DanubeSediment – Transnational Cooperation for Sediment Management in the Danube River

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Sediment management – a common challenge along the Danube River

Sediment transport is an integral component of every river system *(fig. 1)*. It influences a wide variety of sectors dependent on the river such as navigation, flood risk, hydropower production, agriculture, tourism, water supply and the habitats of flora and fauna.

Even the first direct human interventions during the late Middle Ages had a notable impact on the sediment regime of rivers, for example the increasing importance of inland waterway navigation lead to man-made alterations of the river bed and banks, thereby increasing the flow velocity of the water. Dike systems for flood protection, or the construction of hydropower plants in the Danube and its tributaries have led to the current situation, which is characterised by the replacement of natural dynamic processes with unidirectional developments, ongoing incisions of the river bed, sedimentation in floodplains, terrestrialisation, and missing regeneration of typical floodplain habitats and their riparian vegetation (Hohensinner 2015).

Figure 1. *Estuary of the Isar entering the Danube; Source: www. agroluftbild.de.*

The EU Water Framework Directive (WFD, 2000/60/EC), which entered into force in 2000, recognizes rivers as ecosystems that have to be protected and enhanced. In the Danube River Basin, the ICPDR (International Commission for the Protection of the Danube) provides the platform for the implementation of all transboundary aspects of the EU WFD and the EU Flood Directive (EFD, 2007/60/EC).

In order to implement the WFD, ICPDR developed the Danube River Basin District Management Plan (DRBMP) in 2009 and updated the plan in 2015. The DRBMP 2009 stated that "sediment balance of most large rivers within the Danube River Basin can be characterised as disturbed or severely altered. Morphological changes during the last 150 years due to river engineering works, torrent control, hydropower development and dredging, as well as the reduction of adjacent floodplains by nearly 90%, are the most significant causes of impacts." (ICPDR 2009, p 25; ICPDR 2015, p 45).

The DRBMP therefore proposes to establish a sediment balance for the Danube River Basin and to provide sufficient data for this approach. The sediment continuum must be ensured by improving existing barriers and avoiding additional interruptions. Further investigations are needed to identify the significance of sediment transport on the basin-wide scale of the Danube River.

The updated DRBMP of 2015 announced the preparation of a transnational project as necessary to improve the "availability of sufficient and reliable data on sediment transport". The project should develop a "sediment balance" and assess what "additional investigations are needed to identify the significance of sediment transport on the Danube basin-wide scale" (ICPDR 2015, p 45).

In January 2017, the work on these tasks began in the frame of the DanubeSediment project, funded by the Interreg Danube Transnational Programme (DTP). For a period of two-and-a-half years, 14 project partners from higher education institutions and sectoral agencies in 9 countries along the Danube River are collaborating to collect sediment transport data in the Danube River and its main tributaries, to set up a Danube-wide sediment balance, to identify the key drivers of sediment discontinuity as well as the collection of measures that enable a more sustainable sediment management in the Danube River Basin.

As the sediment in the Danube River is managed by a wide range of stakeholders across many countries, transnational cooperation between the different sectors is vital. To develop a sustainable approach, the stakeholders require a good knowledge of sediment processes and tools for joint action on sediment management. The DanubeSediment project will therefore provide a Danube Sediment Management Guidance (DSMG) with key recommendations for reducing the impact of a disturbed sediment balance, e. g. on the ecological status and on flood risk along the river. These recommendations will be fed into the Danube River Management Plan (DRBMP) and the Danube Flood Risk Management Plan (DFRMP).

To directly address the specific needs of the key stakeholder groups, a Sediment Manual for Stakeholders will provide sector-specific know-how and include good practices examples for sediment management in the Danube Basin, e. g. for navigation, hydropower, flood risk and river basin management including ecology.

The collection of sediment data in the Danube River and its main tributaries

In a first step, the project partners established an inventory of metadata about sediment monitoring stations for suspended sediment as well as bed load measurements along the Danube and near the mouths of the major tributaries. The metadata spanned historical and present times. Each project partner provided information on sediment monitoring, as well as on laboratory analysis and sediment load calculation methods applied in their country. This data collection was managed via web-based questionnaires. The collected metadata was then summarized in a report, including tables and base maps that indicate the sediment monitoring practice of each country.

During the second half of 2017, the partners collected sediment data. Suspended sediment load data was gath-

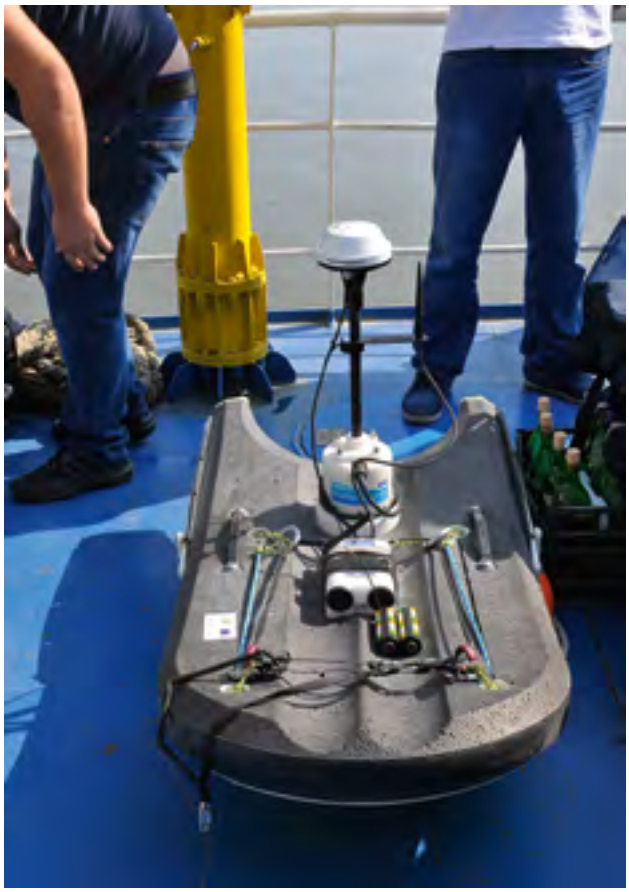

Figure 2. An Acoustic Doppler Current Profiler measures flow velocity and water depth, which are needed to calculate the discharge in a cross section. Source: Marlene Haimann / IWHW – BOKU

Figure 3. Sampler in Bulgaria using the depth-integral method. Source: Marlene Haimann / IWHW – BOKU

ered on a monthly basis, covering the period of 1986–2016. For recent flood events, load values were gathered on a daily basis. Information on suspended sediment was provided for 41 stations along the Danube and for 20 stations from the tributaries. Bedload data was assessed at 22 stations.

In order to reveal sediment data uncertainty and possible bias in the datasets, a comparative analysis of the sediment data was performed. The analysis consisted of two parts:

i) comparison of historical sediment data collected at Danube sections shared by two countries, such as Hungary – Slovakia, Serbia – Romania and Romania – Bulgaria;

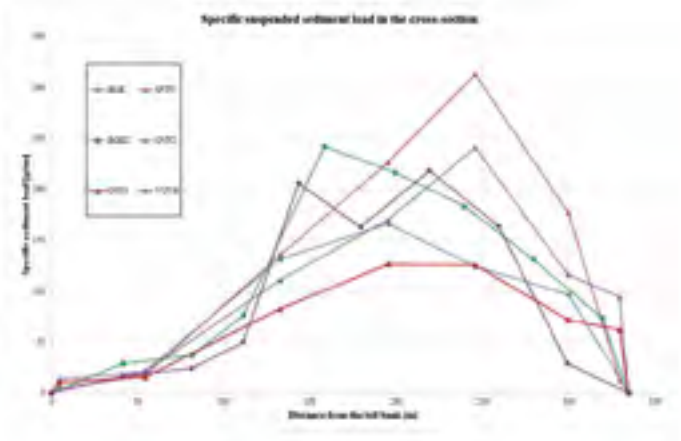

Figure 4. Comparative analysis showing the cross-sectional distribution of specific suspended sediment load measured by project partners with different methods at the measurement site: Danube, Bad Deutsch-Altenburg, Austria. Source: Sandor Baranya, unpublished

ii) comparison of sampling methods *(fig. 2, 3)* in the frame of joint field measurement campaigns. The results of the comparative analysis contributed to the elaboration of good practices in sediment monitoring *(fig. 4)*. The latter information will be compiled as a handbook that will be made available to interested parties.

Using the collected and analysed sediment datasets, longitudinal and temporal variations of the sediment load are in the process of being assessed. The quantified analysis of sediment transport along the Danube will produce key results for the project goals. For example, the sediment data will reveal sections that present problems for sediment continuity, such as reaches with significant bed erosion or sedimentation. Furthermore, the collected data can contribute to analyse the impact of hydropower plants or floods on sediment continuity.

Towards a Danube-wide sediment balance

In a first step towards the evaluation of the sediment balance, project partners checked the availability and accessibility of present and historical data. This information is also needed to understand the influence of long-term morphological developments of the Danube River on the sediment regime.

In order to calculate the sediment balance, the data collected on the suspended sediment load (see above)

was complemented by data on morphological characteristics of the river channel, e. g. bathymetry, longitudinal profiles, minimum navigational water levels, dredging / feeding amounts, bed material and bed load composition. This data has been deployed for three time periods: 1920–1970, 1971–1990 and 1991–2016. Each period is characteristic for different degrees of river channel modification.

Another important component of the sediment balance is the quantification of morphological changes, e. g. areas of erosion and sedimentation or the slope of longitudinal profiles. Depending on the availability of underlying data, these bedload parameters were provided for shorter river reaches and several time periods. In case this bedload transport data is insufficient or missing, the volumes of river bed aggradation / degradation are needed.

In general, the sediment balance analysis covers three morphologically different river sections: Upper Danube, Middle Danube and Lower Danube, as well as the selected tributaries. In selected Danube river reaches for which more data is available, a small scale analysis will be done.

In order to analyse the long-term morphological development of the Danube in the context of sediment balance changes, historical maps from the end of 19th century were compared to the present state (2016/2017): Information gathered in this step, such as the modification of the river pattern and the river bed slope, the narrowing and shortening of the active river channel, spatial and temporal changes of sediment composition, has been quantified to identify changes in the river processes and morphological characteristics of the Danube channel. This gives an under-

Figure 5 and 6. *DanubeSediment Stakeholder Workshop held in Germany (bottom) and Austria (top); Source: LfU (bottom) and Marlene Haimann / IWHW – BOKU (top)*

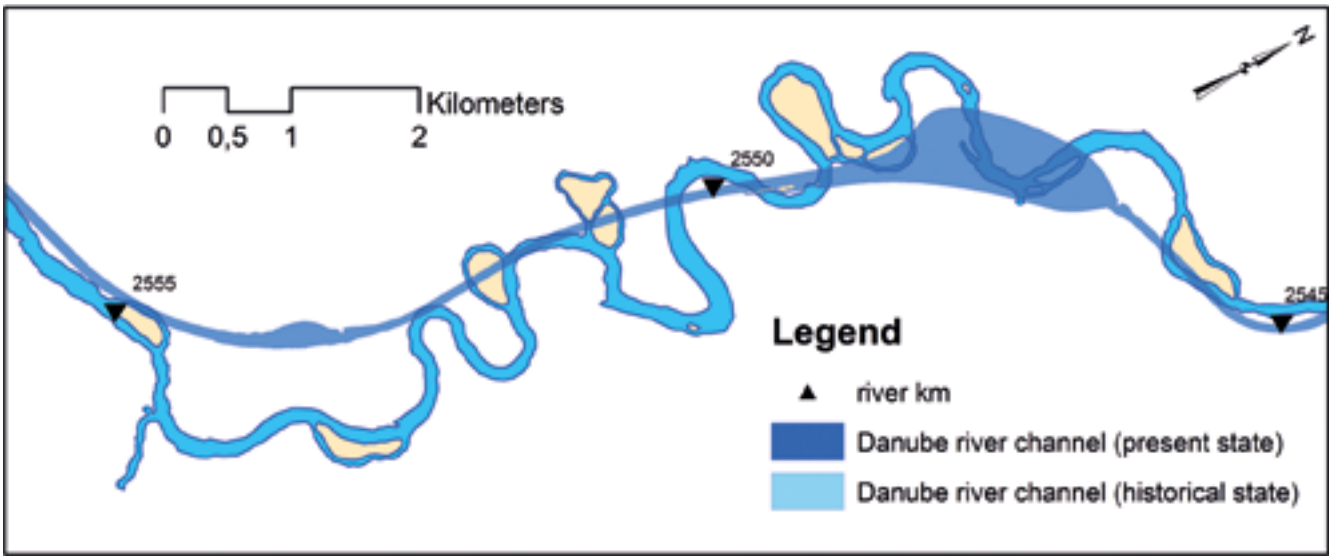

Figure 7. Shortening of the Danube river in Germany; source: VUVH

standing of the degree of hydromorphological alteration in the Danube River.

Determination of the key drivers of sediment discontinuity

Based on the DPSIR (Driver-Pressure-State-Impact-Response) method, past, present and future developments of key drivers causing changes in the sediment balance of the Danube and its selected tributaries (Isar, Inn, Traun, Enns, Morava, Lajta, Raba, Vah, Drava, Tisza, Sava, Velika Morava, Jiu, Iskar, Yantra, Arges, Ialomita, Siret, Prut) were analysed. For that purpose, project partners gathered information by qualitative questionnaires: A total of 33 questionnaires were filled out, one for each national section of the Danube and one for each national tributary. Additionally, the key drivers were collected as GIS-shapefiles.

A first analysis of the data shows that navigation, flood protection and hydropower are considered as the main

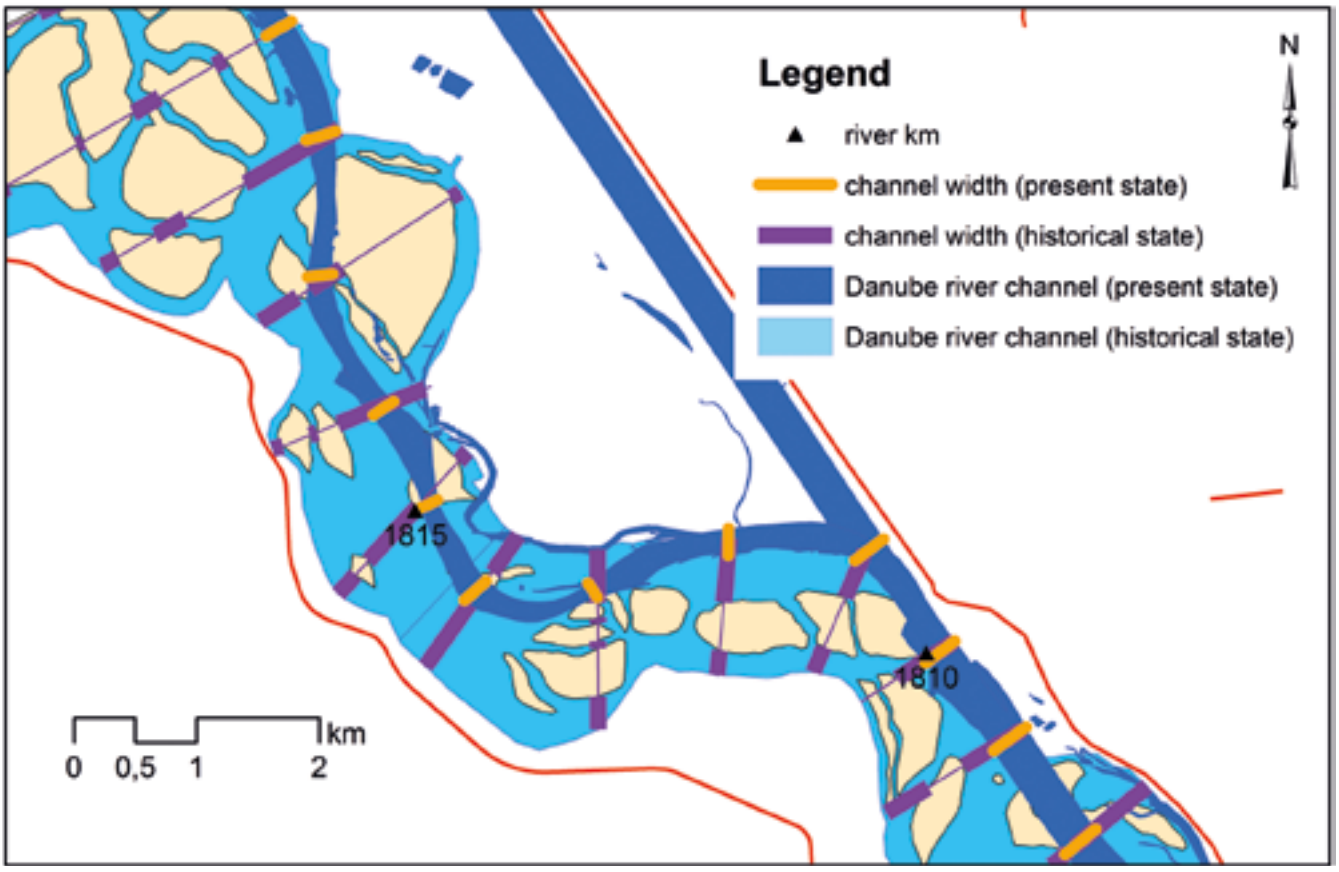

Figure 8. Changes of the Danube river channel width in Slovak – Hungarian section; source: VUVH

drivers for changes of the sediment regime on a Danube Basin level. Furthermore, agriculture and water supply (for drinking and industrial purposes) have been identified as important drivers, though the interaction of agriculture and sedimentation could only be considered on a limited basis within this project. Previous studies have shown that the influence of agriculture on quality issues of sediment is particularly high – an issue that is outside the scope of the DanubeSediment project.

Figure 9. DanubeRiver, east of Vienna, view from Braunsberg; Source: Philipp Gmeiner, IWHW-BOKU, Vienna

A sediment guidance and a stakeholder manual for the Danube River

Based on the knowledge and insights gained during the activities described above, which are flanked by an active and regular stakeholder involvement via workshops on national and international level *(fig. 5, 6)*, the project will produce a Danube Sediment Management Guidance (DSMG) and a Sediment Manual for Stakeholders (SMS).

The DSMG will be a strategic document for decision-makers that seek to improve awareness on sediment quantity-related problems. It will suggest measures for solving sediment-related problems in the Danube River Basin, such as the impacted ecological status and the increasing flood risk. The document will provide a strategy for better sediment management, such as improving the sediment continuity as well as reducing the gap between surplus and deficits of sediments, directly contributing to improved transnational water management and flood risk prevention.

The Sediment Manual for Stakeholders (SMS) will support the guidance document by providing detailed and stakeholder-oriented background information and complimenting it by concrete examples of measures. The SMS will give suggestions for the future planning of sediment management measures and describe sediment-related good practice examples. To address the key stakeholders, the manual will focus on hydropower, navigation, flood risk management and river basin management, which includes ecological issues. Stakeholders such as companies responsible for waterway maintenance, hydropower plant operators or nature protection can benefit from the recommendations made in the SMS, e. g. about new sediment management methodologies, which can be directly implemented into their operation and daily business. A specific chapter of the manual will discuss the importance of multi-stakeholder interrelation and transnational cooperation to tackle the issue of sustainable sediment management. The Danube Sediment Management Guidance and the Sediment Manual for Stakeholders will contribute to the next Danube River Basin Management Plan and the Danube Flood Risk Management Plan.

References

Hohensinner S (2015): Historical patterns along the Danube's course. Danube Watch 2/2015, p.5

ICPDR (2009): Danube River Basin Management Plan 2009

ICPDR (2015): Danube River Basin Management Plan 2015

News and Notes

Comparison between long-term monitoring survey data and "snap-shot" data from investigative monitoring of Joint Danube Surveys – Case study for nutrients along the Romanian stretch of the Danube River

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The assessment of nutrients in the Danube River has a well-known long-term history at the basin-wide level, especially in view of the link between the nutrient loads of the Danube and the eutrophication of the Black Sea. Therefore, monitoring the pressures given by nutrients in the Danube River Basin District and the extent to what the nutrient loads into the Black Sea are being reduced is one of the major objectives of the comprehensive monitoring activity carried out by the Danubian countries within the frame of Trans-National Monitoring Programme (TNMN) of the International Commission for the Protection of the Danube River (ICPDR). Tailored as a long-term surveillance monitoring, TNMN provides a general overview of the selected water quality parameters in terms of concentrations and loads, mainly in transboundary context. On the other hand, even if according to the Water Frame Direc-