Commission to realise an EU-wide stock-taking of experiences made by different types of EU funding programmes (ESIF, IPA, ENI, EU-wide programmes) with an embedding of and alignment with macro-regional strategies and called for a Communication dedicated to this matter to provide clear guidance to programmes on how to achieve a more systematic embedding and alignment in the time after 2020 (*Recommendation XV in Metis 2017*).

ACTIVITIES OF EUSDR PRIORITY AREA WATER QUALITY (PA4) AND ENVIRONMENTAL RISKS (PA5) RELATED TO ALIGNMENT OF FUNDING

Priority Areas Water Quality (PA4) and Environmental Risks (PA5) of the EUSDR focus on the topic of water from different aspects: PA4 from the aspect of quality, while PA5 from the aspect of risks and both have their own targets, dedicated Action Plan and Roadmap. EUSDR PA4 is co-coordinated by Hungary and Slovakia, while PA5 is co-coordinated by Hungary and Romania.

Both priority areas facilitate the alignment of funding in the frame of the above-mentioned circumstances of the Danube Strategy and both coordination teams adopted their alignment of funding document already in 2014. Both EUSDR PA4 and PA5 contributes to facilitate the alignment of funding in a structured and systematic way and made effective actions to embed the priority interventions to the EU programs of the "2014-2020 Multiannual Financial Framework".

The Hungarian coordination teams of the referred priority areas organised Stakeholder Conferences, especially for water projects in November 2015 and in the frame of the Budapest Water Summit in 2016; as well as held general financing conferences in March 2015 and in May 2017. In all stakeholder events, relevant financing programmes were demonstrated/represented to wide range of interested stakeholders and the events also provided a platform for stakeholders for cooperation and networking for the sake of establishing future consortiums.

In practical terms, nearly 20 Danube basin water related projects and ideas were introduced in the frame of the high-level working group of the Water Quality Priority Area (Steering Group (SG) meetings) between the years of 2013-2017. Projects were introduced to the SG, assisted to be set up or selected for different funding instruments from general EU funding possibilities to specific EUSDR funding (Danube Region Project Funds START and TAF, or to the Danube Strategic Project Fund (DSPF).

The EUSDR water related PA coordination teams regularly inform their stakeholders of the different finding possibilities. The most important EU programmes for water- specific needs are listed in the following chapter.

FINANCING WATER NEEDS IN THE EU

There are no specific programmes financing exclusively water needs in the EU. However, several funding possibilities exist that could be appropriate to finance different water- related projects. One needs to distinguish whether to search in sector-specific programmes or consider funding within different decentralized funding programmes via regional or national channels. (Most possibilities exist under decentralized management funds and to be found in different operative programmes of a given country, therefore, as country-specific, these are not detailed in the present document.)

Territorial cooperation

The European territorial cooperation scheme helps regions across Europe to work together to address shared problems. Regional Policy is delivered through three main funds: the European Regional Development Fund (ERDF), the Cohesion Fund (CF) and the European Social Fund (ESF). Together with the European Agricultural Fund for Rural Development (EAFRD) and the European Maritime and Fisheries Fund (EMFF), they make up the _*European Structural and Investment (ESI) Funds.*_ The ESIFs are the European Union's main investment policy tool, € 351.8 billion – almost a third of the total EU budget – has been set aside for Cohesion Policy for 2014-2020. The ESIFs contribute to the Investment Plan for Europe and complement the European Fund for Strategic Investments (EFSI) in several ways: by leveraging public and private investment, supporting structural reforms, and improving access to funding.

The European Territorial Cooperation (ETC) contains: cross-border (Interreg A), transnational (Interreg B) and interregional (Interreg C) programmes, many of which are very effective tools for EISDR stakeholders to obtain water-related funding. Below please find the programmes that are most relevant for EUSDR stakeholders, financing water needs in the Danube region.

There are several _*cross-border cooperation (CBC) programmes*_ in 2014-2020 that promote cooperation between EU countries and neighbourhood countries sharing a land border or sea crossing. All CBC programmes are characterized by balanced partnership between the participating countries on either side of a border, management entrusted to a local – or national – authority in a member state, jointly selected by all countries participating in the programme and that there are common legal framework and implementation rules. CBC has three main objectives:

- promoting economic and social development in border areas
- addressing common challenges (environment, public health, safety and security)
- putting in place better conditions for persons, goods and capital mobility.

The programmes differ in their approach of collecting projects. Some operates with an open-end system, some with periodic Calls and some of them also plan strategic/restricted Calls. Eligible partners are public or public equivalent bodies from the programme areas; the ratio of financial support is the maximum 85% ERDF with an additional 10-15% government co-financing (depending on the legal form of the partner).

The related transnational programmes relevant also for the Danube stakeholders

Interreg Europe helps local, regional and national governments and public authorities across Europe develop and deliver better policy by sharing solutions with each other through interregional cooperation projects. In its third call that was closed on 30 June 2017 Interreg Europe aimed to approve more projects dealing with water management and other environment and resource efficiency topics. The Programme received 234 proposals in the third call, out of which 41% was submitted for environment and resource efficiency, including water. The programme can offer up to 85% co-financing for project activities such as study visits, peer reviews and action plan development. Depending on the number of partners involved (minimum 3, from at least 2 EU countries) and the project duration (3-5 years), the average total budget of a project is expected to be around EUR 1-2 million. To be eligible for Interreg Europe financial support, at least half of the project partners must work on Structural Funds operational programmes.

Interreg CENTRAL EUROPE with its Priority Axis 3, requiring at least 3 partners and in general financing projects in a range of € 1-5 million, builds on existing knowledge to deliver realistic results, driving a measurable change (improvement) of the initial situation in the area. With its upcoming call, Interreg CENTRAL EUROPE will offer around 60 million EUR ERDF for new transnational cooperation ideas as of 21 September 2017. The programme seeks project ideas that help to improve capacities for urban and regional development in four priority areas: innovation and knowledge development, CO_2 reduction, natural and cultural resources, and transport. In some areas, the third call will be exclusively focused on pre-defined topics. It will stay open until 25 January 2018.

Interreg Danube Transnational Programme (DTP) promotes economic, social and territorial cohesion in the Danube Region through policy integration in selected fields. The Danube Transnational Programme finances projects for the development and practical implementation of policy frameworks, tools and services and concrete small-scale pilot investments. Strong complementarities with the broader EU Strategy for the Danube Region (EUSDR) are sought. The DTP's second call for proposals was officially launched on 9th May 2017 and it was closed on 6th June 2017 with 127 applications were received. The Specific Objectives 1.2 (Increase competences for business and social innovation) and 2.2 (Foster sustainable use of natural and cultural heritage and resources) were the ones receiving the highest number of proposals. 1322 institutions from all the Danube region were involved as project partners in the AF considered for assessment. Concerning the distribution of Lead Applicants (LA) per country, most LA came from Hungary, Romania and Slovenia. Programme results of the second call of DTP are not yet disclosed, however, within the first call two important projects strategic for the Priority Area Water Quality - one is dealing with sediment balance of the Danube River (DanubeSediment project) and another with sub basin – Tisza – integration issues (JOINTISZA project) were approved for funding and could commence their activities in January 2017.

Beside territorial cooperation and cohesion possibilities, there are also sector specific EU programmes, which are managed centrally: HORIZON 2020 and LIFE.

Sector specific, centrally managed programmes

Horizon 2020 is the EU's biggest ever programme for research and innovation with its budget of €79 billion. It aims at securing Europe's global competitiveness, strengthening its position in science and its industrial leadership in innovation by providing major investment in key technologies, greater access to capital and support for SMEs. The programme aims at tackling societal challenges by helping to bridge the gap between research and the market. Horizon 2020 is designed to be a different kind of EU research programme - funding the entire value creation chain from fundamental research through to market innovation, and with drastically less red tape.

The LIFE Programme is the financial instrument supporting environmental and nature conservation projects throughout the EU. The priority areas of its sub-programme for environment are: environment and resource efficiency, nature and biodiversity, environmental governance. The programme contributes to the shift towards a resource-efficient, low-carbon and climate resilient economy, to the protection and improvement of the quality of the environment and to halting and reversing biodiversity loss. The current LIFE call is open till the first part of September 2017 (with different deadlines for various brands).

Danube- specific financial instruments

To serve the needs of the EUSDR stakeholders, there are *Danube- specific instruments assisting* funding. Notably, there is a database within the Danube Implementation Facility called *EUROACCESS* that is an online information and search tool on EU-funding available in the Danube Region, that can be used as support for the implementation of the Action Plan of the EUSDR in the period 2014-2020. EuroAccess lists current calls for proposals under EU programmes that are open for applicants in the Danube Region.

The *Danube Strategic Project Fund* (DSPF) is a new facility, managed by PA 10 of the EUSDR (City of Vienna) in close cooperation with EuroVienna aiming at supporting the implementation of transnational strategic projects aligned with the objective of the EUSDR with a specific added value at the interfaces between cohesion and enlargement/neighbourhood policy. Currently DSPF is in the process of decision-making about proposals that were submitted by different priority areas in spring 2017. PA4 was also supportive in 2016-2017 for proposals to be set up for the DSPF and forwarded 4 project proposals to be funded.

The *Seed Money Facility* (SMF) is a funding opportunity provided by the Danube Transnational Programme to support the development of projects in line with the 12 Priority Areas of the EU Strategy for the Danube Region. With Seed Money support, projects can be prepared for further funding source, regardless the financial instrument to be addressed by the project developed, be it national, mainstream EU, transnational or cross border or by any other public or private investor (such as IFIs) or public-private partnership. The details of the upcoming SMF call will be announced in a dedicated event in Vienna on 27 September 2017.

Other possibilities for assistance

The author notes finally that there are several other financial possibilities via international financing institutions, such as for example the European Investment Bank, the European Investment Advisory Hub, the EBRD, the World Bank; and many other national and local sources and private investments as well to serve the needs of the organizations in the Danube.

The aim of the current paper was to provide a short overview and update of the most important possibilities that could be utilized for EUSDR PA4 and PA5 stakeholders.

ACKNOWLEDGEMENT

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Ulm Statement (2015). Joint Statement of Ulm on the EU Strategy for the Danube Region- Ulm, 29 October 2015.

Related webpages:

http://www.danube-region.eu/funding/aligning-eusdr-esif

http://ec.europa.eu/regional_policy/en/policy/what/investment-policy/

https://ec.europa.eu/neighbourhood-enlargement/neighbourhood/cross-border-cooperation_en

https://www.interregeurope.eu

http://www.interreg-central.eu/Content.Node/news/Third-call-focus.html

www.interreg-danube.eu

http://ec.europa.eu/budget/mff/programmes/index_en.cfm

http://ec.europa.eu/environment/life/funding/life2017/index.htm

www.danube-euroaccess.eu

http://www.interreg-danube.eu/news-and-events/programme-news-and-events/877

http://www.eib.org

For Hungarian stakeholders, the following programmes are available and relevant:

ATHU: http://www.at-hu.net/at-hu/hu/program/2014-2020.php

SIHU: http://www.si-hu.eu/

HUHR: http://www.huhr-cbc.com/

HUSRB: http://www.interreg-ipa-husrb.com/

ROHU: http://2014.huro-cbc.eu/

SKHU: http://www.skhu.eu/

HUSKROUA: http://huskroua-cbc.net/

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Agricultural development and good water status in the Danube River Basin – A contradiction?

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Abstract
The Danube River Basin District Management Plan – Update 2015elaborated by the International Commission for the Protection of the Danube River(ICPDR) identified nutrient pollution as one the main concerns towards achieving good water status in the Danube River Basin (DRB). Recent investigations show agriculture as one of the main contributors to the basin-wide nutrient emissions with a share of 42% for nitrogen and 28% for phosphorus. The current nutrient river loads transported by the Danube River to the Black Sea are still 35% (nitrogen) and 20% (phosphorus) higher than the environmental objectives. This requires further reducing agricultural nutrient emissions by implementing agro-environmental policies in a consistent and coordinated way. Aligning water and agricultural policies can only ensure that the water bodies are protected and the farmer's economic growth is not hindered. To support this goal the ICPDR initiated a dialogue between the water and agricultural sectors to develop a guidance document on sustainable agriculture to reduce nutrient pollution. The guidance will offer for the Danube countries a mechanism to adjust their national agro-environmental policies. It will on one hand provide specific advice on how to implement more efficiently the basic measures of the existing relevant legislation and on the other hand will help countries to better identify, target and finance supplementary measures to combat diffuse nutrient pollution. At the end, the implementation of the guidance will bring a win-win situation for the water and agricultural sectors by decoupling future agricultural development from increasing nutrient pollution in the DRB.

Keywords
Agro-environmental policy, Danube River Basin; nutrient pollution; sustainable agriculture; transboundary water management.

INTRODUCTION

The Danube River Basin (DRB) is the most international river basin of the world as its catchment of about 800,000 km² is shared by 19 countries. Water management in such a large and heterogeneous basin is challenging. To address these challenges Danube countries have been cooperating on fundamental water management issues since the late 1980's to ensure that the use of water resources is sustainable. Since 1998 the International Commission for the Protection of the Danube River (ICPDR) has been coordinatingthe transboundary cooperation on water management in the DRB and has been working to ensure that waters in the DRB remain clean, healthy and safe. To achieve these objectives the ICPDR elaborates river basin management plans for the DRB according to the requirements of the European Union (EU) Water Framework Directive (WFD). This includes accomplishing a comprehensive assessment on pollution arising from several sources and developing the Joint Program of Measures (JPM) to be implemented on the basin-wide level.

Improving the socio-economic situation in the agricultural sector is a prerequisite for a successful implementation of agro-environmental policies. Although agriculture is substantially subsidized by the EU and the national governments, the sector is facing socio-economic challenges. Even though more than 50% of the basin territory are under agricultural cultivation, agriculture is not among the strongest economic sectors in the DRB. The share of the agricultural sector in the total national Gross Domestic Product of the EU Member States (MS) is not significant (less than 5%), whilst non-EU MS have a share around and above 10% (ICPDR, 2015). In many regions the intensity of agricultural production is low due to the less favourable economic situation. In areas where land productivity is low, farmers often are facing socio-economic difficulties as agriculture in these regions may not be competitive at all.

Environmental concerns are also related to agriculture since nutrients have been released from agricultural areas of the basin in significant amounts during the past decades. In the Danube River Basin District Management Plan (DRBMP) – Update 2015 nutrient pollution has been identified as one of the significant water management issues in the DRB (*ICPDR 2015*). Currently, about 20% of the surface water bodies are at risk to fail good ecological status/potential by 2021 due to nutrient pollution. The ultimate recipient water body of the Danube is the Black Sea, which is, being the world's most isolated sea, sensitive to eutrophication. The severe eutrophic conditions of the late 1980's might arise again if wastewater treatment and agriculture are not managed sustainably, particularly in the terrestrial catchment area (*IWAG 2005*).

This paper highlights the current figures on nutrient emissions entering the Danube and its tributaries and the progress that has been achieved in pollution control over the recent years. Moreover, it presents what agro-environmental policies and measures are in place and what additional future actions are planned in the DRB toensure that besides an effective protection of the water bodies also a sustainable development of agriculture is achieved and economic disadvantages for farmers are avoided.

METHODS

To assess the point and diffuse nutrient emissions from urban, agricultural and natural areas, the MONERIS model (*Venohr et al. 2011*) has been applied for the entire DRB. The model application has a long story in the DRB (e.g. *IWAG 2005, ICPDR 2015*) resulted in a comprehensive database set up for the DRB and an enhanced model algorithm adjusted to specific regional conditions. MONERIS is an empirical, catchment scale, lumped parameter and long-term average water quality model calculating nitrogen (N) and phosphorus (P) emissions entering the surface waters from several point and diffuse sources and via different hydrological pathways. It also quantifies N and P river loads at sub-catchment outlets taking into account in-stream retention processes. Scenarios for implementing control measures can be developedat the catchment scale and their effectiveness in terms of emission and river load reduction can be assessed.

Model input dataset has been updated for the reference period 2009-2012 and the model has been validated against measured river loads. Model results have been analysed to identify regional scale emission hot-spots within the DRB and to better understand the main pathways and sources of nutrient emissions and their proportions.

RESULTS AND DISCUSSION

Results

The basin-wide nutrient emissions entering the surface water bodies are 605,000 tons per year total N and 38,500 tons per year total P for the reference period (*ICPDR 2015*). Pathway and source apportionment of the total emissions is presented in *Figure 1* and *Figure 2*. Diffuse pathways clearly dominate the total releasesby 84% (N) and 67% (P). For N, subsurface flow (base flow and interflow) is the most important diffuse pathway with a proportion of 54%. In case of P, soil erosion (32%) and urban runoff (18%) generate the highest emissions. Regarding the sources, agriculture (N: 42%, P: 28%) and urban water management (N: 25%, P: 51%) are responsible for the majority of the nutrient emissions. The recently (2005-2015) transported fluxes are 460,000 tons per year total N and 25,000 tons per year total P (*ICPDR 2016a*), which are still considerably higher than those of the early 1960ies which represent river loads under low pressures (*IWAG 2005*). This indicates a further load reduction potential that might be exploited for the benefit of the Black Sea (N: 35%, P: 20%). This would require a further decrease of both, the point source and diffuse emissions generated in the DRB.

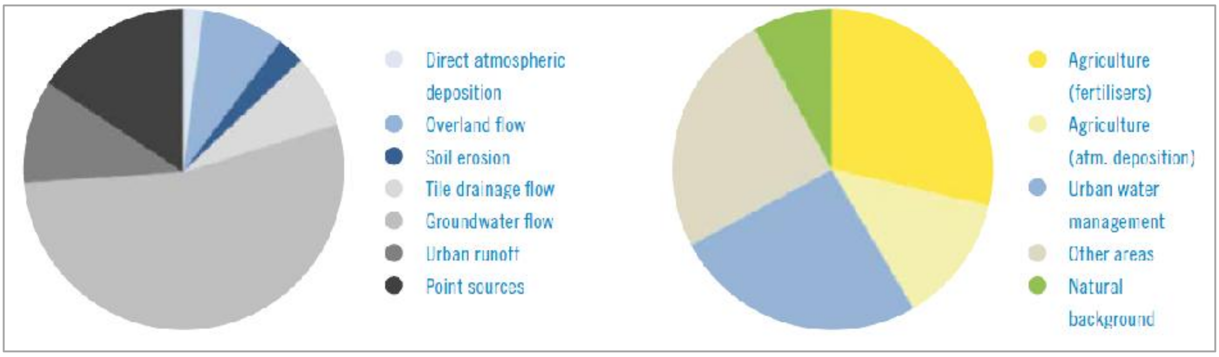

Figure 1. Share of sources in the overall total Nemissions in the DRB for 2009–2012; on the left: pathways, on the right: sources (Source: ICPDR 2015)

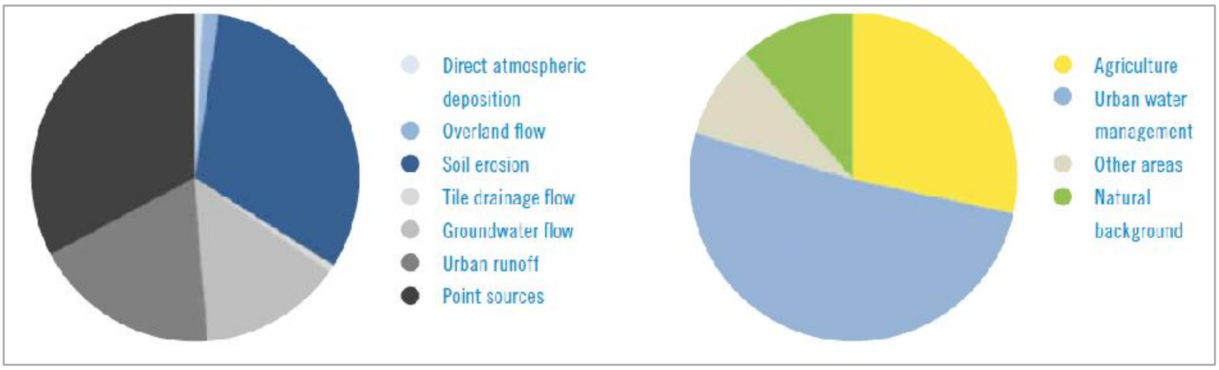

Figure 2. Share of sources in the overall total P emissions in the DRB for 2009–2012; on the left: pathways, on the right: sources (Source: ICPDR 2015)

Country contributions can be seen in *Figure 3*. Germany and Slovenia produce the highest area-specific N emissions in the basin. Regarding the source areas, rural areas have a principal role in nitrogen emission generation. Urban water management is still an importantsource, especially in the new and non-EU MS. In case of P, Serbia generatesthe highest area-specific P emission rates. Upstream countries show similar contribution of theurban and agricultural areas. Movingdownstream in the basin urban areas become more dominant indicating the high potential to improve wastewater treatment by introducing P removal. The importance of the urban sources is strong particularly in themiddle basin.

Comparing recently calculated the emission figures to those reported in the 1st DRBMP (*ICPDR 2009*) for the reference year 2005,remarkable decrease is visible. The N and P emissions from urban waste water treatment plants significantly declined by 32% and 45%, respectively.Diffuse emissions also substantially dropped due to both, the low agricultural intensity inmany countries and the measures implemented (TN: 8%, TP: 28%). The total N emissions decreased by 12% in comparison to the 1st DRBMP whilst total P emissions declined by 34%.

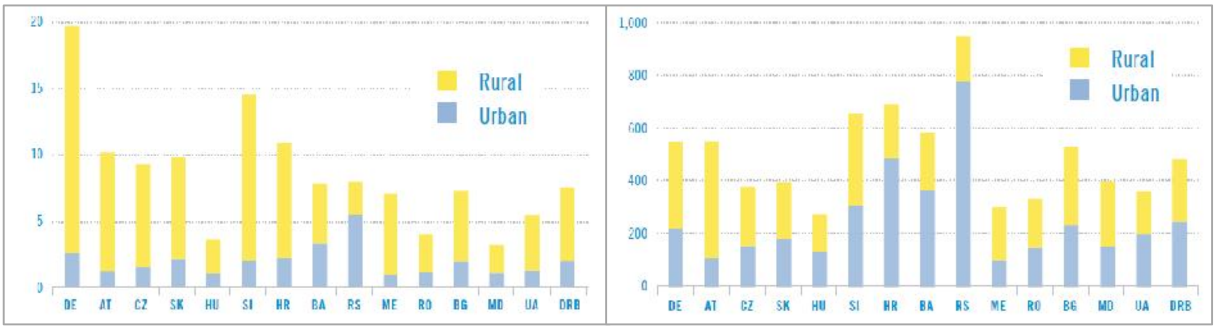

Figure 3. Rural and urban specificnutrient emissions in the Danube countries for 2009–2012;on the left: total Nin kg per hectare and year, on the right: total P in g per hectare and year (Source: ICPDR 2015)

Discussion

Upgrading wastewater treatment plants with nutrient removal technology at agglomerations above 10,000 population equivalents, application ofphosphate-free detergents and implementation of best agricultural practices in agriculture are measures currentlybeing implementedin the Danube countries to reduce nutrient pollution.These measures have been substantially contributing to the reduction of nutrient inputsinto surface waters and groundwater in the DRB but further efforts are still needed. Continuation ofmeasure implementation in urban wastewater, industrial, market production and agricultural sectors isnecessary in the next WFD management periods. Since diffuse pathways and agricultural sources have a remarkable share in the total nutrient emissions, implementation of measures addressing agricultural practices and land management has particular importance.The ICPDR's current activities to facilitate the implementation of the JPM set in the DRBMP – Update 2015 have a strong focus on the reduction of the nutrient pollution of the Danube River, its tributaries and the Black Sea coastal and marine waters to avoid future deterioration of the Black Sea ecosystem and further reaching good status.

With regard to agriculture, in the EU MS the Nitrates Directive (ND) and the Common Agricultural Policy (CAP)are the most relevant pieces of legislation, which have a strong connection to water quality protection (*OJ 1991, 2013a, b*). In the non-EU MS only several analogous regulatory elements are available. These countriesare either lagging behind with establishing a similar legislative background or preparing the administrative and legal framework as part of their accession process to the EU. The ND requires designation of Nitrate Vulnerable Zones (NVZ) that are hydraulically connected to waters polluted by nitrate or sensitive for nitrate pollution or alternatively,to apply the whole territory approach. In the zones (or over the whole territory) the amount of nitrate that isapplied on agricultural fields in fertilizer or manure is limited and the application is strictly regulated throughaction programmes with basic mandatory measures.Moreover, codes of good agriculturalpractices are also recommended to be respected outside the NVZs on voluntary basis to ensure low nitrogenemissions entering the groundwater and river network. As of 2015 on more than 60% of the agricultural areas of the DRB nitrate action programs with strict rules on manure and fertilizer application are being implemented (*ICPDR 2015*). Thanks to these provisions, but also to the economic recession in many Danube countries resulted inter alia in low agricultural intensity, the nutrient surpluses (gross balance) of the agricultural fields are rather low, except some countries where still high amounts of manure and fertilizers are applied on agricultural soils. On the contrary, in countries with less economic power, the surplus values are very small or even negative indicating lack of nutrient inputs which is compensated by the soil stocks accumulated over the previous years. However, future river basin management activities should take into account that the economy and the agricultural sector might be strong again,which might lead to higher surplus values and water emissions that would need appropriate management (*ICPDR 2015*).

The CAP provides a multi-pillar financing mechanism for farmers to ensure the sustainable development of agricultural and rural areas. CAP subsidies consist oftwo main pillars. Direct paymentsare linked to compliance with compulsory measures upon basic standards on environmental sustainability, animal health and welfare and food safety (cross-complianceincluding statutory management requirements, good agricultural and environmental conditions and"greening"). Measures under greening are related to environmental friendly farming practices includingcrop diversification, maintenance of permanent grassland and conservation of areas of ecological interest. Funds for voluntary measures under the rural developmentprogrammesaim at strengthening competitiveness, protecting environment, ensuring vitality of rural communitiesand modernising farms by innovations.Agri-environmental measures help farmers to overcome the challenges of soil and water quality, biodiversity and climate changeby supporting environmentally friendly practices, organic farming and sustainable innovations.In the current financing period 2014-2020more than 40 billion and 25 billion EUR will be invested in the DRB countriesby the EU from the two CAP pillars (direct payment and rural development), respectively (*OJ 2013c*). Out of these funds, more than 30%will be spent for greening and agri-environmental measures.

Although the legislative and financial framework to manage agriculture related water quality issues has long been established, there are several concerns related to the feasibility, efficiency and controllability of these policies.In many Danube countries, there is a significant number of small farms working on a few hectares, which are highly depending on EU or national subsidies but have limited capacity to comply with strict and ambitious cultivation provisions.Therefore, countries should consider differentiating among farm sizes when the specific conditions for receiving direct payments are determined or revisedto avoid too high technical and administrative burdens and the associated economic difficulties.Voluntary agri-environmental measures of the rural development programs should be more (economically) attractive for the farmers offering feasible and advantageous options for additional measures and/or alternatives for agricultural practices. Moreover, funds and measures to improve water quality should be better targeted to critical areas where the pollution comes from and/or where the highest pollutant fluxes enter the surface waters. Controlling of a huge number of small farms is rather challenging, it should focus on the larger agro-industrial holdings, which generate bigger pollution. In general, there is a need for better coordination and alignment between water and agricultural policies to develop win-win strategies and joint actions.This has been recognised at the EU level (*EC 2017*) and discussed at a joint meeting of Water and Agriculture Directors.

With regard to the regional scale, a sound strategic guidance document on sustainable agriculture for the DRB is still missing. To address this shortcoming and the concerns mentioned above,Danube countries agreed in 2016 to start in close cooperation with the agricultural sector a broad discussion process aiming at developing a guidance document on sustainable agriculture to reduce nutrient pollution from diffuse sources. This initiative received full political support expressed in the Danube Declaration and adopted by the ICPDR 3rdMinisterial Meeting in 2016 (*ICPDR 2016b*) and is also supported by the EU Strategy for the Danube Region (EUSDR) Priority Area 4 - Water Quality. The main objective of the guidance is to decouple future agricultural development from increasing nutrient pollution of surface and ground waters. To achieve this goal the guidance paper will recommend sound policy instruments, financial programs and cost-efficient agricultural measures for decision makers in the agro-environmental policy field. It should act as a strategic policy framework providing consistent approaches into which the Danube states are encouraged to integrate their individual national methods. The guidance will facilitate the sustainable development of agriculture in the DRBby carefully balancing the economic, ecologic and social aspects of agriculture and rural activities. It will contribute to strengthen the profitability of farmers, competitiveness of agriculture and vitality of rural areas. It will also ensure an effective protection of both, the DRB water bodies and the Black Sea coastal waters and ecosystems against excess nutrient inputs and their significant adverse impacts.The recommendations should be adoptable for the Danube countries in an “inclusive” way ensuring that the interests of the different groups of stakeholders and the regional differences in the basin in terms of both, the natural and socio-economic factors are considered.

The guidance will outline and promotetwo main development options according to land productivity and land conditions. Favourable areas with high soil fertility and good climate conditions may face investments and sustainable intensification to increase competitiveness. This option would lead to a desirable development to improve the economic situation in rural areas, would give perspectives to people to stay and live there but would also fully integrate natural resources protection.A clear legal framework and an efficient implementation of cross-compliance and „greening“ should be in the focus here, backed up by appropriate control schemes.On the other hand, disadvantaged areas (quite often less favoured areas with a considerable part of high nature value farmland) are threatened by depopulation and land abandonment, which need to be counteracted by integrated rural development programmes including an economic basis for site-specific, traditionally extensive agricultural systems. In these regions but also in areas of high ecologic interest (e.g. riparian zones, floodplains and wetlands) agri-environmental programmes and compensations for ecosystem services (e.g. biodiversity, landscape maintenance and biotope management) and other income options for the agricultural sector like sustainable tourismshall be offered. In both cases, competent advisory services should be part of the business.

The elaboration ofthe guidanceis led by the ICPDR Nutrients Task Group and supported by invited water, agricultural and agro-economy experts. It will be further discussed attwo broader stakeholder workshops and by a public consultation process.The rationale and main objectives of the guidance document have been presented at the EUSDR event “Trust-building between water and agriculture sectors in the Danube Region” (04 October 2016, Bratislava) and at the European Commission workshop on water and agriculture “Enhancing cooperation between water and agriculture stakeholders to deliver sustainable agriculture and healthy waters” (24 October 2016, Bratislava). Moreover, the ICPDR submitted a voluntary commitment to the United Nations (UN) Ocean Conference (5-9 June 2017, New York), which aimed at supporting the implementation of the UN Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. The commitment highlights the guidance documentas a voluntary initiative of the Danube countries aiming at contributing to the implementation of Sustainable Development Goal 14 by reducing of nutrient pollution arising from the DRB and by protecting the coastal and marine ecosystems of the Black Sea (*http1*).

The guidance is planned to be finalised and published in 2019. It will be further discussed after its finalization on follow-up workshops for amendments based on the implementation experiences. This will also ensure that the discussions between the water and agricultural sectors remains on the agenda.The ICPDR believes that the implementation of the guidance documentin the DRB will contribute to a sustainable nutrient management and agriculture and that decoupling of agricultural development and nutrient pollution is a common objective rather than contradiction.

CONCLUSIONS

Nutrient pollution is one of the significant water management issues identified for the DRB. Although nutrient fluxes have significantly dropped in the last decades due to the measures implemented as well as to the declined intensity of agriculture, the nutrient pressure of a number of surface waters within the DRB and that of the Black Sea is still higher than the environmental objectives. Implementation of measures should therefore continue inter alia in agriculture by applying agri-environmental measures and best management practices. However, water policies to reduce nutrient inputs should be better aligned with the agricultural ones. They should combine the traditional approach of regulative enforcement with the perspective of safeguarding farmers' economic situation in order to reach good water status in the DRB in a sustainable way. In this respect, the ICPDR guidance document on sustainable agriculture will provide Danube countries with a consistent policy framework with a set of recommended tools to facilitate national water and agricultural decision makers to identify common goals, to set up targeted policies and to implement joint actions and cost-effective measures. Implementing the guidance will lead to a sound economic development in agriculture and to further nutrient pollution reduction in the DRB. This will be a significant step towards the ICPDR's vision of a balanced nutrient management in the DRB, which ensures that neither the waters of the DRB nor the Black Sea are threatened or impacted by eutrophication.

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The Importance of Good Ecological Status for the Successful Revival of the Danube Sturgeon

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Abstract

The Water Framework Directive (WFD, 2000/60/EC) brought a significant improvement in water management policies due to its integrative approach. For the first time, the hydrographic connectivity of rivers was considered, while the evaluation of the ecological status comprised not only the abiotic characterization of the aquatic environment and its hydromorphological integrity, but also the status of the biological communities. As large rivers know no political borders and flow through different countries, transnational coordination is needed to harmonize the measures at river basin scale; hence, the riparian countries have strengthened their cooperation in elaborating and jointly implementing transboundary River Basin Management Plans in order to achieve the “good ecological status” of the water bodies.

Significant steps have been taken in the Danube River Basin (DRB) since the directive entered into force. However, the achievement of the good ecological status of the Danube water bodies still faces several major challenges: (i) the extent of contamination with hazardous substances, especially with emergent pollutants, the impact of which on aquatic communities needs serious investigation, (ii) although WFD requires no further deterioration of the status of water bodies, new infrastructure projects planned across the Danube Basin (melioration of navigation, hydropower dams, water abstraction for agriculture, flood protection measures) will generate new hydromorphological alterations of the aquatic habitats, while their cumulative impact on the ecological status is not assessed, (iii) the climatic models predict additional changes to the aquatic habitats due to increasing temperatures, modified precipitation regime and increased frequency of extreme weather events (iv) the spreading of invasive alien species threatens the indigenous biodiversity, some of the most successful invaders already being present in the Danube countries.

All these challenges should be integrated in the evaluation, as they contribute to the overall decline of the freshwater environment status and the consequent decline of its biodiversity: at European level, over one third of freshwater fish species are threatened with extinction.

Large predatory fish, such as sturgeons, situated at the top of the trophic pyramid, are sensitive to the ecological status of water bodies: good water quality is essential to ensure an adequate aquatic environment, good hydromorphology is important to ensure the integrity of and access to their habitats, while the good status of the biological communities is essential to provide proper food resources. As such, the status of their populations reflects the ecological status of their environment, being good indicators of the ecosystem health. Therefore, reaching a good ecological status of the Danube water bodies represents an essential step towards the revival of Danube sturgeon populations.

Considering the numerous challenges faced by the freshwater ecosystems of the DRB, a stronger enforcement of water and nature directive requirements is needed to foster the achievement of a good ecological status in the DRB by 2027.

Key words

Water quality, hydromorphology, biological communities, good ecological status, climate change, invasive alien species, River Danube, sturgeons

INTRODUCTION

With the adoption of the Water Framework Directive, a new era of water management strategies started; first of all, by upscaling the management units from local to regional level and by taking river hydrographic basins into consideration. Moreover, the systemic approach was introduced in the evaluation of ecological status, by taking into account, besides water chemistry, also habitat integrity and aquatic communities. The monitoring parameters defined by WFD include:

- chemical characterization: general parameters (temperature, pH, oxygen, salinity), nutrients, specific pollutants, priority substances or other substances discharged in significant quantities into the water bodies
- hydromorphological characterization: hydrological regime, water flow (quantity and dynamics), connection to groundwater bodies, river continuity, morphological conditions, river depth and width variation, structure and substrate of the river bed, structure of the riparian zone
- quality of the biological communities: aquatic flora, benthic invertebrates, fish community

For the first time, the connection of aquatic species with their habitats was taken into account in the assessment of the ecological status, aquatic communities playing a key role in ensuring the ecosystem’s functionality and the provisioning of ecosystem services such as food and drinking water, oxygen production, nutrient recycling, water self-purification, regulation of atmospheric composition, recreational services, etc.

The paper offers a brief insight into the connections between the three main components defining the ecological status, additional challenges that should be taken into account when assessing the ecological status, and the key role played by the ecological status for the successful revival of the critically endangered sturgeons, the flagship species of the Danube river basin.

CHEMICAL CHARACTERIZATION

The chemical composition of the aquatic environment is essential for determining water quality. Daily, the aquatic ecosystems receive a cocktail of chemical substances generated by anthropogenic activities, from nutrients to xenobiotics, posing an increasing hazard not only to the environment, but also to human health.

While nutrient and organic pollution are increasingly tackled by the extension of sewage systems and wastewater treatment plants, for hazardous substances, however, there is no control on the total amount, levels and fate of toxic chemicals entering the aquatic ecosystems. The Water Framework Directive and the EU Watch list require the monitoring of a very limited number of compounds compared to the high diversity of pollutants reaching the water bodies, such as detergents, pesticides, persistent organic pollutants, endocrine disruptors, pharmaceuticals, microplastics, etc.

The high amount of chemical products in use at EU 28 level, posing health hazard to the environment, gives a glimpse at the high contamination risks of EU water bodies with hazardous substances (*Table 1*), as these substances will eventually find their way into the freshwater or marine systems, i.e. into our drinking, irrigation, bathing and recreational waters.

Table 1. Consumption of chemical substances hazardous for the environment between 2006–2015 (million tons). (Source: EUROSTAT, env_chmhaz)

HAZARD	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Hazardous and non-hazardous - Total	378.0	388.7	355.0	305.7	355.3	340.3	340.4	338.5	351.8	349.5
Hazardous to health	240.6	244.7	223.8	201.6	226.5	216.8	218.0	214.1	220.2	220.8
Carcinogenic, mutagenic and reprotoxic (CMR) health hazard	39.5	41.7	35.4	35.8	39.4	38.7	34.8	34.4	36.0	34.9
Chronic toxic health hazard	22.4	22.3	22.8	18.4	20.0	18.8	19.8	19.9	19.1	18.2
Very toxic health hazard	46.6	48.8	45.7	37.5	43.1	38.8	41.1	41.6	43.4	44.1
Toxic health hazard	67.0	66.8	61.5	55.0	62.6	60.0	59.7	57.9	57.9	60.1
Harmful health hazard	65.1	65.1	58.4	54.8	61.4	60.5	62.7	60.3	63.8	63.6
Hazardous to the environment	141.0	141.5	131.0	119.2	134.7	129.5	128.9	126.1	126.5	127.0
Severe chronic environmental hazard	42.8	41.6	37.4	35.6	39.6	37.0	37.7	36.8	37.2	37.4
Significant chronic environmental hazard	28.8	29.5	30.1	26.8	30.1	29.8	27.9	26.9	29.7	29.1
Moderate chronic environmental hazard	37.1	38.1	33.8	29.6	34.3	33.5	35.1	35.4	33.1	32.3
Chronic environmental hazard	6.6	6.2	6.4	5.6	6.2	6.3	6.5	6.0	6.0	6.7
Significant acute environmental hazard	25.8	26.1	23.2	21.7	24.5	23.0	21.6	21.0	20.6	21.4

Hundreds of millions of tons of hazardous substances are produced and consumed on an annual basis at EU 28 level only (*Table 1*), the most critical being the chronic, mutagenic and reprotoxic (CMR) substances (37 million tons/year), chronic toxic substances (20 million tons/year) and very toxic substances (43 million tons/year). Based on their structure and bio-availability, some of these compounds can be biodegraded and diluted by the aquatic environment, while others have more stable molecules and can be adsorbed on detritus or sediment particles, increasing the chances to be ingested by aquatic organisms and introduced to the food webs. Here, they can be stored in different organs or tissues (gills, liver, kidney, muscles), being subject to bioaccumulation or biomagnification within the food webs. This is how some of the hazardous substances not only induce sublethal effects on aquatic organisms, such as feminization of male fish, endocrine disruption, ill effects on health, growth rate, reproduction success, feeding rate, parental care, predator avoidance, schooling and shelter seeking (*Brodin et al. 2014*), their DNA structure or the health of their offspring, but can also reach alarming concentrations in higher trophic levels, also posing potential risks to human health.

Of the emergent pollutants, pharmaceuticals are of the highest concern, in particular due to their possible cumulative impact on aquatic biota and human health. Several hundred thousand tons of pharmacologically active substances are estimated to be used yearly for the treatment of human and animal diseases, including livestock and aquaculture (*Kümmerer 2010*), most of them reaching the aquatic environment. The increased use of antibiotics in human and veterinary medicine is already reflected at human health level, either by the increased incidence of allergies and antibiotic resistant bacteria, or as a result of their transfer with drinking water or vegetal food (*Bouki et al. 2013, Kabir et al. 2015*) or by possible genomic injuries of DNA (*Li et al. 2007*). Anti-inflammatory drugs are another highly problematic group: e.g. 10 µg/l diclofenac affects aquatic microbial communities (*Dorne et al. 2007*), while experiments on its accumulation in rainbow trout have shown a bioconcentration factor (BCF) ranging between 12-2732 in liver, 5-971 in kidney, 3-763 in gills, and 0.3-69 in muscles, depending on the applied concentrations (*Schwaiger et al. 2004*).

The same substance has proved to have a catastrophic impact on 3 eagle species in India and Pakistan, as the birds feed on carcasses of cattle treated with diclofenac, and even doses as low as 7 µg/kg lead to the eagles' death (*Dorne et al. 2007*). Endocrine disruptors such as PCBs, dioxins, perfluorinated compounds, DDT are also of high concern, as they can get into the human body by direct consumption of contaminated food and water, pesticide residues in food or beverage, or leaching chemicals from food and beverage containers (*Kabir et al. 2015*).

Besides pharmaceuticals, plastic pollution is of growing concern, especially considering its impact on the marine environment, aquatic organisms and human health: besides entanglement and ingestion of macro debris by large vertebrates, microplastics are accumulated by planktonic and invertebrate organisms, being transferred along food webs. Negative consequences include the loss of feeding ability, physical damage, exposure to pathogens and transport of alien species. In addition, plastics contain chemical additives and efficiently adsorb other toxic environmental contaminants, thus representing a potential source of exposure to such compounds after ingestion (*Avio et al. 2017*).

Close cooperation on the implementation of WFD, Marine Strategy Framework and REACH directives are needed in order to develop a new strategy for a non-toxic aquatic environment in the DRB and the Black Sea, by e.g. (i) extending the monitoring programmes to more hazardous substances, (ii) studying the synergistic effect of chemical combinations on aquatic biota and human health, (iii) minimizing production, use and exposure to known harmful substances, (iv) producing new generation materials with lower health risks, (v) adopting stronger environmental regulations preventing pollution with such substances, etc.

HYDROMORPHOLOGICAL CHARACTERISTICS

In the past decades, it has been increasingly acknowledged that river channels, riparian areas, floodplains and aquifers form a unitary riverine system, where hydrological connectivity and the exchange of matter and energy among these components ensure the functioning of the ecosystem. This hydrological connectivity takes place in longitudinal, lateral and vertical dimensions and over time (*Ward 1989*), and its loss constitutes the main cause of the ecological degradation of rivers (*Wohl 2004*). Hydrotechnical constructions, such as hydropower dams, embankments and dikes for flood protection, channelization by cutting meanders and side arms to meliorate navigation, gravel extraction and water abstraction for various human uses (irrigation, industrial or household use, etc.) and the subsequent alteration of flow dynamics and sediment transport, river bed incision, increased bank erosion, reduced capacity of floodplains to store water and buffer floods and droughts, severely affect the life of the aquatic communities and the functioning of the ecosystem (*Sandu 2005*). This impact is worsened by climatic changes, as increasing temperatures and modified precipitation regime may dramatically alter river discharge, sediment transport and dissolved oxygen content, with increasing occurrence of hypoxia and fish mortality (*Sandu et al. 2009*). Vertical connectivity is also affected by decreased flow dynamics, as fine sediments can accumulate on the river bed and reduce permeability (*Kondolf and Wilcock 1996*), affecting the incubation and survival rates of fish embryos dependent on the upwelling or downwelling of groundwater, like in the case of salmonids (*Baxter and Hauer 2000*).

For the River Danube, it is presumed that the construction of the Iron Gates dams has led to a reduction of sediment transport by 55% (*Teodoru and Wehrli 2005*), which affects river geomorphology, intensifying the erosion processes in the Danube Delta and along the NW Black Sea coast. Moreover, at river basin level, over 80% of the floodplains have been destroyed or lost their function. The situation, however, differs along the river, as in the Upper Danube, over 95% of the floodplains have been lost, while in the Middle and Lower Danube about 25-30% are still available (*Schneider 2002*).

Given the considerable impact of hydromorphological alterations on water quantity and quality, this is considered a Significant Water Management Issue (SWMI) by the International Commission for the Protection of the Danube River (ICPDR). Consequently, the Danube River Basin Management Plan recommends measures to restore river continuity interruptions along the River Danube and its main tributaries (*ICPDR 2015*), some of the most important ones targeting the restoration of fish migration at the Iron Gates dams, which could have a significant positive effect on the critically endangered sturgeon populations, reopening their access to major tributaries such as the rivers Tisza, Drava and Sava and to an additional 800 km of habitats located along the River Danube.

However, due to the inclusion of the River Danube in the TEN – T corridor for navigation (Rhein – Main – Danube), the Middle and Lower stretches of the River Danube are subject to additional technical measures that jeopardize the current conservation efforts undertaken by the Danube Sturgeon Task Force in the framework of the EU Strategy for the Danube Region Priority Areas 6 (Biodiversity) and 4 (Water quality). In particular, a submerged construction located at the bifurcation of the Old Danube and Borcea secondary arm (approx. Danube rkm 345), hinders sturgeons' spawning migration upstream this sector, threatening with extinction the long distance migrants that should be eventually supported to pass the Iron Gates and migrate towards the upper reaches of the Danube. A second navigation melioration project will soon start on the Romanian – Bulgarian stretch of the Danube, between the Iron Gates II and Danube rkm 375, with the potential to create additional negative impacts on Natura 2000 protected species and habitats located along this river section. Flood protection measures, plans to erect additional hydropower dams or to develop new reactors at the existing nuclear power plants located along the River Danube, water abstraction for irrigation and tourism development complete the picture of future hydromorphological alterations foreseen along the River Danube. A strategic environmental assessment of their cumulative impact will allow a better understanding of the magnitude of future changes as well as of the risks to achieving WFD requirements.

An intensified dialogue between environmental stakeholders (governmental and non-governmental organizations, research institutes, local authorities, etc.) and infrastructure development companies is needed in order to identify environment-friendly solutions and avoid/mitigate the impact of future technical development on the Danube biodiversity, in particular on species and habitats protected by the European environmental legislation and international conventions ratified by riparian countries.

BIOLOGICAL COMMUNITIES

Aquatic ecosystems are inhabited by myriads of organisms fully dependent on the quality of their habitats. They ensure the functioning of the ecosystem and provide various services such as oxygen production, biogeochemical cycling of nutrients, decomposition of organic waste, water purification, provisioning of drinking water and food, etc. These organisms are grouped in three major classes (producers, consumers, decomposers), each category with distinct roles in the aquatic ecosystems, strongly interlinked with each other.

In the presence of light, the primary producers (planktonic and periphytic algae, macrophytes) synthesize organic matter through photosynthesis, rendering it available for the higher trophic levels. The primary consumers (zooplankton, benthic macro-invertebrates, fish juveniles and planktivorous fish) ingest the organic matter created by the producers, becoming in turn food resource for secondary or tertiary consumers (small fish, larger fish, aquatic birds). In aquatic ecosystems, large predatory fish (pike, catfish, sturgeon) or waterfowl feeding on fish (pelicans, cormorants, white-tailed eagles) are the highest ranked consumers and therefore, they are good ecological indicators of ecosystem health. The microbial communities play an essential role in recycling organic matter as they decompose the excreta of aquatic organisms, the detritus and the decaying bodies, preventing their accumulation in the aquatic systems and mineralizing the nutrients, to be used again by primary producers in a new cycle.

Freshwater ecosystems, such as rivers, lakes and wetlands are particularly important for biodiversity conservation, as although they only represent 0.01% of the world's water resources, they host almost 10% of known species (*Balian et al. 2008*). As many human activities rely on freshwater resources, these water bodies are highly impacted by industrial and agricultural pollution, hydromorphological alterations, land use change, overexploitation, invasive alien species and climate change. Consequently, the species living in freshwater habitats have undergone the most dramatic decline among all groups of species: 81% between 1970 – 2012 (figures based on data from 3,324 monitored populations of 881 freshwater species) (*WWF 2016*).

At European level, a seven-year assessment has shown that 200 out of 522 of Europe's freshwater fish species are at risk of extinction, 12 already being extinct (*Kottelat and Freyhof 2007*).

The Danube River Basin still hosts rich biodiversity and a high number of species and habitats of community interest, especially in its middle and lower stretches. Numerous critically endangered fish species are sheltered here, such as sturgeon, European eel and pontic shad, being protected by several EU directives and international conventions and included in the Natura 2000 network. However, the pressures exerted on the aquatic habitats, especially overfishing and the hydrotechnical constructions obstructing their spawning migration have led to a dramatic decline of long-distance migratory species. This is particularly true for the Danube sturgeon, considered the flagship species of the Danube River Basin (*ICPDR 2016*). After the construction of the Iron Gates dams in the 1970s and the consequent loss of spawning habitats located upstream the dams, they suffered a sharp decline, being nowadays in a very critical situation: according to *IUCN (2010)*, one species is already extinct (*Acipensersturio*), four species are critically endangered (*Acipensergueldenstaedti, Acipensernudiventris, Acipenserstellatus, Husohuso*), and one is vulnerable (*Acipenserruthenus*).

As part of the Biological Quality Elements, sturgeons should be monitored under the WFD. On the other hand, sturgeons are listed in the Annexes II and V of the Habitats Directive (*HD 92/43/EEC*), and hence, the monitoring of their conservation status is an obligation arising from Article 11 of the HD. The results of the national assessments of the conservation status of species and habitats of Community interest in the EU member states are summarised and reported under Art. 17 of HD to the EU Commission every six years. The year 2013 marked the third reporting date since the adoption of the HD, and the first time when Lower Danube countries such as Romania and Bulgaria, where wild populations of anadromous sturgeons still occur, reported the progress made with the implementation of the HD. In Romania, for instance, the sturgeon conservation status was assessed as "unfavourable – bad" (U2) in all the biogeographic regions where these species are distributed (*Mihăilescu et al. 2015*), indicating that urgent measures are needed at national level.

The national conservation measures should be harmonized with the Sturgeon 2020 Programme and strategy to secure sturgeon revival in the Danube River Basin and the adjacent Black Sea (*Sandu el al. 2013*). Intense cooperation and the commitment of relevant stakeholders in the Danube and Black Sea areas are required in the long term to achieve a "Favourable Conservation Status" of these critically endangered species.

ADDITIONAL CHALLENGES FOR ACHIEVING GOOD ECOLOGICAL STATUS

Water quality and hydromorphology are key drivers controlling the status of the aquatic communities and therefore, they are pre-requisite conditions for achieving the "good status" of the aquatic ecosystems. However, habitat quality and the diversity of the biological communities are subject to additional challenges that may affect the ecological status, the most important of them being the increasing impact of climate change and the occurrence of Invasive Alien Species (IAS).

Climate change

Worldwide, the impact of climate change has become ever more obvious during the past decades: air and water temperatures are increasing, glaciers are melting at an unprecedented rate, the precipitation regime has changed and the frequency of extreme meteorological events has increased significantly. At European level, an increase of precipitation level by Sup to 10-40% is expected in the Northern part of the continent, while in the Central and Southern part it will decrease by up to 20% (*IPCC 2008*). Widely accepted climate change scenarios suggest more frequent droughts in summer, as well as flash-flooding, leading to uncontrolled discharges from urban areas and land sources into receiving water courses and estuaries, resulting in possible microbiological (faecal coli, E. coli) and heavy metals contamination (former mining areas), increased loads of suspended solids (*Lane et al. 2007*) and soil erosion. Lower flows, reduced velocities and higher water residence times in rivers and lakes will enhance the potential for toxic algal blooms (*Whitehead et al. 2009*). Adaptation policies such as the culture of biofuels and increased water demand for irrigation, construction of new hydropower plants or higher dikes and embankments for flood protection will aggravate the impact on the freshwater ecological status. As the establishment of invasive alien species is more successful in disturbed ecosystems, with simplified trophic networks and reduced competition, any factor affecting ecosystem functionality may favour their further expansion: it has already been acknowledged that changes in forest species, the establishment of invasive alien species and disease outbreaks have been caused or enhanced by global climate change (*EEA 2016*).

The increase in water temperature leads to the decrease of dissolved oxygen content, affecting the self-purification capacity of natural water bodies and increasing the occurrence of hypoxia in the water column. Such environmental changes lead to a decline of oxyphylous species, which tend to migrate towards upper reaches with lower temperatures, and a proliferation of thermophilic species (*Sandu et al. 2009*). In the case of habitat fragmentation and connectivity disruption, the lack of migration corridors jeopardizes the survival of species with low tolerance of environmental changes.

Additionally, water temperature increase accelerates chemical processes and the decomposing activity of microbial communities, controls the growth rate of algae and macrophytes (*Wade et al. 2002*), regulates the emergence and abundance of aquatic macro-invertebrates (*Durance and Ormerod 2007*) and fish migration (eel, shad, sturgeons), rendering freshwater bodies sensitive to rising temperatures, with major implications for meeting WFD objectives and reference conditions for the restoration and improvement of the ecological status (*Whitehead et al. 2009*).

In the Danube river basin, according to the climate scenarios, the impact is expected to be particularly aggravated in the Southern part, as reduced precipitation ratios, increased temperatures and frequent droughts will occur, especially in summer (*ICPDR 2013*)

The water temperature of the River Danube increased by 1-3°C in the last century (*EEA 2007*), while the discharge recorded a decreasing trend after 1960 (*Michaylov 2004*). In fragile environments, such as coastal and deltaic areas, the climate change impact is even stronger; recent trend analyses emphasize that the area near the Black Sea will very likely become more arid in the next decades (*Cheval et al. 2017*). The climate change has already affected the Danube Delta, where the River Danube is the main water source. Some lake complexes already record decreasing depths and increasing temperatures (*Dumitrache el al. 2017*) with subsequent changes in species dominance: higher temperatures and reduced depths favour mass development of cyanobacteria, outnumbering other algal or macrophyte species, which result in cascading changes in the food webs.

Due to modified precipitation ratios, discharge fluctuations, increased frequency of floods and droughts, increased temperatures and evapotranspiration, climate change may significantly affect the river basins. Improving the climate models and the predictions of climate change may significantly contribute to the adaptation of the management strategies and to increasing the resilience of aquatic ecosystems. Identifying vulnerable areas, creating natural water retention measures to mitigate the impact of floods/droughts, restoring riparian and floodplain areas or creating buffer strips along the rivers to filter the pollutants brought by flash-floods, limiting water abstraction for human consumption during droughts, limiting deforestation and habitat fragmentation are just some adaptive measures that can be taken to mitigate the impact of climate change on aquatic ecosystems.

Invasive Alien Species

Invasive Alien Species are rated worldwide as the second major cause leading to biodiversity decline. Brought to Europe for aquaculture, farming, aquariums and the pet trade or accidentally (transport, e.g. ballast water, cargo ships), these species have escaped into the wild and have spread since, outcompeting the native species and establishing stable populations, while pushing indigenous species towards extinction.

Several of the 49 species included in the EU list of Invasive Alien Species of Union concern (*COM 2016, 2017*) are already present in countries of the Danube Basin, and may negatively impact the ecological status by modifying the characteristics of aquatic habitats and by eliminating native species, reducing aquatic biodiversity and inducing high economic damages on fishery, aquaculture, flood defence, agriculture and recreational activities. Due to their potential impact on the biological communities and reference species assessed according to the requirements of WFD (planktonic and periphytic algae, macrophytes, macroinvertebrates, fish), they should be taken into account in the evaluation of the ecological status of water bodies.

According to a recent assessment undertaken at EU level (*EC 2017*), some of the worst groups of “invaders” include: (1) aquatic plants, able to overgrow and create dense mats at the surface, impacting the whole ecosystem by preventing light penetration in the water column and inducing oxygen depletion, leading to the decline of native species; (2) crayfish, due to their predatory behaviour and competition with native species, to their burrowing activities inducing ecological damage to riverbanks or lakes, as well as to their ability to spread the crayfish plague, leading to the severe decline of native European crayfish species, (3) amphibians and reptiles, due to their capacity to outcompete native species through their breeding strategy, appetite and ability to disturb aquatic habitats, also posing a hazard to wildlife and human health due to the diseases they carry, (4) fish, with a significant negative impact especially on amphibians and other freshwater fish species, not only through predation and competition for food sources, but also through the disruption of the food webs and the transmission of diseases (5) semi-aquatic mammals, due to their ability to disrupt natural habitats and food webs, altering natural plant communities and fauna structure through their burrowing activities, reproduction strategy or voracious feeding behaviour.

Considering their high impact at ecosystem level, measures to reduce their local impact and prevent their future expansion should be urgently taken in future management strategies, as they may severely affect the ecological status of the Danube water bodies, as well as the conservation status of protected species and habitats under the EU Birds and Habitats Directives and the Marine Strategy Framework Directive. In such situations, the IAS and water management measures should be further harmonized with the conservation measures for protected species/habitats taken under these directives.

18 of the worst invaders connected to the aquatic environment, occurring in the Danube countries, are briefly presented below (*EC 2017*):

- *Cabombacaroliniana* (Carolina fanwort) – aquatic plant native to South America, brought to Europe as a decorative plant for aquariums, spreading rapidly due to its capacity to grow from tiny stem fragments to dense mats, clogging up lakes, ponds or water courses. The species is present in Danube countries such as Austria and Hungary.

- *Elodea nuttallii* (Nuttall's waterweed) – brought from North America for the aquarium trade, the species spread in slow flowing water bodies and lakes, being now present in Danube countries such as Austria, Bulgaria, Germany, Hungary, Romania, Slovakia and Slovenia.

- *Hydrocotyleranunculoides* (Floating pennywort) – originally from America, this fast-growing aquatic plant was brought to Europe for aquariums and garden ponds. The species is present in Germany.

- *Lagarosiphon major* (Curly waterweed) – native to South Africa, the species was introduced to Europe for aquariums. Of the Danube countries, the species is present in Austria, Germany, and Hungary.

- *Ludwigia grandiflora* (Water-primrose) – introduced from North America as an ornamental plant, it has established populations in European slow flowing rivers, streams, lakes and ponds. Besides its capacity to develop compact mats at the surface, blocking light and reducing oxygen content, it also has the ability to release alleopathic substances impairing the native species and affecting the entire ecosystem. It is already present in Germany and Hungary.

- *Myriophyllumaquaticum* (Parrot's feather) – originally from South America, the plant was brought for ornamental purposes and spread rapidly across the EU, being able to grow in lakes, ponds, wetlands, slow-running streams and canals. It is present in Austria, Germany, Hungary and Romania.

- *Myriophyllumheterophyllum* (Broadleaf watermilfoil) – native to North America, this aquatic plant is able to grow in all types of aquatic ecosystems, including wetlands. It is already present in Austria, Germany and Hungary.

- *Eriocheirsinensis* (Chinese mitten crab) – native to Eastern Asia, it probably entered Europe with ballast water, spreading rapidly from marine and brackish water to freshwater habitats. In the Danube countries, it is present in the Czech Republic, Germany, Hungary, Romania and Slovakia.

- *Orconecteslimosus* (Spiny-cheek crayfish) – native to North America, it was introduced to Europe for farming, since then colonizing rivers, streams and lakes. It is present in Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Romania, Slovakia and Slovenia.

- *Pacifastacusleniusculus* (Signal crayfish) – native to North America, it was introduced to Europe for farming, since then colonizing rivers, streams and lakes. It is present in Austria, Croatia, Czech Republic, Germany, Hungary, Slovakia and Slovenia.

- *Procambarusclarkii* (Red swamp crayfish) – native to North America, this large crayfish species was brought to Europe for farming, having now spread in slow-flowing rivers, marshes, canals and lakes. It is present in Danube countries such as Austria and Germany.

- *Procambarusfallax f. virginalis* (Marbled crayfish) – brought to Europe for aquariums, it is the only crayfish with the ability to clone itself. It is present in Croatia, the Czech Republic, Germany and Slovakia

- *Lithobatescatesbeianus* (American bullfrog) – this large amphibian, native to North America, was brought to Europe for farming and pet stores, since then colonizing ponds, marshes and reservoirs. It is present in Germany and Slovenia.

- *Trachemysscripta* (Red-eared, yellow-bellied and Cumberland sliders) – this large freshwater turtle originates from North America and has been brought to Europe for the pet trade. It is now present in several Danube countries: Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Romania, Slovakia and Slovenia.

- *Perccottusglenii* (Amur sleeper) – native to Asia, the species is especially widespread in Eastern Europe, being present in the Danube countries of Bulgaria, Croatia, Germany, Hungary, Romania and Slovakia.

) *Pseudorasboraparva* (Stone moroko) – native to Asia, the species spread across EU MS, being present in several Danube countries: Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Romania, Slovakia and Slovenia.

) *Myocastor coypus* (Coypu) – this large rodent from South America was brought to Europe for fur farming. It is present in Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Slovakia and Slovenia.

) *Ondatrazibethicus* (Muskrat) – introduced from North America for fur farming, the species has spread across Europe, establishing populations in 19 EU MS. It is present in Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary and Romania.

The recommended management measures most often include an EU ban on the trade of such species, a ban on keeping/releasing them, a strong control of the usual pathways for their introduction and spreading, as well as a rapid eradication of any newly emerging population, to prevent their further invasion in other EU member states. In countries where these species are already established, additional management measures should be taken to control their development (*EC 2017*). A close cooperation between authorities implementing Water Framework Directive and Nature Directives with transport and trade authorities is highly recommended in order to curb the expansion of invasive alien species in the Danube River Basin.

CONCLUSIONS

Good ecological status has a crucial role for the revival of the Danube sturgeon: their conservation status depends on good water quality, on the availability of food resources and on good hydromorphology. Their long-distance migratory behaviour between marine and freshwater habitats renders them particularly vulnerable to river continuity disruption, as this prevents access to key habitats and the completion of their life cycle.

The achievement of good ecological status in the Danube River Basin will require an enhanced cooperation of water management authorities with relevant stakeholders and enforced implementation of water and nature directives, especially in the context of emergent pollutants, planned infrastructure projects, expansion of invasive alien species and climate change, in order to prevent further habitat alterations and consequent biodiversity loss.

Considering the vital role of biodiversity for human wellbeing and economic welfare, the European Parliament has recently called for the stricter implementation of environmental legislation in order to meet the goals of the EU Biodiversity Strategy and avoid the loss of ecosystem services essential for human society such as clean air, clean water, food, pollination, etc. (*EP 2016*).

The EU Strategy for the Danube Region could become the major conveyor of this message at political and public level through an active dialogue with economic stakeholders on the crucial role played by biodiversity and well-functioning ecosystems for the sustainable economic development of the region.

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Flood management education in the Danube basin - needs and challenges

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Abstract
The even more disastrous transboundary floods, the catastrophic events in 2002, 2013 and 2014 indicated strong societal and political will for basin-wide actions to strenghten regional and cross-border co-operation along the Danube as the most international river of the World. Nowadays emphasis has been put on living together with floods rather than coping with them and simple flood defence turned into integrated flood management. The possibilities of non-structural ways to mitigate flood risk became significantly important. Strenghtened resilience and better preparedness can also be reached with the help of education related to flood management and civil protection. Therefore, both the education of the general public – provided mainly at the elementary and secondary school levels – and postgraduate courses/trainings for experts working at the water directorates or at the civil protection field is essential to reduce losses. Nevertheless, secondary school geography textbooks in the Danube countries containing the description of natural disasters only at 2,7 % of the pages in average. Descriptions of risk assessment, prevention, rescue methods, types of renovation and complex or problem-based descriptions are less common. At universities, flood protection topics are covered by the Civil Engineering degree programmes, but the topic of flood management is discussed mainly within other subjects. The same problem applies for the Disaster Management programmes in Hungary. The lack of an education/training network in the basin was identified in 2015 by the EU Strategy for the Danube Region Environmental risks priority area based on their survey. In the first Flood Risk Management Plan of the Danube River Basin (DFRMP) 12 countries highlighted the need towards trainings for experts and education of the inhabitants. Therefore a workshop has been organized in June 2017 for experts to promote networking, to discuss the needs and challenges in this field and to get acquainted with the funding possibilities. The main findings of this workshop have been summarized in the present article.

Keywords
Danube river basin, education, flood risk prevention, strengthening flood resilience, EU Strategy for the Danube Region.

INTRODUCTION

The Danube basin covers more than 801.463 km^2 in 19 countries which makes it the most international river of the World. Transboundary floods typically affect larger areas, can be more severe, result in a higher number of deaths and cause increased economic loss than non-transboundary rivers (Baaker 2009) due to non-harmonized strategies, incoherent flood forecasting systems and flood protection measures, administrative burdens, or the lack of co-operation between countries. Under the umbrella of the International Commission for the Protection of the Danube River (ICPDR) the countries are multilaterally co-operating towards a harmonised flood protection in the Danube River Basin since the Danube River Protection Convention was signed in 1994 – by the countries with territories above 2000 km^2 from the watershed –and ICPDR was established by the Contracting Parties. (*ICPDR 2015a*).

The severe floods of 2002 made thousands of people homeless, caused casualities and several thousand million Euro damage in many countries across Europe. European Union Solidarity Fund (EUSF) was set up to support EU member states and accession countries by offering financial support after major natural disasters. The Fund was created in the wake of the floods. The informal meeting of Water Directors of the EU and Candidate Countries after the flood decided to collect best practices on flood prediction, prevention and mitigation in 2003 as an update of the UNECE Guideline on Sustainable Flood Prevention (*IWDM 2003*). National administrative and legislative provisions were done like the German Flood Protection Act in 2005 (*Thieken et al. 2016*). On European level since 2007 the EU Floods Directive's (2007/60/EC) main objective to require member states to assess and manage risks of flooding and to develop flood risk management plans. Plans are restricted to areas considered at high risk of floods, these are not integrated into other types of plans and maps available, nor are they used for developing preparedness response measures in advance of an accident or natural disaster, such as in the case of the Seveso Directive (2012/18/EU). Though the Floods Directive was expected to reduce flood risk, experts voiced disappointment regarding the limitations of integrating disaster risk more broadly, particularly in relation to water quality and accidental pollution (McClain et al. 2016). In May and June 2013, much of Central Europe was affected by extreme flooding again in many areas: causing damages to houses, infrastructure, and services. Though the floods were more severe and more extensive, total direct damage was 9.6 billion EUR in Germany, Czech Republic and Austria. It was less than that of the floods in 2002, particularly in Austria and the Czech Republic. This is partly due to the effectiveness of flood protection and risk control measures being introduced since 2002 (*EC Press Release 2013*). One year later the floods in Serbia, Bosnia and Herzegovina and Croatia caused 3.65 billion EUR damage (15% of the GDP in BiH that year) and more than 2.6 million people were affected, 137.000 evacuated and 79 casualties occured (*COWI-IPF 2015, Tadjbakhsh et al. 2016*). These circumstances indicated strong societal and political will for basin-wide actions to strenghten regional and cross-border co-operation. Danube countries also expressed their need for the usage of existing structures as ICPDR, Sava Commission and the EU Strategy for the Danube Region Priority Area 5 (EUSDR PA5 – environmental risks) and target the not fully utilized funds of the EU Programmes to implement structural and non-structural measures.

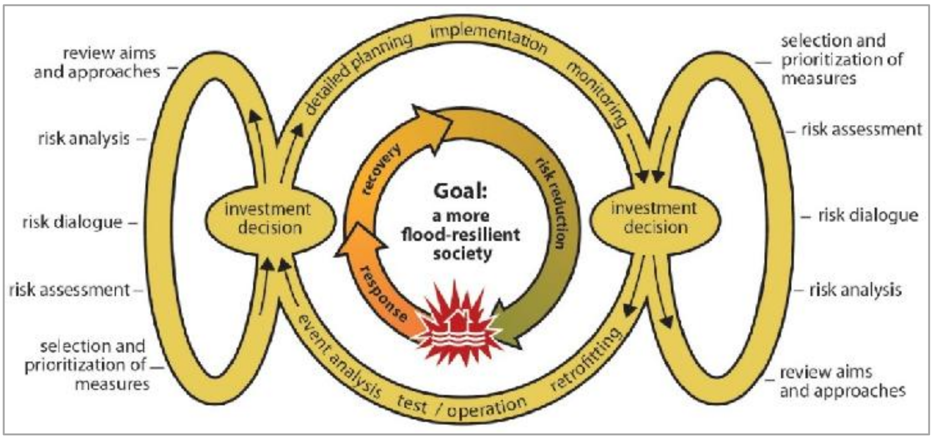

Figure1. Cycle of flood risk management (Source: Thieken et. al 2016)

The flood management cycle (*Figure 1*) consists of three phases: pre-flood preparedness, response during floods and post-flood recovery of areas and communities (*Shreshta et al. 2011*). Nowadays emphasis has been put on living together with floods rather than coping with them. Thus, simple flood defence turns into integrated flood management (*Thieken et al. 2006*). The mitigation of flood-related hazards can be reached with the help of structural and non-structural measures. Creation of headwater dams, improved embankments and the construction of new and heightening of already existing levees, or even the application of mobile solutions and water retention with the help of emergency flood reservoirs belong to the classic structural solutions. Despite structural measures (defence structures) will remain principal element to secure goods, property and primarily human health and safety, the possibilities of non-structural ways to mitigate flood risk became significantly important nowadays, because they tend to be potentially more efficient and more sustainable solutions on the long run (*IWDM 2003*). The promotion of rainwater infiltration, the enhancement of soil conservation with reduction of soil erosion, proper landuse, the conservation and restoration of vegetation in mountainous areas and riparian woodlands, the reconnection of rivers with their floodplains, the maintenance of the vegetation, the improvement of land reclamation, the reconnection of dead branches, the relocation of dykes and opening natural levees, the discharge of excess water into natural flood retention areas, the dismantling of man-made obstacles of flow are well known non-structural solutions to reduce flood risks. They also support the three-step approach (retaining, storing and draining) in avoidance of the passing of water management problems to other regions (*IWDM 2003*). Improved common hydro-meteorological monitoring systems (like the Trans-Carpathian Flood Monitoring System along the Upper-Tisza River), data exchange platforms and flood forecasting models (e.g. the Morava-Dyje rainfall-runoff model, or the Rába/Raab, Ipoly/Ipel flood forecasting system), the setting up and operational use of early warning systems like the European Flood Alert System are essential steps in reaching well-preparedness (*Demeritt et al. 2013, ICPDR 2015a*).

Raising awareness is also essential to increase preparedness in all the regions. The elaboration of flood management strategies and flood defence and evacuation plans, furthermore regular joint exercises are essential, especially in transboundary areas. Nevertheless, these strategies should be better communicated to both insurance companies and property owners. Informing people about the flood risk of their residence and possibilities for flood insurance and flood loss mitigation would be a first step in strenghtening the disaster preparedness of private households. The role of insurance companies is also undeniable in risk management. Insurance companies should acknowledge the mitigation activities of private households through incentives (e.g. certificate of disaster resistance), or disseminate flood-adaptive building use and materials. An investigation (*Thieken et al. 2006*) has shown that 80% of insurers informed building owners of which flood hazard zone they were living in and only 25–35% of the insurers gave advice before the 2002 flood in Saxony-Anhalt (Germany) on how to mitigate flood losses. In Saxony-Anhalt 35% of the insured households without flood experience declared that they had known about their living in a flood-endangered area in 2002. This applied only to 26% of the uninsured households without flood experience. In 2002 only 14% of private households clearly knew how to protect themselves and their assets, in 2013 this ratio was already 46 % and a higher percentage of households implemented mitigation measures. Nearly half (48.5%) of the insured households had acquired information regarding flood mitigation or participated in emergency networks, whereas only the third (33.9%) of the uninsured ones had done likewise (*Thieken et al. 2006*).

The combination of flood insurance with land-use planning and damage mitigation is important to increase resilience. Dynamic adaptation of households to changing flood risk over time can reduce estimated flood risk by 19% to 56% as it was shown in case of Rotterdam (*Haer et al. 2016*).

Strenghtened resilience and better preparedness can also be reached with the help of education related to flood management and civil protection. Therefore, both the education of the general public – provided mainly at the elementary and secondary school levels – and postgraduate courses and trainings for experts working at the water directorates or at the civil protection field is essential to reduce losses in any river basin.

EDUCATION IN FLOOD MANAGEMENT, FLOODS IN EDUCATION

Knowledge on floods starts with local experience which is space-specific, as it is the complex of adaptive responses of inhabitants to change (e.g. hazard history, as the location, intensity, frequency and duration of previous hazards, the interpretational knowledge of changes in animal behaviours as early warning signals, knowledge of the safest and fastest roads, life stories about impowerishment processes of households). Communities which have been living with natural hazards for generations coped and adapted to minimise negative effects. Local knowledge can contribute to safety by giving local advice on safe locations for construction sites (buildings and roads) and if used together with conventional knowledge for hazard mapping. Local knowledge can also be used in information: in early warning systems, surveys, and other inventories to verify information, as well as to help adapt communication strategies to local understanding and perceptions, and to integrate local values into the decision-making processes. The incorporation of local knowledge into disaster preparedness and management activities can be made cost-effective, efficient, and sustainable. We all have local knowledge, but it may differ by ethnicity, clan, gender, age, sex, socio-economic group, and educational level. Local knowledge is dynamic, it is both created and lost over time. It depends more on memory, intuition and the senses than on the intellect. It is always gained through experience and is transferred from one generation to the next (*Shrestha et al. 2011*).

The example of Tilly Smith shows why education in small communities is needed. She was a 11 years old British school-girl in 2004 when she warned others before a tsunami arrived at Phuket shoreline (Thailand) during her holiday recognizing the signs of the phenomenon based on her geography lessons studied two weeks before and saving hundreds of people (*UNISDR Education 2017*).

General public is often involved too late into the planning process, however, affected people are obliged to obtain information to implement mitigation measures. Therefore risk dialogue should be carried out properly, integrating local interest, experiences and knowledge into locally adapted risk management strategies. The importance of this has become evident between the floods of 2002 and 2013 in Germany. Probably due to intense flood experience as well as improved risk and emergency communication residents, businesses and authorities were better prepared (*Thieken et al. 2016*). Local actions like "Memo'Risks" developed and applied in the Loire River catchment (France) have shown a good example. The initiative brought together local government and schools in order to survey local disaster risk situations and awareness. Thus, it not only supported the knowledge and motivation bases of pupils, but it also documented the risk perception and local knowledge about hazards (Komac 2013). Partners from the five affected countries of the recently running JOINTISZA project – aiming to prepare the update of integrated river basin management plan of the Tisza catchment area – are also aware of public involvement, organizing stakeholder seminar to train the planners and testing Shared Vision Planning (SVP) methods during the planning process (*JOINTISZA 2017*).

Several Danube countries have realized the importance of flood protection related education as a non-structural preventive measure in the past 15 years. Education has been identified as a gap in flood management, highlighted by experts in relevant documents as well.

Integration of flood protection research knowledge into graduate and post-graduate education programmes and trainings for professional engineers, the staff of local authorities landuse planners and rescue teams was a core part of the "best practice document" presented at the Water Directors meeting already in 2003. In order to reach well-preparedness of communities, the education and transfer of knowledge about flood risk with the availability of flood hazard maps and other appropriate information is essential (*IWDM 2003*).

The EU Floods Directive also does not mention education directly and says in *Article7* that flood risk management plans shall address all aspects of flood risk management focusing on prevention, protection and preparedness considering appropriate non-structural initiatives like flood forecasting, early warning systems, sustainable land use practices and improved water retention. As a provision since 2007 every flood risk management plan in the EU should contain a summary of measures and their prioritisation.

EUSDR PA5 experts started an on-site survey in the Danube countries in 2013-2014 (following the exceptional floods of the region) to collect what lessons have been learnt and compile proposals regarding transboundary challenges of floods, also to be prepared for the financial framework 2014-2020 of the EU and to help complement the Danube flood risk management plan with projects ideas. All the 14 countries and states/lands were consulted and the result was summarised in the Danube Region Operative Flood Management and Cooperation Programme (DR Oper&Cooper) which was adopted by the EUSDR PA5 Steering Group in April 2015. Out of the seven measures the sixth identified the importance of the development of an education/training network in the Danube river basin (*EUSDR PA5 2015*).

In Annex 2 of the first Flood Risk Management Plan of the Danube River Basin (DFRMP) 12 countries highlighted the need towards trainings for experts and education of the inhabitants in 2015 (*Table 1*). The list of transboundary projects considered supportive to the implementation of the plan were also listed as it was required by the Flood Directive. This list also contains the measures of DR Oper&Cooper including the establishment of an education/training network in the basin (*ICPDR 2015a*).

Table 1. Education-related measures highlighted by the Danube countries in the first Flood Risk Management Plan (edited by the authors based on the Annex 2-5 of ICPDR 2015a)

	Measures to avoid new risks in the DRB	**Measures reducing the existing risks**			**Awareness raising, Measures strengthening resilience and implementing the solidarity principle**
	Emergency event response planning/Contingency planning and other measures to establish or enhance preparedness	**Measure to adapt receptors to reduce the adverse consequences in the event of a flood actions on buildings, public networks, etc...**	**Other measure to enhance flood risk preventio n**	**Public awareness and preparedness**	**Measure to establish or enhance the public awareness or preparedness for flood events and other measures**
Germany	– Information and training				
Austria					– Educational activities
Czech Republic					– Raising of public flood risk knowledge – Flood exercises for flood and crisis authorities
Slovakia					– Training campaigns focused at flood preparedness among municipalities
Hungary		– Training local defense leaders, municipality responsible groups	– Education		– PR methods and education to increase the awareness of the population
Slovenia					– Information and education of highly endangered inhabitants
Croatia					– Establishment of a system for regular education of the public regarding flood risk management issues, especially in areas under significant flood risks
Serbia					– Introduction of water management issues into schools (from elementary school to university level) – Training exercises – Municipal authorities capacity building and training
Bosnia& Herzegovina		– Capacity building on municipal level, organizing educational workshops			– Public awareness of flood life strategy
Romania	– Flood exercises simulation with inter institutional participation			– Flood exercises simulation with inter institutional participation	– Active education/training of the population (brochures, leaflets, media communication)
Bulgaria					– Educational activities – Training and information campaign
Moldova					
Ukraine					– Trainings for authorities and population

The Serbian Water Management Strategy and the gap analysis of the Western Balkans regarding the implementation of Flood Directive also identified in 2015 that the lack of capacities in water directorates makes them insufficient to respond to all legal requirements (*COWI-IPF 2015, Ministry of Agriculture and Environmental Protection 2015*). Higher education institutions in most of the Western Balkan countries are not providing sufficient number of flood management experts and water professionals with the required skills to establish and operate databases, monitoring and early warning systems necessary for the Floods Directive implementation.

The lack of skilled professionals, uncertainties of employ-ment, poor working conditions and low wages create a situation where the complex exercise of implementing the Directive requires external assistance. Therefore region-wide undergraduate and professional educational and training programmes need to be developed. Considering that results of any complex educational programme must be tangible and will require time, initiatives to address this must be taken as soon as possible to avoid further weakening of the professional background in the region. An increase in the capacity of technical and scientific institutions and extensive networking with the administration is needed. Engineering capacities needed in Serbia to implement development projects were also summarized (*Table 2*).

Table 2. Required engineer capacity building in the field of water management in Serbia from 2015 (Source: Ministry of Agriculture and Environmental Protection 2015)

Period	Funding mill. €/y (average)	Engineers (annual average)		
		Planning and Construction	Design	Total
Up to year 5	240	1 200	400	1 600
Years 6-10	480	1 500	1 000	2 500
After 11 years	550	1 500	1 700	3 200

An important step was made in Slovenia towards an improved education related to natural hazards by introducing a special elective primary school subject titled 'Protection against natural and other disasters' for pupils between twelve and fourteen years old (Komac et al. 2013). A new postgraduate school was established by the Anton Melik Geographical Institute of the Slovenian Academy of Sciences and Arts focusing on natural hazard modelling and the University of Ljubljana participates in an ERASMUS MUNDUS international Flood Risk Management Master Programme which has been finished already by 200 students. ASummer School on Natural Disasters was also organized in Ljubljana in May-June 2017 preparing around 20 e-learning tools and video presentations with on-line access (*EUSDR PA5 2017*).

University of Bucharest in cooperation with universities from Athens, Belgrade and Ljubljana in 2013-2014 offered international courses in frame of the EDUCATE! project which had a 15 weeks Integrated Flood Management and a similar length Stormwater Management module.

There is a historical past in flood management training in Hungary for a long time. At universities, flood protection topics are covered by the Civil Engineering degree programmes. The Budapest University of Technology has traditionally trained water management professionals, including flood protection in the curricula, since its establishment. The predecessors of the Faculty of Water Sciences of the National University of Public Service in Baja had always specialised in practical rather than theoretical training, its graduates forming the core of flood specialists of the country for decades. This institution was founded in 1962, when the National Water Management Authority initiated the establishment of a higher education institution on water management in Baja, with the specific task of training practical water management engineering staff for the Water Authorities. From the beginning, the education of flood management was always an important and integrate part of the training here, meaning that theoretical and practical courses on a compulsory basis are being taught for all students. However, the complex topics of flood management required a bigger effort, and in the 1990s the leadership of the training programme started the elaboration of a specialised flood engineering postgraduate course, which was first announced in 2000. To date, this is the only dedicated Flood management education in Hungary, which is now offered by the Faculty of Water Sciences of the National University of Public Service. Already 231 students – in substantial number experts of Hungarian water directorates – have enrolled and graduated at the Excess Water and Flood Management postgraduate programme since 2003 (Table 3). Over the past decade, there was a clear need for this type of postgraduate training in Hungary. At present, there are 54 students having altogether 400 hours of lectures and practicals in the field of flood management engineering. Teaching staff consists of more than 50 professional academics and practical instructors.

Table 3. Number of graduates at the Excess Water and Flood Management postgraduate programme of the Faculty of Water Sciences of the National University of Public Service in Hungary (Source: Szlávik, L. pers.comm.)

Year	Place of instruction	Number of graduates
2003	Baja	30
2008	Nyíregyháza	43
2010	Nyíregyháza	47
2012	Baja	36
2015	Szolnok	43
2016	Baja	32
2018 (expected)	Nyíregyháza	54
Total		**285**

Apart from graduate and postgraduate engineers, at secondary school level there are today altogether 9 schools which educate young water managers in Hungary, however, the number of trained experts in the field of flood management is still far too low, according to surveys conducted by the educating institutions.

Hungarian government harmonized the disaster management related education, training and research by the Act 128 of 2011. Disaster management related vocational trainings are organized by the Hungarian Disaster Management Education Center under the supervision of the National Directorate General for Disaster Management (background institute of the Ministry of Interior). Disaster Management BA and MA degree programmes are coordinated by the Institute of Disaster Management at the National University of Public Service in Budapest. Neither vocational trainings, nor the curriculum of Disaster Management BA and MA degree programmes in Hungary contain any courses dedicated especially to flood management. However the bachelor programme incorporates civil protection, disaster prevention, relief operations, disaster recovery subjects, or catastrophe psychology and master students have 'Meteorology and climatology' and 'Geography of Disasters' courses. In 2016 all together 115 students were enrolled to Disaster management BA and 49 to MA programme (*Felvi 2017*).

In 2005, during the World Conference on Disaster Reduction in Kobe almost a third (36 of 113) of the reporting countries claimed to have national efforts to teach disaster-related subjects or some form of disaster-related education in primary or secondary schools. From the Danube basin, the Czech Republic, Hungary, Romania and Slovenia were among them. Risk education themes are included in different school forms and are distributed in the curricula of several subjects, such as geography, biological sciences, physics, social sciences, history, forensics and domestic sciences. One of the most important school subjects in which natural hazards are being taught is geography. Geography textbooks transmit knowledge about landscape phenomena and processes as well as social developments and problems of hazards. Therefore, a horizontal content analysis of 166 secondary-school geography textbooks from 36 countries – including 12 from the Danube basin – was conducted in 2013 by Komac et al. Research findings reported that on average 3.1% of the pages are dedicated to natural disasters in the examined 36 countries.

However, this ratio is lower (only 2,71%) in the Danube basin *(Table 4)*. Approximately 80% of the pages describing natural disasters present various forms of natural hazards. Descriptions of risk assessment, prevention, rescue methods, types of renovation, and complex or problem-based descriptions are less common. The largest share of specific descriptions is dedicated to earthquakes (23.2 %) and volcanic eruptions (21.2 %), followed by floods (18.1 %), erosion (14.5 %), landslides and rock falls (7.9 %), storms (7.1 %), droughts (3.5 %), and avalanches (2.5 %). The least discussed topics are the impact of tidal waves and tsunamis (1.1%), and forest fires (0.8 %). The textbooks do not mention the effects of extremely high temperatures (heat waves) and extremely low temperatures (frost, glaze ice). Comparing the descriptions of natural disasters in textbooks with the actual occurrence of natural disasters in Europe in the past century volcanic eruptions are significantly over-represented. Only a third of the pages contain descriptions of earthquakes, however these have caused the largest number of victims (89%) and a third of the total damage. In the past hundred years, floods have been extremely frequent in Europe (representing nearly 40% of all disasters), causing 44% of the total damage. Therefore, it seems more than appropriate that nearly a fifth of all the pages are dedicated to floods. Storms, which are very frequent (24% of all the events), are only described on 9% of the pages, which means they are underestimated considering they have caused 19% of damage and 2% of victims in Europe. Landslides are described on 10% of the pages, and are thus covered well, given the frequency (8%), the number of victims (5%), and damage (1%). Very little space (1 %) is dedicated to forest fires, even though based on the frequency (7 %) of their occurrence (*Komac 2013*).

The highest percent of textbooks is dedicated to natural hazards in Romania (6,02%), Germany (4,72%) and Slovenia (4,09%). Less than 1% of the investigated geography textbooks highlights hazards in Czech Republic (0,53%) and Ukraine (0,33%) and no pages were found in Slovakia mentioning floods or any other natural disasters.

Table 4. Natural hazard descriptions in Geography textbooks of the Danube basin (edited by the authors based on the data of Komac et al. 2013)

Country	No. of text-books	No. of text-book pages	No. of pages containing descrip-tions of natural disasters	Share of pages containing descrip-tions of natural disasters
Austria	4	911	19	2,09
Bosnia&Herze-govina	6	1 083	21	1,94
Bulgaria	no data	no data	no data	no data
Croatia	4	748	11	1,47
Czech Republic	3	374	2	0,53
Germany	10	2 226	105	4,72
Hungary	7	1 225	35	2,86
Moldova	3	714	14	1,96
Montenegro	no data	no data	no data	no data
Romania	3	399	24	6,02
Serbia	5	1 020	36	3,53
Slovakia	3	254	0	0
Slovenia	7	831	34	4,09
Ukraine	6	1 514	5	0,33
Total	**61**	**11299**	**306**	**2,71**

NEEDS AND CHALLENGES – COMMON FINDINGS OF A WORKSHOP

EUSDR PA5 (Environmental risks) and the Faculty of Water Sciences of the National University of Public Service organized a workshop on the International Danube Day (29/06/2017) in Budapest. The workshop brought together the related EUSDR priority areas namely PA7 (Knowledge Society) and PA9 (People&Skills), the representatives of universities, vocational schools, water directorates and SMEs being interested in education of flood management in order to discuss the problems, needs and possibilities in this field.

The participants also shared their education experiences related to flood protection, and they also presented previous project outcomes and recent initiations. Attendants were informed about the forthcoming funding possibilities of different programmes like ERASMUS+, CEEPUS, DAAD, Horizon2020 in order to start a discussion and set up a network of institutes to establish an international flood protection education network in the region, the importance of which was identified by several countries in the 1st Flood Risk Management Plan of the Danube Basin (DFRMP).

The opinions and experiences of the participating 32 experts from 6 countries of the Danube region have been summarized in a Common Findings document by PA5 Hungarian coordination (*EUSDR PA5 2017*). A short list of international education programmes and projects was alsocollected which is related to the activities of the participants. The key messages will be communicated to the PA5 Steering Group to enhance the PA5 action plan respectively and to ICPDR FP-EG in order to find proper measures to be included during the update of the DFRMP.

The main findings of the event were the following:

- In vocational schools because of the aging of teachers and their limitations in speaking foreign languages (mainly English), the attrition of young professionals, the low number of full time teachers and the lack of continuity caused huge fluctuation, that is why secondary school level technical education is disappearing, therefore enhanced dual education is needed. In some cases water supply companies started to set up postgraduate and secondary level courses (i.e. in Bratislava);
- Recruiting of prospective students is a constant problem for universities. There is a lack of proper marketing and people (students) aren't aware of these fields of expertise. Therefore, close cooperation between secondary schools and higher education institutions is important;
- There is a low interest for technical studies and a deacreasing number of university students in general, that is why less educated people are present in this field;
- General knowledge of hydrology is given during civil engineering studies at the bachelor level, but hydraulic engineering is appearing only as a specialization. Some of the specialised master studies are focusing on flood issues and climate change induced problems, or urban floods and related EU legislation;
- At university level, the topic of flood management is covered mainly within other subjects (e.g. hydrology, hydraulic structures, river regulation, economy), that is why students are not able to see this issue in an integrated way as a complex whole problem;
- Social issues of hazards (e.g. socio-hydrology, social memory in natural hazards, resilience of landscapes and population, social aspects of floods, participatory planning methods) and green measures should be more in focus. Interdisciplinary research in the field of victims and real estate should also be emphasized;
- Several problems could be overcome with good co-operation of water directorates, giving special courses and organizing technical excursions, therefore co-operation with water institutions should be sustained or enhanced;
- Traditional education and local knowledge are disappearing and implementation of education in small communities is needed;
- Training of volunteers and inhabitants is important;
- Lack of knowledge on floods in administration-related sciences results in inadequate education of municipal experts, who indeed need to be prepared and to effectively cooperate with water resources and disaster risk management as well as urban planning sectors in order to see the flood problem in an integrated way. Implementation of the learnt knowledge is also missing, because educated people are usually not present in the field;
- Changing political background and missing long-term strategy of water policy results in interference in the sector (and this can also influence project implementation and investments). Despite big floods, political attention on floods is very low;
- Several discussions took place on the ways of application of the 2nd, 3rd and other cycles of the Water Framework Directive. Flood Directive is also not complete at all. Flood Directive is not enough to re-establish education;
- Re-establishment of the Danube hydrology discussion is necessary. There are very few good experts in hydrology, therefore networking should be emphasized;

The key messages of the workshop will be communicated to the EUSDR PA5 Steering Group to enhance the PA5 action plan and to ICPDR Flood Protection Expert Group in order to find proper measures to be included in the pursuance of the Danube Flood Risk Management Plan update.

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MANAGING WATER QUALITY

– ongoing projects and future challenges –

(Tisza River at Dilove, Ukraine; Photo from Diana Heilmann)

DANUBE REGION strategy Water Quality

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Interreg
Danube Transnational Programme

Capitalization within Thematic Pole 4 Water Management

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Abstract
The paper gives a short overview of the thematic capitalization strategy of the Danube Transnational Programme and its Water Management Thematic Pole in operation as of 2017.

Keywords
Danube Transnational Programme, water management, capitalization, Danube Strategy

BACKGROUND

The late South East Europe Programme 2007-2013 (SEE) designed a Thematic Capitalisation Strategy to streamline the process of creating synergies between 122 SEE transnational partnerships, and capitalising on results of previous initiatives. The SEE Capitalisation Strategy was formally launched close to the edge of the previous programming period, in June 2013 and it aimed to strengthen the links between projects working on similar topics (Thematic Poles), to enable projects to exploit and consolidate one another's achievements, and create a higher leverage effect (*Southeast*).

THE DTP CAPITALIZATION STRATEGY AND ITS PROCESS

At the end of 2016 the Danube Transnational Programme (DTP) initiated to start its Capitalisation Strategy right at the momentum of projects awarded funding in the first DTP Call commenced. Capitalization was launched on 25-26 January 2017 in Budapest, with the first Call Lead Partner Seminar for the Lead Partners of all those 54 projects selected (*http1*, *http2*, *http3*). The launch was attended and welcomed by the newly approved projects of the DTP and by the Priority Area Coordinators (PACs) of the EU Strategy for the Danube Region (EUSDR) as well. With this early start, the capitalization process would make it possible for the projects and PACs to get to know each other's work, establish professional links to cooperate and score better outcomes and results through peer learning, benchmarking. As the DTP announced, the DTP Capitalization *Strategy would grow together with the projects, hand in hand, grasping important aspects, welcoming and integrating the projects from the future calls and working as "knowledge and inventory manager*" (*Interreg-Danube*). The overall aim of DTP capitalization is therefore to cooperate with each other most efficiently, to build synergy between the DTP projects, as well as with other projects funded by other financial instruments; the latter meaning that capitalization is not limited to DTP projects only, but other projects are welcomed as well.

The capitalization process is mutually beneficial for the selected projects, for the Programme, but also for the EUSDR stakeholders as well as all DTP Priority Axis and related Specific Objectives show direct linkages to the pillars of one or more EUSDR Priority Areas. In relation to the EUSDR, the DTP Joint Secretariat (JS) has created the different Thematic Poles (TP) based on the EUSDR Priority Areas to reinforce the links between the Programme and the Strategy and foster the capitalisation opportunities (*Interreg-Danube*). It is indeed efficient for the EUSDR as it could benefit of newly formed networks and collect information and valuable inputs from the ground.

The objectives of DTP Capitalisation Strategy (*Interreg-Danube*)

- To valorise and further build upon the knowledge resulting from projects working in a thematic field
- To fill knowledge-gaps by linking actors with complementary thematic specialisation, experiences, methodological approaches or geographical scope
- To increase the visibility of the projects and the programme and to ensure their impact on the policy making process at local, regional, national and European levels
- To strengthen strategic thematic networks in the Programme area
- To encourage the wider take-up of project outcomes from outside the DTP Programme area
- To contribute to the design and/or implementation of future transnational cooperation in the area.

Target groups

- DTP projects working on similar or complementary topics
- Beneficiaries of DTP project outputs
- DTP stakeholders
- DTP Programme bodies
- EUSDR bodies and stakeholder
- Projects and stakeholders outside the programme area, relevant to the identified thematic poles

Activities

The DTP Capitalisation Strategy provides the list of capitalisation activities which includes but not limited to:

- Joint communication actions (e.g. newsletters, etc.)
- Joint thematic meetings to exchange on projects' content and outputs
- Joint thematic studies and policy recommendations
- Peer review or benchmarking of project outputs
- Exchange visits between projects, if this enables cross- fertilisation and/or take-up of results
- Joint dissemination activities such as joint (final) conferences addressing common stakeholders.

THEMATIC POLE WATER MANAGEMENT

Four DTP projects were identified by the JS originally in January 2017 to cooperate in the capitalization framework of DTP Thematic Pole 4 in connection to Water Management (Thematic Pole Water Management). While the projects address different issues like steering land use to safeguard water resources and reduce flood risk; coordinating sediment management along the Danube river; developing an integrated river basin and flood risk management plan for the Tisza River Basin; improving drought monitoring, management and emergency response in the Danube Region; they seek for synergies for the common benefit (*Interreg-Danube*).

The DTP projects involved in the DTP Thematic Pole 4 – Water Management are the following:

1. CAMARO-D - Cooperating towards advanced management routines for land use impacts on the water regime in the Danube River Basin (*http4*)	Interreg Danube Transnational Programme CAMARO-D
2. DANUBESEDIMENT - Danube Sediment Management - Restoration of the Sediment Balance in the Danube River (*http5*)	Interreg Danube Transnational Programme DanubeSediment
3. DRIDANUBE - Drought risk in the Danube Region (*http6*)	Interreg Danube Transnational Programme DriDanube
4. JOINTISZA - Strengthening cooperation between river basin management planning and flood risk prevention to enhance the status of waters of the Tisza River Basin (*http7*)	Interreg Danube Transnational Programme JOINTISZA

Apart the above-mentioned DTP projects and the JS designated project officer, Mr Gusztáv Csomor, also two Priority Areas of the EUSDR take active part in the capitalization procedure: the coordination teams of Priority Area Water Quality (PA4) and Priority Area Environmental Risks (PA5). At the initial discussion at the referred Lead Partner Seminar in January 2017 the Pole members agreed that the Thematic Pole Water Management will be lead and coordinated by EUSDR PA4 Coordinator, Mr Balázs Horváth, from the Hungarian General Directorate of Water Management.

In February 2017, the Thematic Pole Water Management agreed and adopted its document on capitalization, where identified its next steps towards capitalisation, its potential synergies and created its contact list. During spring 2017 the Thematic Pole Water Management further elaborated its Capitalisation Strategy, identified synergies, described its internal and external communication, listed its planned events for 2017, elaborated its peer review and established a Roadmap. The Thematic Pole Water Management Capitalization Strategy document is a working document that is regularly being reviewed and updated. During the 13th Steering Group (SG) Meeting of Priority Area Water Quality on 25-26 April 2017 in Bratislava, further projects were identified that are welcomed to take part of the capitalization: STREAM, DANUBEparksCONNECTED, FramWat, DREAM, Sturgeon 2020, some of which are funded by different financial sources than DTP.

Direct results of the DTP Capitalization Strategy are already visible: Thematic Pole Water Management projects invited each other to their own kick off events in March 2017; and all Pole projects were invited to the SG meetings of Priority Area Water Quality and Priority Area Environmental Risks. JOINTISZA and DANUBESEDIMENT held a joint event on Transnational Cooperation for Sustainable River Basin Management Conference on 11 April 2017 (Budapest, HU). All team members participated and jointly held an EUSDR PA4 and PA5 organized side event of the Hungarian Hydrological Society's Annual Conference on 5-7 July 2017 (Mosonmagyaróvár, HU). Further joint events are already foreseen for 2017: several DTP Capitalization Workshops will be held in the frame of the Annual Forum of the EUSDR in Budapest, in the morning session of 19 October 2017, where capitalization will be discussed further (*Danube-Forum*).

Networking and further capitalization is under progress based on the great initiation of DTP and we, on behalf of the concerned Priority Areas of EUSDR look forward to a streamlined cooperation together with the projects to gain additional, synchronized and tangible results for our Danube Strategy and turn policy into practice.

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Strengthening cooperation between river basin management planning and flood risk prevention to enhance the status of the waters of the Tisza River Basin (JOINTISZA)

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Abstract
In the framework of the International Commission for the Protection of the Danube River (ICPDR), the countries of the Tisza River Basin committed themselves to continue the joint cooperation, which started in 2004 in the framework of the ICPDR, and renewed their Memorandum of Understanding in 2011(*ICPDR MoU 2011*). In addition, in June 2011, the EU Strategy for the Danube Region (EUSDR) was adopted and endorsed during the Hungarian EU presidency including an objective to strengthen sub-basin cooperation. In line with the initiative of the EUSDR, the ICPDR Tisza Group and the countries of the Tisza Basin committed themselves to developing a flagship project to support and intensify the cooperation between water management and relevant sectors in the Tisza River Basin (*ICPDR MoU 2011*). As a result of the cooperation, the JOINTISZA project proposal was developed in 2015 and 2016, which was deemed successful and received funding from the EU Danube Transnational Programme. This paper introduces the JOINTISZA project.

Keywords
Integrated Tisza River Basin Management Plan, strengthened cooperation among sectors, Flood Risk Management Plan, strengthened stakeholder involvement, integrated approach.

INTRODUCTION

Setting the Scene

The River Tisza, as one of the natural assets of Middle Europe, flows from the Carpathian Mountains until it reaches the Great Hungarian Plain and spreads idly in the lowland. The River Tisza is an area rich in biodiversity including nature reserves and national parks. As a unique natural feature of the river, every year for just a few days between late spring and early summer, the Tisza comes alive with millions of mayflies. This long-tailed mayfly species (*Palingenia longicauda*) is the largest in Europe and called 'Tisza-flower' in Hungarian. Just before sunset, the 'blooming' of the Tisza, the beautiful bridal-dance of the mayfly begins on the river's surface.

The Tisza River Basin provides livelihood for many through agriculture, forestry, pastures, mining, navigation and energy production. The past 150 years of human influence, however, have caused serious problems for the basin's waters. The waters of the Tisza Basin are under the threat of pollution from organic substances coming from urban settlements, nutrients from waste water and farming and hazardous substances from industry and mining. In some cases, changes in land use and river engineering have reduced the length of the rivers (especially of the Tisza) and modified the natural structure of the river, which has resulted in the loss of natural floodplains and wetlands. These changes have led to an increase in extreme events, such as severe floods, periods of drought (particularly in Hungary and Serbia) as well as landslides and erosion upstream (in Ukraine and Romania). Due to these, the Tisza River sub-basin faces very special challenges, which need strong cooperation among countries in the shared river basin as it is also indicated by the EUSDR Priority Area 4 in its Action 2 aiming "to greatly strengthen cooperation at sub-basin level".

The five countries of the Tisza River Basin – Hungary, Romania, Serbia, Slovakia, and Ukraine – share not only the beauties of the basin, but also face serious challenges to be overcome by joint. The overexploitation, water regime modification, contamination and increasing flood events, amplified by the negative effects of climate change, require harmonized, integrated action by countries in shared river basins.

There is a long history of cooperation in the Tisza River Basin. Integrated water management started in the 1970s, when the first complex water management plan was designed. In 2004, the signing of the Tisza Memorandum of Understanding in the framework of the International Protection of the Danube River (*ICPDR Tisza MoU 2004*) was an important initiative, the aim of which was to jointly develop an integrated river basin management plan for the Tisza River Basin. As the first step, the Tisza Analysis Report was written in 2004, and by 2011, the first Integrated Tisza River Basin Management Plan (ITRBMP) was completed. Following the finalisation of the first ITRBMP, the participants committed themselves to continuing the work and the countries of the Tisza River Basin renewed the MoU at a ministerial meeting in Uzhgorod, Ukraine on 11 April 2011.

In addition, in June 2011, the EU Strategy for the Danube Region (EUSDR) was adopted and endorsed during the Hungarian EU presidency. The priority area on water quality emphasises that sub-basin cooperation must be strengthened. Activities related to the Tisza river cooperation have been going on since 2013, with the assistance of the 'water quality' Priority Area (PA4) of the Danube Strategy.

In order to manage national activities as well as to contribute to the work of the international Tisza Group, –together with the ICPDR and EUSDR priority area on 'water quality', the *National Tisza Office*– was established and ceremonially opened in the premises of the Middle Tisza District Water Directorate in Szolnok in the heart of the Tisza River Basin in November 2014.

In line with the initiative of the EUSDR PA4 Hungarian coordination, the ICPDR Tisza Group and countries of the Tisza Basin decided to develop a flagship project to support and strengthen the cooperation among the water management and relevant sectors in the Tisza River Basin (*ICPDR MoU, 2011*). As a result of the cooperation, , the JOINTISZA project proposal was developed in 2015-2016, which was deemed to be successful and received funding from the Danube Transnational Programme. The JOINTISZA project will be introduced in the following pages.

THE JOINTISZA PROJECT AND ITS OBJECTIVES

A key conclusion of the Tisza Analysis Report (*ICPDR 2008*) is that water quantity is a relevant water management issue and the integration of water quality and quantity in land and water planning is essential for the ITRBMP. At the Danube River Basin District level four significant water management issues (SWMI) were identified that impact the quality of both surface and groundwater: organic pollution, nutrient pollution, hazardous substance pollution and hydromorphological alterations. The ITRBMP addresses the same SWMIs but the assessments are targeted to specific elements in the Tisza. The Tisza countries next to organic and nutrient pollution, hazardous substances and hydromorphological alteration defined that management issues related to water quantity needed special attention and are therefore treated as an additional relevant water management issue. Water scarcity and droughts, as well as flood and excess water are major challenges in the TRB. Climate change is expected to further influence the water cycle. Floods and droughts impact biodiversity and water quality and thus exacerbate previously mentioned problems (*Heilmann 2012*).

The first ITRBMP identified that flood and excess water, drought and water scarcity as well as climate change can influence and inhibit to reach the good status of different water types in the Tisza River Basin. The integration of water quality and water quantity aspects in the Tisza River Basin is of crucial importance.

The JOINTISZA project – *Strengthening cooperation between river basin management planning and flood risk prevention to enhance the status of waters of the Tisza River Basin* – focuses on interactions of two key aspects, the river basin management (RBM) and flood protection. It takes into account relevant stakeholders, who play a key role in the Tisza RBM planning process. The main aim of the project is to further improve the integration of the water management and flood risk prevention planning and actions in the next RBM planning cycle, in line with relevant EU legislation. The project fully addresses the Danube Transnational Programme (DTP) objective to strengthen transnational cooperation on water management and flood risk prevention aiming at creating a new and updated plan for water management and flood risk prevention / protection elements using a common umbrella including relevant partners in the region.

The project has many innovative approaches, such as integrating water and flood management objectives into the river basin management planning process; applying shared vision planning to involve stakeholders; setting up ground for drought and climate change issues in river basin management planning; improving methods for urban hydrology management purposes; simulation of dike failure with a transboundary effect and preparing a manual for the Joint Tisza Survey.

The project will ensure better embedding of flood risk management planning into the RBM planning process and aims to encourage the involvement of relevant sectors (such as flood risk management, water resource management, urban hydrology management, drought management) and interested stakeholders.

In 2011, Ministers of the Tisza countries committed themselves to the continued efforts to achieve integrated river basin management in the Tisza River Basin via facilitating dialogues among sectors. The main focus of the JOINTISZA project is the development of the updated Integrated Tisza River Basin Management Plan (ITRBMP) based on the methodology of the EU WFD (2000/60/EC) and outlining the following main technical work packages (WPs) outlined:

- Characterization of the basin and assessment of water quality – focus on surface waters
- Water quantity issues and groundwater characteristics (quantity and quality)
- Flood Risk Management Plan (FRMP) elements integration into river basin management plan (RBMP)
- Synthesis of the outcomes of the above three work packages and drafting the updated ITRBMP.

As a first step towards the development of the management plan, the work package on basin characterisation (WP3) focuses on collecting and analysing information about the surface water, which would be integrated into the management plan (synthesis part). A specific task of this WP is to develop a Manual for the next Joint Tisza Survey.

Water quantity is identified as a significant water management issue in the Tisza River Basin due to the over-abstraction of groundwater (GW), the increase in irrigation and surface water (SW) abstraction and key integrated water management issues (excess water, droughts, and climate change). In addition, achievement of good status for both GW and SW is hindered by different sources of pollution. Due to these connections between water quantity and water quality, management issues are identified within the TRB.

The main objective of the work package related to water quantity (WP4) is to evaluate water demand, GW status and design measures that will sustain balanced water quantity management and help to achieve good water bodies status. A specific output of the water quantity WP will be a pilot activity on urban hydrology. Urban sites are the second largest water consumers after agriculture, and pilot activities on urban hydrology management are implemented on the basis of a developed spatial decision tool that provides a framework for a sustainable urban water management strategy that can be employed by stakeholders and authorities. The results of this WP will also be integrated into the management plan (synthesis part) and synergies will also be ensured with the characterisation part and flood issues of the project.

As an important notion, the first ITRBMP highlighted that climate change and its hydrological impacts (droughts and flash-floods) should be fully addressed in decision-making to ensure the sustainability of ecosystems. The management objective to progress towards a harmonised implementation of the WFD and the Flood Directive was set. In line with the objective, an important WP aims to develop a strategic paper on the Tisza River Basin Management Plan (ITRBMP) and the Tisza Flood Risk Management Plan (TFRMP) integration process in WP5. Outcomes of WP5 will also be integrated into the synthesis part. The outcomes of the technical WPs on the characterisation of surface water, water quantity issues and flood issues will be integrated into the ICPDR GIS database.

As it was already indicated in the above paragraphs, the synthesis part (WP6) is one of the core elements of the project aiming to consolidate the results of the work packages of the characterisation of surface water, water quantity and flood issues (WP3, WP4 and WP5) and harmonize the recommended joint programme of measures. Moreover, it also includes a pilot activity on drought management in light of the climate change. This pilot activity is linked to the flood activities. The public participation activities, as one of the key supporting processes in the development of the ITRBMP will also be unique and important elements of the synthesis (WP6) package.

The Public Involvement and Participation Strategy (PIPS) will be one of the outputs of the project, and will cover the aspects of communication, information access and public participation related to the development of the updated ITRBMP. It will aim to ensure that engagement will take place at points where it can influence the planning, as well as to create a supportive social environment for the implementation of the Joint Programme of Measures (JPM).

Obligatory elements of the project are the management and communication tasks.

INFO BOX:

*Number of partners***:** 17 (10 ERDF, 2 IPA and 5 ASPs).
*Project Budget***:** 2,254,126.80 €
*Project Duration***:** January 2017 - June 2019.
*Project Lead Partne***r:** General Directorate of Water Management-Hungary (OVF)
*Project Manager***:** Mr Balázs Horváth
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Project co-funded by the European Union through the Danube Transnational Programme (DTP)
Official website of the project: www.interreg-danube.eu/jointisza

PROJECT CONSORTIUM AND TARGET GROUPS

The partnership is composed of four levels of the most relevant institutions: national ministries and water management administrations for ensuring the implementation of measures on national level (policy level); water research institutes for professional work (operational level); international organizations for overall controlling results and outputs (control level) and different stakeholder institutions for transparency (social level).

To address unique and complex issues of water management in the Tisza River Basin (such as high sensitivity to contamination, extreme water regime, which means water scarcity and flood events alternating within short time periods, many artificial and heavily modified water bodies, weak urban hydrology, unique water-dependent flora and fauna, etc.), international cooperation is needed and the involvement of all five countries of the Tisza River Basin in the work is crucial. The Tisza countries are aware of these complex problems and many relevant institutions from the Tisza countries are ready to be involved in the joint workfor the development of a river basin management plan for the basin with the leadership of the Hungarian General Directorate for Water Management.

An important aspect of the project is that the transparency of available transboundary and basin-wide knowledge is ensured by the involvement of international organisations, which are important partners to the project such as the International Commission for Protection of the Danube River (ICPDR), the Global Water Partnership for Central and Eastern Europe (GWP CEE), the World Wide Fund for Nature, Hungary (WWF Hungary), and the Regional Environmental Centre for Central and Eastern Europe (REC). The UNEP ViennaSecretariat of the Carpathian Convention (UNEP Vienna-SCC) is involved in the project as an associated strategic partner.

It is important to identify who to address the results to and who will the beneficiary of the project outcomes be. The project involves four types of target groups: national water administrations, water research institutes, international organisations and other interested stakeholders and NGOs. The project will be carried out by of the joint action of the five countries (UA, RO, SK, HU, RS) that share the TRB. The bridge between stakeholders will be ensured via the ICPDR Tisza Group and EUSDR PA4 platforms, where information will be transferred from the experts' operational level to policy level. The management and communication plan will ensure the wide-range involvement of target groups. Moreover, the pilot actions will give specific platform for information sharing and learning interactions. As the result of the transnational cooperation, the main output of the project is the final, updated Integrated Tisza RBM Plan, which already includes the main aspects of the Flood Risk Directive.

INTERLINKAGE WITH THE EUSDR

Water quality priority area "*To restore and maintain the quality of waters*" of the European Strategy for the Danube Region (EUSDR) emphasizes the importance of supporting joint efforts in sub-basins.

In 2013-2017, the EUSDR 'water quality' priority area facilitated the ICPDR Tisza Group activities jointly with the ICPDR Permanent Secretariat and the development of the JOINTISZA project is the result of their successful cooperation.

The DTP seeks complements with the broader EU Strategy for the Danube Region (EUSDR) and reinforces the commitments of the Europe 2020 strategy.

The JOINTISZA project will greatly contribute and give direct input to the implementation of the water quality priority area (EUSDR PA4) work plan. The main and specific objectives of the project are fully relevant to its objectives aiming to strengthen cooperation at sub-basin level. The project will strengthen cooperation in the Tisza River Basin and will develop the updated ITRBM Plan, which is an importantn input to the EUSDR action plan. Moreover, the project will also continue to invest in and support the information collection systems already developed by ICPDR as well as promote measures to limit water abstraction. The project also contributes to achieving the goals outlined in the priority area on environmental risks (EUSDR PA5) action plan via the development of an overview of the flood risk management strategy at Tisza River basin level.

An interactive communication channel between the project and the high-level coordination bodies (Steering Groups) of both EUSDR PA4 and EUSDR PA5 is provided.

SYNERGIES WITH OTHER INTERREG PROJECTS

The JOINTISZA project is involved in the Thematic Pole 4 – Water Management and started to plan possible joint actions with the relevant projects. In case of the DriDanube project link between drought-related pilot actions has already been established.

ACKNOWLEDGEMENT

The development of the successful project proposal is the outcome of joint efforts of experts from the Hungarian coordinating body of the EUSDR Priority Area on Water Quality (Ministry of Foreign Affairs and Trade), ICPDR, the Tisza Office of Hungaryand the Global Water Partnership Central and Eastern Europe (GWP CEE). The ICPDR Tisza Group experts, as well as observers from the five countries of the Tisza River Basin also contributed to the successful development of the project proposal.

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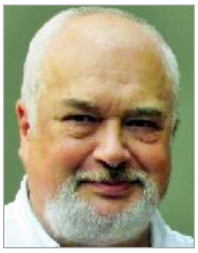

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Danube Sediment Management - Restoration of the Sediment Balance in the Danube River

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Abstract

An increasing discrepancy between surplus and lack of sediment can be observed in the Danube Basin. This leads to an increase of flood risks and a reduction of navigation possibilities, hydropower production and biodiversity. Thus, sediment transport and sediment management are urgent issues. Since the Danube crosses administrative and political borders, sediment management can only be treated in a transnational, basin-wide approach. The lack of sediment management has been recognized by the ICPDR in the Danube River Basin Management Plan. Therefore, the main objective of the DanubeSediment project is to improve water and sediment management as well as the morphology of the Danube River. To close existing knowledge gaps, sediment data collection will be performed. This will provide information for the sediment data analysis and will lead to a handbook on good practices of sediment monitoring methods. Furthermore, a baseline document on the Danube Sediment Balance will be prepared, which explains the problems that arise with sediment discontinuity negatively influencing flood risk, inland navigation, ecology and hydropower production. Possible answers to these problems will be provided by a catalogue of measures. The main outputs of the project will be the first Danube Sediment Management Guidance comprising measures to be implemented and a Sediment Manual for stakeholders consisting of approaches on implementing these measures. The outputs will deliver key contributions to the Danube River Basin Management Plan and the Danube Flood Risk Management Plan. A sustainable sediment management in the Danube Basin will improve navigation conditions, reduce flood risk and enhance the ecological status as well as sustainable hydropower production. International Stakeholder Workshops will be organized to reach the target groups and end-users of the project results, to establish an efficient interaction with them and to train experts.

Keywords

Danube, sediment balance, Danube Transnational Programme.

PROJECT BACKGROUND

In the Danube Basin an increasing discrepancy between surplus (e.g. reservoir sedimentation) and deficit (river bed and coastal erosion) of sediment can be observed. As a consequence, it increases flood risk, reduces navigation possibilities, reduces hydropower production, deteriorates the ecological conditions of the Danube River. The lack of coordinated transnational sediment management has been recognized by the First Danube River Basin Management Plan, DRBMP, evidently indicating the need for a change and calling for a relevant concrete answer. There exist examples for basin wide sediment management plans for European rivers such as the Sava, but no sediment management strategy exists for the Danube River, despite the fact that Danube plays an essential role in the economy and the society of the Danube Region. It is now clear that sediment transport along the Danube River has an immediate impact on water management activities and flood risk and there is a strong need to bridge the knowledge gap and to improve the sediment management which directly contributes to strengthening transnational water management and flood risk prevention.

By addressing the need to develop the first transnational Danube Sediment Management Guidance the project will feed concrete recommendations, explaining what sort of measures to be implemented to improve sediment management, into the next Danube River Basin Management Plan as well as into the Danube Flood Risk Management Plan. Additionally, a Sediment Manual for Stakeholders will be developed which explains how to implement these measures, and will also introduce good practices for sediment management. The involvement of a large group of relevant stakeholders will ensure the project sustainability on the level of the major water users within the Danube Region.

PROJECT MAIN OBJECTIVES AND STRUCTURE OF THE PROJECT

The main objective of the project is to improve the transnational water and sediment management as well as the morphological conditions of the Danube River. There will be three specific objectives of the project. The first one is to improve awareness on sediment quantity related problems in the Danube River Basin. The second one is to develop an innovative approach for transnational sediment management. The combination of a multi-sectoral with a multi-stakeholder interrelation and a transnational, cross cutting sediment management at basin, sectoral and local scales forms an innovative approach. This approach combines the data based sediment balance and good practice sediment management measures, aiming to a Sediment

Management Guidance for future transnational water management activities. The third specific objective is to strengthen inter-institutional collaboration in sediment management. A well-established and permanent communication among experts and a participatory and transnational approach, including all relevant stakeholders and policy makers on national and transnational levels are a pre-requisite to reach the overall project objective. The partnership composition and the implementation methodology of the project ensure this interaction between the key players in sediment management of the Danube River.

The project is composed of six work packages out of which two run through the whole period: WP1, WP2. WP1, Project Management will be performed on four levels: Steering Committee (1), Lead Partner (2), Work Package Leaders (3) and Project Partners (4), respectively. Also, an independent Advisory Working Group of experts consisting of the Associated Strategic Partners (ASPs) guarantees the quality of the project implementation. WP2 covers both internal and external communication. WP6, the synthesizing WP produces the main outputs of the project and manages stakeholder involvement to ensure that all the relevant beneficiaries are involved in the communication.

There are three technical work packages (WP3, WP4 and WP5), built up in a bottom-up and participatory approach, each of them having permanent interaction with WP6. International Stakeholder Workshops will be organized within each technical WP to transfer the gained knowledge directly to the user of the results of the given work package. Sediment data collection (WP3) will provide information to the sediment data analysis (WP4) and will provide a guideline for good practices of sediment monitoring methods. In WP4, the main result will be the sediment balance of Danube, which explains the problems which arise with sediment discontinuity negatively influencing flood risk, inland navigation, ecology and hydropower production (main findings go to WP6). Possible answers to these problems will be given in WP5 analysing the impacts and providing measures via case studies (main findings go to WP6).

As the most important outputs of the project two comprehensive documents will be prepared (WP6). First, the Danube Sediment Management Guidance will give concrete recommendations explaining what sort of measures can improve sediment management. Second, a more detailed Sediment Manual for Stakeholders explaining how to implement those measures for each stakeholder.

The innovative character of the project is a first and unique multi-sectoral with a multi-stakeholder interrelation and a transnational, cross cutting sediment management at basin, sectoral and local scales. This approach combines the data based sediment balance and good practice sediment management measures, aiming to a sediment management guidance for future transnational water management activities.

LINK WITH THE EUSDR ACTIONS, EXPECTED PROJECT RESULTS

This project applies a multi-level governance approach and contributes on EU, Danube Region, and national levels. On EU level, the project addresses the Water Framework Directive, which aims at achieving the good status of European waters by 2015, to which the project directly contributes. To achieve a good status, a series of actions has been already implemented. In the Danube River Basin the first "Danube Basin Analysis Report" of 2004 prepared by International Commission for the Protection of the Danube River (ICPDR) is the starting point. It revealed that there is a gap in our knowledge on sediment and a proper sediment balance (surplus and deficit) cannot be set up. A "Sediment Issue Paper" was prepared in 2006, which emphasized that further investigation of the sediment is needed. The First "Danube River Basin Management Plan" (2009) and the second one (2015), required by the WFD and prepared by ICPDR and the Danube Basin countries, mentions that the sediment transport is among the potential "Significant Water Management Issues". As this project proposes appropriate measures for improving the sediment management, sets up a sediment balance for the Danube River and furthermore, develops a sediment management guidance, the results directly contribute to the next Danube River Basin Management Plan (2021) and to Action 1 "To implement fully the Danube River Basin Management Plan" and Action 2 "To greatly strengthen cooperation at sub-basin level" of PA4 "To Restore and Maintain the Quality of Waters" of EUSDR. Through contributing to a reduction of flood risks with the project main outputs, the link to the Danube Flood Risk Management Plan and to the EU Floods Directive, Directive 2007/60/EC, and to Action 1 "To develop and adopt one single overarching floods management plan at basin level or a set of flood risk management plans coordinated at the level of the international river basin" of the PA5 "To Manage Environmental Risks" is also ensured. The project is agreed and highly recommended by the ICPDR Flood Protection Expert Group. The mentioned two plans coordinate the transnational river basin management and flood risk management on the Danube Region level thus the project results will have a direct impact on REGIONAL level, too. This horizontal nature of the sediment transport further connects the project to Priority Areas PA1a "To improve mobility and intermodality of inland waterways", PA2 "To encourage more sustainable energy" and PA6 "To preserve biodiversity, landscapes and the quality of air and soils". The project is closely linked to the EUSDR flagship project DREAM (Danube River Research and Management). The project contributes to NATIONAL level by formulating concrete recommendations for coordinated transnational sediment management both for national and local policy makers and stakeholders.

The project will contribute to an intensified cooperation in transnational water management by improving sediment management. This leads to reduced flood risk, improved navigation conditions, better ecological status and enhanced sustainable hydropower production in the Danube River. The project outputs are not specific to the Danube River, thus with the application of the Danube

Sediment Management Guidance, the results will be transferable to tributaries of the Danube River, other river basins in Europe and globally via a direct link to the UNESCO World´s Large Rivers Initiative.

INFO BOX:

Number of partners: 28 (14 project partners and 4 associated strategic partners).
Project Budget: 2,254,126.80 €
Project Duration: 30 months, from January 2017 till June 2019.
Project Lead Partner: Budapest University of Technology and Economics
Project Manager: Ms Barbara Kéri
Contact Details: keri.barbara@epito.bme.hu, +3614631709
Funded by: INTERREG Danube Transnational Programme - European Territorial Cooperation (ETC)
Official website of the project: http://www.interreg-danube.eu/approved-projects/danubesediment

PROJECT CONSORTIUM AND TARGET GROUPS

14 project partners (LP+11 ERDF + 2 IPA) and 14 ASPs are going to work together in the DanubeSediment project from the following countries: Germany, Austria, Slovakia, Hungary, Croatia, Slovenia, Serbia, Bulgaria, and Romania. The LP (Lead Partner) has significant experience in managing large EU projects and has long been dealing with managing sediment related problems. Together with the LP, there are eight academic partners, all having major experiences in international cooperation and competence in sediment management, who provide the professional basis performing data collection, analysis, case studies and will prepare the main outputs of the project. There are five project partners and two asps from the water management sector, who ensure the practical implementation of the project and the permanent interaction with stakeholders. Moreover, ministries of Austria, Hungary and Romania represent policy makers, which, together with ICPDR (as ASP) play a relevant role in the implementation of the water framework directive, the floods directive and the EU strategy for the Danube Region (EUSDR). The most relevant beneficiaries of sediment management, stakeholders such as inland navigation, hydropower companies and nature/environment protection agencies are also involved. Transferability of all the project results will be ensured by the involvement of international organizations, such as the ICPDR. Besides all countries with significant reaches of the Danube River, two Slovenian institutes participate in the project in order to bring in and integrate good practices based on their recent experiences in sediment management connected to the Slovenian part of the Sava River.

The most important target groups are policy makers, water management authorities responsible for water and sediment management, navigation companies, hydropower companies, environmental agencies, higher education and research, the International Commission for the Protection of the Danube River (ICPDR), the Danube Commission (DC).Many of these beneficiaries are directly involved in the project implementation either as PPs or as ASPs ensuring the durability and sustainability of the project results. Other relevant target groups (even from other territories) will be reached in the frame of the three International Stakeholder Workshops, to be organized during the project implementation, to ensure the knowledge transfer by training 100 experts that will continue the project implementation in their daily work.

SYNERGIES WITH OTHER INTERREG PROJECTS

The project integrates results from several recently implemented projects. One of the most relevant ones, the "SEDDON" project was carried out in the frame of the Austria-Hungary CBC 2007-2013 program. Within SEDDON, a common sediment monitoring methodology and joint sediment measurement protocols were developed. The main results of SEDDON will be integrated in WP3 to support sediment data collection and to develop good practices for sediment monitoring. The project integrates the results from the "Joint Danube Survey 3" project which focused on the longitudinal survey of the Danube River and the major tributaries including hydromorphology survey. Outcomes of JDS3 will be used for WP3 to support sediment data collections and for WP4 for the assessment of long-term morphological development of the River Danube. The "DuReFlood" project (Hungary-Slovakia CBC 2007-2013 program) focused on the improvement of flood protection in the Slovakian-Hungarian section of the Danube (Sap-Szob). The collected sediment data and other data relevant to the Danube sediment balance can be integrated in WP3 and WP4 of this project. „Waterway forward" and "NEWADA" with "NEWADA DUO" projects aimed the improvement of the multifunctional waterway usage. Both projects brought the corresponding stakeholders together and formed strong cooperation on regional and international/catchment level. The DanubeSediment project can benefit from the continuation of the former intersectoral discussions (WP2, WP6), and incorporation of the identified gaps and synergies from the project outcomes (WP5). "FAIRway Danube" is a parallel running pilot project and it can support Danube Sediment with survey results and sediment samples' analyses results. The project "SEE River" was developed within the SEE TC Programme. The main results and achievements of the SEE River project: SEE River Toolkit for Facilitating Cross-Sectoral River Corridor Management will be extrapolated and used in this project, in development of WP5.The project "SEE HYDROPOWER" was also developed in the frame of the SEE TC Programme (EU), aiming to a sustainable exploitation of water concerning hydropower production in SEE countries. One of the outcomes of the project was a common methodological approach for optimal management operations in sediment field. The developed approach will be incorporated in the topic of WP5 where good examples of sediment management techniques will be analysed. The

"DANUBE FLOODRISK" SEE project focused on the most cost-effective measures for flood risk reduction. The approach developed within that project (i.e. the methodological background) can well support the methodology to be used in the DanubeSediment project. "SedAlp" focused on the integrated management of sediment transport in Alpine basins. The project included piloting actions and contributed to sediment monitoring in Alpine catchments, in order to understand spatial and temporal variability of processes.

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BARBARA KÉRI, graduated from the Budapest University of Technology and Economics as an infrastructural-civil engineer MSc specialized on both Water and Hydro-Environmental Engineering and Highway and Railway Engineering. After graduation she worked in the field of waterway management within via Donau – Österreichische Wasserstraßen Gesellschaft mbH as a project manager for over 4 years. Since 2017 she is the project manager of the DanubeSediment project at the Budapest University of Technology and Economics.

PÉTER BAKONYI, graduated from the Budapest University of Technology in 1973. Defended his university doctorate in 1981 and his PhD in1997 at BUT. He has got 12 years of teaching experience at the Faculty of Civil Engineering at BUT. Joined VITUKI in 1985. In 1992, he was nominated managing director at VITUKI Consult and held this position till 1996. Then he returned to VITUKI where his highest position was Director General. Retired in 2013.

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MARLENE HAIMANN, senior scientist, graduated from the University of Natural Resources and Life Sciences, Vienna (BOKU). Since her graduation she is employed at the Institute of Water Management, Hydrology and Hydraulic Engineering (BOKU) and was working on several research-projects with a focus on suspended sediment transport. She was also involved in the compilation of the Austrian guideline on monitoring suspended sediment transport.

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MIROSLAV LUKAC, graduated from the Slovak University of Technology, Faculty of Civil Engineering. Senior researcher at the Water Research Institute in Bratislava, Department of Hydrology and River Morphology. He has been involved in numerous projects and studies focused at the hydrology and hydraulics of surface water flow, sediment transport, river restoration, flood hazard and flood risk assessment.

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CAMARO-D - a Danube basin approach to land use management

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Abstract
The paper gives a short overview of the cooperation of 23 partners relating to the Danube river basin within an Interreg project CAMARO-D – the sustainable protection of water resources and improved flood risk prevention through enhanced land use management in river catchment areas by means of coordinated and harmonized land use activities

Keywords
Danube Transnational Program, water management, flood risk prevention, fresh water protection, Land Use Development Plan, transnational guidance

SETTING THE SCENE – THE PROJECT IDEA OF CAMARO-D AND ITS BACKGROUND

The lack of integrated river basin management, both in terms of water resources and flood-risk, is currently one of the most crucial challenges, further intensified by climate change. In order to engage in concerted action – particularly as the impacts of land use and vegetation cover on water regime within the Danube basin area are quite similar – the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management established a project-consortium consisting of 14 partners in 9 countries and submitted the CAMARO-D project idea at the first call of the Danube Transnational Programme in May 2016.

The primary goal of the project idea was to create a strategic policy for the implementation of an innovative transnational catchment-based "Land Use Development Plan" (LUDP) for the Danube river basin. It will guarantee both the sustainable protection of water resources and improved flood risk prevention. The project initiates an advanced trans-sector and transnational cooperation of key stakeholders and aims at maintaining it beyond project-end by creating an institutionalized transnational Danube Region Platform.

The idea to achieve this challenging objective is to start various pilot actions within the project – a total of 18 actions in 8 different countries, in order to test and document the newly developed best practices in function-oriented sustainable land use management. The pilot actions are divided into three clusters, according to their interdependences of land use and vegetation cover, respectively dealing with three different types of water resources (groundwater, torrents and rivers).

What are the main outputs of the project?

For stakeholders and decision-makers, an innovative transnational guide (GUIDR) is developed, complemented by a tailored, application-oriented tool kit for utilisation in their respective working spheres. This is supported by intensive stakeholder workshops and trainings; the initiation of the practical GUIDR implementation is conducted within the pilot areas in order to mitigate of interest and to develop prospects for essential actions.

The land-use development plan will demonstrate procedures for a sound water management on a transnational basis and give important inputs for the further development of EUSDR and other relevant policies. The cooperation of various stakeholders within CAMARO-D should serve as a blueprint for policy development and can be a model for similar cooperation processes in other thematic fields in the EU.

MAIN OBJECTIVES AND STRUCTURE OF THE PROJECT

CAMARO-D project was submitted in the programme-priority "Environment and culture responsible Danube region" with the specific objective to "Strengthen transnational water management and flood risk prevention". This objective is clearly substantiated by one of the main project outputs, the transnational guide for functional land use management (GUIDR) and furthermore lined out in a best practice catalogue, also regarding climate change. By this means, the aims of the River Basin Management Plans for the transnational Danube basin are supported.

The project aims at improving land use practices for the protection of water resources and flood risk prevention in the transnational Danube River Basin, encompassing

- jointly developed methods towards an integrated and efficient approach to water management and proposed measures to adapt existing practices
- improved status of ecosystem services regarding water resources in the Danube region through sustainable and integrated land use management practices and measures demonstrated through pilot actions
- improved effectiveness & sustainable use of capacities as well as efficient organisational structures for land use management.

LINK WITH THE EUSDR ACTIONS FOCUSING ON WATER MANAGEMENT RELEVANCE, EXPECTED PROJECT RESULTS

In the EUSDR, the importance of the availability and quality of freshwater resources as well as the proper functioning of ecosystems to maintain and restore biodiversity is highlighted. Water management as a central issue for the Danube region requires strong coordination and cooperation across different countries and sectors. Additionally, floods and water scarcity are future challenges and should be tackled in an integrated way.

In CAMARO-D, with the state-of-the-art application, combined with newly developed innovative best practices in function-oriented sustainable land use management and derived from experiences of pilot activities, the approaches to the various challenges and needs are applied and evaluated. In addition, the LULUCF (Land Use–Land-Use Change–Forestry) task within the COP21 process mentions the efforts in reducing CO_2 with adequate land use adaption measures. With the transnational catchment-based “Land Use Development Plan”, the project shall provide a strategic outline for coordinated, target-oriented land use to guarantee the sustainable protection of water resources and improved flood risk prevention for the Danube river basin, moreover, its operational, country-wide implementation (for example within River Basin Management Plans) is initiated.

Concerning EUSDR, CAMARO-D contributes to the Priority Area 4 (To Restore and Maintain the Quality of Waters), especially to

- Action 2: to enhance cooperation at sub-basin level by transnational cooperation throughout the project activities and a survey on sub-basin levels within the pilot actions
- Action 5: to establish buffer strips; to retain nutrients. This is a typical example for a land use action with the aim of improving water quality, which is reviewed and monitored within the pilot areas resulting in recommendations.
- Action 6: to foster an active process of cooperation between authorities through intensive, active stakeholder involvement.

Furthermore, CAMARO-D contributes to Priority Area 5 (To Manage Environmental Risks), especially to

- -Action 2 (To support wetland and floodplain restoration as an effective means of enhancing flood protection): as wetland and floodplain restoration can reduce flood risks, such measures are reviewed, monitored within the pilot areas and recommendations will result.
- -Action 3 (To extend the European Floods Alert System including early warning systems): one Romanian project-partner will develop a warning system and tools for the assessment of extreme events, tested within the pilot areas
- -Action 7 (To anticipate impacts of climate change through research): the protection of water resources against impacts of climate change corresponds to one of the specific objectives of the project; results from previous projects dealing with this issue are reviewed and integrated into the guidelines and policy.
- -Action 8 (To develop spatial planning … in the context of climate change and increased threats of floods): adequate land-use management is identified and agreed on in an integrated way, the promotion of sound forest and pasture management, adapted cultivation on slopes of hills, protection of biodiversity, restoration of ecosystems as well as a function-oriented spatial planning are the main topics surveyed within CAMARO-D. A review is followed by recommendations as implementation strategy and finally by integration into the Land-use-development plan.

PROJECT CONSORTIUM AND TARGET GROUPS

The main target of CAMARO-D, the sustainable protection of water resources and improved flood risk prevention through enhanced land use management in river catchment areas by means of coordinated and harmonized land use activities, calls for improved trans-sector and transnational cooperation between all relevant stakeholders. Therefore, the project requires the extensive participation of different partners, not only in geographic scope but also in diverse scientific and governmental fields of responsibility. Thus, nearly all of the Danube basin countries are involved: Austria, Slovenia, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Romania and Serbia.

CAMARO-D partnership consists of 14 financing partners and 9 ASPs from 9 countries, covering nearly the whole geographical scope of the Danube Transnational Programme Area. Selected associated partners (many of them representing governmental institutions) foster the actual implementation of CAMARO-D outcomes, in particular the implementation of the catchment-based “Land Use Development Plan”. All partners have already been involved in several transnational projects, and some of which are integrated into and contribute to the development of EUSDR.

The partnership consists of representatives of governmental bodies, water suppliers, research and education institutions, agro-meteorological institutions, environmental agencies and spatial planning institutes acting on local, regional and national levels. Their main fields of expertise are environmental status assessment, elaboration of adequate target-oriented, sustainable land use guiding principles, enhanced flood forecasting, policy and strategy preparation in their respective thematic fields, spatial planning and water supply issues, rural development (guidelines and adapted subsidies), regulation and impact assessment considering the current knowledge about climate change influences and, last but not least, the approval and control of the implementation of forest- and river-related management plans and national / regional strategies and respective legislation.

As some project partners also represent target groups of CAMARO-D, their needs and interests serves as a basis for the project idea and project development and are now met by the project content and related outcomes.

The governmental institutions (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management – BMLFUW in Austria; Herman Otto Institute (HOI) in Hungary; National Forest Administration (ROMSILVA) and the National Meteorological Administration of Romania (NMA) in Romania; Executive Forest Agency (EFA) in Bulgaria), together with the Environmental Protection Agency EPAC in Romania are mainly responsible for policy-related issues concerning recommendations for legislation and funding possibilities and their implementation, thus influencing future strategies towards optimal land use management within river catchments. Furthermore, the relevant information transfer to the respective stakeholders and the development of national implementation-roadmaps for LUDP are important responsibilities for the governmental institutions.

In addition, water suppliers of CAMARO-D (Municipality of the City of Vienna Department 31 – Vienna Water - MA 31 in Austria, Public Water Utility JP VODOVOD-KANALIZACIJA Ljubljana - JP VO-KA in Slovenia) provide their experiences and problems related to actual drinking water supply situations and the necessary improvements.

Last but not least, the tasks of research and educational institutions in CAMARO-D (Agricultural Research and Education Centre Raumberg-Gumpenstein - AREC in Austria, University of Ljubljana - UL in Slovenia, Croatian Geological Survey - HGI in Croatia, Czech Technical University - CTU in the Czech Republic, Forest Research Institute Baden-Württemberg, Dept. Soils and Environment - FVA in Germany, The Jaroslav Černi Institute for the Development of Water Resources - JCI in Serbia) not only make a considerable contribution allowing new scientific insights, but they also undertake public relation activities and dissemination of project outcomes as well as specific trainings for project-related stakeholders. The broad experiences of the involved institutions gained within previous projects and studies are incorporated especially within the envisaged pilot activities.

The agro-meteorological institution NMA in Romania has comprehensive experiences in weather forecasting, especially flood forecasting, and develops (amongst others) an early-warning system and tools for the assessment of extreme events (floods and droughts) within the project in order to protect water resources and mitigate flood risk. Issues related to spatial planning are covered by respective subcontractors, Associated Partners and governmental institutions of CAMARO-D.

The main target groups are public authorities ranging from local and regional to national level, various experts such as farmers, foresters, spatial planners, NGOs as well as the general public. CAMARO-D outputs such as GUIDR and LUDP are strongly tailored to the needs of the respective target groups and directly communicated to the relevant stakeholders and decision makers by the following means:

- organising different learning interactions: workshops and pilot-specific trainings with relevant stakeholders in selected pilot areas for sharing new know-how and adequate measures for application, cross-sector stakeholder workshops and trainings for durable implementation of GUIDR within the pilot areas also beyond project lifetime
- signing a Memorandum of Understanding covering joint proceedings towards further implementation of LUDP by notable representatives of each partner country.

SYNERGIES WITH OTHER INTERREG PROJECTS

CAMARO-D is a further step in a number of former projects, performed by various members of the partnership, from small-scale pilot investigations in the field to basin-wide guidelines.

In the CADSES and CE 2007-2013 programmes, the impacts of different land use types were studied in small-scale pilot surveys within the ILUP project, based on comparable surface water runoff field tests in different types of land cover. Together with the projects LABEL and SEE River integrated land use and spatial planning for flood prevention and soil protection at regional and river basin scale were discussed.

“KATER II”, “CC-WaterS”, “CC-WARE”, “ALLEGRO”: Impacts of land use and climate change on drinking water resources and adaptation strategies for mitigating their vulnerability; especially the CC-project series outlined a follow-up from large-scale climate prognosis into small-scale pilot actions on different land use types in various climate regions within the SEE program. The impact of climate change and means to mitigate its negative effects on the water requirements of different crop types, grassland and forest ecosystems was elaborated.

The results of these pilot exercises were distilled into guidelines for more sustainable land use in view of the anticipated climate change in different clusters. This was also the theme of the OrientGate project, which was based on climate models related to the SEE program space.

Several projects like “Optimisation of water and ecology demands to forest management”, “ForestFocus project BioSoil”, “DriWaS” and “ISIS” dealt with the assessment of water quality and critical deposition loads and the improvement of measures regarding EU legislation.

Building on these experiences in combination with the outcomes of previously implemented pilot actions and surveys, CAMARO-D generates best practices considering different interdependencies in close cooperation with relevant stakeholders. Furthermore, for the first time, basin-wide views of interdependencies regarding the management of different land -use types are meant to lead to a new approach t regulations within a European context.

The results of CAMARO-D shall be used as a basis for new funding regulations within the ELER 14-20 program.

Permanent know-how exchange is conducted through current projects/programmes, like “Danube:Future” (the largest pool of institutionalized knowledge in the Danube River Basin as a Flagship Project of EUSDR).

INFO BOX:

Number of partners: 14 financing partners, 9 associate partners
Project Budget: 2,588,138.36 EUR
Project Duration: 1st January 2017 – 30th June 2019. (30months)
Project Lead Partner: Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
Project Manager: Mr Hubert Siegel
Contact Details: hubert.siegel@bmlfuw.gv.at
Funded by: ERDF, IPA
Official website of the project: http://www.interreg-danube.eu/approved-projects/camaro-d

CONCLUSIONS

To sum up, it may be concluded that the CAMARO-D project consortium, comprising institutions from Austria, Slovenia, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Romania and Serbia aims at:

- *Setting the* frame for a harmonized transnational land-use management system, taking into account the requirements for water resources protection and flood prevention.
- *Harmonizing and improving* the protection of water resources against negative impacts of land use and climate change as well as the reduction of flood risk.
- *Bringing life to* the project outcomes by developing a transnational "Land-use Development Plan" as a driving force for transnational land use management.

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Towards efficient and operative drought management in the Danube region. The DriDanube project - Drought risk in the Danube Region

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Abstract

Water scarcity and droughts hit the Danube region frequently and have a large impact on the economy and the welfare of people. Despite the damages in the past decades, drought is still not considered an issue of high priority, and people are not aware of its impacts. Therefore, DriDanube aims to increase the capacity of the Danube region for drought emergency response and enhance preparedness for drought management by introducing newly developed monitoring and risk assessment tools. One of the main products of the project will be a Drought User Service, which will make more accurate and efficient drought monitoring and early warning possible. The service will integrate all available data, including a large volume of the most recent remote sensing products, using modern web services and "Big Data" management techniques. Apart from early warning, a risk analysis is required to mitigate the effects of drought. Following a transnational approach, DriDanube will harmonize the currently heterogeneous methodologies for risk and impact assessments, based on existing achievements in participating countries and on EU guidelines in the framework of the Civil Protection Mechanism. Users' capacities at different level in the management cycle (monitoring–impact assessment–response–recovery–preparedness) will be strengthened through sharing experiences and project learning interactions. The main result expected from DriDanube is a strategy to improve drought emergency response (tested on pilot actions) and a better cooperation among operational services and decision-making authorities in the Danube Region.

Keywords

Drought, drought management, environmental risk, remote sensing, emergency responses

INTRODUCTION

The Danube catchment area is characterized by high climate variability, especially with regard to the precipitation. The neighbouring region is the Mediterranean region, where climate model projections unanimously show strong summer precipitation decrease. Observations highlight the growing frequency and severity of drought events, especially in the middle and lower part of the Danube region.

The growing number of heat waves and the temperature increase in summer, the most warming season, cause more frequent summer droughts. High precipitation variability can cause droughts even during wintertime, in spite of the generally increasing precipitation in this season. Increasing drought damages have drawn attention to this disaster. That was the reason why the World Meteorological Organization (WMO) and the United Nations Convention to Combat Desertification (UNCCD) jointly established the Drought management Centre for South-Eastern Europe (DMCSEE), operating in the framework of the Slovenian Environmental Agency (ARSO), the organisation leading this project with a lot of experience in managing national and international projects.

BACKGROUND

The precursor of the DriDanube project was the Drought Management Centre for South-Eastern Europe project in the framework of SEE Transnational Cooperation Programme (2009-2012). The project objectives were the following:

- to prepare regional drought monitoring, analysis and early warning products;
- to assess regional vulnerability to drought impacts;
- to promote and strengthen the capacity for drought preparedness, monitoring and management (training events, national seminars);
- to set up a Drought Management Centre for South-Eastern Europe;
- to exchange knowledge, experience and best practices on drought issues (SEE network);
- to enhance the implementation of EU policies in the context of drought preparedness, monitoring and management, particularly in working out national drought strategies;
- to raise awareness among decision makers, relevant stakeholders and end users about the importance of effective drought preparedness, monitoring and management.

In the framework of the DMCSEE TCP project, Monthly Bulletins were issued (http://www.dmcsee.org/en/drought_bulletin/). The leading organisation of the DMCSEE project was ARSO, and the project partnership was built on the initiative of national authorities responsible for the management of natural resources in the participating countries. The partnership consisted of national meteorological and hydrological institutions, which provided relevant data for regional drought monitoring and risk assessment, as well as universities and research institutes from the field of agricultural and soil science, which provided know-how on risk assessment and good practices.

More about the DMCSEE SEE TCP project can be found on the homepage of the DMCSEE centre:

http://www.dmcsee.org/en/home/

When the DMCSEE project finished, Global Water Partnership Central and Eastern Europe (GWP CEE) initiated the Integrated Drought Management Programme (IDMP CEE) within the framework of the joint, global WMO/ GWP Integrated Drought Management Programme. The aim of this programme is "to support stakeholders at all levels by providing them with policy and management guidance through the globally coordinated generation of scientific information and sharing best practices and knowledge for integrated drought management".

The Programme has four main components:

1. Investment in regional and national development: to advance regional/transboundary cooperation on drought management by integrating water security and drought resilience into national development planning and decision-making processes.

2. Demonstration projects: to develop and implement several innovative solutions for addressing critical drought management challenges.

3. Knowledge and capacity development: to organize regional and national workshops, publish policy briefs, work with the social media and implement other activities in order to raise awareness among water managers, farmers and other water users.

4. Partnership and sustainability: to ensure that the network which facilitates IDMP CEE is strengthened, as well as to organise further fundraising for programmes promoting water security and drought resilience within the framework of sustainable development.

Some of the main achievements of the IDMP CEE in the first implementation phase (2013 – 2015) were:

- a concise overview of the situation regarding drought management in CEE
- guidelines for the preparation of the Drought Management Plan in connection withthe EU Water Framework Directive and global direction
- increased capacity of participants to implement the entire process of preparing a Drought Management Plan in their respective countries
- a collection of existing drought monitoring indices, methods, and approaches from the CEE region

Through this programme, IDMP CEE and DMCSEE partnerships joined forces and started to work on drought management challenges in the region together. During this process, in 2016, a new project (DriDanube) was developed. IDMP CEE continues its mission in the region – "enhancing resilience to drought" and the programme can be viewed at the following link: http://www.gwp.org/en/GWP-CEE/WE-ACT/Projects/IDMPCEE/

PROJECT OBJECTIVES

The main objectives of the DriDanube project are the following:

- to increase competence in the Danube region to manage drought-related risks;
- to improve drought monitoring by an innovative operational service (Drought User Service);
- to unify drought risk assessments based on the Civil Protection Mechanism;
- to improve drought emergency response (to change mainly ad-hoc drought response to pro-active response based on risk management procedures).

The main results expected from DriDanube are improved drought emergency response and better cooperation among operational services and decision-making authorities in the Danube region. Its primari target groups are:

- National Hydrometeorological Services
- Emergency response authorities
- Non-governmental organizations
- Water and Agricultural organisations/chambers
- Industries

PROJECT PARTNERS

Drought is a large-scale natural disaster; therefore, transnational cooperation is especially important. The project partnership consists of the most relevant institutions, which are directly or indirectlyinvolved in drought monitoring and management in 10 countries of the region. There are15 project partners and 8 associated strategic partners from 7 EU and 3 non-EU countries.

Almost half of the project partners are National Hydrological and Meteorological Services (NHMSs) from Slovenia, Hungary, Romania, Croatia, Slovakia, Serbia, Bosnia and Herzegovina and Montenegro (in the order of partnership). Other partners are research-oriented knowledge centres with strong end user outreach: 3 universities (Vienna University of Technology, University of Novi Sad and Szent István University in Gödöllő), a research institute and 3 organizations (EODC Earth Observation Data Centre for Water Resources Monitoring GmbH, Global Change Research Centre AS CR, Centre of Excellence for Space Sciences and Technologies) specializing in state-of-the-art IT and remote sensing techniques. This composition ensures the best environment to transfer technical capacities to NHMSs, which generally do not have sufficient internal resources to follow new developments in the relevant fields. Contact with end users is ensured through an international organization, Global Water Partners CEE, which is responsible for the smooth transfer of know-how to the target groups of the project.

The administrative organisations and authorities are in the group of Associated Strategic Partners: Administration of the RS for Civil Protection and Disaster Relief of Slovenia, State Land Office of the Czech Republic, Agricultural Station/Forecasting and Warning Service of Serbia in Plant Protection of Serbia, Environment Agency Austria, Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, Water management directorate of Ministry of Agriculture of Croatia, International Commission for the Protection of the Danube River, Ministry of Agriculture of Hungary.

PROJECT CONTENT

The project consists of 6 work packages: 4 technical ones, one for management and one for communication. The work packages contain 22 activities. The technical work packages will be introduced in more detail.

WP3: Drought User Service. Responsible partner: EODC. The main objective of this work package is to develop a user service for drought monitoring and early warning. The main output of this WP is a web-based user service for targeted users (national and regional meteorological and emergency response authorities). It will continue the work on existing collaborative platforms developed within the EuroGEOSS and DMCSEE projects and implemented in the European Drought Observatory and DMCSEE. It will be developed and operated on a cloud platform, providing access to large volumes of satellite data sets with high spatial resolution and precision and ensuring the seamless transfer of service prototypes into operations. The necessary satellite data sets will be collected and made available for the platform. The user interface will enable access for individuals with different skill levels, ranging from basic to expert users. Finally, a training of trainers will be organized within the project partnership to gain competence in organising national trainings.

WP4: Drought impact assessment. Responsible partner: CzechGlobe. In the case of drought, the impact usually cannot be easily related to the hazard intensity as they also depend on the sensitivity of the impacted ecosystem or sector. This WP focuses on the development methods that will allow a quick and efficient assessment of drought impacts during an ongoing drought episode. It will be combined with a retrospective analysis of the connections between past drought intensities and reported impacts. In order to improve the management of drought risks and drought events, it is critical to estimate not only drought intensity but also expected impact. Therefore forecasting of impacts will be an essential part of WP4 activities.

The project will integrate and build a network of impact reporters. The WP4 will also coordinate data collection on drought impact for the whole project and will lead research activities in the field of impact forecasting. Each partner will be responsible for engaging and training the system users in their countries, who will in turn provide near-real-time impact assessment via the project User Service.

WP5: Drought risk assessment. Responsible partner: Hungarian Meteorological Service. WP5 will use the main results and outcomes of the DMCSEE, ORIENTGATE and CARPATCLIM and its enlargement projects. In the DMCSEE project, drought indices were calculated, drought periods were collected on the basis of historical records and drought vulnerability was examined. The SEERISK project produced Guidelines with a demonstration of drought risk assessment in a single municipality. This methodology will be updated and applied in the participating countries. These results will be the input for drought risk assessment. In the CARPATCLIM project, a daily gridded meteorological database was established, which can be the basis for drought risk calculation in this project. Drought risk assessment will be based on existing achievements in participating countries (collected in a review) and on agreed methodology (based on EU guidelines in the framework of the Civil Protection Mechanism).

According to the EU guidelines, drought risk can be expressed as the product of hazard impact and the probability of occurrence. Values of hazard impact will be obtained from different target groups (case studies) and probability values, based on meteorological variables, will be estimated. A manual on common risk assessment methodology will support the implementation of the methodology; reports on regional and national risk assessments (including risk matrices and maps) will be prepared and included in the User Service (WP3). The result of the WP will provide input for WP6. Capacity building activities will be held for different stakeholders, end users and scientific communities.

WP6: Drought response. Responsible partner: ARSO. The main purpose of this WP is to capitalize from previous WPs and to prepare a strategy to improve the drought management cycle for each participating country. One of the starting points is the output of the Integrated Drought Management Plan CEE project: the Guidelines for preparation of drought management plans. Since there are numerous legislation mechanisms that regulate drought response and preparedness measures, the strategy to optimize the drought management cycle within countries should cover a broad set of regulations. The screening of drought-related regulations with focus on the structure of management procedures within the participating countries will be carried out. As soon as the prototype of Drought User Service with the methodology for near-real-time drought impact assessment is completed, pilot implementation will start in 4 countries. Pilot implementation of a decision-making model will be implemented in 2 countries (EU, non-EU). Two strategy implementation plans for improved cooperation and interoperability among emergency response authorities and stakeholders will be prepared as pilot implementation for two countries.

The strategy to improve drought emergency response will be based on the current status of drought management, examples of previous drought episodes (including responses and mitigation measures) and the consideration of new available tools (outputs of WP3 and WP4). For competence building, ten national seminars will be organized for users on understanding drought information gained from the User Service.

PROJECT RESULTS

Based on the objectives above, the following outputs are expected:

- Drought User service
- Methodology for drought risk assessment
- Methodology for drought impact assessment including forecasting
- Pilot actions testing the Drought user service and both methodologies
- Capacity building on national and regional level
- Stakeholders' engagement in the development of DriDanube tools and their use in everyday work.

CAPITAIZATION

DriDanube project works in close co-operation with other DTP projects having similar topics using synergetic effect of their cooperation. These projects are the JOINTISZA, CAMARO-D and SEDIMENT projects. Link: http://www.interreg-danube.eu/relevant-documents/dtp-capitalisation-strategy/thematic-pole-4-waterways.

CONCLUSION

Drought is becoming one of the main topics for water management in the near future (https://www.icpdr.org/flowpaper/viewer/default/files/nodes/documents/icpdr_report_on_2015_droughts_in_the_danube_river_final.pdf),but it is still not considered an issue of high priority despite its impacts on the economy and welfare of the people. DriDanube wants to change this and move from mainly ad-hoc drought response to a pro-active response based on risk management procedures. Cooperation and capacities among all relevant institutions must be strengthened and the current slow reactions during drought must be speeded up with an improved decision-making process in all parts of the drought management cycle (monitoring–impact assessment–response–recovery–preparedness). This will lead to an increased awareness throughout the Danube region.

THE AUTHORS

ANDREJA SUSNIK works in the Agrometeorological Department of the Meteorological Office at the Slovenian Environment Agency. She holds a PhD in Agronomy, with emphasis on agrometeorology. Being the head of the Agrometeorological Department, her work is mainly focused on operational agrometeorology. Besides, she has been coordinating the activities of the Drought Management Centre for South-Eastern Europe since 2006. The main areas of her work are developing agrometeorological services for different stakeholders, preparing strategic documents related to vulnerability assessments and adaptating agriculture to climate change, developing drought monitoring tools and methodology and management on national and international scale. She has been involved in the work and coordination of many national and international projects (including the DriDanube project) and working groups related to agrometeorology/drought management. She also leads learning activities with different target groups.

GREGOR GREGORIC has obtained B.Sc. and Ph.D. degrees in meteorology from the University of Ljubljana, Faculty of Mathematics and Physics, where he had a position as assistant lecturer between 1996 and 2010. He was assisting in courses of physical and dynamic meteorology. He is employed in Slovenian environmental agency (ARSO) since 2002. He has been appointed as member of ad-hoc national committee for estimation of drought impacts during drought episodes in 2003, 2006, 2007, 2012 and 2013. Since 2007 he acts as coordinator of activities of the Drought Management Center for Southeastern Europe (DMCSEE). Between 2009 and 2012 he coordinated the initial DMCSEE project (supported by the EU Transnational coordination programme, with 15 cooperating partner institutions). He has also coordinated one of the activities in IDMP CEE project (2012-2015). Currently he is a member of DriDanube ARSO project team.

SÁNDOR SZALAI works in the Department of Water Management of the Faculty of Agricultural and Environmental Sciences of Szent István University. He holds a Candidate of Science degree on climate modelling. He is a member of several national and international bodies, chair of the Adaptation to Climate Change Working Group of the Carpathian Convention, Agro- and Biometeorological Committee of the Hungarian Meteorlogical Society, Hydro- and Agrometeorological Subcommittee of the Meteorological Scientific Committee at the Hungarian Academy of Sciences, etc. He has taken part in national and international projects such as the DMCSEE project.

SABINA BOKAL has over 7 years of experience in environmental management, project planning and team leading. For the past four years, she has been working as a project manager with Global Water Partnership in CEE on developing and working on projects related to climate resilience, transboundary cooperation and waste water management. Since 2013 she has been coordinating an Integrated Drought Management Programme (IDMP) in CEE. Before that, she was involved in the Drought Management Centre for South-Eastern Europe (DMCSEE), building strategic partnerships and helping with project coordination. She received her degree in Geography from the University of Ljubljana and is passionate about water and sustainable development. She has completed courses in the areas of climate change, environmental policy and management, stakeholder engagement and EU funds.

Hydrological balance of water resources for agriculture in the Slovakian part of the Danube Region

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Abstract
According to climate scenarios and outputs of models of general circulation of atmosphere, what can be expected is an extraordinary increase in precipitation totals as well as an increase in the number of days without any precipitation. These facts will impact the stability of agricultural production, especially in lowland areas. The area of land with water deficit has increased and the moisture demand of crops has also increased. However, the disposable resources of irrigation water are decreasing, whichwill limit the extension of irrigation. The areas with water deficit have been determined according to the ratio of actual and potential evapotranspiration E/E_0. The irrigation demand of crops was calculated with the help of model Daisy. Disposable resources of irrigation water were evaluated with the help of hydrological balance according to scenarios CCCM for time horizons 2030 and 2075.

Keywords
Evapotranspiration, moisture demand of crops, water deficit, disposable water resources

INTRODUCTION

The necessary amount of water in the soil and its proper distribution during the vegetation period is an indispensable condition for successful soil management. Irrigation optimizes the moisture regime of the soil through the demands of plants and therefore it is a significant part of production-cultivation technologies of field crops and production of fruit and vegetables. Analyses have proved that several river basins will have a tense hydrological balance in the near future and some of them will even have a passive hydrological balance, which will limit water abstraction for agriculture including water abstraction for irrigation.

MATERIAL AND METHODS

High intensity agricultural production in lowlands is conditioned by high solar radiation and natural soil fertility and requires corresponding levels of inputs and further production factors (fertilizers, pesticides and the most efficient seeds). Growing the main crops requires irrigation in lowlands because permanent dry vegetation periods are regularly repeated. Water as a non-alternative production factor significantly affects the stability and production of agro-ecosystems in agricultural production areas.

The areas with moisture deficit were identified on the basis of climate regions and soil parameters of agricultural production areas (*Buday and Vilček 2013*). However, evapotranspiration was chosen as the determining factor: the ratio of actual (E) and potential evapotranspiration (E_0) during a representative period, so-called relative evapotranspiration (E/E_0).

DISTRIBUTION OF RELATIVE EVAPOTRANSPIRATION IN SLOVAKIA

It has been shown by several studies that the optimal growth conditions of field crops mean that the actual evapotranspiration (E) only slightly differs from potential evapotranspiration (E_0), which is understood as the maximum possible evapotranspiration in given climate conditions if the surface root soil layer contains enough water for the normal growth of field crops (*Rehák 1994, Šútor et al. 2007*).

Relative evapotranspiration and evapotranspiration deficit (E_0–E) make it possible to quantify the lack of water in the soil for the optimal growth of crops, which means that the amount of water needed for irrigation can be determined.

The background for the assessment of relative evapotranspiration in the territory of Slovakia was a model calculation of monthly totals of potential and actual evapotranspiration during vegetation period at 32 meteorological stations in the period between 1981 and 2010. Annual values E/E_0 were used as supplementary data for the period between 1951 and 1980 at 54 stations.

E and E_0 monthly totals were calculated by the application of a method based on a common solution of the equations of energetic and water surface balance. A mathematical model was designed at the Department of Meteorology and Climatology of the Faculty of Mathematics and Physics at the Comenius University in Bratislava.

On average, the smallest annual values E/E_0 during the period between 1981 and 2010 were recorded in the Danube Lowland ($E/E_0 < 60$ %), which is the warmest and driest area in Slovakia. The Western part of Záhorie Lowland, Southern Slovakia and the Southern part of the Eastern Slovakia Lowland are characterized by a relative evapotranspiration smaller than 65% on average annually. In the Southern part of Košice Basin, South-Western Slovakia, the Eastern part of the Záhorie Lowland, Považie South of Trenčín, middle Ponitrie, the central part of Eastern Slovakia Lowland South of Michalovce and in the South-Eastern part of the Zvolen Basin, the average annual value E/E_0 is smaller than 70%. In the north of Slovakia, mainly in the mountains, there is enough precipitation the whole year round and therefore annual values of relative evapotranspiration are higher than 90%.

Area I. Danube Lowland – South is bordered by *the isoline of relative evapotranspiration 0.6.* It is the driest area in Slovakia with the highest intensity of agricultural production.

Area II. Danube Lowland – North is located between Bratislava and Šahy in the territory between *the isolines of relative evapotranspiration 0.6 to 0.7.* It is a slightly dry area where densely sown crops should prevail in the future.

Area III. Záhorie Lowland is a slightly dry area bordered by *the isoline of relative evapotranspiration 0.7* and the River Morava**.***Area IV. Southern Slovakia Basin* is a slightly dry area bordered by *the isoline of relative evapotranspiration 0.7* from Šahy to Lenártovce and the border with Hungary.

Area V. Eastern Slovakia Lowland is a slightly dry area bordered by *the isoline of relative evapotranspiration 0.7* and Hungary and Ukraine.

Area VI. Košice Basin is an important areafor growing fruit and vegetables for the urban population, and therefore there is the potential for the development of micro-irrigation.

The above-mentioned lowland areas of Slovakia are typical for annual precipitation totals being lower than annual totals of potential evapotranspiration.

Increasing the difference between precipitation totals and the potential evapotranspiration totals makes the area more sensitive to droughts

It means that the dependence of water balance components of the territory on climate change impact is considerable in complicated soil conditions.

On the basis of submitted results (*Šútor et al. 2007*), it is possible to state that the occurrence of extremely long time periods without precipitation has a dominant impact on the origin of soil drought in agricultural production areas during the vegetation period in the process of retrospective monitoring and assessment of the periods without precipitation.

Periods without precipitation are a significant phenomenon of climate change

Results show that it is impossible to find any regular occurrence of no precipitation periods; they are of stochastic nature.

In Europe, with the consideration to climate change, irrigation has stopped to be assessed and designed as an intensifying factor of agricultural production but it is considered as a stabilizing factor of sustainable agricultural development.

It is presumed that the extension of irrigation systems in the main irrigation areas will be a primary adaptation measure to mitigate the negative impact of climate change.

The extension of irrigation to almost 500 thousand ha will create a high pressure on available water resources. The total irrigation water demand is expected to increase by 115% and irrigation water consumption by approximately 75% by the year 2075 (*Table 1*).

Table 1. Current status and expected development of irrigation in Slovakia till 2075

Irrigation area	Irrigation size [thousand ha]			
	2005	**2010**	**2030**	**2075**
I.	177	160	255	325
II.	76	60	70	75
III.	22	15	25	35
IV.	18	8	25	35
V.	27	7	25	30
VI.	1	0	0	0
Total	**321**	**250**	**400**	**500**

PROGNOSIS OF IRRIGATION WATER DEMAND ACCORDING TO SCENARIOS OF THE CLIMATE CHANGE FOR THE YEARS 2030 AND 2075

A prognosis of irrigation water demand is made for each moisture deficit area in Slovakia. There were simulated amounts of irrigation water demand, prognosis of irrigation size for these areas and time horizons of the years 2010 (referential/verification year), 2030 and 2075 (*Table 2*).

Table 2. Prognosis of irrigation water demand according to the scenario CCCM (Takáč in Alena et al. 2005)

Area	Horizon 2010			Horizon 2030			Horizon 2075		
	m^3 ha^{-1}	**1000 ha**	**million m^3**	**m^3.ha^{-1}**	**1000 ha**	**million m^3**	**m^3 ha^{-1}**	**1000 ha**	**million m^3**
I.	1 380	160	220,8	1 400	255	357,0	1 480	325	481,0
II.	1 000	60	60,0	990	70	69,3	1 050	75	78,75
III.	900	15	13,5	950	25	23,75	1 030	35	25,75
IV.	1 090	8	8,75	1 130	25	28,25	1 320	35	46,2
V.	1 020	7	7,15	1 040	25	26,0	1 210	30	36,3
VI.	400	0	0	430	0	0	430	0	0
Total	**Ø 1 240**	**250**	**310,2**	**Ø 1 240**	**400**	**504,3**	**Ø 1 336**	**500**	**668,0**

In the next 60 years, the total water demand for irrigation is likely to increase by approximately 115%, which will be caused by the increase of the deficit of potential and actual evapotranspiration. The size of necessary irrigation area should be increased by approximately 100% in comparison to the current status (the year 2010).

PROGNOSIS OF AVAILABLE WATER RESOURCES FOR IRRIGATION

The prognosis of water management balance (*Fekete 2013*) estimates water demand for irrigation on the basis of the scenario CCCM for the horizons 2010, 2030 and 2075. Water resources are calculated on the basis of natural average monthly discharges with high availability and minimum residue discharges are considered within valid values MQ (*Fekete 1985, 1990*). The balance is prepared by the assessment of outlet profiles of individual subbasins. Results are declared through the capacity of water resources (discharges). Negative numbers mean the lack of water resources (*Table 3, 4 and 5*).

Table 3. Capacity of water resource in months in 2010 (data are in $m^3.s^{-1}$) – reference year / verification year

River Basin	Month						
	April	**May**	**June**	**July**	**August**	**September**	**October**
Bodrog	26,85	18,71	9,801	0,383	0,196	3,604	6,140
Hron	6,461	6,042	3,072	1,165	-1,554	0,961	-0,111
Ipeľ	0,763	0,110	-0,686	-0,972	-0,792	-0,053	0,311
Slaná	1,894	3,496	1,480	0,476	0,221	0,549	0,550
Nitra	2,456	0,575	-0,833	-1,018	-1,453	-0,026	0,567
Váh	47,42	17,95	13,64	4,707	-2,042	0,529	-1,365
Morava	30,99	22,93	9,396	3,022	2,013	5,314	3,219
Danube	888,5	828,4	824,1	890,8	437,5	276,7	13,6
Bodva	-0,005	0,339	0,306	-0,249	-0,299	-0,318	-0,178
Poprad	5,386	6,261	8,239	3,874	2,923	2,137	1,381
Hornád	2,047	3,396	2,024	1,745	1,035	0,126	0,604

Note: Grey field means lack of water resources

Table 4. Capacity of water resource in months in 2030 (data are in m^3s^{-1})

River Basin	Month						
	April	**May**	**June**	**July**	**August**	**September**	**October**
Bodrog	26,56	17,38	7,691	-1,166	-1,001	3,168	5,928
Hron	5,047	3,980	0,957	-0,321	-3,040	-0,103	-0,886
Ipeľ	0,206	-1,129	-2,023	-2,050	-1,655	-0,331	0,203
Slaná	1,475	2,595	0,409	-0,425	-0,590	0,223	0,415
Nitra	2,294	0,214	-1,223	-1,332	-1,720	-0,107	0,551
Váh	45,73	15,31	10,78	1,890	-4,015	-0,257	-1,722
Morava	30,51	22,21	8,566	2,218	1,363	4,997	3,143
Danube	881,8	815,9	811,1	880,3	428,2	272,8	11,2

Note: Grey field means lack of water resources

Table 5. Capacity of water resource in months in 2075 (data are in $m^3 s^{-1}$)

River Basin	Month						
	April	**May**	**June**	**July**	**August**	**September**	**October**
Bodrog	26,40	16,64	6,538	-2,012	-1,654	2,929	5,813
Hron	4,242	2,602	-0,467	-1,190	-3,909	-0,599	-1,126
Ipeľ	-0,216	-2,069	-3,036	-2,867	-2,309	-0,543	0,122
Slaná	1,075	1,735	-0,614	-1,285	-1,364	-0,088	0,286
Nitra	2,036	-0,360	-1,841	-1,831	-2,144	-0,236	0,526
Váh	43,66	12,04	7,237	-1,571	-6,459	-1,221	-2,151
Morava	29,94	21,33	7,569	1,254	0,582	4,618	3,051
Danube	875,5	804,0	798,4	870,0	419,4	269,4	9,3

Note: Grey field means lack of water resources

DISCUSSION

Currently, the main means of irrigation is spraying (approximately 95%). More progressive irrigation modes are gradually being introduced, e.g. micro-irrigation (approximately 5%). New ways of irrigation and automated irrigation management should increase the effectiveness of irrigation and save irrigation water. This trend in irrigation modernization should continue and the ratio of spraying and micro-irrigation should be 70% to 30% by 2075.

Water can be saved by increasing the qualitative parameters of irrigation, e.g. the degree of stable distribution of irrigation water; increasing the stable distribution from 50% to 60% in spraying, the most typical irrigation mode, and from 90-96% in the case of micro-irrigation. Saving 40-50% of the available irrigation water volume is a visible contribution to these issues.

For the purpose of affecting the soil water regime, existing drainage systems appear to be very convenient, since besides their primary drainage function, they would have a function of irrigation during the vegetation period. In the areas with suitable location, affected by the delay of drainage outflow or by drainage canals it would be possible to cover 30-50 mm of the total water demand of crops during the vegetation period.

CONCLUSION

Water as a non-alternative production factor significantly affects the stability and production of agro-ecosystems in agricultural production areas. Relative evapotranspiration and evapotranspiration deficit (E_0–E) make it possible to quantify insufficient water amount in the soil for the optimal growth of crops. Thus, it is possible to determinate the amount of water needed in agricultural production areas or in irrigation areas. So-called relative evapotranspiration (E/E_0) was chosen as the value to identify irrigation areas. The extension of irrigation systems in the main irrigation areas will be a primary adaptation measure for the mitigation of the negative impact of climate change.

A prognosis of irrigation water demand is prepared for each main irrigation area in Slovakia, including the average simulated necessary amount of irrigation water and the status of irrigation size for the time horizons till 2030 and 2075. In the currently prepared prognosis for water management balance, irrigation water demand is calculates on the basis of the scenario CCCM for the horizons 2030 and 2075. The above-mentioned prognoses for the years 2030 and 2075 indicate that dry periods will not be expected in the Danube and Morava basins; however, there will be insufficient amount of water in the Ipeľ and Nitra basins in the summer months. The scenario for the year 2075 indicates that related river basins will suffer from the lack of water not only in the summer months (Ipeľ river basin in April-September and Nitra river basin in May-September). The basins of the rivers Bodrog, Hron, Slaná and Váh (scenario for the years 2030 and 2075 – table 3 and 4) will be affected by drought mainly in summer. When planning agricultural production, it is necessary to take these scenarios into consideration in the future.

An increased demand for irrigation water could be met by introducing new irrigation methods with the focus on irrigation efficiency and water saving. Despite the technical progress in irrigation, the water demands of field crops can only be partially met because of limited disposable water resources for irrigation in some river basins in Slovakia. This will inevitably create the need for building new water resources, such as small water reservoirs.

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Co-operation between the Slovak Republic and Hungary in the Hydrology of Transboundary Waters

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Abstract

The paper gives a short overview of the cooperation method in the hydrology of transboundary waters between the Slovak Republic and Hungary.

Key words

Hydrology, transboundary waters, cooperation, Hungary, Slovak Republic.

BACKGROUND TO THE AGREEMENT

The cooperation in water management issues on transboundary waters with Hungary takes place on the basis of the Agreement between the Government of the Czechoslovak Socialist Republic and the Government of the Hungarian People's Republic on the regulation of water management issues on transboundary waters, signed in Budapest on 31 May 1976 (hereinafter the "Agreement"), which came into force on 31 July 1978.

As a consequence of the dissolution of the Czech and Slovak Federative Republic with the establishment of two independent states, the Slovak Republic and the Czech Republic, a new Agreement on Cooperation on Transboundary Waters needed to be concluded. A new Agreement between the Government of the Slovak Republic and the Government of Hungary on cooperation in shared river basins and on transboundary waters, which is to replace the above-mentioned Agreement still in force, is being drafted at present.

The text of the new Agreement takes into consideration current knowledge of cooperation on the Slovak-Hungarian transboundary waters and fully takes into account and applies the principles and provisions of in particular Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, as well as Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, and is in compliance with the Slovak legal order and with the principles and provisions of valid international conventions regarding waters, environment and nature protection, as well as with the obligations undertaken within other valid international treaties and conventions.

THE COMMISSION AND ITS WORKING GROUPS

Based on the Agreement, a Slovak-Hungarian Commission for Transboundary Waters was established (hereinafter the "Commission") which, at its annual meetings, negotiates and solves all the issues of water management on transboundary waters, which also makes it possible to avoid possible adverse impacts on water management conditions in the territory of the other party's State. Each party appoints a permanent government plenipotentiary to the Commission, a deputy plenipotentiary and working group leaders and members. Currently, the Plenipotentiary of the Government of the Slovak Republic for water management issues on transboundary waters is Ing. Vladimír Novák, and the Plenipotentiary of the Government of Hungary for water management issues on transboundary waters is Ing. István Láng. Other experts can be invited to Commission meetings, too, if it is necessary for the solution of a specific problem. The working groups fulfil their tasks on the basis of their mandates, principles of cooperation and directives approved by the Commission, as they result from the intergovernmental agreement specifying individual areas of cooperation and the resulting tasks. The group's work plan for the current period is approved annually at Commission meetings.

Working Group for Hydrology

For the cooperation in hydrology, a "Working group for hydrology" was established (in 2011 it was renamed "Joint working group for the quality of transboundary waters and hydrology"). Its holds meetings twice a year, in the Slovak Republic and in Hungary in turn.

The basic document for the work of the "Joint working group for the quality of transboundary waters and hydrology" is the "Rules of exchange of hydrological data and information between the Slovak Republic and Hungary" (hereinafter the "Rules"), which regulate the uniform execution of tasks pursuant to Article 17 (notification of hydrological and hydrometeorological data) and Article 3 (general commitments), Section 2 of the valid Agreement, taking into account:

- Convention on cooperation for the protection and sustainable use of the River Danube (Sofia, June 1994),

- Resolution of Plenipotentiaries at Meeting LIV of the Slovak-Hungarian Commission for Transboundary Waters in Item 21 c of the Protocol on Establishing a Group of Hydrology Experts (Palárikovo, November 1993).

Annexes to the Rules constitute an integral part thereof and contain a list of data, profiles and structures, the means and frequency of data exchange, as well as contact addresses. The Annexes to the Rules are updated as necessary at the meeting of the Joint Working Group.

The expert group for hydrology, within the "Joint working group for the quality of transboundary waters and hydrology" fulfils the tasks resulting from the Rules of Exchange of Hydrological Data and Information such as measuring, exchanging data, harmonising the results of measuring and processing), performing the joint analyses of data and approving of maximum and minimum flows on boundary profiles, harmonising the methodologies and processing hydrological data.

In 2006, the joint values of N-year maximum flows for bridge profiles on the River Ipel / Ipoly (Pösténpuszta – Peťov and Rárospuszta – Raroš) were approved. In the same year, the values of common ecological minimum flows on the entire common Slovak and Hungarian section of the River Ipel / Ipoly were approved.

On 23 October 2007, Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks was adopted. In accordance with national legislations, the background data for the preparation of flood risk maps and flood hazard maps of the boundary rivers (N-year flows) are to be prepared in the respective commissions of transboundary waters. These issues are dealt with by the expert group for hydrology. The longitudinal profiles of N-year maximum flows on the River Danube from Devín to Budapest have been processed gradually (*Figure 1*), as well as the common values of N-year maximum flows on the boundary profiles of the River Hornád / Hernád and River Slaná / Sajó; currently (the second half of 2017), the calculations of N-year maximum flows on the River Bodva are carried out and should be approved in autumn 2017.

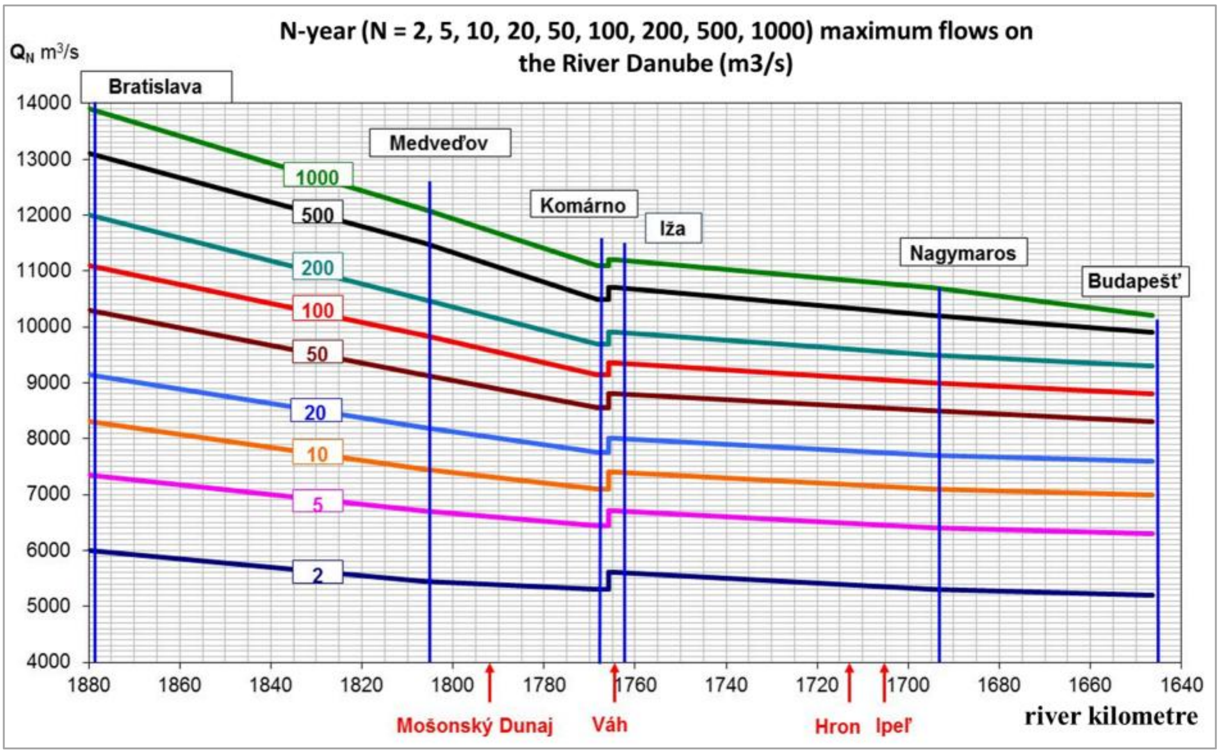

Figure 1. Longitudinal profile of N-year maximum flows on the River Danube from Devín to Budapest

DATA EXCHANGES

At the meetings of the "Joint working group for the quality of transboundary waters and hydrology", hydrology experts inform each other on the cooperation in utilising the data resulting from the innovation of the monitoring network, on detailed balancing of flows in a monthly cycle, and also on the preparation of flood risk management plans in each country.

In the area of underground water data exchange, eight areas of common interest were specified and 56 mutually approved underground water bodies were selected in accordance with Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy in the transboundary Slovak and Hungarian territory. Since 2011, basic annual hydrological data from the hydrological networks of underground waters for the specified areas and underground water bodies have been bilaterally exchanged on an annual basis. At the same time, a summary of annual withdrawn quantities of underground waters exploited in individual underground water bodies is provided. Negotiations also include the exchange of information on the changes in the structure of observation networks of underground waters, on the progress in measurement automation and prognoses of utilisation of new water sources of ordinary and geothermal waters in the transboundary territory.

The exchange of the operative data necessary for the activity of hydrological forecasts and warnings takes place at a standard level in accordance with the Annexes to the Rules of Exchange of Hydrological Data and Information. The data exchange exceeding the Annex is carried out on the basis of a contract between organisations. Moreover, the Slovak Party (Slovak Hydrometeorological Institute and the state enterprise Slovenský vodohospodársky podnik, š.p.) is involved in the DARREFORT Project as a partner. The project is to regulate the data policy of the Danube States.

EVALUATION OF THE WORK OF REGIONAL WORKING GROUPS

The evaluation of the work of Regional Working Groups constitutes an important task of the expert group for hydrology. The Regional Working Group for the West deals with hydrological issues of the common boundary section of the River Danube, and the Regional Working Group for the East deals with hydrological issues of the common boundary section of the River Ipeľ /Ipoly and the boundary profiles of the Rivers Slaná / Sajó, Hornád / Hernád, Bodva, and Bodrog. Hydrometry during the flood in June 2013 and the evaluation and approval of peak flows are considered the most important parts of this activity. It was the biggest flood on the River Danube in the section Devín – Štúrovo since the year 1899.

In the area of hydrometry, joint hydrometry measurements using ADCP ultrasonic instruments for the purpose of the calibration of the instruments represented an important step. The measurements were carried out at Balassagyarmat in June 2015 and at Salka in June 2016. Based on these control measurements, the Hungarian Party worked out a detailed certificate for the confirmation of calibration of RiverRay, RiverSurveyor, and StreamPro instruments and sent it to the Slovak Party. The joint working group approves the results of joint hydrometry measurements on the boundary rivers, as well as the plan of measurements for the next year in accordance with the national Monitoring Plans.

Regarding the growing problems caused by climate change, the importance of cross-border cooperation in water protection and management with the neighbouring countries increases; the area of hydrology is a key aspect of cooperation. The long-term bilateral cooperation on the transboundary waters between the Slovak Republic and Hungary creates a good basis for overcoming problems and challenges expected in connection with recorded changes in natural cycles.

THE AUTHORS

VALDIMIR NOVÁK graduated from the Slovak University of Technology, Faculty of Civil Engineering. He has had a lot of experience with state administration, namely with the Ministry of Environment. During previous years at the Ministry of Environment, he focused on international cooperation in the field of integrated water management, flood protection and water ways transport. Presently, he is the Director General of the Water Section and EU Water Director of the Slovak Republic and Slovak Governmental Plenipotentiary for bilateral cooperation on transboundary water with all neighbouring countries.

ISTVÁN LÁNG graduated from the Budapest Technical University as a civil engineer specializing in water engineering. After graduation, he worked in the field of water management as an investor, contractor and operator for over 10 years. Then he started to work for the water public administration mainly on flood protection issues and became head of department within the Ministry responsible for water management. Since 2012, he has been the chief engineer at the General Directorate of Water Management of Hungary and also the head of the national organization for water damage mitigation. Regarding the Slovakian transboundary water relations, he is the Hungarian Governmental Plenipotentiary.

MANAGING ENVIRONMENTAL RISKS

– flood protection experiences and cooperation in the Danube River Basin –

(Mobile flood protection wall in use, Szentendre - Hungary; Photo from Stockphoto.com)

DANUBE REGION strategy Environmental Risks

https://www.danubeenvironmentalrisks.eu/

Interreg Danube Transnational Programme

Integrated Heavy Rain Risk Management in Central Europe – RAINMAN project summary

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ABSTRACT

Risks of heavy rain events are increasing all over Central Europe. They can hit any location at very short notice. In 2015, the economic loss amounted to 1.2 billion Euros. The devastating impact of extreme rainfall is the most significant natural risk in Central Europe.

The main objective of the project is to improve the integrated management competence of public authorities to mitigate heavy rain risks. Partners from 6 countries are jointly developing practice-oriented innovative methods and new tools to reduce fatalities and damages. They are implementing alert infrastructure in the participating regions.

The main joint outputs are:

- A transferable toolbox with new tools and methods to assess, map and reduce heavy rain risks.
- Innovative forecasting and smart warning tools for short notice.
- Measures to reduce damage to health and the environmental and to improve emergency responses.

The project aims to achieve sustainable change on all levels of the public sector. New technologies and innovative tools are implemented with benefits for businesses, agriculture, cities and people. Trainings and educational measures increase competence. Policy makers at regional, national and EU-level also take part in the process. Recommendations for the integration of heavy rain risks into the EU floods directive are being developed.

The new tools go far beyond existing practice in CE and in the rest of Europe. The transnational strategic approach will effectively reduce these risks and damages. Experience from previous river flooding projects will be taken into consideration and further developed for heavy rain events.

Key words

Heavy rain, risk management, assessment and mapping, early warning system, emergency response, transferable tools, examples of best practice

PROJECT BACKGROUND

Since 2004, the Middle Tisza District Water Directorate has had good relations with Saxon partners, as the Directorate was involved in previous INTERREG Projects, such as ELLA and LABEL, and achieved great results in the sustainable use and management of alluvial plains in diked river areas and flood management measures by transnational spatial planning.

Heavy rain events are increasing all over Central Europe. They can hit any location at short notice. Every year in the middle of Europe, thousands of people lose their homes and high economic losses occur due to heavy rain events and environmental damage such as water pollution is induced. The devastating impact of extreme rainfall has been identified as the most significant natural hazard in Central Europe (*Figure 1*).

The main objective of the project is to implement an improved integrated and transnational risk-management approach in order to reduce the risks in Central Europe. The management capabilities of the participating countries will improve.

The project will reduce risks and protect human life with the cooperation of partners from Germany, Austria, the Czech Republic, Hungary, Croatia and Poland. The partners jointly develop practice-oriented, new and innovative methods, tools and solutions to assess, map and predict heavy rain events and implement warning infrastructure in the participating regions (e.g. in pilot actions). The project will make the region a safer place to live and work and will allow the economy to grow. Land users (local as well as regional) and the environment alike will benefit from the project.

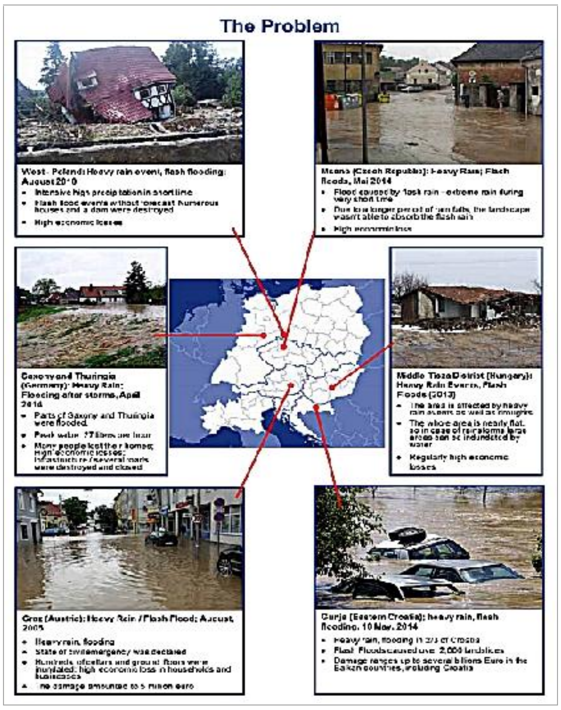

Figure 1. Overview of similar problems in the project partner countries

The joint outputs of the project will be:

- Assessment and mapping: development of a joint and transferable method to assess and map heavy rain hazards in Central Europe.

- Forecast and warning: Developing and implementing innovative forecasting and warning systems.
- Solutions for risk and damage reduction: Cataloguing available measures and approaches to reduce heavy rain risks and developing new and innovative measures.

The result of the project will be a sustainable change at all levels of the public sector. The experiences and the new tools will be implemented in different sectors (e.g. local businesses, agriculture, cities and rural areas). Competence will be increased by workshops, trainings and educational measures. Furthermore, policy makers at regional, national and EU-level will be involved in and targeted for compiling recommendations for the integration of pluvial flood risks into the implementation process of the EU floods directive.

The developed tools and strategies go beyond the existing practice of all involved partner regions, as no transnational, strategic vision to handle risks from heavy rain events has existed so far. Local solutions and available best-practice experiences will be taken into account and developed further.

THE MAIN OBJECTIVES AND STRUCTURE OF THE PROJECT

The main objective of the project is to improve integrated management competence for the reduction of environmental risks of heavy rain events in order to reduce the losses in the natural and built environment (including the economy, human life, environmental resources and cultural heritage). The project aims to create transnational, integrated management tools for heavy rain risks and to raise the respective management competence of the participating countries.

The objectives will be reached by developing, testing and implementing transferable solutions to assess, map and manage the risks. This will be done together with relevant stakeholders from different governance levels, who will jointly work on improving the competence of the public and private sectors to handle heavy rain risks. Moreover, the project will provide an important input on how to handle heavy rain risks in the framework of the EU floods directive.

The project contributes to the specific programme objective to improve integrated environmental management competence in the sector of integrated risk management and to integrate these with different planning sectors and civil protection.

The project answers the challenges of increasing risks and damages from heavy rain events in Central Europe. It develops and implements innovative and transferable tools and measures to reduce risks from heavy rain events by building competence for the management of heavy rain risks at all levels of the public sector as well as parts of the private sector. This will ensure better management of the increasing risks both locally and at national as well as European level. Consequently, with improved management and preventive solutions, less damage will occur in housing and infrastructure, providing a stronger and more reliable basis for the sustainable use and economic development of environmental resources.

The main result of the project will be improved competence to manage environmental risks by integrating risk assessment and mitigation into complex environmental management tools. The project will improve the competence of the public sector (municipalities and regions) to better handle heavy rain risks by developing tools, pilot implementations and trainings.

This is comprised by the following outputs:

- Solutions for risk and damage reduction in a toolbox consisting of a joint and transferable method to assess and map heavy rain risks and risk areas in Central Europe and implemented innovative forecasting and warning systems for municipalities and regions.
- A catalogue of best practice examples of available and newly developed, innovative measures and approaches to reduce heavy rain risks.
- Joint recommendations for the integration of heavy rain risks in flood risk management planning.
- Joint strategy to raise the awareness of heavy rain risks in Central Europe.

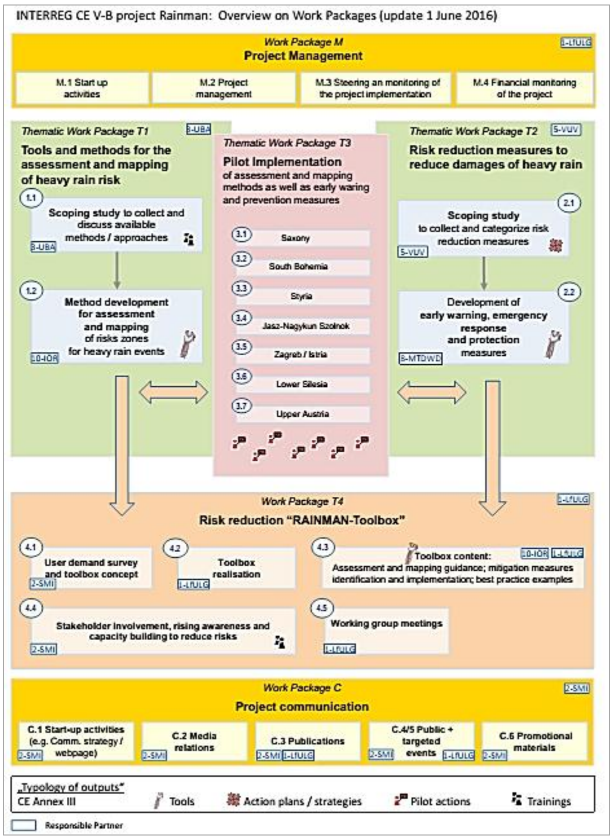

Figure 2. Overview of the project structure

Altogether 4 tools, 9 pilot actions, 9 meetings and 2 action plans will be designed and implemented within the project. These will contribute to the expected results and specific objectives of the programme. The project results will enable the public sector on different governance levels to better manage the increasing risks of heavy rain events and thus reduce potential damages. Consequently, this provides a stronger and more reliable basis for the sustainable use and development of resources.

The project consists of 8 Work Packages (WPs): Preparation – P; Management – M; Thematic -T1: Tools and methods for the assessment and mapping of heavy rain risk.

Thematic - T2: Risk reduction measures to reduce the damage caused by heavy rain; Thematic - T3: Pilot actions to test and improve the developed methods for risk assessment and prevention; Thematic - T4: Risk reduction RAINMAN Toolbox; Investment specification - I1: Optimising rain water storage pond Kakat as a test measure in the Tisza Region (HU); Communication – C. *Figure 2* shows the interconnections among the WPs.

INFO BOX:

Number of partners: 23 (10 project partners from DE, AT, CZ, PL, HU, HR, and 13 associated strategic partners from all of these countries).
Project Budget: 3,045,286 €
Project Duration: 36 months, from 1st July 2017 till 30th June 2020.
Project Lead Partner: Saxon State Office for Environment, Agriculture and Geology
Project Manager: INFRASTRUKTUR & UMWELT
Contact Details: Dr. Peter Heiland Tel: +49(0)6151-8130-0, http://www.iu-info.de/
Funded by: INTERREG Central Europe Programme
Programme priority: 3. Cooperating on natural and cultural resources for sustainable growth in CENTRAL EUROPE
Programme priority specific objective: 3.1 To improve integrated environmental management capabilities for the protection and sustainable use of the natural heritage and resources
Official website of the project: *http://www.interreg-central.eu/Content.Node/RAINMAN.html*

PROJECT CONSORTIUM AND TARGET GROUPS

The transnational project partnership from DE, AT, CZ, HU, HR and PL wants to improve the competence of the relevant public authorities for integrated management of risks from heavy rain events. The Project Management (PM) consists of several cross-cutting elements: project management unit (PMU), Steering Group (SG) and Working Groups (WGs). The overall strategic and operational coordination is done by the PMU (project coordinator, financial manager at the Lead Partner (LP) and external PM support). PMU is responsible for reaching the project goals, deliverables and overall performance. It is responsible for all project & financial management: reporting (collecting input from all Project Partners (PPs)), monitoring progress, risk and quality management and communication issues. Tools include a project handbook (PHB), a budget plan, updated semi-annually, and a work plan to monitor and point out deviations. The PMU will also update, inform and give decision support to the SG and thematic WGs. The SG consists of 1 representative per PP. The SG decides about all major issues concerning the project (its content and financial progress, risk and quality management, major joint events and products). Input is provided by the PMU and the WGs. Also, tasks are assigned to the WGs, especially on project risks and quality management. The WGs provide a platform for the exchange of ideas among the project partners about their experiences and findings. Each PP is responsible for their respective regional project implementation according to the Work Plan and for cooperating in the joint tasks. These are designed by all PPs in the WGs. The WGs cooperate on thematic work packages and are coordinated by the WP leaders (WPLs). Topics are identified on the basis of the Work Plan and actual needs. Internal / day-to-day communication: the LP organises monthly meetings with the WPLs (both conference calls and face-to-face meetings), and issues regular updates to PPs (no rarer than monthly). Risk and quality management: quality management measures will be detailed in the PHB. Risk management will be ensured by specific scaling-up procedures and the monitoring of risk factors during regular meetings with WPLs and PPs. A mid-term review will be organized.

The target groups of the project are the following:

- Local public authorities
- Regional public authorities
- National public authorities
- Sectoral agencies
- Interest groups including NGOs Higher education and R & D
- The general public

Stakeholders and policy makers will be directly engaged in identifying the needs, for assessment and mapping as well as for the warning and alarm systems and the risk reduction measures. Furthermore, they will be involved in the implementation of the procedures and will help to initiate and manage the pilot activities. Public authorities, partly as associated partners, will be involved in the elaboration of policy guidelines through international meetings and exchanges.

SYNERGIES WITH OTHER INTERREG PROJECTS

RAINMAN builds on existing methods & strategies, funded by ERDF in the last periods. Especially, river flood management (rfm) strategies, methods & measures were developed by several former research & INTERREG-projects (such as CE IIIB/IVB ELLA, LABEL, CEFrame, INARMA, SUMAD, FLOODMED, RISKAWARE or SEE IVB DANUBE FLOODRISK, FP7 FLOODsite etc.). All partners have been involved in at least one of these projects. They ensure the utilisation of the results & skills of these (see also PP sections). Additionally, scoping studies (D1.1.1; D2.1.1) and workshops (D1.1.2) will explicitly ensure the integration of the existing knowledge into the activities foreseen. All Partners provide input.

The great advantage of these projects for RAINMAN is that river form approaches can partly be transferred to other types of flood, like heavy rain events and flash floods. However, they cannot simply be copied or duplicated. E.g. management strategies, like risk robust urban developments, have similar bases but different applications, because of diffuse origin (flash floods) compared with clearly defined sources (river floods). RAINMAN creates synergies but at the same time goes far beyond their scope and its focus has not been covered by any INTERREG project so far. Especially assessing, modelling and mapping of heavy rain risk is far from being everyday practice.

At the same time, RAINMAN creates synergies with ongoing implementations of the EU COM within the scope of the floods directive: How to integrate heavy rain risks in proper form is an ongoing task. In RAINMAN, these synergies will be used, mainly by focused events (A.C.4; A.C.5) and recommendations will be given, which go beyond existing knowledge and strategies (D4.3.3).

Moreover, contacts with currently funded ERDF projects, e.g. CE V B FramWat will be explicitly sought to use further synergies, e.g. by invitations as guest speakers at project events.

THE ROLE AND CONTRIBUTION OF THE MIDDLE TISZA DISTRICT WATER DIRECTORATE

MTDWD undertakes the following activities in the joint context: assessment and mapping of risk zones for heavy rain: coordination on and contribution to the work on the joint method; testing the joint method in a pilot area (lowland specification); prevention measures: contribution to the joint catalogue of measures and pilot implementation (optimisation of lowland storage areas); hosting an international conference and trainings for stakeholders and local experts. The specific know-how and resources (e.g. experts, data) will be made available and exchanged with the other PP and MTDWD experts will learn from the experiences and competences of other regions. MTDWD undertakes all necessary partner management obligations. The organisation benefits from the project by using international experience in assessing and mapping the risk areas to develop and implement risk mitigation measures. Pilot actions will be implemented in highly endangered cities, which are already identified as associated partners (Tiszakécske and Kunhegyes). This will enable the cities to improve their competences in managing heavy rain risks by participating in pilot actions. Other pilot actions will support the implementation of the toolbox in the whole district. Know-how of staff and local experts within the region will be enhanced and cooperation and networking will be expanded. MTDWT has actively participated in developing the project and writing the tender.

Activities planned by the Directorate (including two pilot actions):

- Activity 1: Creating a Best Practice Guide to the management of rain storage reservoirs on lowland areas; Emergency Guide Book
- Activity 2: Organising an international conference In Hungary
- Activity 3: Study tour to Germany
- Activity 4: Study tour to the Czech Republic
- Activity 5: Optimising rain water storage at the Kakat pond
- Activity 6: Risk assessment, mapping and possible solutions in Tiszakécske

THE AUTHOR

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EAST AVERT Project MIS ETC 966 implementation – Good Practice Example of Cross-border Cooperation for Flood Risk Prevention

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*** Romanian Co-Coordinator of the PA 5 of EUSDR

Abstract
Over time, all countries of the Danube Region have expressed their common intention to strengthen their cooperation in responding to natural disasters such as massive floods. The EU Danube Strategy creates a frame for this collaboration, especially within Priority Area 5 "Management of Environmental Risks".
As one of the major consequences of climate change, flood events generate hydromorphological alterations to riverbeds and water regime, have a negative impact on the quality of surface waters determining pollution loads from different point and diffuse sources, on natural landscapes and biodiversity, and also result in loss of life and damage to economic activities. Flood prevention is therefore of particular importance. The EU Floods Directive provides a legal framework for a coordinated approach to assessing and managing flood risks. This paper gives an overview of the main challenges occurred during the implementation of a project in the border region between Romania, the Republic of Moldova and Ukraine. The EAST AVERT MIS ETC 966 project brought into attention and focused on both short-term planning measures by modernizing the Early Warning System, as well as long-term flood risk management by flood hazard and flood risk mapping.

Key words
Flood risk; flood protection; water quality; environmental risk; economic and social vulnerability; flood risk management; flood hazard and risk maps.

SETTING THE SCENE

The Ministerial Declaration adopted by the Danube countries in the framework of their cooperation on water management states that "flood prevention and protection are not short-term tasks but permanent tasks of the highest priority". The Declaration commits the signatories to "develop one single international Flood Risk Management Plan based on the ICPDR Action Programme for Sustainable Flood Protection".

Many regions throughout the Danube Region are particularly subject to high flood risks, as was illustrated by the disastrous events in 2006 and 2008. This flood disaster affected large parts of the Danube floodplains in Central and Northern European countries and the loss induced was more than 700 million Euros. Besides extraordinarily high precipitation, the disaster was also due to the loss of flood retention areas such as floodplains and wetlands. *Figure 1* and *Figure 2* show images of floods recorded on the River Prut in Romania.

The prevention of flood hazards caused by transboundary rivers is a global issue to be addressed on a cross-border level. Efforts to deal with the impacts of natural disasters need to be coordinated jointly, facilitating the identification of common problems and the application of appropriate intervention measures. The project idea was generated by the needs of a cross-border approach, since the competences of tackling water management issues are dispersed over countries and institutions. The Project partners were identified among responsible authorities in the field from each country, with the specific aim to cooperate in the development and transfer of common methodologies and tools, thus also contributing to preventing the pollution of the cross-border environment and, to a certain extent, to improving the unfavourable ecologic situation in the region.

EAST AVERT MIS ETC 966 is one of the Flagship Projects both for ICPDR Action Programme for Sustainable Flood Protection and for the EU Danube Strategy Action Plan for the coordination of the Priority Area 5 "Management of Environmental Risks". Within the EAST AVERT MIS ETC 966 project, the protection of the border areas against flood risk through preventive measures is one of the main goals. 3 large cities and many communities along the two river basins (Rivers Prut and Siret) will receive a better flood warning system. As a main output, the project will improve the bilateral water management agreements between Romania, Ukraine and Republic of Moldavia. A common action plan will be agreed upon and applied in the border area and Flood Directive implementation will be assured in the upper Prut and Siret cross-border river basins.

The project is crucial for the entire programme area since one of the main results of the implementation of the project is the fact that the technical and functional parameters of the Hydro-technical Complex "Stanca-Costesti" will be improved, which will prevent future flood hazards in the cross-border region.

MAIN OBJECTIVES OF THE PROJECT

Overall objective

The overall objective of EAST AVERT MIS ETC 966 project is to protect the border areas in the upper Siret and Prut River Basins against flood risk and other natural hazards of the water cycle and accidental pollutions and to reduce the environmental, economic and social vulnerability of targeted localities in the border region against flood risk.

Locations of the action: Prut and Siret River Basins

Romania:
- Counties (for Siret River): Suceava, Iasi, Neamţ, Bacău;
- Counties (for Prut River): Botoşani, Iasi, Vaslui, Galaţi.

Ukraine:
- Ivano-Francovsc region
- Chernivtsi region.

Republic of Moldova:
- Briceni, Edineţi, Rişcani departments

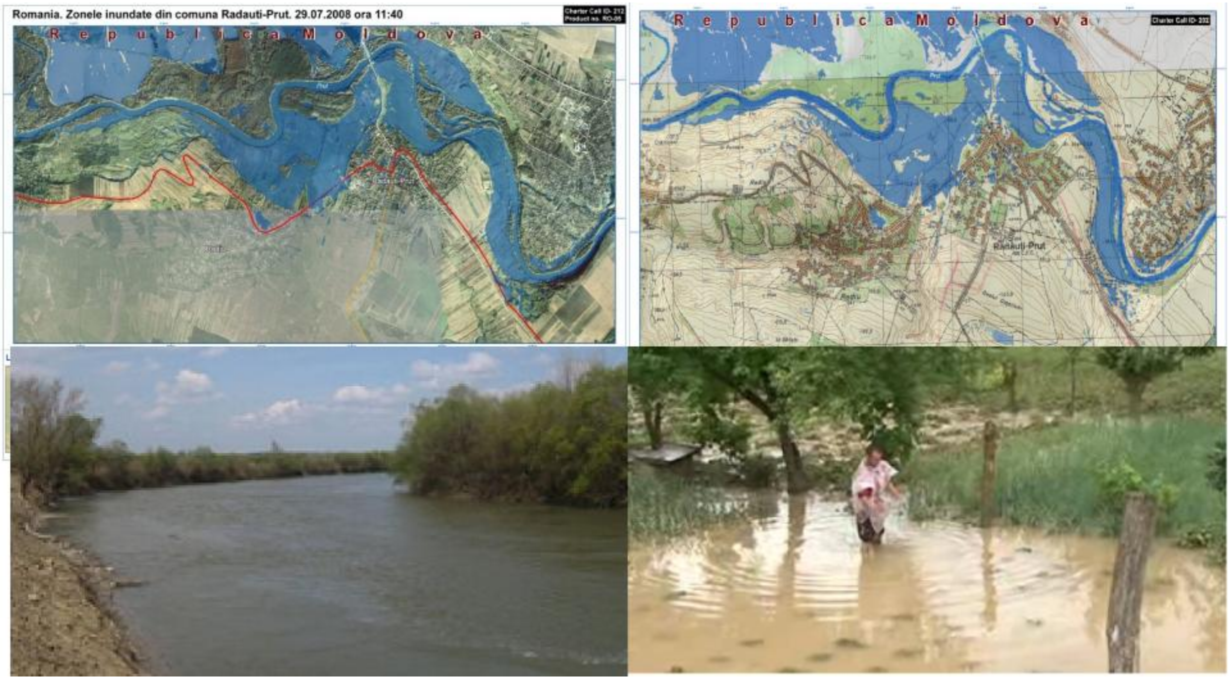

Figure 1. Floods affecting Prut during 2008 and 2010

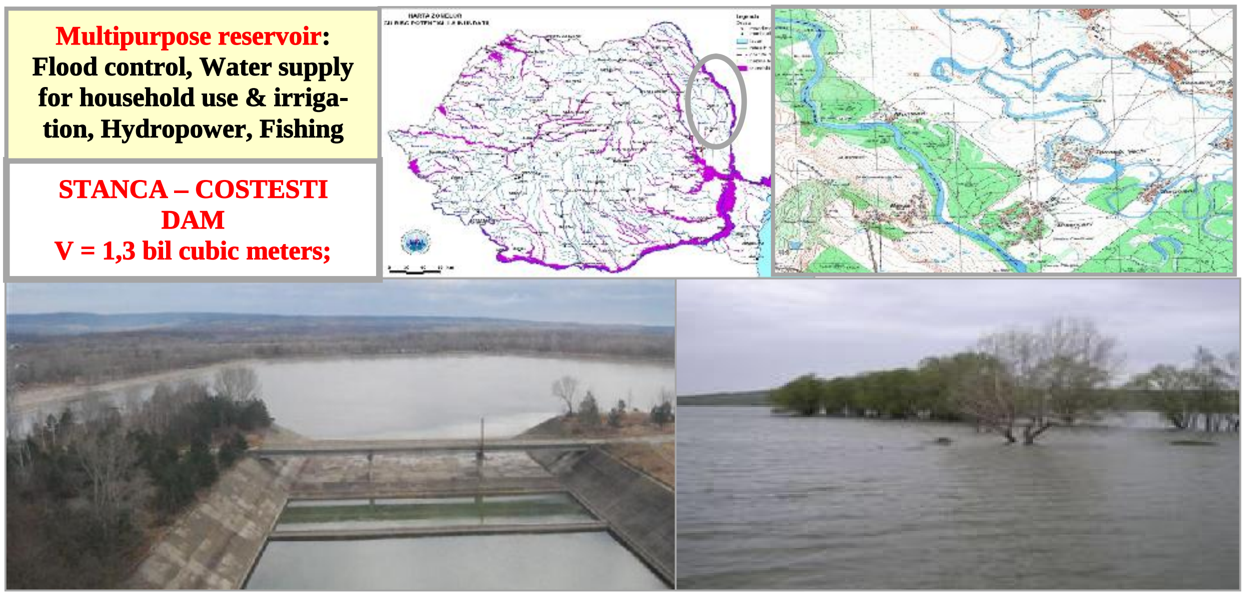

Figure 2. Large flooded area downstream - Stanca Costesti reservoir

Specific objectives

1. To reduce the environmental, economic and social vulnerability of targeted localities in the border region between the Republic of Moldova and Romania against flood risk by enhancing the functional capacities of the Hydro-technical Complex "Stanca-Costesti" (*Figure 3*).

2. To increase data availability and ensure a high monitoring level of the Siret and Prut River Basins, including the main hydraulic infrastructure as Stanca-Costesti Dam and Reservoir for prevention and protection against floods and accidental pollution events, by installing 32 automated monitoring stations (30 in Ukraine and 2 on Stanca-Costesti dam – Romania & Rep. of Moldova) (*Figure 4*).

3. To create maps representing the flooded areas during historic flood events in the Siret and Prut river basins, hazard and vulnerability maps at an adequate scale (using high-resolution satellite images) and risk maps for the Siret and Prut river basins.

4. To design a River Basin Plan for the protection against ice-floods, hydrological drought, accidents occurring at the hydrotechnical constructions and accidental pollutions for the Siret and Prut river basins.

Figure 3. Enhancing the main hydraulic infrastructure on the Hydro-technical Complex "Stanca-Costesti": installing new dam equipment for water level discharge control; rehabilitation works of the reservoir dam for prevention and protection against floods and accidental pollution events

Figure 4. Instalment of 32 automated monitoring stations in the upper Prut & Siret River Basins (border region between Romania & Republic of Moldova (2 stations) and Ukraine (30 stations); works & bank protection for flood on the Ukrainian side

5. To improve the warning system by better joint forecasting procedures and modelling.

6. To increase the reaction capacity by better data and forecast dissemination, public information about flood hazard and a common exercise testing the hydrological information system (Figure 5).

STRUCTURE OF THE PROJECT

The project structure comprises 6 project activities, as follows:

1. Creating hydrological information, forecasting and early warning system reducing order to reduce environmental, economic and social vulnerability
   - Establishing a project implementation basis through special questionnaires and data bases, national and trilateral workshops, site visits, seminars, extensive discussions, international presentations and publishing leaflets to reveal the common platform of the project and a detailed action plan for the following project activities for a wider professional and public support
   - Feasibility and EIA Studies elaboration and the technical design projects preparation for fully automated station locations, according to the characteristics of the Siret and Prut upper river basins and for Stânca-Costești Dam, as the largest flood protection infrastructure on the Prut River
2. Modernising hydrological information (HIS), forecasting and early warning system (EWS) in the Prut and Siret basins for flood prevention
   - Purchasing 32 automated hydrometric stations to be assembled in the upper basins of the rivers Siret and Prut river and equipment and works for installation at Stanca-Costesti dam and reservoir
   - Calibrating the stations and validating the data resulting from the measurements

- Training 20 specialists in the processing and communication of primary data and in designing dispatch and cartographical applications
- Processing and communicating data– designing the trilateral informational system for water and emergency situations management
- Modernising the hydrological information and forecasting system

3. Preparing the Flood Directive (2007/60/EC) reporting to the Preliminary Flood Risk Assessment and Flood Hazard and Risk Mapping along the Prut floodplain and in the Siret basin, upstream Romania
   Partners from Ukraine and Republic of Moldova have applied unitary methods, assisted by Romanian experts (who already reported to EC according to the Flood Directive), in order to carry out the mapping of historical floods for the river basins. Also, they delivered the historical flood analysis and cartographic products for the territory of the Siret and Prut basins in the two countries. Based on these results, the mentioned partners will produce the necessary reports for the Flood Directive and will assist the Ministry of Environment (LP (PP1)) in preparing the integrated report for the cross-border area to the EC.
4. Collaboration for improving the framework of bilateral agreements in case of floods
5. Transparency
6. Management and coordination

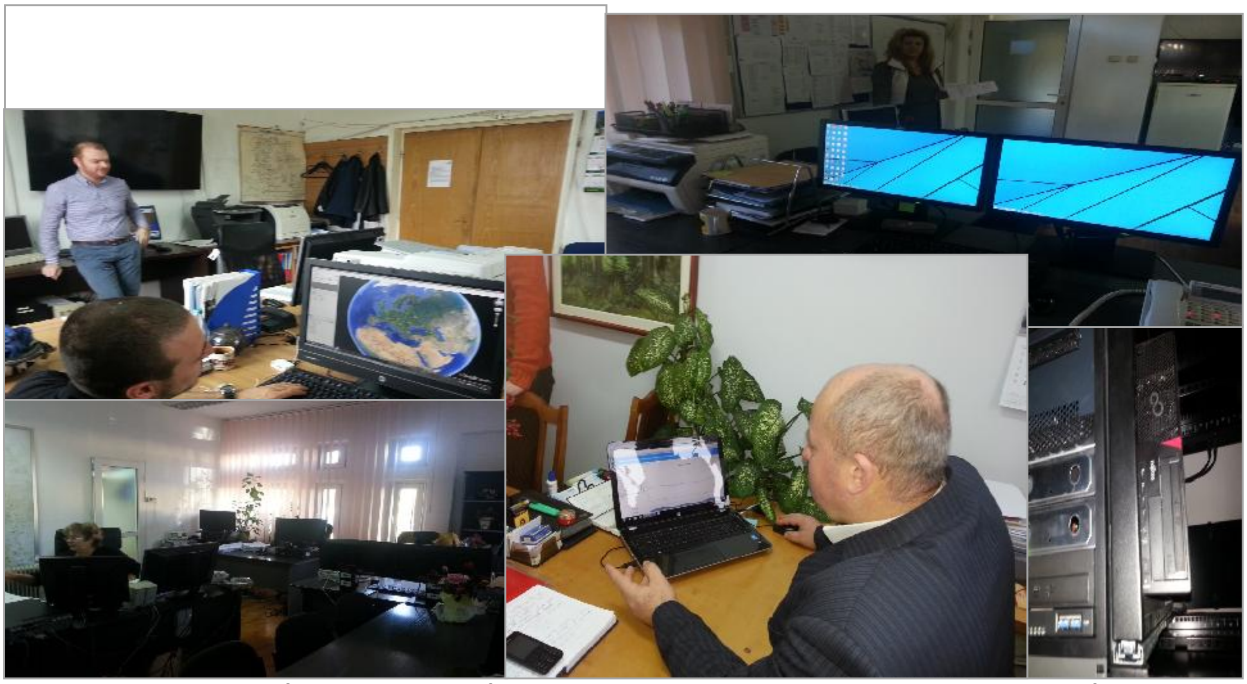

Figure 5. Improving the functional capacity of Integrated Monitoring & Early Warning Systems: equipment for 9 hydro-meteorological data collection centres, 3 regional computational centres and 1 national forecasting centre for forecasts, 11 administrative dissemination centres

INFO BOX

Number of partners: 8 partners
Project Budget: 9,243,784.56 €
Project Duration: 29 November 2013 – 31 December 2017
Project Lead Partner: Ministry of Environment, Romania
Project Manager: Mrs. Marisanda Pîrîianu
Contact Details: marisanda.piriianu@mmediu.ro
Funded by: Joint Operational Programme Romania-Ukraine-Republic of Moldova 2007-2013
Official website of the project: http://eastavert.mmediu.ro (available in the near future)

LINK WITH THE EUSDR ACTIONS, EXPECTED PROJECT RESULTS

The results to be achieved by the EAST AVERT MIS ETC 966 project are the following:

- Developing a modern, integrated monitoring and warning system to protect communities living in the border areas of the Prut and Siret river basins;
- Long-term development of the integrated approach to prevent and protect communities against floods, by a strategic land development plan, utilising the flood hazard and vulnerability/risk maps;
- Elaboration of the "River Basin Protection Plan against ice-floods, hydrological drought, accidents occurring at the hydro-technical constructions" through the cooperation of the responsible stakeholders in the territory of Romania, Ukraine and Republic of Moldova;
- Improving the management of floods, accidental pollutions in the river basin and the quality of the

water resources, for the prevention of emergency situations;

- Adjusting and implementing the national strategy for the fight against flood risk, by informing local communities, local public authorities and the public of issues regarding the protection against floods in the Siret and Prut river basins, and also in the vulnerable areas by creating vulnerability and risk maps for both the Prut and Siret river basins in the areas with transboundary impact;
- Reviewing bilateral agreements in the field of water management and improving the part for data exchange, warning and the coordination of preventive activities.
- The expected outputs of the EAST AVERT MIS ETC 966 project are the following:
- Increasing data availability by installing 32 automated hydrological stations;
- A flood forecasting methodology and forecasting model will be used at the basin level, gaining an increased reaction time for flood protection measures, downstream the Ukrainian border, on the Romanian and Republic of Moldova territory, providing better protection for communities in the border area;
- Increased capacity for flood attenuation by a better monitoring system at the Stanca-Costesti Dam and by safety measures;
- Increased competence of the personnel by trainings for automatic station calibration, maintenance and data processing; using ArcGIS, specialized EC Inspire software for mapping information.
- Creating flood hazard and flood risk maps for a better flood protection measures integration in the border area and EU policy implementation (Flood Directive 2007/60/EC).

PROJECT CONSORTIUM AND TARGET GROUPS

Project consortium comprises

4 partners from Romania:

- Ministry of Environment,
- Prut-Bârlad Water Basin Administration,
- Siret Water Basin Administration,
- National Institute of Hydrology and Water Management;

1 from Republic of Moldova: “Apele Moldovei” Agency;

3 from Ukraine:

- Dniester-Prut Basin Department of Water Resources,
- Chernivtsi Regional Centre on Hydrometeorology,
- State Scientific and Technical Centre for intersectorial and regional problems of Environmental Safety and Resources Conservation “EcoResource”)

Through the implementation of the EAST AVERT MIS ETC 966 project, the targeted cross-border areas with high vulnerability will be better protected in case of flood events or related potential pollution events, and also better protection of the cultural, historical and natural heritage within these river basins will be ensured.

SYNERGIES WITH OTHER INTERREG PROJECTS

The EAST AVERT MIS ETC 966 project is related to and further develops the outcomes of the Danube Flood Risk project, one of the flagship projects of the EUSDR. It will apply the basin wide approach used for flood risk control more specifically to the Eastern part of the Danube basin. Moreover, it will create the necessary capacities for a better real-time monitoring and forecasting of floods, particularly in the transboundary areas between the three countries.

The results of this project will be shared and used in another two ongoing INTERREG projects, namely, JOINT TISZA and CAMARO-D. Strengthening the transnational water management for flood risk prevention is a vital issue for increasing social and economic resilience.

ACKNOWLEDGEMENT

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Common borders. Common solutions. http://www.ro-ua-md.net

Programme funded by the European Union

Romania-Ukraine-Republic of Moldova
CROSS BORDER COOPERATION

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GHEORGHE CONSTANTIN is the Romanian co-coordinator of the Priority Area 5 dealing with environmental risks. For the last 18 years, he has been the Director in charge of water resources management within the Ministry of Environment and then the Ministry of Water and Forests. In the last four years, he has been involved in the implementation of the EAST AVERT project.

Multilateral efforts towards basin wide flood control along the Tisza River: The Hungarian-Ukrainian joint Upper-Tisza flood development program

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Abstract
The floods of the past decades, that have been historical in several instances, and caused several dike breaches are a clear indication, that the Upper-Tisza flood protection system needs urgent development, both on the Hungarian and on the Ukrainian side. The root causes were reviewed in severala assessments and studies, and just about all of them indicate that the growing trend of flood levels will continue in the future, so we have to prepare to cope with them as soon as possible. We discuss the legal background of the Hungarian-Ukrainian joint Upper-Tisza flood development program, taking a brief look at the articles of the program and its specific content that helps with managing a transboundary catchment. The foundations of the current joint program were laid by a Government Regulation (11 November 1997) signed by both the Ukrainian and the Hungarian Government. Since then both parties have understood the importance of a joint expert task force, and have worked together for better flood protection in the region. The flood development program is constantly updated, and provides an excellent framework for the related parties to apply for flood protection funding for the region. We also introduce the Hungarian, the Ukrainian and the joint elements of the current flood development program, some of which are already under implementation; others are still in a preparatory phase. In general, we are trying to present a transboundary cooperation that is viable and beneficial for all concerned parties.

Keywords
Flood control, Tisza River, Hungary, Ukraine, transboundary cooperation.

INTRODUCTION

The flood-hydrologic and hydrometeorologic properties of the Upper-Tisza, as well as the statistics of the recent floods show an extremity (e.g.: frequency, intensity, retention time/reaction time, peak levels, etc.). These seem to confirm the findings of recent studies, which discuss in detail that in the near future we have to expect the formation of floods that are higher and different in their general flood-hydrologic properties as previously (*FETIVIZIG and VIZITERV Consult Kft. 2004*). Based on these – and several other considerations – the maintaining of reasonable risk level required that the decision makers in charge of flood protection rethink the development of the operative hydrological, flood forecasting and real-time flood risk calculations, and plan a new integrated flood information and resource optimized forecasting system. The system needs to have a renewed approach, has to be able to react to the current and future changes, is transboundary, and is of common interest and operation to affected parties (*ENPI CBC HUSK-ROUA/1001/221 project 2013*). This can be reached via a joint Upper-Tisza flood development program, where all parties are represented at an appropriate level, and the joint long term goals are clearly defined. The Upper-Tisza transboundary region (*Figure 1*) has had for a long time a good cooperation, which is beneficial for both parties, as it is an area that is prone to flood hazards. In the following I would like to briefly introduce the transboundary cooperation and its specific results (*Hungarian-Ukrainian joint Upper-Tisza flood development program 2013*).

Hydrography of the Upper Tisza Region

Originating from the eastern Carpathians the Tisza travels 200 kilometres through Ukraine, traveling across narrow valleys and reaching the Bereg-Szatmár plains by the Hungarian-Ukrainian border, there it is the natural border for a 50 km section of the Ukrainian and Romanian border. It steps into Hungary next to Tiszabecs and is the Hungarian-Ukrainian border on a 25 section, down until Tarpa. From Tarpa to Lónya the Tisza flows for 78 kilometres on Hungarian land, then it is again the natural border between Hungary and Ukraine, down until Győröcske. The next section of the Tisza is the Hungarian-Slovakian border, then the river flows through Hungary, down until the southern border, where it passes on to Serbia, where, after a 160 kilometre long section, it joins the Danube (*FETIVIZIG and VIZITERV Consult Kft. 2004*).

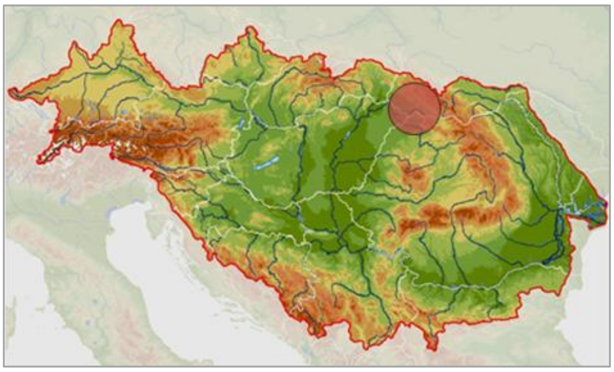

Figure 1. The affected area

THE BACKGROUND OF THE TRANSBOUNDARY COOPERATION

The legal basis of the current Hungarian-Ukrainian transboundary cooperation was laid between the government of the Republic of Hungary and the government of Ukraine, signed on 11. November 1997, through a Convention (117/1999. (VIII.6.) Government Regulation), which discusses transboundary water resource management. The Convention contains 17 articles and 2 annexes (*Hungarian-Ukrainian joint Upper-Tisza flood development program 2013*).

All articles of the Convention are directly or indirectly connected to the joint preparation for flood events, furthermore the water damage response, hydrometeorological, water management and water quality reports are organically linked to it as well (*Hungarian-Ukrainian joint Upper-Tisza flood development program 2013*).

The current Hungarian-Ukrainian transboundary Convention provides the necessary conditions to prevent a flood catastrophe, in a way that is not only valid for the closed proximity of the border sections, but for the whole catchment. With this the collaborating parties commit themselves that they will consult in advance with one-another regarding all water management interventions affecting the transboundary area or the catchment (*FETIVIZIG 2017*).

The spatial scope of the Convention also prevails in the hydrometeorological and water management regulations, which are directly linked to the transboundary water Convention, which also requires a flood forecasting system on the whole Ukrainian Upper-Tisza catchment supporting daily data and information exchange (*FETIVIZIG 2017*).

The transboundary Hungarian-Ukrainian Convent currently effective was the first transboundary Convent after the change of regime, which took into account international recommendations, as it refers to the UNECE document "Convention on the protection and use of transboundary watercourses and international lakes" accepted in Helsinki 16 Marci 1992, and the document "Convention on Cooperation for the Protection and Sustainable Use of the Danube River" signed in Sophia 29 June 1994 (*ENPI HUSKROUA/0901/044 project 2013*).

The Hungarian-Ukrainian joint Upper-Tisza flood development program raises the transboundary water cooperation to a higher professional level, by coordinating the future joint tasks needed to build up flood protection against the commonly defined and accepted design flood level. With this the cooperating parties can optimize the development costs and both parties will have the same level of flood protection.

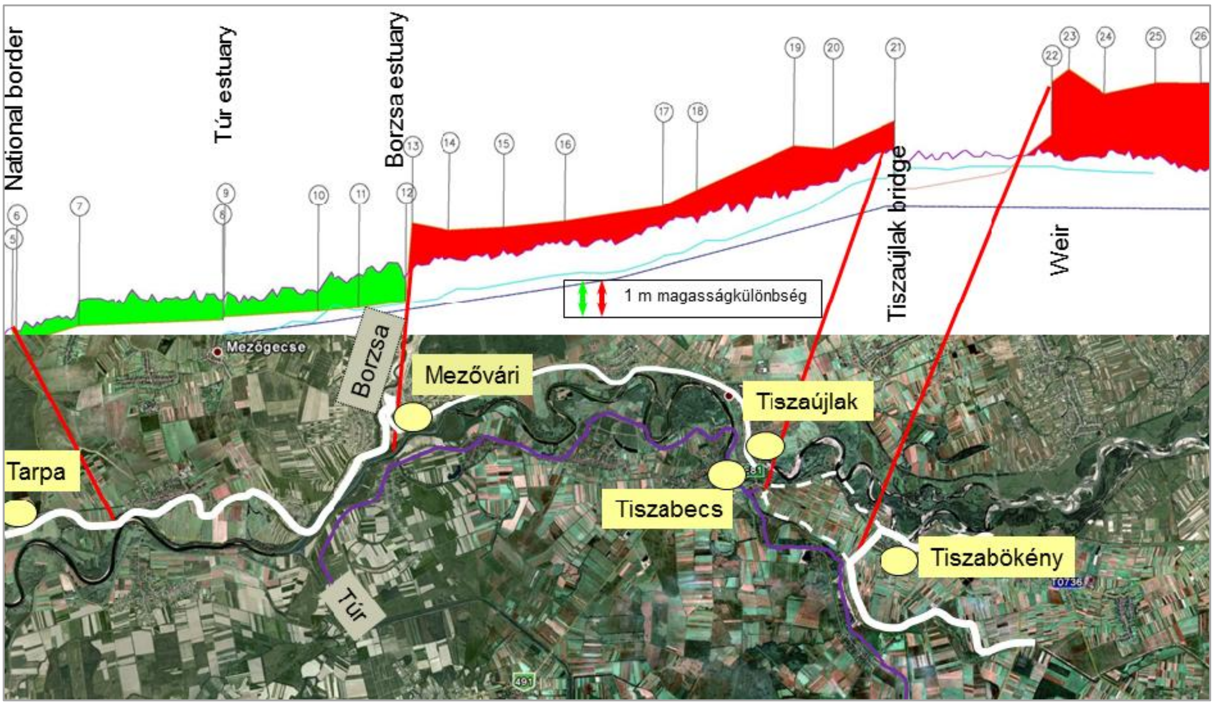

Figure 2. The equivalent resistance locations of the flood levee. Because of the joint flood protection systems, only a joint development can be efficient

In the past decade, for the development of the foundations of the system, national development plans have been prepared and launched. In Hungary the "*Development of the Upper-Tisza region flood protection system*" and the "*Further development of the Vásárhelyi plan*", while in Ukraine the "*Complex flood protection program of the Carpathian catchment of the Tisza River 2006-2015*" (*Figure 2*).

THE SPECIFIC PROJECT ELEMENTS OF THE JOINT UPPER-TISZA FLOOD DEVELOPMENT PROGRAM

The primary location affected by the transboundary cooperation, the joint flood development plan and the ENPI project is the North-Eastern part of the Upper-Tisza, where 4 countries share the river catchment: Hungary, Ukraine, Slovakia and Romania. The immediate area affected by the project covers roughly 4000 km^2. This is the area where harmonization is needed in the flood development plans, as well as coherent intervention measures. For sufficient and successful flood protection, a constant cooperation and collaboration between the 4 effected countries is inevitable and necessary.

Taking a brief look at the hydrological regime of the river we can see that the water level alteration on the Upper-Tisza region can be 10-12 meters, the long term average flow of the river is 217 m^3/s at Tiszabecs and 400 m^3/s at Záhony, while the flood peak discharge can be above 4000 m^3/s and the end of summer discharge can be under 50 m^3/s, so we can see that the flood discharge is more than 80 times that of the low water discharge (*FETIVIZIG and VIZITERV Consult Kft. 2004*). Trend analysis also shows that the peak water levels in the past

100 years have greatly increased along the transboundary river section:

- 0.35 cm/year in Tivadar
- 0.73 cm/year in Vásárosnamény
- 0.43 cm/year in Záhony.

The data series of the peak stages shows 9 different interval periods, where the average period length is 11.2 years. This average period length matches the 11.2 year period of sunspot activity (*FETIVIZIG and VIZITERV Consult Kft. 2004*).

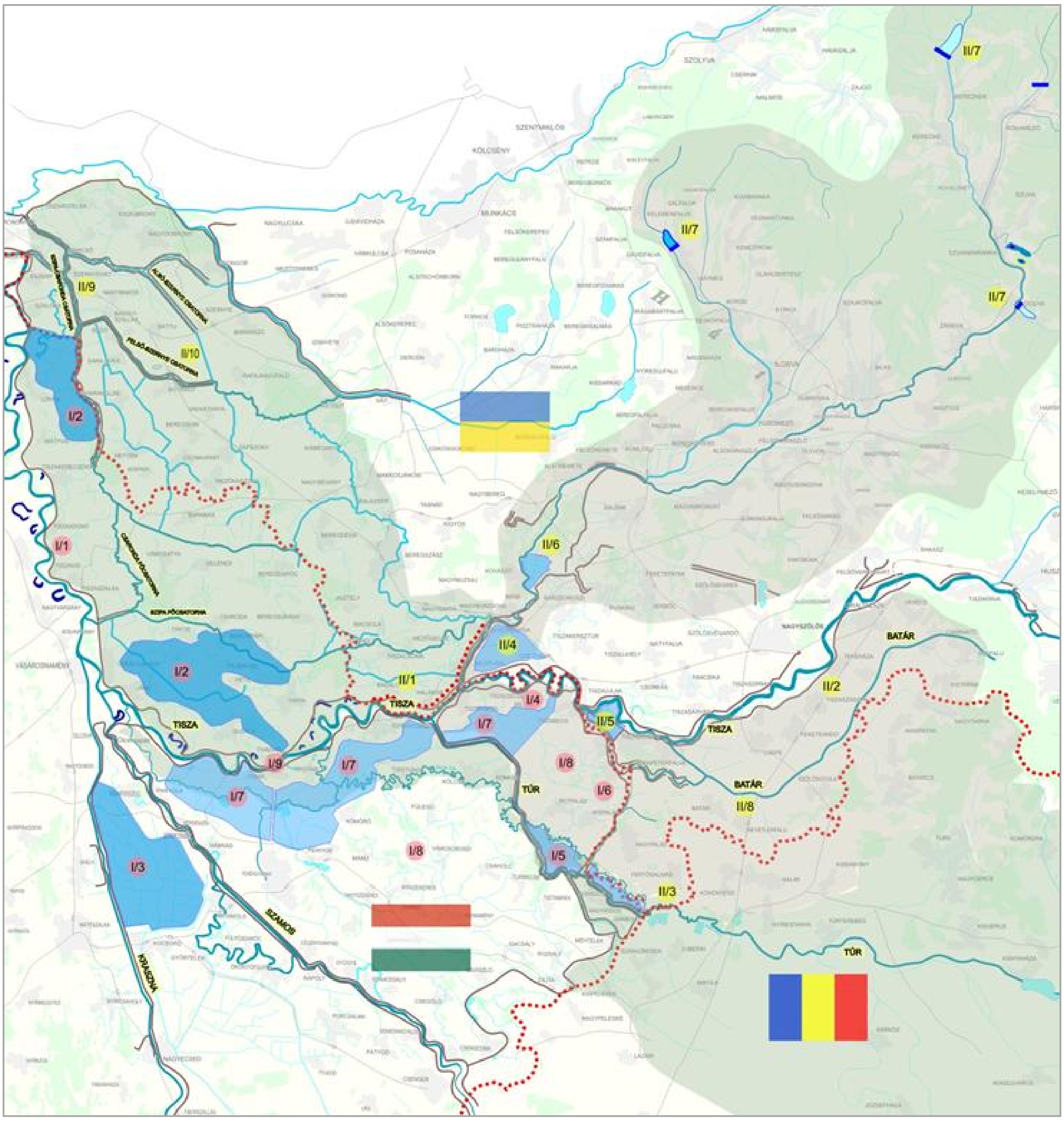

Figure 3. Areas affected by the cooperation in the Upper-Tisza region

Accumulation time in the region is extremely short; it is hardly more than a day. This is the time that is available for the flood protection teams to prepare for the unexpected and reach the areas in danger. This requires a new type of cooperation, where the experts of the different countries have to work together as one, each of the existing working groups have to have experts from each efected country. This also means that the flood defence plans and scenarios have to be more focused on the catchments, rather than on the countries. Several fully developed flood defence plans have to be elaborated, as the available time before the flood peaks is not enough to prepare full plans, they can only be adapted, based on the forecasted peak. The following diagram shows a schematic view of a fast rising flood event.

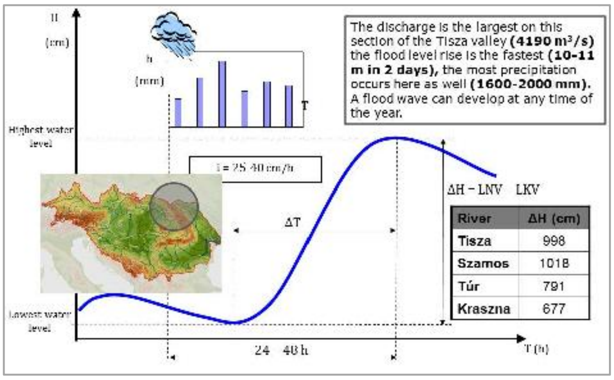

Figure 5. Illustration of the short accumulation time on the Upper-Tisza section

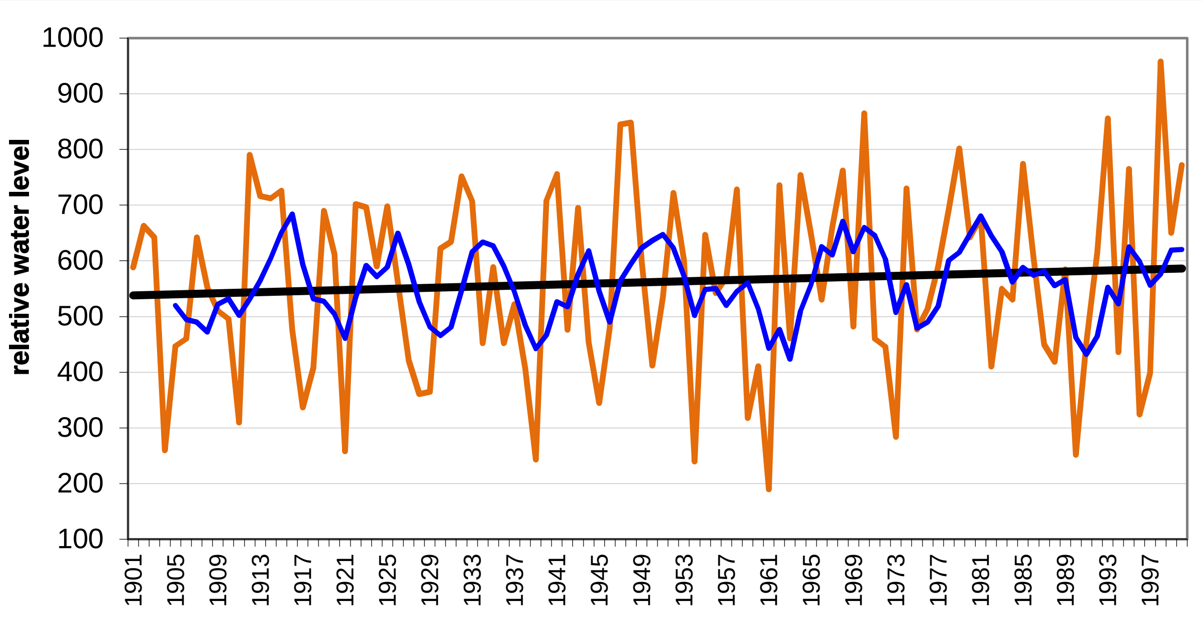

Figure 4. Long term data series of peak stages on the Upper-Tisza

A strong cooperation is needed, because in the past 10-15 years we have seen a number of floods that exceeded anything that previously occurred, anything that was previously recorded. These facts put such a burden on the flood protection system that it could not meet the requirements and it failed. This means that the flood damage, both in Hungary and in Ukraine were severe, raising the attention to an undeniable problem. Our project tried to assess a number of these problems, and come up with viable solutions (*Hungarian-Ukrainian joint Upper-Tisza flood development program 2013*).

Basic principles and concepts of the joint Hungarian-Ukrainian flood protection developments

- To be in line with the EU Flood Directive (based on trans-boundary hazard mapping)
- To be fitted to the Hungarian and Ukrainian national flood development strategies and programs
- To follow a complex approach (using structural, non-structural methods)
- To integrate into regional development ideas
- To take advantages of current state of the art methods
- To support reasonable usage of water, to satisfy the needs of all water users
- To prevent the pollution of water resources
- To develop the quality and quantity monitoring and the data exchange network
- To develop flood and inland water control
- To develop the warning telecommunication system, which helps with forecasting extraordinary situations and overcoming the adverse effects of them
- To elaborate the quality regulations and technical criteria for transboundary water bodies

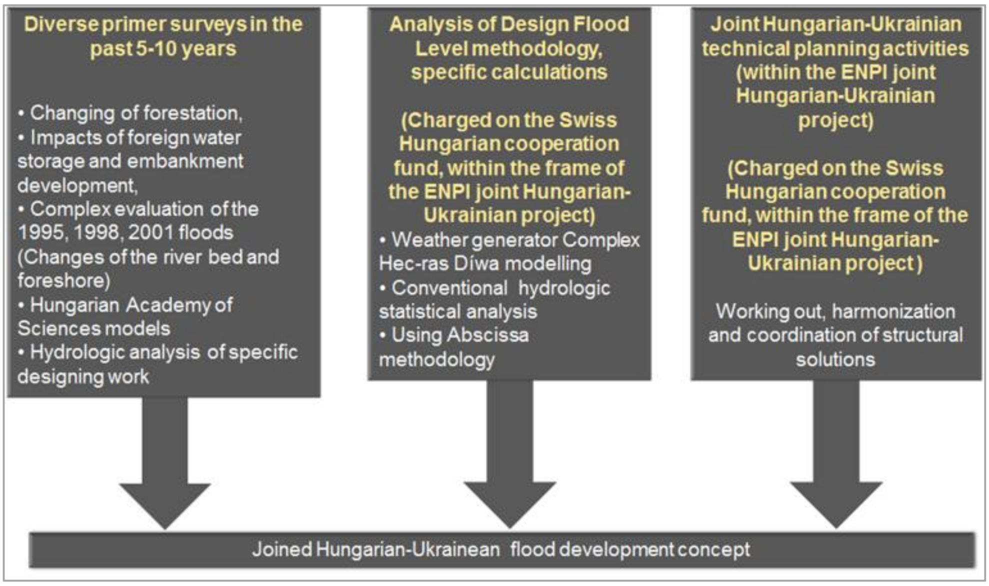

Figure 6. Basic concept of the Joint Hungarian-Ukrainian flood development concept

Taking into account the EU Flood directive guidelines in this case meant the preparation of a common hazard mapping (*SH/2/1 2015*) that was implemented for the transboundary catchments, which show the need for the harmonization of the developments. Joint definition of the design flood level was successfully implemented after several years of cooperation. The cooperation also included the preparation of the combined DTM, harmonizing cross sections, considering future hydrological events a common definition of hydrologic-hydraulic scenarios

Five examined shared sub catchments of the region

- Ukrainian side of Batár
- Tisza-Túrköz
- Borzsa - Tisza left dike
- Joint Bereg
- Tisza-Szamosköz (*Figure 7*)

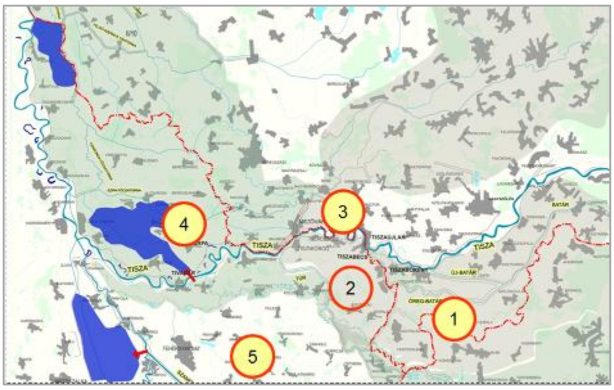

Figure 7. Five shared sub catchments, which have specific projects

THE UKRAINIAN ELEMENTS OF THE PROJECT ELEMENTS OF THE DEVELOPMENT PLAN

Foundations for the updating of the Ukrainian flood development were also prepared as a joint task, ENPI being the provider of the necessary funds. This was led by the Ukrainian partner Ukrvod project (*ENPI CBC HUSKROUA/1001/221 project 2013, ENPI HUSKROUA/0901/044 project 2013, Hungarian-Ukrainian joint Upper-Tisza flood development program 2013*).

Dike developments

The program was prepared on the Hungarian side and on the Ukrainian side using a similar approach, suggesting a complex approach to increase the flood security. This means strengthening embankments, using mountain and lowland reservoirs and using non-structural methods. The dike developments on the Ukrainian side are along the border (*Figure 8*).

Mountain reservoirs

Another result of the harmonization of the flood protection development plans is the optimization of the mountain reservoirs (*Figure 9*). Previously there were 64 mountain reservoirs in the plan, this was optimized and rethought during the recent developments, as a result of which 39 reservoirs remain.

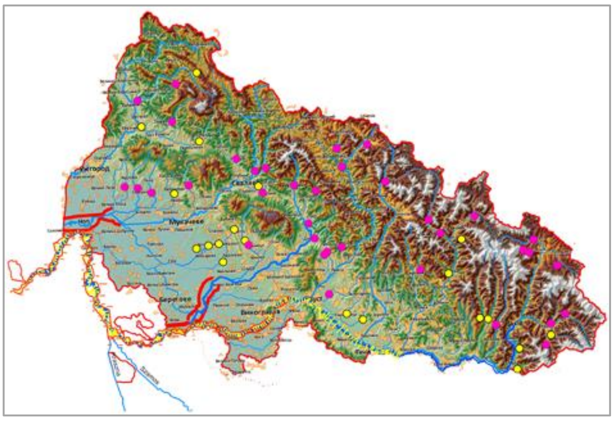

Figure 8. Dike developments on the Ukrainean side of the joint section marked by the red lines

These primarily serve to provide protection against local flash floods on streams and river tributaries. The hydrological parameters for each planned reservoir location are discussed in detail in the plans.

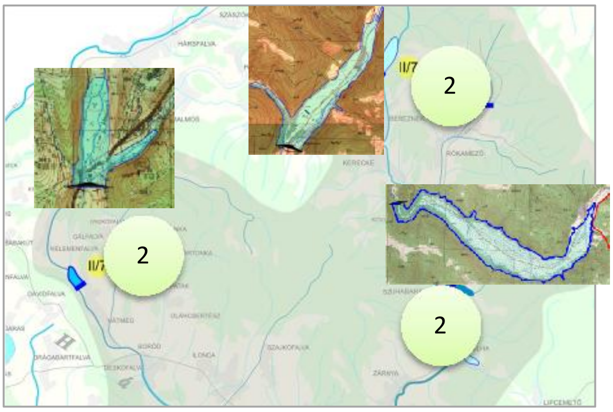

Figure 9. An example of the analysed mountain reservoirs on the Ukrainian side of the joint section

Lowland reservoirs

In previous plans 24 possible lowland reservoirs were selected. With new surveys and methods this was optimized, and as a result of which 6 reservoirs were highlighted. Out of these 6 reservoirs, 4 are on the joint area, have a positive effect for both countries, and are a part of the joint program (*Figure 10*). These 4 have a capacity of roughly 130 million m^3.

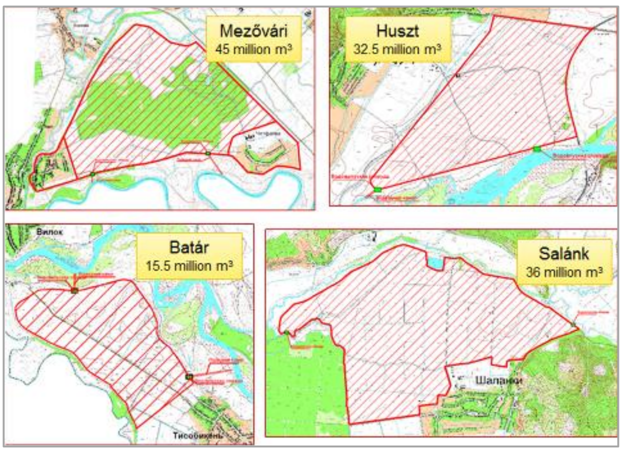

Figure 10. The 4 Ukrainian reservoirs on the joint section

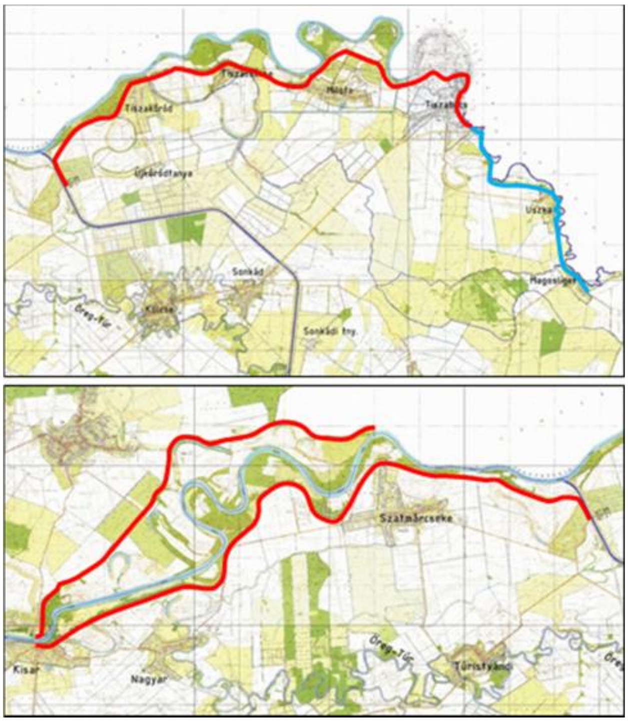

Figure 11. Dike developments on the Hungarian side of the joint section

THE HUNGARIAN ELEMENTS OF THE PROJECT ARE THE FOLLOWING

Dike developments

The development of the existing embankments meant that the heights of the dikes along the border were increased, in locations shown on the maps. These were done on border sections, where this development can have an effect in both countries (*Figure 11*). It is crucial for uniform flood protection in the region, which the development plans are done along the same directives, otherwise flood risk and hazard can vary along the non-uniform section (*ENPI CBC HUSK-ROUA/1001/221 project 2013, ENPI HUSK-ROUA/0901/044 project 2013, Hungarian-Ukrainian joint Upper-Tisza flood development program 2013*).

Flood retention reservoirs

The second Hungarian project element is the examination of further opportunities for flood retention, other than the already existing reservoirs, or the ones being currently constructed (*Figure 12*). This would roughly mean 150-180 million m^3 capacity (*ENPI CBC HUSKROUA/1001/221 project 2013*). Such a capacity would help increase the general flood security in the region, helping to decrease the flood hazards along the Upper-Tisza.

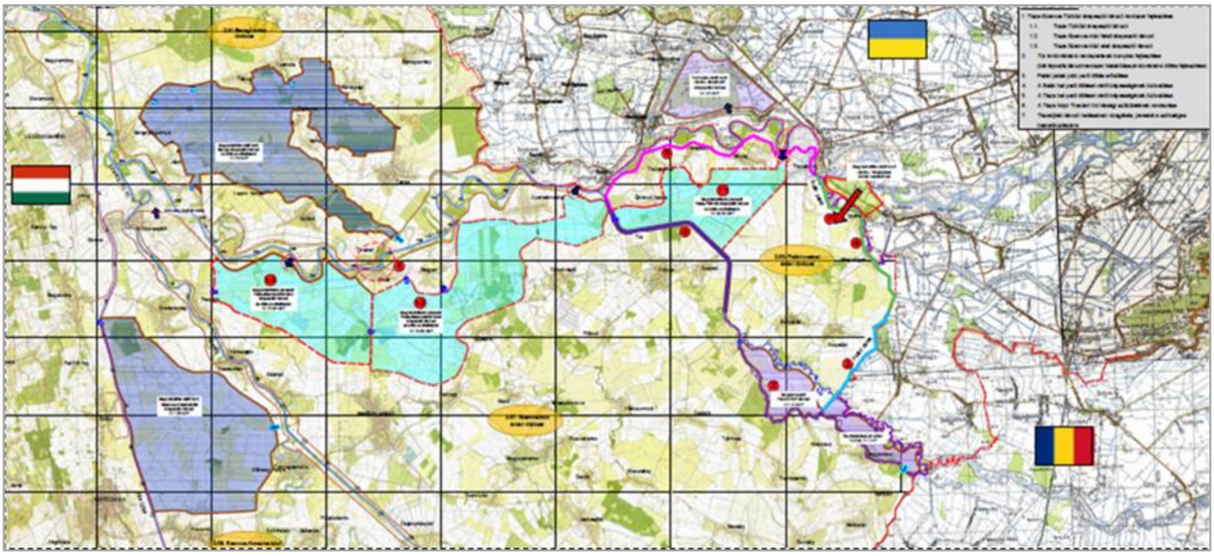

Figure 12. Reviewed flood retention reservoirs on the Hungarian side of the joint section

THE JOINT ELEMENTS OF THE PROJECT

They are probably the most important aspects of the flood development plans, as they contain several non-structural elements, which are crucial for a live transboundary co-operation:

- impact assessment
- impacts of structural developments
- development of the joint monitoring system.

Impact assessment

To be able to correctly assess the impact on the whole area, we had to build a complex database, containing both the Hungarian and the Ukrainian elements of the system. This required vast amounts of data harmonization, acquiring new data for previously blank areas, as well as discussions and negotiations with expert from both sides. The result was a new river model, covering the whole design area. This was necessary for the elaboration of the new design flood level, and for the complex analysis of the flood retention reservoirs.

Flood retention reservoirs

Preliminary risk assessments showed that with the development of the flood retention reservoirs and the construction of the dikes, the flood protection can be significantly improved of the section of the border that is of common interest. The joint effect of the actions sum up to about 1-1.5 m flood peak reduction in the Upper-Tisza region (*Hungarian-Ukrainian joint Upper-Tisza flood development program 2013*). The positive impacts of the developments extend over the border of Hungary and Ukraine, as they can be felt in Slovakia and Romania as well (*Figure 13*).

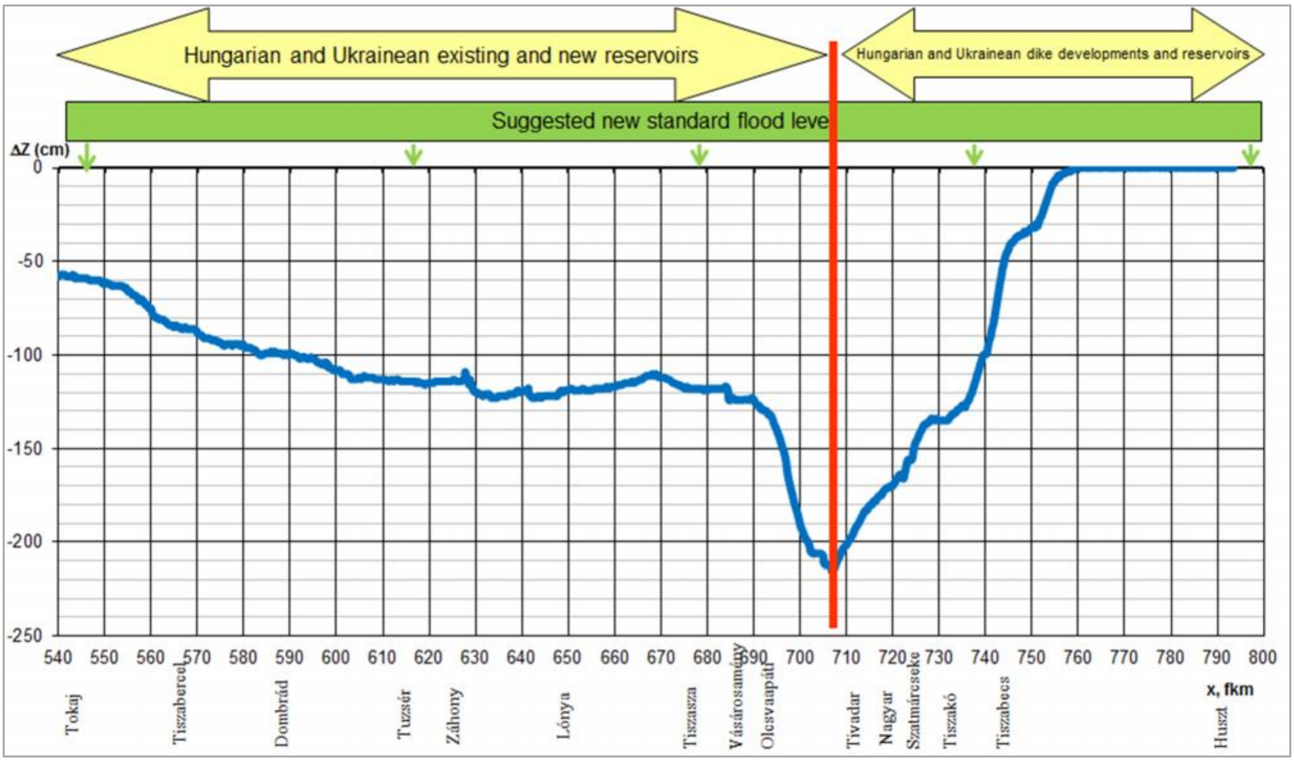

Figure 13. Effect of flood retention reservoirs on the Hungarian and the Ukrainian side

Monitoring system

The Upper-Tisza region is the mountainous area of the Tisza, where a flood can form in 2-3 days (*Hungarian-Ukrainian joint Upper-Tisza flood development program 2013*), this is why the monitoring development elements of the project are of particular importance, which means the further development and expansion of the already well-functioning system. The planned active elements of the system – *the reservoirs* – can only be effective if they are correctly operated, for which we need a good monitoring and early warning system. Currently there are 122 Hungarian and 50 Ukrainian stations (*FETIVIZIG 2017*). These are connected via a microwave based data transfer system and function under identical operation rules.

There are plans for the systems further development with Ukrainian mountain stations, which will increase the lead time in case of a flood, and provide essential data for runoff models. The data transfer system will also undergo improvement, in line with available new technologies.

IN CONTEXT OF THE DANUBE STRATEGY

The Danube Strategy in full requires a transboundary approach. Our project is a good and working example of a collaboration of the experts and the knowledgebase of two countries, as well as elaboration of a complex network that truly takes into account the needs of both countries.

Our opinion is that the Danube Strategy is a good opportunity to be able to access and coordinate funding, as well as to provide a much needed framework for possibly extending the project to other regions or maybe even other countries, for example Slovakia and Romania.

As we have experienced, multilateral forms of cooperation and a uniform professional framework are very important to be able to achieve results on a larger scale. The professional content of the project was accepted by the Danube Strategy Steering Committee in May 2013, which was a great step forward in trying to provide the financial frame for the project. The joint program was approved by the plenipotentiaries in June 2012, and since then, certain elements of *the Hungarian-Ukrainian Joint Upper-Tisza Flood Development Program* have been implemented, and several others are in the preparatory phase. As it is visible, the transboundary cooperation along the Hungarian-Ukrainian section of the Upper-Tisza has been strong for quite some time, as both parties understand the need to properly maintain and manage the shared catchment. Several projects can only be implemented correctly, if the effected parties take part at their full potential. We hope that the joint flood protection in the region does not only have a past, but also a future.

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Extremities in winter season – outlook for mitigation measures

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Abstract
The increased frequency of the appearance of icy conditions is a potential consequence of the climate extremities that have been experienced recently. There are many possible field measures to avoid the adverse effects of the ice transport or conglomeration. One of those is the fluvial ice-breaking with ice-breaking ships where appropriate conditions are present – like in the Danube River. Despite the locally favourable impacts the effective mitigation measures are based on mutually accepted basin-wide masterplans and cooperation of the interdepended countries in the catchment. "Several initiatives are known currently and EU SDR PA5 is willing to support the activities to receive funding.

Keywords
Icy flood hazard, ice phenomena, ice breaker, ice forecast, mitigation measures, Danube basin, water scarcity, mitigation measures

INTRODUCTION

The following article will discuss the potential flood protection measures related to the winter season and draws up the basin-wide development opportunities for mitigation measures related to frozen conditions. Special attention is necessary on catchment level to maintain the awareness and preparedness against the hazards and risks of ice conveyance on rivers.

DESCRIPTION OF THE CONCERNED ISSUES

Ice is a special type of water scarcity and the due effects are less predictable. The climate change/alteration scenario analyses point out generally that the hydrologic extremities will be more frequent in future. In publicities commonly the global warming related floods and drought events are highlighted as potential scenarios. Although the other end of the temperature scale could result in comparable devastating consequences – in among much worse circumstances to fight against them. The „lower end" is the freezing zone and icy condition, where permanent ice cover, ice jams and ice floods can appear on the rivers, endangering the hazard areas with inundation and erosion by the overwhelming force of mass movement.

Picture 1. Frozen dam, Rába River, Nick, Hungary in 2012 (Photo: © ÉDUVIZIG)

The ice transport and permanent ice cover on rivers itself blocks navigation, harms water regulation structures and occupies their operation. In certain cases the whole structure could be covered with ice like it happened just 5 years ago at the Nick dam on the Rába River (*Picture 1*). The natural dilatation of the ice cover and especially the impulse of the floating ice plates can remarkably effects the manmade structures and the natural habitats in the riverbed, along the banks and extensively in the floodplain. Under permanent low temperature the ice plates are growing constantly and freezing to each other. The driftwood and floating debris accelerate the cumulating process. If the ice conveyance is obstructed, ice jams can occur e.g. at shallow sections, bridges or low radius bends which can lead to elevated flood water levels peaking way above the normal conditions. Even if the discharge is low, the backwater effect of the ice barrier appears quite suddenly and immediate actions are needed to avoid inundation and/or structural failures. The worst case scenario seems to be having an encumbered section and an approaching flood wave from upstream.

The increased and continuous monitoring of the conditions is very important but difficult. Airborne survey or satellite images provide the best perspectives but they cannot replace the manmade visual observations. Moreover the icy conditions could hinder the water level remote sensing and that need to be provided as well. In 2012 in the Upper-Danube floodplain the field investigation was the most adequate data collection activity (*Picture 2*).

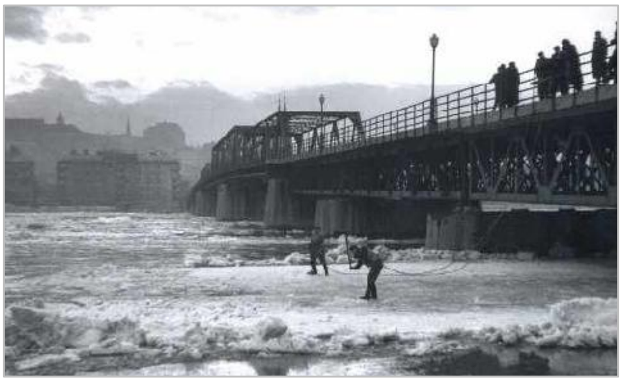
Picture 2. Ice monitoring at Dunakiliti, Hungary in 2012 (Photo: © ÉDUVIZIG)

The hard winter conditions are not easy to handle due to the freezing circumstances and low temperature, so special equipment is needed. Also human resources are limited to be utilized and the performance capacity is far less than in the summer. Because of the modest focus on the topic, the knowledge about handling such ice cases is disappearing even on professional level. May the skills are reserved somewhere, the number and availability of the experienced crew is disappearing, causing loss of the personal impressions that could be utilized in a havaria situation.

An effective - but in the same time the least natural - way of avoiding such problems of ice is to artificially correct the centreline of the river and the floodplain. It means to excavate and rebuild the banks or deploy hard coverage (bank protection), clean and reshape the riverbed. Due to the nowadays horizontal engineering perspective which considers the Water Framework Directive and other eco-friendly regulations, the utilization of such measures are applied only if any alternative possibilities have no effect and the activity is a must. Anyhow, properly considering the ice hazard is a very important aspect at the design phase of any water management structure.

In order to maintain the flood protection level some of the possible measures to avoid ice jam on rivers are listed below:

- Thermal shield: Utilized on structures to temper moveable parts like a sluice gate. The protected component has internal heating assemblies which keeps its' temperature above the freezing point. It has only local effect and the aim is to secure the function/operability of the structure. The electric consumption and the cost of the solution is matter of the size of the structure. In special cases the warming could be carried out by manpower as well.
- Oscillation of the water level: In case of having a water level influencing structure in the problematic area, it is possible to constantly lift-and-drop the water level in order to avoid the forming of the full surface ice coverage or shredding the plates. This solution eases the upstream conditions as far as the backwater effect still plays a role but the impact is limited and not controlled. The intensified ice plate conveyance could endanger the structure operation and the stability as well.
- Intervention from the banks with machinery: Only on smaller streams from banks, bridge pavements or solid structures it is possible to execute measures with excavators or long cranes. As the ice core develops the effectiveness of such activities decreases. It is quite dangerous in general and the river banks usually hard to be reached, particularly those sections which are subject of protection measures.
- Blasting with explosives: Formerly it was an applied routine to use explosives in order to fragment the large ice plates. The location of the detonation determines the effect of the method so the placement of the explosive shall be carried out by divers or by (precise) throwing, dropping. It is very dangerous not just because of the shrapnels thrown out by an explosion but also the handling of the explosive materials. Special permissions and qualifications have to be obtained. An extraordinary placement activity is demonstrated on *Picture 3*.The utilization has to take in account the seismic effect and the potential demolish of the riverbed or structures around. Despite the complicated circumstances are, it is a feasible solution at certain segments.
- Gunfire, bombardment: Special treatment of river sections where there is no other tools could be utilized. Needs military intervention.
- Ice breaker ships: On larger rivers one of the most important tasks is to keep on the conveyance of the ice plates and in the same time provide a sufficient route for navigation. Both of these goals could be served with special icebreaker ships with reinforced hulls and other appropriate equipment. There are different types of boats and technics to slice the ice plates or the massive surface ice cover. The effectiveness of the measure based on the thickness and the location of the boats, so pre-arrangements are necessary. From downstream to upstream the boats can operate the best. The fleet need to be maintained to avoid turning obsolete nevertheless the usage is quite random in time depending on the weather conditions.



Picture 3. Placing explosives at former Kossuth Bridge, Budapest, 1956 (Source: Kor-képek 1956 - MTI 2006)

INTERNATIONAL ASPECTS OF ICE MANAGEMENT

The international aspects of the ice phenomenon are similar to other water related hazards and the effects could go beyond national borders. The observation is a key issue to frequently exchange base data for forecasting. The backwater effect influences the water levels in the upstream country and an intensive ice flow could create devastating situation in a downstream country. The development of the ice-formations is key information and the ice input from the tributaries could play important role for adequate preparatory actions. Preforming an action in the national territory might be less effective than an internationally coordinated operation.

In general we can say that Hungary does have an ice protection regulation with all the neighbouring countries regarding the major border intersecting water courses. The ice protection regulations are always based on the intergovernmental bilateral water management cooperation agreements, the cross border treaties. These regulations in most cases have – as part of the water damage protection regulation – different level of details and different technical content adjusted to the local conditions concerning the management of the ice situations and the necessary measures. The jointly established ice protection regulations always incorporate section description, detailed site plans, longitudinal profile and cross section, hydrological specification, previous experiences and data of hazardous sections, organizations, intervention protocol etc. For river sections with high importance, more detailed ice protection plans were made over the general regulation (e.g. Dunakiliti SK-HU, Dunaföldvár-Vukovár HU-HR-SRB). The joint ice protection plans contain the adequately detailed elements described above and over the general regulation also include the intervention plans, the detailed description of the joint measures.

The ice protection tasks done by icebreakers is a special case as Hungary – compared to the neighbouring countries – has a significant icebreaker fleet of 19 ships. The operation of this fleet beyond the borders is necessary also for the protection of Hungarian territories. Separate regulation administers the ice breaking tasks regarding for instance the Serbian and Croatian relations. These regulations determine the ice protection levels: I. degree – icebreakers in standby at their harbour location, II. degree – deployment of the icebreakers at their assigned position ready to depart, III. degree – execution of icebreaking tasks, extraordinary alert. The regulations also administer the bearing of the costs and the extent of the area of icebreaker operation.

CHARACTERISTICS OF THE ICEBREAKER SHIPS

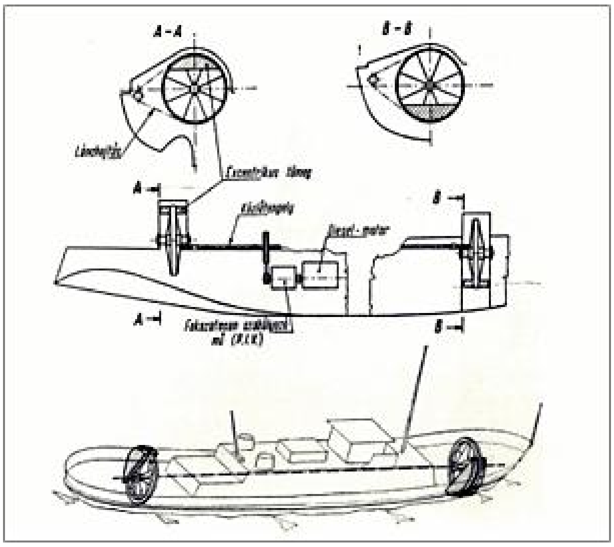
This chapter is based on the presentation of Mr. Pál Kötél, navigation expert of the North-Transdanubian Water Directorate (ÉDUVIZIG, owner of „Széchenyi"), which was performed during the XXXV. Annual Conference of the Hungarian Hydrological Society in July, 2017.

The icebreaker ships are vessels with special features for effective manipulation of ice. There are many varieties based the body size, the water displacement (weight), equipment and development generation. The crew has to meet strict criteria and the working on these ships is legally considered as extremely dangerous in Hungary. The vessels can only operate in grouped formation at least of 2 units for security reasons.

The tasks of these vessels are usually to delay the setting of ice cover and reduce the possibility of the stopped, congested ice become an ice wall. If it has happened they are breaking up the congested ice and creating or maintaining a corridor through the fully-iced river surface in order facilitate ice and water flowing, additionally provide space for transport.

Specialties of the vessels – not all of them possess with the listed elements bellow or the features are diverse:

- Scrolling equipment: puts the boat in a tug-twisting motion so it can break ice not only by its weight but by its movement energy also. The schematic upbuild is shown in *Picture 4*.
- Reinforced bow formation: 20 mm thick high-strength steel sheet covering (6 mm on normal vessels)
- Special hull reinforcement system at the bow with so-called ice-frames
- Spoon-based bow formation for better discharge of broken ice
- Special stern design: effective ice breaking in reverse movement
- Propellers are made from steel for smashing ice (*Kötél 2017*).



Picture 4. Conceptual illustration of the scrolling equipment (Source: Magyar Hajózásért Egyesület, http://www.hajoregiszter.hu/

Unfortunately due to the shape and the build-up of the ships they are dedicated to their function and less deployable for any other purpose. That is the reason these ships are standing by at their harbour most of their lifetime. A noble drive through in front of the Hungarian Parliament was captured on *Picture 5*.

Picture 5. The "Széchenyi" Hungarian icebreaker fleet flagship in front of the Hungarian Parliament in 2017 (Photo: © OVF)

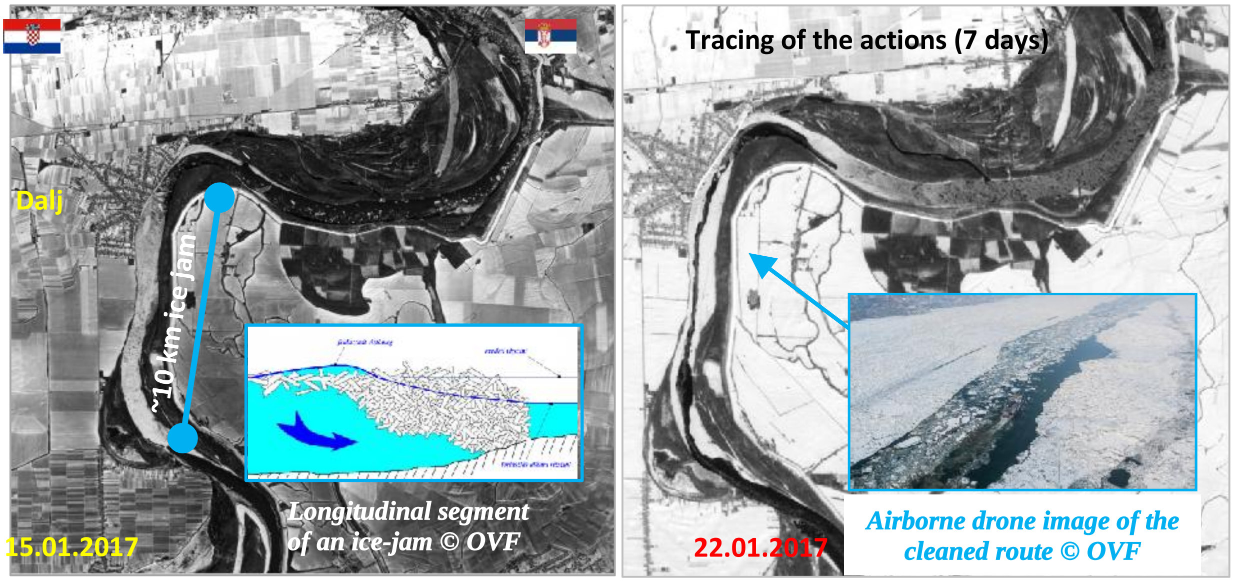
EXAMPLE OF AN INTERNATIONAL COOPERATION IN WINTER, 2017 (HUNGARY-CROATIA-SERBIA)

Due to the meteorological circumstances January/2017 was the 10th coldest January since 1901 and the coldest since 1985. The minimum temperatures were below the freezing point all month long and were dropped below -20 – -23°C on the coldest mornings over snow covered territories. Water temperatures decreased very quickly due to typically low water levels across all rivers and the ice development was constant. It escalated to a 170 km continuous ice formation on the Danube River where the thickness reached four meters in some areas. Based on the trilateral treaty, Croatia and Serbia initialized the ice-breaking activities. The local authorities provided the contact and supply *(Láng 2017).*

The operations took place on two locations for 17 days:

- „Icebreaker XI." and "Icebreaker VI." ship couple were deployed to the section Dunaföldvár-Vukovár. The most important task was to create a route through the ~10 km ice cover near Dalj (1348-1358 rkm).
- „Széchenyi" flagship and the "Icebreaker VII." ship couple was ordered the section Vukovar-Belgrade to minimize the damages in ports, marines, bridges etc. The main goal was opening of 80-100 m width channel on the jammed ice and keeping clean the opened channel.

Icebreaker XI. and Széchenyi are stronger ships and they were the ones to go forward. Icebreaker VI. and VII. provided backup. The leading ship broke into the ice barricade twice, some 40 meters apart. Between the two entering the ship's waves broke the congested ice into pieces. The pieces were shredded further into smaller ones by the secondary unit, ensuring that the ice do not close the opened channel. The direction of the opened channel was chosen to follow the alignment of the fairway. In order to speed up our progress they tried to make the channel more narrow, but in that case the broken ice could not be able to flow away, closed it and they had to clean it repeatedly. The cleaned lane is visual from the stratosphere as it is shown on *Picture 6.*



Picture 6. Satellite images of the Danube band at Dalj, 1358-1348 rkm (Source: U.S.G.S., Landsat, 2017)

The operation was successful and the problematic sections could have been broken through. However the work was exceptional because both ships had to cut themselves through the icefield from upstream. Cutting from upstream of the congested ice involves considerable risks as the ice has no place to clean behind the ship. It can slips back to the ship's aft and closes her (as it happened with Jégtörő VI and VII as well). For successful crossing, it is necessary for the ships to keep moving in the ice and this requires „scrolling" ships. Without scrolling equipment it is impossible to cut through an ice-wall from upstream. It also became apparent that without the high-performance two-engine vessels the crossing would not have been possible.

The ice breaking activity was necessary in order to stop the upraising of the water level due to the ice blockade. The elevated water levels could cause inundation or endanger assets in Croatia, Serbia and Hungary as well. The conditions were suitable to operate with the ships and available time frame was also enough, because no serious flooding appeared from upstream. The cooperation among the countries is a great example of efficient resource sharing for mutually understood purposes and jointly defined criteria based on legally binding agreements.

BASIN WIDE PERSPECTIVES OF MITIGATION MEASURES

The ice management in the Danube Basin is an important issue, but not all the countries have to face with equally severe consequences of the ice transport. The solidarity principle applies in the catchment as it is stated in the International Commission for the Protection of the Danube River (ICPDR) 1st Flood Risk Management Plan of the Danube Basin District (DFRMP) which was endorsed in 2016 by the Danube Ministers. The Annex-2 of the document is listing agreed project proposals. Among them there is one called DANICE - DANube river basin ICE conveyance investigation and icy flood management. The initiative aims to create Danube Basin Ice Management Plan and long-term ice-management initiative of the Danube Basin. It would reveal the actual ice situation of the basin and the probable effects of the ice conveyance. The project shall deliver national and basin-wide operative resource management plan for icy flood or other certain situations together with mitigation measures. Harmonization of ice management planning methods and recommendations for common standards are part of the proposal, too. The project has not been applied for any funding but there are many countries supporting the idea and willing to contribute actively to the project development and execution. ICPDR Flood Protection Expert Group (FP-EG) and EU SDR PA5 jointly looking for the proper funding program.

The formerly mentioned activity could be sub served by project DAREFFORT - Danube River Basin Enhanced Flood Forecasting Cooperation. The project was submitted by the support of EU SDR PA5 to the Danube Transnational Programme 2nd call in June, 2017 with Hungarian Lead Partner. The evaluation closes only in spring, 2018. It would deliver an outstanding overview about the present status of the national forecasting capabilities where from the partners and the stakeholders could derive the common goals in order to develop the existing system in a comprehensive way. The mutual understandings will be recorded in a common vision of the partners. The partners jointly work out the policy recommendations to be submitted to ICPDR in the interest of the establishment of the Danube Hydrological Information System (DanubeHIS) which is a fundamental step towards flexible and sustainable data exchange. The main focus is to enhance the access to the recorded hydrologic and ice data and to provide harmonized distribution for all the countries in the Danube. The project would deliver an e-learning material as well which includes the ice management knowledge.

EU SDR PA5 in the 2017-2019 timeframe will contribute with expertise to the ICPDR Climate Change Adaptation Strategy 2018 Update where the ice –related chapters shall be enhanced with the gained experiences Also a pilot study on coordination of operative flood management and civil protection plans (OFMP) in the Danube Basin will be carried out and the ice mitigation measures should be included.

SUMMARY

Efficient management of ice transport requires overarching approach from the countries in Danube River Basin. The platform for the discussions is provided by ICPDR FP-EG and EU SDR PA5 SG meetings. Both organizations working closely to reach this step forward and numerous project ideas and activities are ready to support the regional cooperation and joint planning. The subject is not kept on ice and the earlier the funding will be provided the sooner the risk management will develop.

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Flood hazard modelling of the River Mura based on the silting up processes of the inundation area

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Abstract
In my dissertation, the flooding and silting up processes of the inundation area of downstream sections of the meandering river were studied. The travel zones in the flood-plain forming during the travel time of the flood wave were determined by using 2D hydraulic modelling. The flooded status of the inundation area was compared during the flood peak and the falling limb of the flood wave in order to get information about the changes in the river bed and the silting up of the inundation area. The results of different research methods were compared (hydraulic modelling, geomorphological methods, sedimentological analyses, dating of the layers in the sediment sample) in order to evaluate the possible effect of the changes of discharge on the flood hazard due to climate change. The geomorphological characteristics of the meandering outfall river sections were studied. Morphometric inundation area parameters and the trend of long-term development of the meanders and the river were evaluated.

Key words
Hydraulic modelling, MIKE 21, flood hazard, silting up of the inundation area, geomorphology, morphometric analyses, development of meanders, dating of the sediment sample core, river Mura.

INTRODUCTION

In my dissertation, the flood hazard modelling was studied on the outfall stretches of the rivers (*Figure 1*), based on the silting up process of the inundation areas. The process of flooding and the conveyance of the inundation area were analysed and we tried to learn if the silting up data could be used for calibration and validation for hydraulic modelling. Comparisons were made between the flooding of the inundation area at different times, such as the rising and falling limbs of the flood wave. The propagation of flooding was analysed. In the research, various methods were used and the results were compared with the aim to evaluate the effect of flood events caused by climate change on flood hazard.

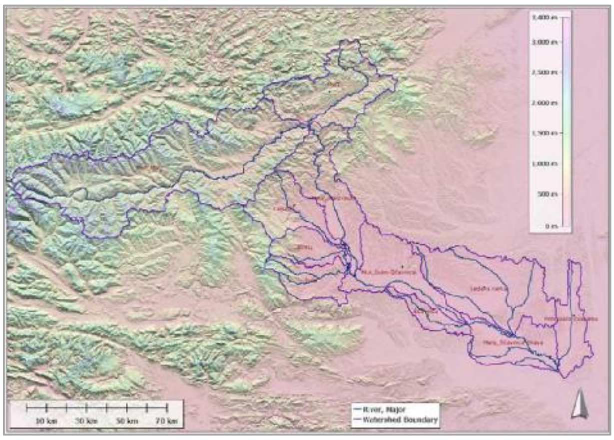


Figure 1. The catchment area of the River Mura
(adapted from: Hydrological Study of the River Mura, 2012)

The Mura originates in the mountains of Styria, 1,898 m above sea level. The total length of the river is 465 km, of which 295 km is in Austria, 35 km on the border between Slovenia and Austria, 98 km in Slovenia, and 30 km on the border between Croatia and Hungary. The total area of the river basin is 14 241 km^2, of which about 10 200 km^2 belongs to Austria, 1 400 km^2 to Slovenia, 590 km^2 to Croatia and 2 040 km^2 to Hungary.

Water regulation work was first started in the 18th century on the upper section of Mura (Hochenburg regulation between Graz and Cven river section). The river became rapid flow type due to the construction of 26 hydropower plants operating in chain (*Kovačič et al. 2004, Balažič 2004*). The natural sediment transport completely stopped between the upper and the middle, lowland-type river sections, which caused the morphological degradation and, consequently, the deepening of the riverbed (*Hornich et al. 2004, Novak 2004*). The flow was concentrated in the main riverbed, the connection with the side channels and branches was terminated, so flow velocity and tension in the riverbed increased. 40% of the discharge of the Mura was in the main riverbed, 40% was in oxbow lakes and 20% was still water (*Novak 2004*). The natural sediment transport cycle disappeared because the hydropower plants on the upper Mura completely dammed the above-mentioned section of the river in Austria. No natural processes of bar formation and or any significant hydromorphological changes happened. The riverbed became 1.2 m deeper on average, but it reached 2.28 m deepening at some places (*Globevnik and Mikoš 2009*). Erosion of the bottom of the bed was happening at a lower rate due to the bigger width of the riverbed in the middle section of the Mura and on the Slovenian-Croatian border, so the deepening of the bed of the Mura was about 30-40 cm. The ground-water level decreased as a consequence of the deepening of the riverbed after radically cutting off the meanders (*Petkovšek and Mikoš 2000, Hornich et al. 2004, Novak 2004, Ulaga 2005, Globevnik and Mikoš 2009*).

Meanwhile, completely different problems arose in the part of the Mura on the Hungarian-Croatian border. The construction of dikes was finished in the 1970s and the floodplain between the dikes became 600-750 m wide. Agricultural developments were started according to the economic policy of the time. The areas along the river, together with the side branches, slowly lost their function and biodiversity decreased. Interfering with the natural status by deforestation, the drying of wetlands, changing land use and the coastal stripe have all contributed to the change of primary fields. New uses for land appeared: meadows, pastures and forest remnants. The newly established vegetation is full of foreign and invasive species that cause an impenetrable barrier in the floodplain (*Figure 2*). The higher water level of floods is a consequence of this when the Mura enters the floodplain (*Hercsel 2008, VIZITERV Consult and Láng 2012*). 1580 m^3/s discharge and 514 cm water level were measured on the Mura in 1972, but only 1200 m^3/s discharge and 509 cm water level in 2005 (*Engi et al. 2011*).

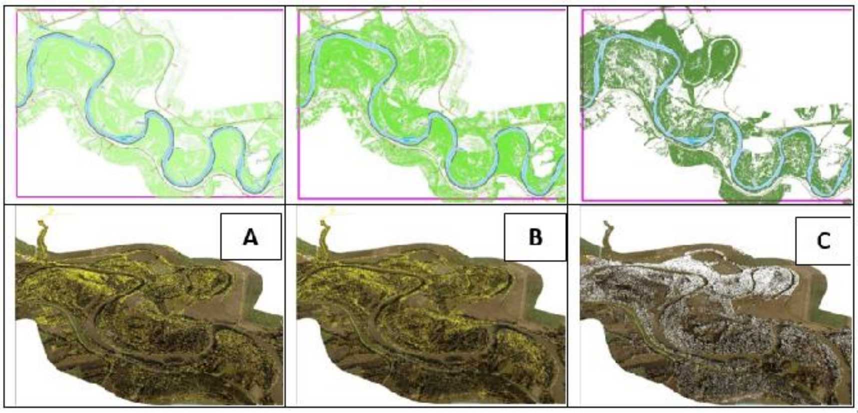


Figure 2. Overgrowth with low vegetation (A), medium vegetation (B), and high vegetation (C) on the basis of LiDAR data in the experimental area 2

Furthermore, there was no complex water management due to the historical changes of the state borders in the 20th century (*Tóth et al. 2013*). The riverbed changes and floods require constant attention, which need has been further amplified by extreme climatic changes in the last decades. Almost 300 m^3/s volumetric capacity has disappeared from the floodplain in the last 3-4 decades. The flood protection dikes are not able to cope with this tendency, but it would be too expensive to elevate them. Thus, the present capacity of the floodplain is not enough to contain the high discharge.

METHODS, RESULTS AND CONCLUSIONS

Sedimentological analyses of the samples and dating of the layers in the sample

In order to determine the tendency of the silting up process of the inundation area, the sediment sample was taken from the oxbow lake Hosszúvíz (*Nguyen et al. 2008, Braun et al. 2010, Korponai et al. 2010*) (*Figure 3*).

The layers of sediment relating to flood events could be distinguished on the X-ray image. Sedimentology analyses were also carried out and the grain size distributions of 195 sediment samples were analysed (*de Boer et al. 1987, Blott and Pye 2001*) (*Figure 4*).

The sand fraction grains (the first three categories) were taken into account for the dating of the drill core. The increased velocity transports the larger grains during flood events. The sampling location has been an oxbow lake since about 1830. The remarkable floods of the river Mura, registered in recorded by the Water Directorate, have been attributed to the extremely high sand fraction values. On the grain size distribution curve, the sediment of floods from the years 1972 and 1998 could be identified very clearly. The sediment samples were dated and the speed of the silting up process of the inundation area was calculated (*Engi et al. 2016 b*). The value is 1.17 cm/year (*Engi 2016*) (*Figure 5 and Table 1*).

Table 1. Connecting sample sections and ages

Depth (cm)	10 cm	30 cm	50 cm	70 cm	90 cm
Date (year)	1990	1973	1956	1939	1922

The method gives an adequate forecast for the future silting up process. The result was compared with similar data from other floodplains (*Károlyi 1960, Szlávik 2001, Keesstra 2007, Szabó et al. 2008, Oroszi 2009, Sándor 2011*).

Hydraulic modelling - Flood simulation

The experimental areas

MIKE 2D FM modelling system was used for the hydraulic modelling. In the dissertation, the model was developed using DEM data from the Mura Hydrographic Atlas of 2014 and the hydrological data of the 2009 flood. The experimental area covers the Hungarian section of the River Mura (*Figure 6*). The model was built from 9 km to 48 km (*Engi et al. 2016a, Engi 2016).*

The effect of flood propagation

The effect of flood propagation on the inundation area was studied. The values of specific discharge and velocity were analysed for the whole inundation area and in detail in 20-60 points of monitoring profiles. The main direction of the flow and the depth of the water was also shown on maps using different layers (*Figure 7*). The results show separated zones of specific discharge and velocity with the values of 0.2 $m^3/s/m$–0.8 $m^3/s/m$ and 0.2–0.8 m/s (*Engi, 2016*).

The possible locations of meander cut-offs

The studied river is of the alluvial type with developing meanders in spite of the standard bank protection. The possible locations of meander cut-offs were identified using separate layers for this purpose. The model forecasted the possible direction of the meander cut-off in a location which was evaluated in May 2016 (*Engi 2016, Engi et al. 2016a*) (*Figure 8*).

Comparison using a GIS method

Old historical maps were used for comparison. 7 digitalized river paths from 1785, 1860, 1880, 1920, 1976, 2002 and 2014 were analysed. The conclusion was that the Mura flows also in the old river paths and uses them for the conveyance of discharge in the inundation area. The old Mura river paths were identified in two experimental areas from the time of the Second and Third Military Surveys (*Engi 2016, Engi et al. 2016a*) (*Figure 9*).

The effect of flash floods

Simulations were run to discover the effect of flash floods on the development of the inundation area, specific discharge and velocity. The results were shown on flood maps of the four experimental areas in characteristic time steps and the flood wave propagation was described (*Engi 2016*) (*Figure 10*).

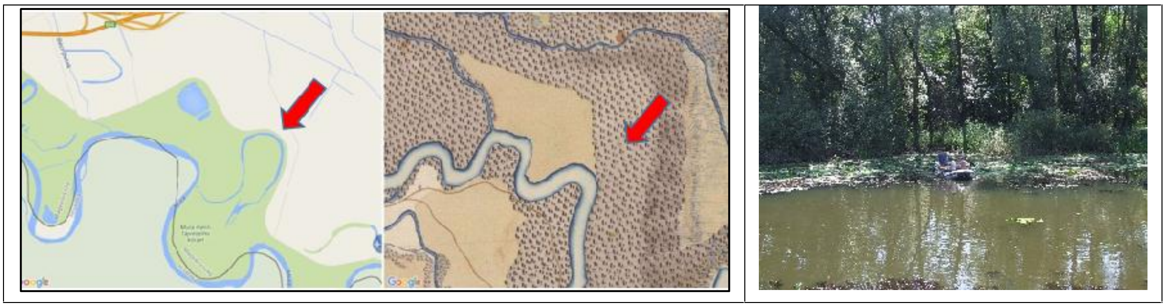


Figure 3. Location of experimental sampling shown on today's map and on the map of the First Military Survey (left) and the photo of oxbow lake Hosszúvíz (right)

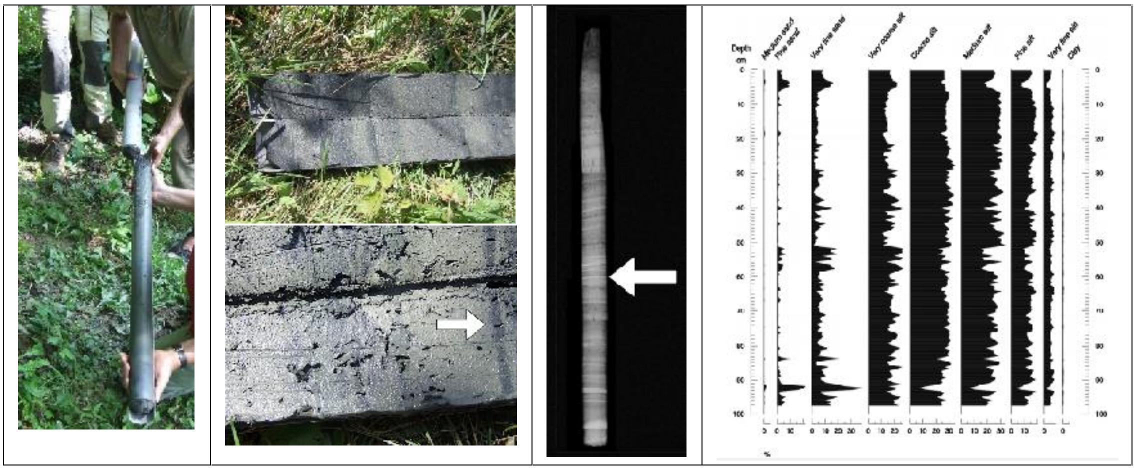


Figure 4. Adequate sample of sediment and a detail of the sample (left), x-ray image of the sediment sample (middle) and the grain size distributions of the sediment samples in the depths of 1 m (right)

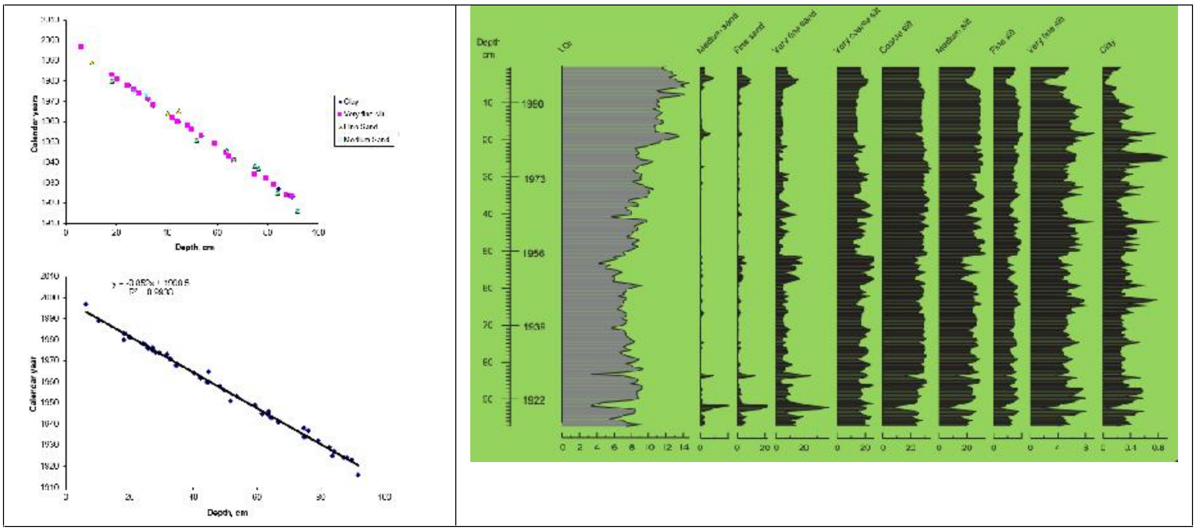


Figure 5. Connection between the flood event and the silting up value (left) and the i.e. dating of the layers in the sample (right)

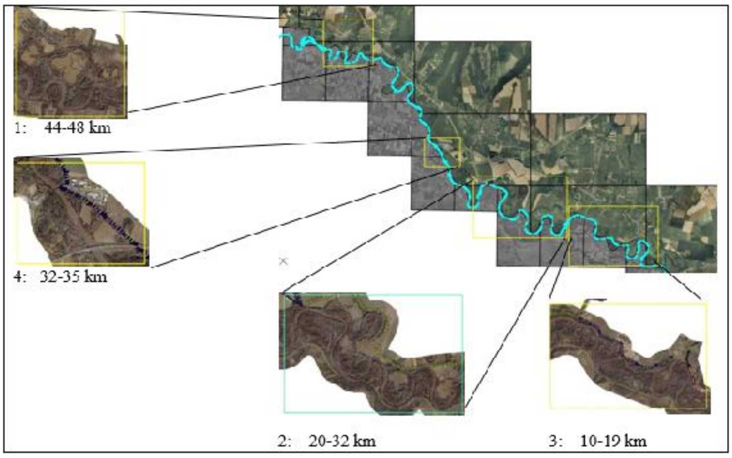


Figure 6. Location of 4 experimental areas

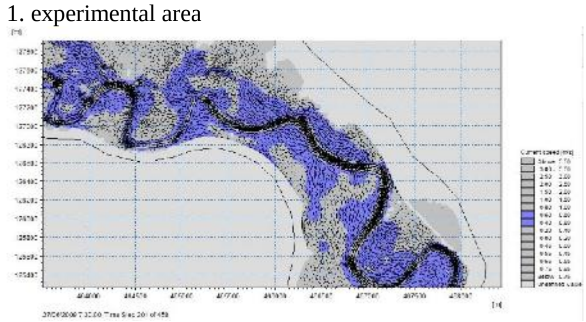
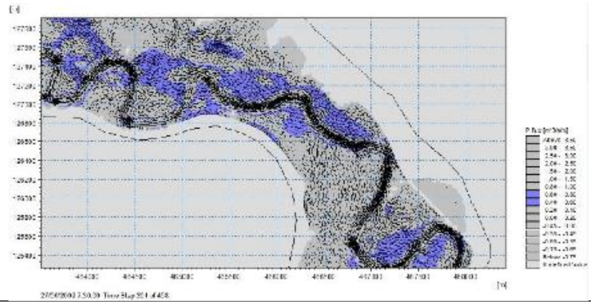
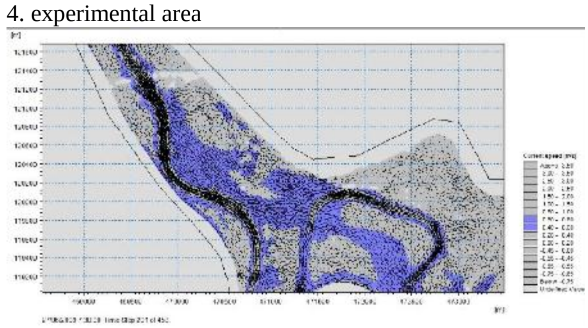
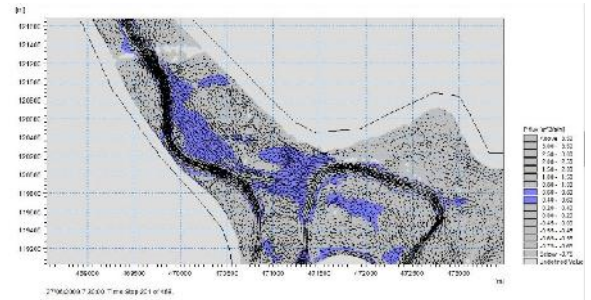
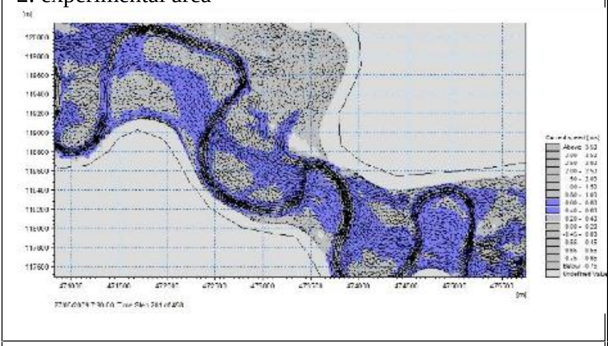
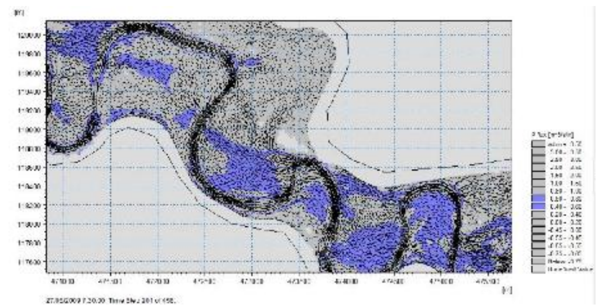
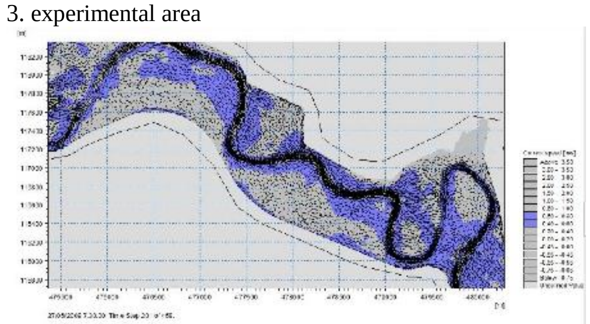
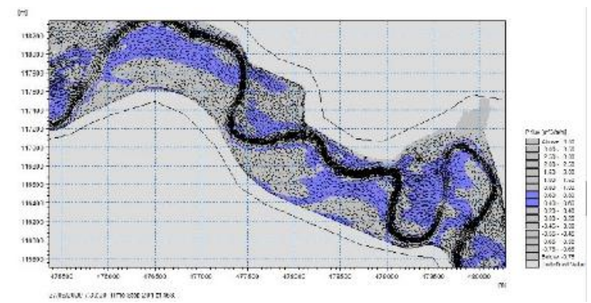
Velocity m/s	Specific discharge $m^3/s/m$
1. experimental area 	
4. experimental area 	
2. experimental area 	
3. experimental area 	

Figure 7. Development of specific discharge zones 0,4–0,8 $m^3/s/m$ and velocity zones in the experimental areas

Figure 8. The meander cut-off near the village Muraszemenye (left) and the meander (right) (adapted from: NYUDUVIZIG 2016)

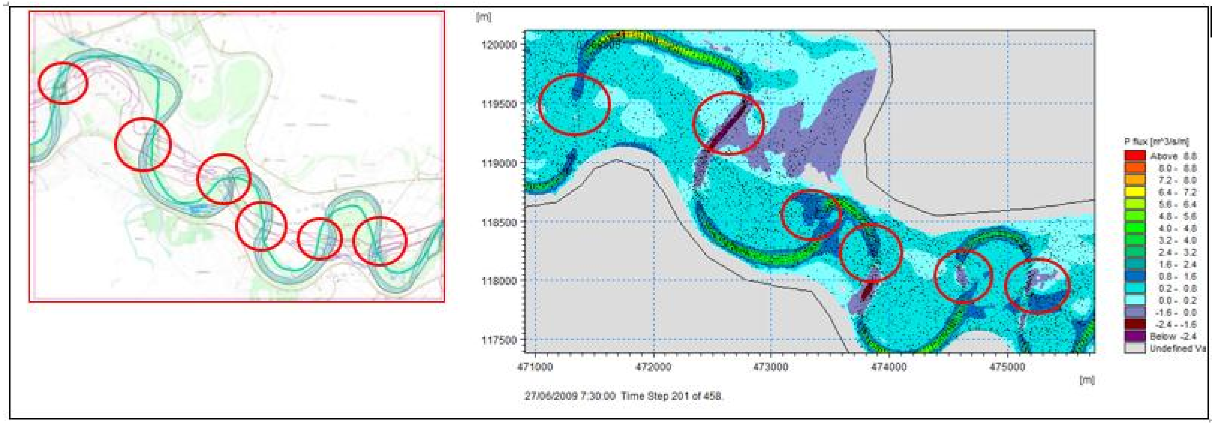


Figure 9. Comparison of old flow paths (left) and the modelled flow paths in experimental area 2 (right)

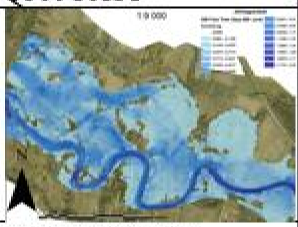
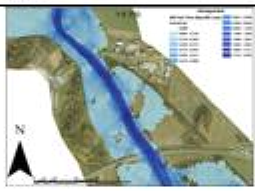
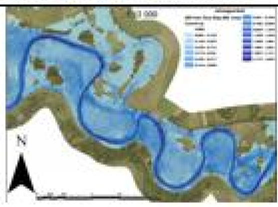
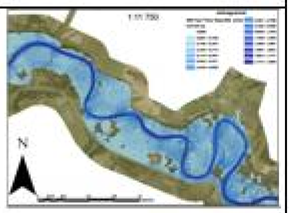
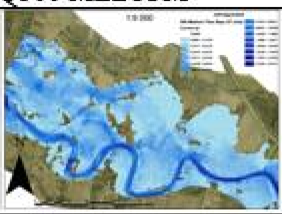
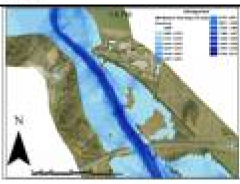
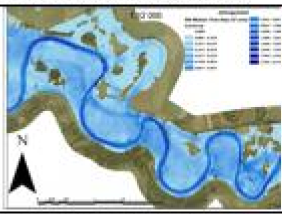
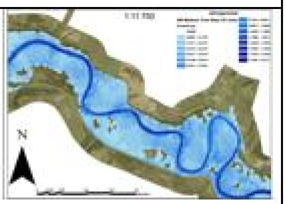
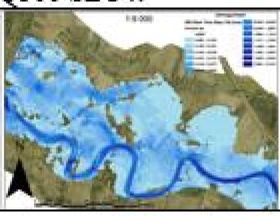
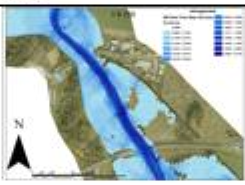
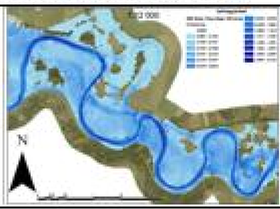
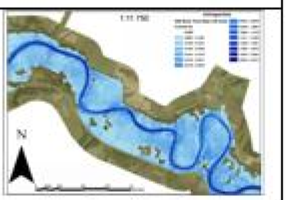
1. experimental area	4. experimental area	2. experimental area	3. experimental area
Q500 FAST	098	2005/08/23 08:25:00	
			
Q500 MEDIUM	127	2005/08/24 08:35:00	
			
Q500 SLOW	120	2005/08/24 02:45:00	
			

Figure 10. Simulation of flooding during the flood wave peak in the four experimental areas

Hydraulic modelling - Simulation of the silting up process in the inundation area

For the purpose of modelling the silting up process in the inundation area of the river Mura, the modelling systems MIKE 11 ST- Graded ST and MIKE 2D FM ST were used. 1D model was used to support the decision making to further develop the 2D model. In the sediment transport modelling process, the Van Rijn (*van Rijn 1984a*, *1984b*, *1984c*) and Engelund-Hansen (*Engelund and Hansen 1967*) equations were used (*Table 2*).

The results of erosion and the silting up process were underestimated with the sediment transport method of Van Rijn (*Figure 11*).

Table 2. Data about model development

	Transport formula	d50			Start time step, Time step factor		Start time step	Morphology	Start time step
v2_0	Van Rijn	2 mm	Smagorinsky HD	non equlibrium	T: 1440 st,30	helical flow	2880	no bed erosion	1440
v6_0	Engelund- Hansen	2 mm	Smagorinsky HD	non equlibrium	T: 1440 st,30	helical flow	1440	no bed erosion	1440
v3_0	Engelund- Hansen	6 mm	Smagorinsky HD	non equlibrium	T: 1440 st,30	helical flow	1440	no bed erosion	1440
v8_0	Van Rijn	6 mm	Smagorinsky HD	non equlibrium	T: 1440 st,30	helical flow	1440	no bed erosion	1440

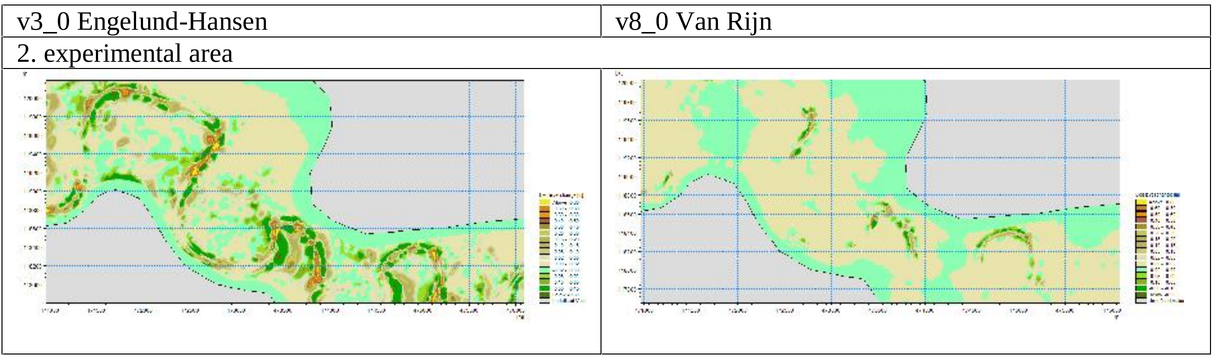


Figure 11. Erosion (m) or the silting up (m) process during the simulation of bed level geometry change in versions v3_0 (Engelund-Hansen) and v8_0 (Van Rijn)

The transport method of Engelund-Hansen yielded more realistic values, but in some locations the forecasted erosion and silting up of the bed level was »beyond possibility« (*Figure 12*).

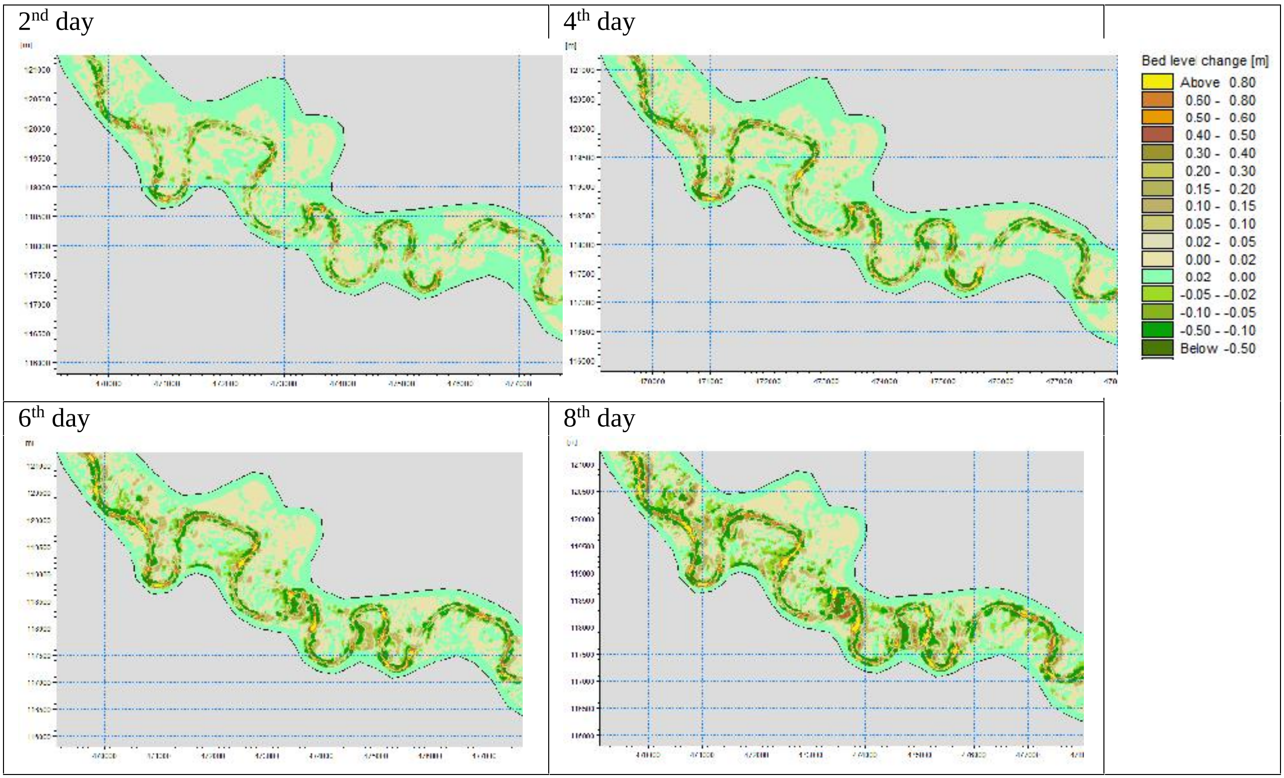


Figure 12. Morphological changes of the experimental area 2

The comparison of the forecasted bar locations by the model v6_0 with registered locations of bars on maps was also shown (*Engi 2016*) (*Figure 13*).

The development of meanders was also studied where bank erosion occurred (*Knighton 1998*) (*Figure 14*).

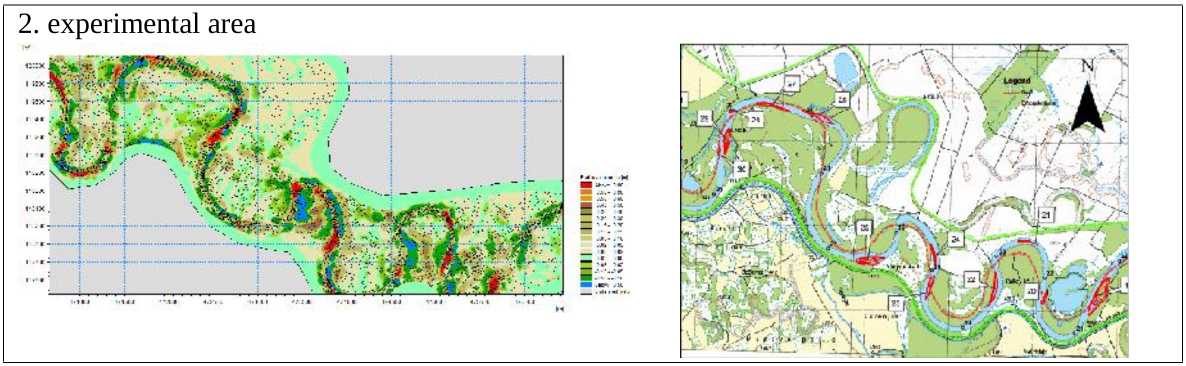


Figure 13. Comparison of the forecasted bar locations by the model v6_0 with registered locations of bars on maps

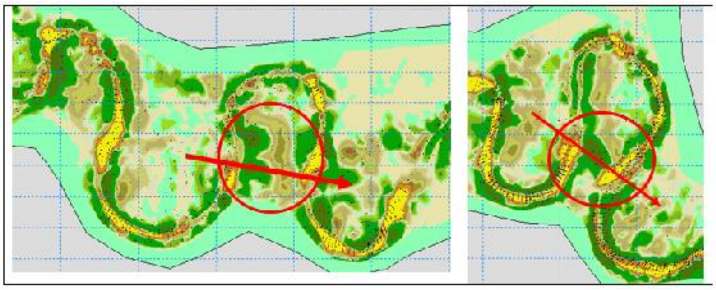


Figure 14. Development of meanders during the simulation of flood wave Q500 SLOW

Morphometric parameters for long-term development

Morphometric parameters for the long-term development of the river were analysed on the basis of digitalized paths of the river at different times (1785, 1860, 1880, 1920, 1976, 2002 and 2014). The long-term changes could be observed by comparing the values. In the past, the effects of river training or regulation works were evident in the short term. The effects of climate change will only appear in the long run, but if we identify the changes in the morphometric parameters of the river network we will be able to forecast the potential flood hazard in the future. The database contains seven vectorised river paths of the studied Mura section (*Figure 15*) and 535 meanders (*Brice 1983, Hooke and Harvey 1983, Rosgen 1994, Hooke 1997, 2006, 2207a and 2007b, Gregory and Walling 1973 in Tímár and Telbisz 2005*) in different developing stages (*Laczay 1982*). On the basis of the river-training works, the anthropogenic sections of the river were separated (*Engi et al. 2012, Engi 2016, Engi et al. 2016a*).

The morphometric parameters of different times were studied and compared (*Table 3*)*:* the central line and the width of the river, amplitudes of meanders, the length of the bend, etc. (*Engi 2016*).

Using these parameters, conclusions were drawn about the development of meanders (*Engi 2016, Engi et al. 2016a*) (*Figure 16*).

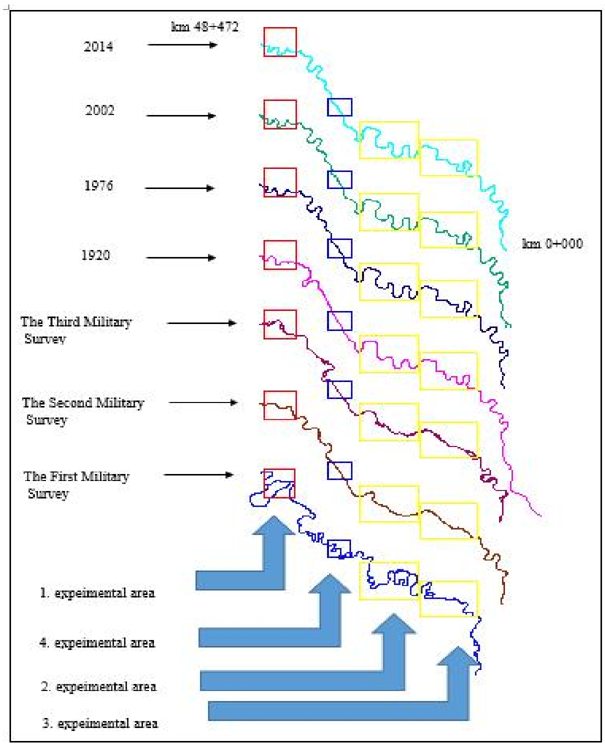


Figure 15. Comparing the historical paths of the Mura River in different periods in the river section 0+000 km – 48+472 km

Short and long-term methods were also compared (*Figure 17*). The lateral movement of meanders was evaluated (*Engi, 2016*).

Table 3. Changing of significant morphometric parameters of the river at different times

Significant morphometric parameters	1785	1860	1880	1920	1976	2002	2014
Total length of the central line (m)	53856	37586	37598	43141	49241	50306	49552
Width of the river (m)	185	154	140	-	94	74	80
Number of meanders	71	52	52	62	100	101	97
Length of the bend (m)	759	723	723	696	492	498	512
Amplitude of meanders (m)	126	110	88	122	73	75	81

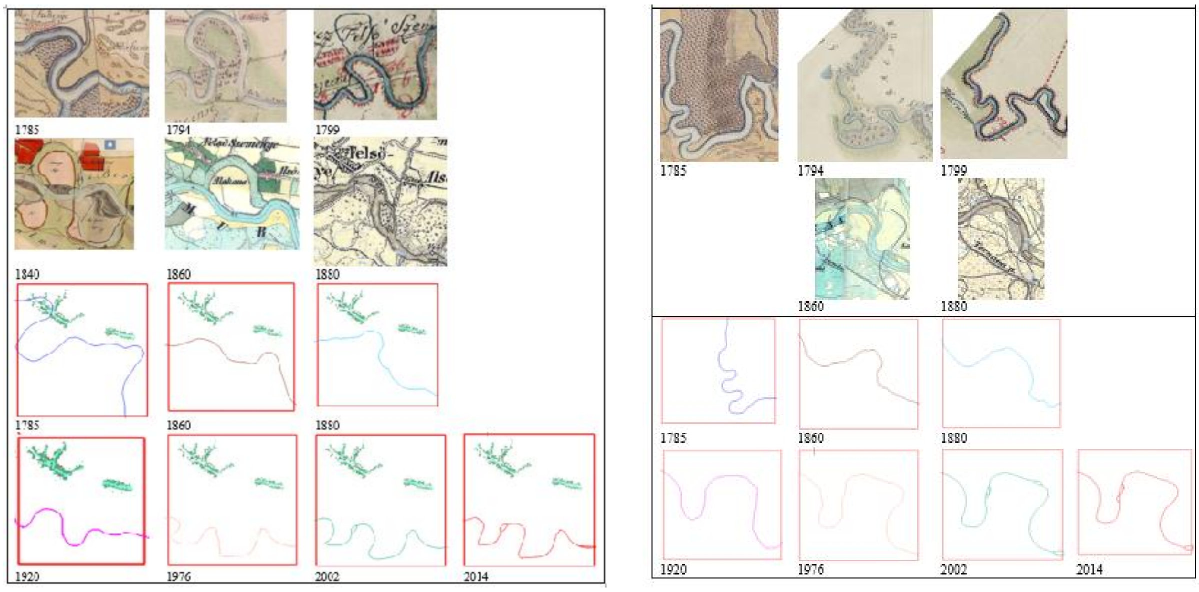


Figure 16. Development of meanders in experimental area 1 (near Muraszemenye) and the development phases of the omega-meander in experimental area 2 (adapted from: Hungarian Archive – Arcanum; Engi et al. 2016a)

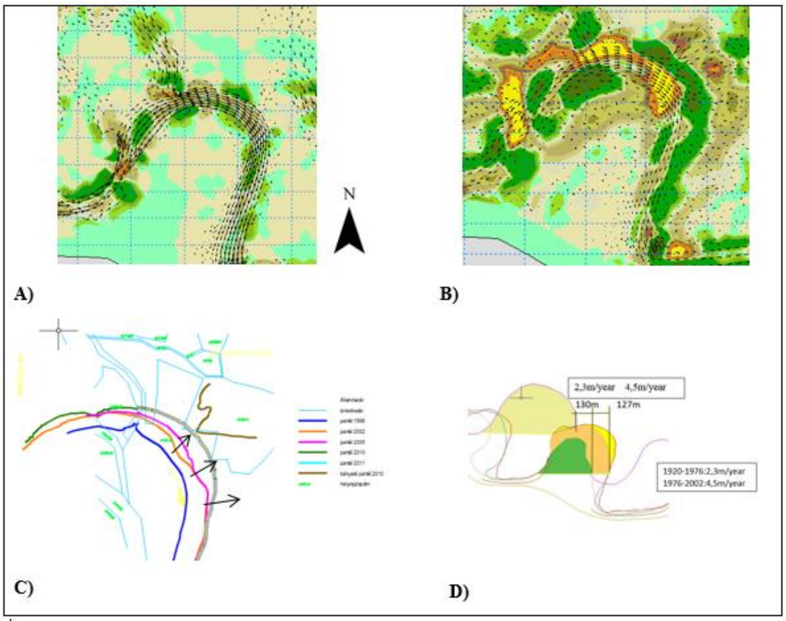


Figure 17. Lateral movement of the meander near the village Muraszemenye: after one flood event A) – B), in the period of 1998–2011 C) and between 1920–2014 D) (Engi 2016)

The meander belt

The meander belt (*Leopold and Wolman 1960, Gurnell 1995*) was delineated for the mentioned time periods (*Figure 18*) and the areas were calculated. The details of the belt area movement were shown and it was suggested that more room was needed for meander movement. Currently, the flood hazard maps are produced on the basis of the static path of the river, not taking into account the possible meander movements that might cause an increase in the flooded area.

The path of the river during the First Military Survey, which crosses the flood protection dykes in some locations, was shown (*Engi, 2016*) (*Figure 19*).

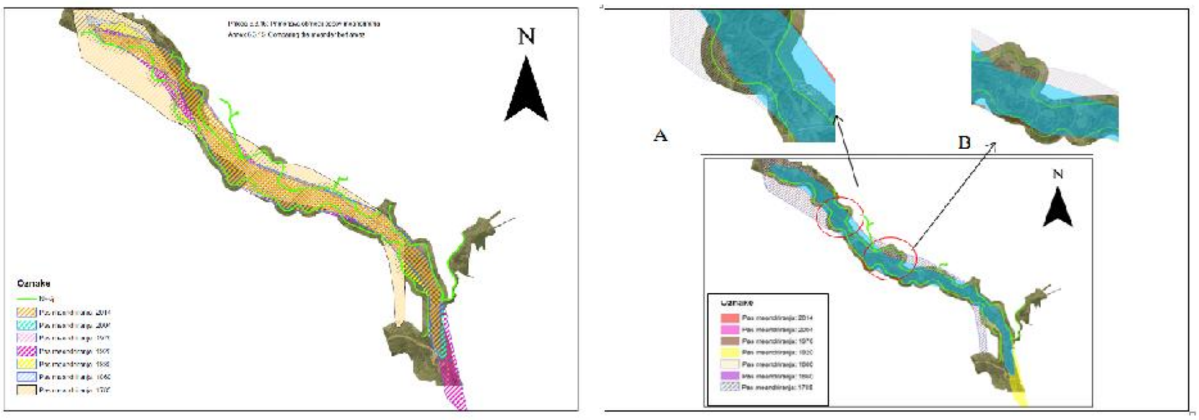


Figure 18. Comparison of meander belt areas in different periods (left) and the details of the narrowed inundation area (A and B) with the meanders (right)

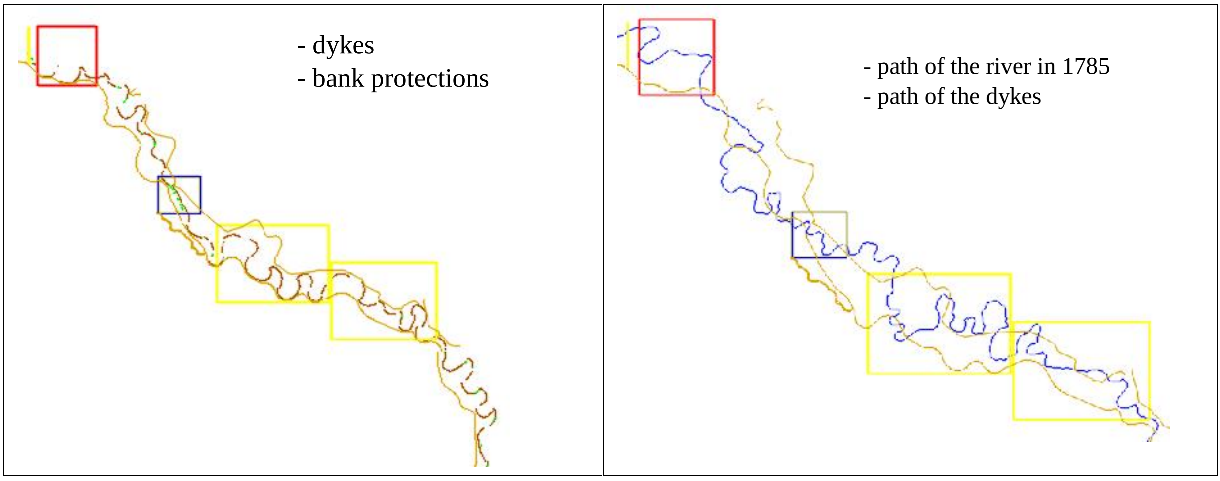


Figure 19. Flood protection dykes and bank protections from the profile km 48+472 to km 0+000 of the Mura river (left) and the path of the river during the First Military Survey, which crosses the dykes in some locations (right)

SUMMARY

In this brief overview of my doctoral dissertation, the main results of the research work were shown.

In the dissertation, the flooding and silting up process of the inundation area of downstream sections of the meandering river Mura were studied. The results of different research methods were compared (hydraulic modelling, geomorphological methods, sedimentological analyses, dating of the layers in the sediment sample) in order to evaluate the possible effect of the changes in discharge on the flood hazard due to climate change.

The silting up processes in the experimental area of the River Mura were studied using two research methods: sedimentological analysis and hydraulic modelling. On the basis of sedimentological analysis and the age of the sediment layer samples, the speed of the silting up process in the inundation area was calculated and compared with similar silting up values of other inundation areas. The conclusion is that this research method could be used for forecasting long-term silting up processes.

For the purpose of 2D hydraulic modelling, the MIKE 21 FM program was introduced. The travel zones in the flood-plain forming during the travel time of the flood wave were determined by using 2D hydraulic modelling. Flood maps from hydraulic modelling were also produced. We tried to simulate the effect of flash floods using three types of synthetic flood waves. The flooded status of the inundation area was compared during the flood peak and the falling limb of the flood wave in order to gain information about the changes of the riverbed and the silting up of the inundation area. The data were compared and the process was described in detail and presented on figures and flood maps which constitute annexes of the dissertation.

For the purpose of hydraulic modelling the silting up process, the MIKE 2D FM ST program was used. The basic data were taken from previous flood simulations. Results of the simulations provided information about the changes in the riverbed, the silting up or erosion processes of the inundation area and about bar locations. Because such research work has not been carried out on this downstream section of the Rriver Mura, the results were evaluated on the basis of measured silting up values after previous floods.

The geomorphological characteristics of the meandering outfall river sections were also studied. By using GIS methods, changes in the riverbed of the River Mura over the past 250 years were reconstructed in the dissertation. The main point of the method is that we can forecast future changes in the riverbed by projecting the lines of different ages ontoeach other. By using this method, it is possible to separate and date/periodise anthropogenic influences.

Using morphometric parameters, the long-term development of the river and the meanders were analysed. On the downstream section of the River Mura, no complete analysis of morphometric parameters has been carried out before. We carried out such a study, which also constitutes an annex to the dissertation (*Engi 2016*). Using the values, the meander movements and cut-offs are also forecasted. The long-term development of a special omega-meander is shown.

Flood maps from 2D hydraulic modelling and old historic maps were compared and evaluated. It was concluded that the River Mura uses the old river paths for the conveyance of discharge in the inundation area during flooding.

In the dissertation, the method for the calibration and verification processes for 2D hydraulic modelling were shown (*Engi 2016, Engi et al., 2016a and 2016b*). From the silting up process of the inundation areas, we draw conclusion about the development of the hydraulic status of the area. On the basis of the results, adequate interventions could be suggested for the decreasing of flood hazard in the inundation area.

By synthesising the research methods, we tried to evaluate what future effects on the flood hazard could be caused by changes in water level or discharge due to climate change.

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